The Impacts of Digitalization

Identifying emerging challenges and opportunities for sustainability reporting

Authors

Alper Cezmi Ozdemir, Research Associate, GRI

Miguel Perez Ludena, Research Lead, GRI

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Executive summary

Digital technologies are being adopted and integrated into numerous sectors by businesses, governments, and individuals at remarkable rates. The growing use of new digital tools and services will create – and in certain areas already creates – various sustainability-related impacts.

To better understand emerging sustainability reporting needs that arise from this trend, we consulted peer-reviewed academic literature and key resources from leading international organizations. We identified three primary categories of actual and potential impacts: environmental, economic, and human rights-related. We then assessed how well the existing GRI Standards capture digitalization-related impacts and identified reporting gaps. We also analyzed various international initiatives to inform the direction of new, universally applicable reporting standards that address impacts related to data privacy and management, cybersecurity, and the use of artificial intelligence (AI) systems.

Environmental impacts linked to digitalization primarily stem from the development, production, maintenance, and eventual disposal of the physical infrastructure that enables and sustains digital systems. This infrastructure is robust, complex, and growing, encompassing resource-intensive data centers, undersea and underground fiber optic cables, satellites, cell towers, base stations, and personal devices.

From an economic perspective, digitalization affects factors like productivity, competition, labor, and employment. The impact of digital technologies on productivity has been uneven, largely depending on how effectively organizations harness these technologies. Regarding impacts on labor and employment, the influence of digital technologies differs from previous waves of automation. While there has been some job displacement, it is simultaneously generating new opportunities at an increased pace.

Digitalization has significant implications for human rights through the collection and use of personal data and interaction with digital services, including artificial intelligence (AI). The extensive collection and utilization of personal data raises concerns about privacy and protection, with existing regulatory frameworks struggling to keep up with technological advancements. Additionally, the increased use of AI and algorithmic decision-making can contribute to biases and discrimination, particularly in areas such as employment and access to essential services.

Despite numerous claims about digitalization being a transformative opportunity for sustainable development, realizing this potential depends on various other intervening factors. While digital technologies do offer promises for advancing sustainable development goals, evidence suggesting that this potential has been achieved is limited. In fact, there are indications that the acceleration of digital transformation has intensified resource consumption and led to negative environmental impacts – including a surge in e-waste, higher energy and water usage in data centers, and increased production of technological hardware. Regarding human rights impacts, the lack of transparency in data governance and AI systems underscores the need for robust governance and reporting frameworks.

The GRI Standards provide some coverage of the broader impacts of digitalization. The environmental and economic Topic Standards are robust and comprehensive. With the ongoing update of the economic impact and labor-related Standards, it is possible to capture the impacts of digitalization in these areas. Additional reporting guidance on these impacts would help organizations understand how their decisions to adopt digital technologies affect various outcomes. However, there remains a significant reporting gap in addressing the more unique impacts of digitalization, including issues related to data governance, AI usage, and algorithmic decision-making. While certain unique aspects, such as in *GRI 418: Customer Privacy*, are covered, updates to existing disclosures are necessary, and reporting expectations must align with internationally recognized frameworks. Furthermore, new disclosures concerning AI deployment should be developed.

On a global scale, a rapidly evolving regulatory landscape is influencing the trajectory of digital transformation, with diverse efforts across jurisdictions aiming to shape its development. However, it is apparent that the GRI Standards and other internationally recognized sustainability reporting frameworks are lagging behind in setting reporting expectations for the adoption of digital technologies and the implications of the transition.

Introduction

Digitalization, defined as the use of digital technologies, data, and interconnectivity that results in new or altered activities, is often described as the 'transformational opportunity of our time' [76] [13]. Digital connectivity and data are essential for everyday life, from online shopping to maintaining critical services like healthcare, energy, water treatment, and agriculture. Digital technologies are also being increasingly adopted for environmental purposes, with applications ranging from monitoring salinity levels of oceans to biodiversity monitoring. Despite the digitalization gap[1], digital technologies are being adopted faster than any previous technological advancement [2] [13].

Since 2010, the number of internet users worldwide has more than doubled, while global internet traffic has expanded 25-fold [37]. At least 63% of the world's population has internet connectivity [73]. While the initial connectivity surge occurred in developed economies, emerging economies are also rapidly catching up, accounting for around 90% of total growth in mobile broadband subscriptions between 2012 and 2017 [35].

This data, technology, and connectivity surge has been described as the second machine age [13]. The rapid advancements in digital technologies mark a significant departure from the first machine age, the Industrial Revolution. While the first machine age transformed the world with the advent of production at the industrial scale, the second machine age is revolutionizing the digital landscape with the potential to create fundamental societal change [13].

An equally impressive growth in the technology sector is accompanying the digitalization boom. At the time of writing this report, the top five most valuable companies globally by market capitalization are technology firms, collectively valued at over USD 14 trillion. Figure 1 depicts their growth over a 15-year span, during which technology organizations such as Apple, Google (Alphabet), Microsoft, Amazon, and Meta overtook firms from traditionally dominant industries like energy, retail, and pharmaceuticals. Organizations in the technology sector are also seeing unprecedented levels of overall investment through various streams of public, private, and capital market funding.

[1] The digitalization gap refers to the disparity between individuals, organizations, or regions in terms of access to, adoption of, and effective use of digital technologies. This gap can manifest in various ways, including differences in internet connectivity, digital literacy, availability of digital infrastructure, and the ability to leverage digital tools for economic, educational, and social benefits. The digitalization gap often results in unequal opportunities and outcomes, reinforcing existing socio-economic inequalities and creating barriers to participation in the digital economy and society.

Figure 1. Largest companies by market capitalization between 2002-2017

Key message: Digital technology companies have become global leaders by market capitalisation, though energy companies still lead in revenues.

Notes: Rankings are for publicly traded companies; market capitalisations calculated at the end of Q2; circle sizes are relative to market capitalisation.

The rise of digital technologies and their ongoing transformation is expected to continue. In the past few years, advancements in machine learning and big data have facilitated the widespread adoption of artificial intelligence tools [19]. The proliferation of digital technologies and the potential of digital transformation offer developing nations opportunities to enhance well-being, boost economic productivity, and promote growth [53]. As a result, many developing economies are implementing strategies to effectively utilize digital technologies to meet governance and developmental challenges [76].

Major economies also drive further digital innovation and adoption through official government policy. In doing so, they aim to simultaneously gain an edge in technological innovation while accounting for risks around new digital technologies. The United States Safe Innovation Framework aims to position the U.S. at the forefront of global technological innovation while establishing a robust regulatory framework to ensure that innovations are secure, accountable, and explainable. Similarly, the European Union’s Digital Strategy seeks to achieve digital transformation by 2030 while also promoting it to enhance the EU’s global competitiveness [22]. Through its National Digital Plan, China intends to expand its digital infrastructure and economy positioning the country as a leader in advancing digital innovation [66].

The adoption of new tools and services facilitated by digital technologies is likely to create various impacts, some of which are already being observed. For example, energy companies are introducing smart power meters and household devices that adjust electricity usage based on supply and demand in the grid. In urban environments, cities are utilizing digital tools for predictive maintenance and optimizing traffic flow through adaptive signal control systems. In manufacturing, the availability of data from interconnected sensors can lead to more efficient resource use and customized production outcomes. Emerging technologies are unlocking new capabilities that enable monitoring of at-risk ecosystems [67].

The digitalization of customer-facing services, such as financial and health services, retail, and others, has transformed these sectors. However, this rapid change has also brought to the forefront concerns about data privacy and security and the risks of bias and discrimination [7]. Moreover, the environmental cost of digital transformation is unclear. Some have referred to digitalization as a 'potential fire accelerant' [27], an environmental 'game changer' [59], or 'a core component of the green transition' [30]. Indeed, while digital technologies hold transformative power that can promote the sustainable use of resources, experts and academic literature approach this potential with caution. The German Advisory Council on Global Change concludes that 'technical innovation surges do not automatically translate into sustainability transformations but must be closely coupled with sustainability guidelines and policies' [27].

Amidst far-reaching changes brought about by the ongoing digital transformation of the economy, organizations are likely to face growing scrutiny over the impacts a change of this magnitude brings. It is, therefore, essential that organizations are provided with the necessary reporting tools, guidance, and training to effectively report on these impacts and remain transparent and accountable to their stakeholders. This paper aims to provide a survey of the most significant impacts related to digitalization, identify reporting gaps within the GRI Standards, and discuss the outlines of a global reporting standard that would capture the impacts of digitalization.

The report is structured as follows: it begins with scoping and methodology, followed by an overview of digital technologies, including the associated physical infrastructure and services. Subsequent sections identify and elaborate on the impacts of digitalization across three main categories: the economy, the environment, and people, specifically human rights implications. To understand the need for a Topic Standard on digitization, the next section assesses the adequacy of relevant GRI Standards in capturing the previously identified impacts. The final section provides an overview of existing reporting expectations surrounding digitalization impacts, followed by the concluding remarks.

Scoping and methodology

Scope

Digitalization is a complex topic that has widespread effects across many sectors. These impacts can occur throughout the entire life cycle of a digital technology, from its initial design and deployment to its eventual retirement. The process of digitalization relies on the interconnection of technological devices and digitized data, all supported by a strong physical infrastructure that forms the backbone of the digital ecosystem.

While it is essential to prioritize responsible design and development of new digital technologies, this research project specifically examined the impacts of adopting digital technologies. It also considered the physical infrastructure that supports digital activities and its effects on the economy, the environment, and people, including their human rights. This broad approach was chosen because focusing exclusively on technology companies and the development phase would limit the exploration of digital technology's impacts across various sectors.

The responsible design and development of digital technologies warrant separate research focused on the technology sector. Therefore, this research was conducted with a sector-agnostic perspective to provide a comprehensive understanding of digitalization's impacts.

Methodology

To prepare this research paper, the following methodology was employed:

1. **Scoping:** This phase aimed to clarify what digitalization entails, specifically distinguishing the activities of organizations within the technology sector from the broader concept of digitalization. This distinction was essential to guide the research according to the existing GRI Sector and Topic Standards while maintaining a sector-agnostic perspective.

2. **Desk Research:** Relevant qualitative and quantitative data on the impacts of digitalization were identified through desk research. As detailed in the bibliography section, a diverse range of sources was utilized, including academic journals, scholarly search engines (such as Google Scholar, Scopus, and Web of Science), and websites of globally recognized organizations, including the United Nations, the Organization for Economic Cooperation and Development (OECD), and the International Labour Organization (ILO), among others.

3. **Framework Analysis:** A review of 26 existing frameworks, guidelines, principles, and regulations was conducted to understand the regulatory and reporting landscape of digital technologies. Due to

the inconsistent and fragmented nature of regulations surrounding digital technologies, texts from various regulatory jurisdictions were examined. This analysis contributed to the drafting of the report, and a database of these frameworks can be found in the project documentation.

4. **External Engagement:** The principal researcher participated in workshops and conferences focused on digitalization, technology policy, and tech ethics and held two consultation meetings with experts—one from academia and the other from the NGO sector.

CHAPTER 1
Overview of digital technologies

Describing digitalization

Digitalization refers to the increasing use of information and communication technologies across the economy [35]. However, there is no consensus on its definition. A widely cited academic paper on digital transformation points to the lack of academic literature on this concept:

> 'Despite the ubiquity and visible impact of digital transformation and resultant new digital business models, the academic literature has so far paid surprisingly little attention to these developments, only recently starting to address the topics of digitization, digitalization, and digital transformation.' [72]

Among international authoritative instruments, the OECD defines digitalization in its landmark document, *Digitalisation and Responsible Business Conduct,* as '*the use of digital technologies and data as well as interconnection that results in new or changes to existing activities'* [57]. This definition captures the essential components of digitalization - data and interconnection - that enable widespread adoption. It also touches on the transformative nature of digitalization, which has become a focus for research to investigate the potential and actual impacts of adopting digital technologies.

Digitalization is made possible through digitization and interconnection, both of which are technological trends in their own rights [13] [6]. Digitization refers to the process of converting analog information such as sound, image, or printed text to digital data that can be interpreted by digital devices without degradation and at a very low cost. Without digitization, digital technologies would lack the data to function, making digital transformation impossible [13]. Interconnection (also known as connectivity or interconnectivity) involves integrating and facilitating communication between various digital systems, devices, and technologies through digital communication networks [6] [53]. It enables real-time data flow, exchange, and processing across different technologies. By leveraging interconnectivity and digitization, a range of new digital technologies have emerged over the years, driving digital transformation [6].

The increasingly complex, robust, and expansive physical infrastructure is central to digital transformation. This includes data centers, undersea and underground fiber optic cables, satellites, cell towers and base stations, and personal devices. The following section briefly describes some of the most significant digital technologies and the physical infrastructure that supports them.

Artificial intelligence

Artificial intelligence (AI) is a crucial component of digitalization, with the new wave of digitalization being partially driven by the interplay between AI systems and other digital technologies.

AI processes vast amounts of data from diverse sources, including human language, sensors, and text, using software that allows it to draw conclusions, adjust its parameters, and produce outputs. The combination of high precision and low computation time makes AI an advanced digital technology [19]. AI can be integrated with larger digital technologies to compound their impact [20].

Although there is no universally accepted definition of AI, AI systems typically share similar characteristics [50]. The OECD provides a widely accepted definition: ‘An AI system is a machine-based system that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments’ [31].

Machine learning, a subset of AI, involves techniques that enable machines to improve their performance automatically by learning from training data, which helps identify patterns and regularities without explicit instructions from a human [55]. Machine learning is integral to the entire lifecycle of AI systems from development to the end-use phase.

Wider adoption of new digital technologies, such as artificial intelligence, incentivizes further substantial data collection, storage, and processing. Training AI systems requires large datasets, amplifying the need for transparency and reporting on AI use and development [68].

Big data analytics

Big data refers to large datasets that are high in volume[2] and variety,[3] and are created and shared at high speeds. It involves collecting large amounts of data from an array of digital sources and sensors, including online personal, behavioral, and biometric data of people [41]. Big data analytics includes a set of tools and techniques deployed to process, analyze, and visualize data generated through the digitization of content and the tracking of human activities and physical objects [41] [18] [27].

Cloud technology

Cloud technology enables the storage of digitized data over connected networks. Due to the expansion of digital services, organizations have come into possession of considerable amounts of data, often without the hardware and infrastructure needed to store it [47]. Cloud technology allows organizations to overcome this issue without needing significant upfront investments in hardware and infrastructure. A cloud service provider – for instance, Amazon or Google – provides access to its services to manage, secure, and store data [16].

The rapid growth of cloud services brought about pressing challenges related to commercializing private consumer data, data privacy, and data ownership. The relationship between data providers, data hosts, and third-party cloud service providers often lacks transparency. Cloud providers may

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[2] Amount of data.

[3] Type of data (text, video, satellite data, sensor data, activity logs).

engage in data mining or sell whole datasets without explicit consent. It is also unclear who holds ownership of consumer data in the cloud environment as data crosses multiple physical geographical locations, blurring jurisdictional lines. This raises issues about legal rights to data access and control, especially when data is subject to different regulatory frameworks where it is stored [39].

Internet of Things

The Internet of Things (IoT) refers to the interconnection of physical devices and objects that can be controlled or modified via the Internet, with or without human intervention [53]. The IoT consists of sensors that collect and share data among devices and with humans. These networked sensors and the data they gather can be utilized to monitor health, track locations and activities, oversee production processes, and evaluate the efficiency of city services and the natural environment [6].

Online platforms

An *online platform* is a digital service that facilitates interactions and transactions between two or more sets of users who interact via the Internet. These platforms can take various forms, such as social media, e-commerce, educational forums, and collaborative workspaces, each designed to support specific user engagements and activities [13]. An online platform typically includes user registration, content creation, communication tools, and transactional capabilities. The architecture of such platforms often relies on a combination of digital and physical technologies, databases, and cloud services [6].

Physical infrastructure

Data centers and data transmission networks

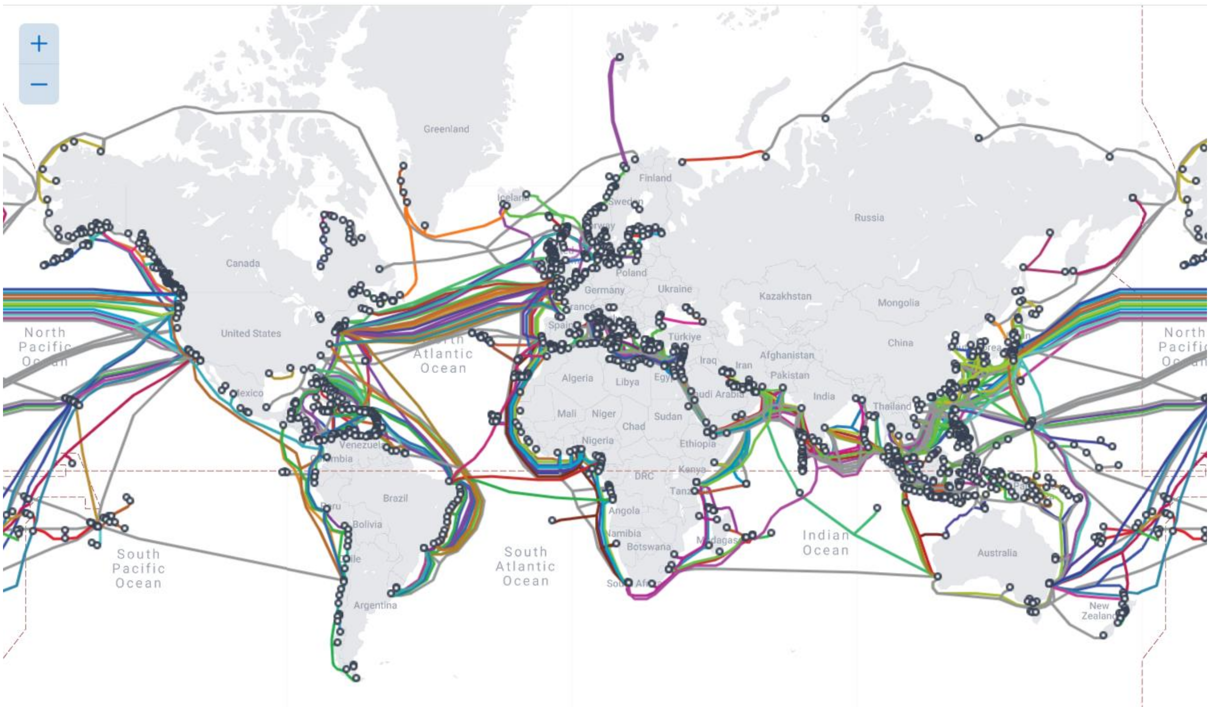
Data centers are facilities that house servers and storage systems responsible for processing and storing vast amounts of data. They serve as the physical locations where cloud computing and storage services operate, enabling all the digital technologies that businesses and individuals rely on. Subcomponents of data centers include power supply and energy infrastructure, which encompasses uninterruptable backup power supplies (UPS) and generators to ensure continuous operation. Cooling systems maintain appropriate working temperatures in data centers and other high-density electronic environments, preventing overheating and equipment failure.

Figure 2. An Amazon data center in Umatilla County, Oregon, USA

Fiber optic cables

Underground and submarine fiber optic cables are essential to the physical infrastructure of the Internet. They enable high-speed data transmission over long distances. Submarine fiber optic cables link terrestrial telecommunications networks and facilitate the rapid exchange of vast amounts of data globally.

Figure 3. Illustration of submarine cables based on publicly available data as of June 2024 [64]



Cell towers and base stations

These structures support wireless communication by connecting mobile devices to the broader telecommunications network.

Satellites

Satellites facilitate communication in remote and underserved areas where terrestrial infrastructure is lacking. They enable the reach of digital technologies across the world. Services such as broadcasting, navigation, and global positioning systems (GPS) rely on satellite connections to transmit signals between devices.

Internet of Things infrastructure

The Internet of Things (IoT) infrastructure comprises different technologies and components of technology that work together to enable the connectivity, communication, and management of IoT devices. This includes sensors,[4] actuators,[5] and connectivity modules[6] that allow smart devices to collect and transmit data among themselves or to networks of other devices.

Personal technology devices are also essential to the IoT infrastructure as they serve as the primary interface through which individuals interact with digital technologies and data. These personal devices include smartphones, computers and laptops, tablets, wearable devices, and smart home gadgets.

[4] Devices that detect and measure physical properties such as temperature, humidity, light, motion, and pressure.

[5] Components that perform actions in response to commands received from the IoT system, such as adjusting a thermostat, turning on a light, or opening a valve.

[6] Communications technologies such as Wi-Fi and Bluetooth or through cellular networks.

CHAPTER 2

Impacts of digitalization

While not exhaustive, this section highlights the most significant impacts associated with a broader uptake of digital technologies.

The impacts of digitalization arise primarily from the development, production, maintenance, and disposal of physical infrastructure. This includes information and communication technologies equipment, data centers, and data transmission networks. Additionally, it encompasses the development and adoption of digital technologies or software [27] [42] [47]. Therefore, when considering the sustainability impact of digitalization, it is important to consider the immediate tools and services available in the digital space, the physical infrastructure enabling digitalization, and the production of both personal and commercial technology. However, the impacts associated with using and maintaining digital technologies are complex and multidirectional, making it challenging to categorize these impacts into distinct categories. For instance, assessing the carbon footprint of digital technologies throughout their lifecycle requires examining the intricate supply chain of the technology sector, including its connections with the energy and extractives industries.

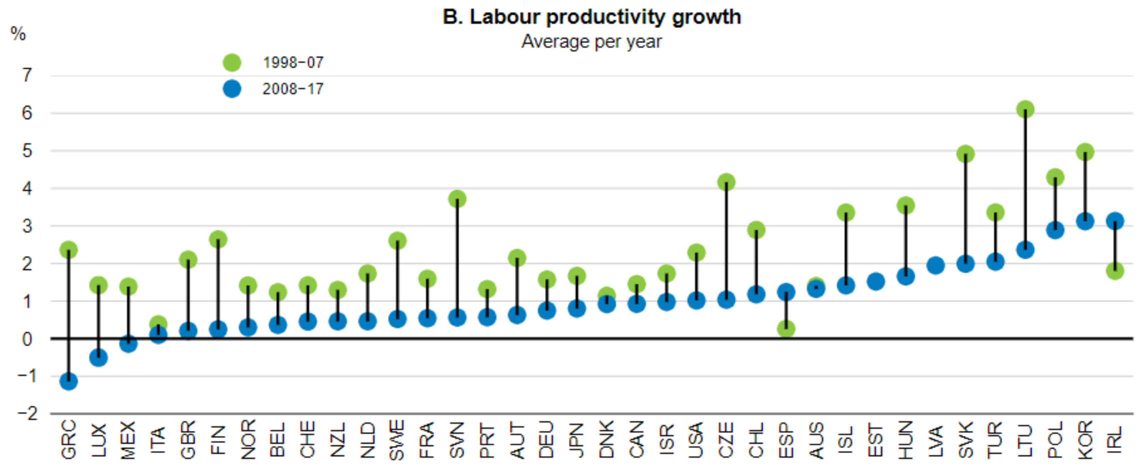
Impacts on the economy

Digitalization has impacts on the economy by affecting economic aggregates, particularly productivity, competition, labor, and employment. Digital technologies enhance a company's ability to gather and analyze information, addressing various market inefficiencies [52] [53] [2]. By monitoring, interconnecting, and manipulating physical production processes, digital technologies facilitate the collection, management, and analysis of data, leading to better insights about materials, products, and processes [71] [6].

However, digitalization has had uneven economic impacts on organizations from a productivity standpoint. Despite leading the digital transformation, many OECD countries have experienced a sharp decline in productivity growth over the past two decades [52]. Although the reasons behind this decline depicted in Figure 4 are multifaceted, productivity gains from digitalization have not sufficiently offset other influencing factors.

The OECD suggests that declining or even gaining productivity may result from an uneven distribution of capabilities and resources among organizations [52]. Additional research indicates that small- and medium-sized enterprises (SMEs) and start-ups may struggle accessing and using data, information, and knowledge generated by these technologies. This may prevent them from fully leveraging digital technologies compared to firms with established technological expertise [6]. The OECD also notes that companies with more resources to develop and implement digital technologies have experienced greater benefits from digitalization [52], implying that the productivity impacts of digitalization may be more limited than previously thought.

Figure 4. Source: OECD (2019)



Labor and employment impacts

The adoption of digital technologies can greatly impact employment and livelihoods. Job displacement is a recognized potential negative impact associated with AI and automation, as noted by the IEEE, OECD, and the World Economic Forum [53] [65] [75]. Changes to business models prompted by the adoption of digital technologies can result in employment impacts across most sectors in terms of job creation, job displacement, changes in job quality, and widening skills gaps [6]. A survey conducted by the World Economic Forum found that over 85% of organizations believe that the increased adoption of disruptive digital technologies, such as AI, is likely to drive organizational transformation, with 75% expecting to adopt such technologies soon [75].

The wider adoption of AI systems and the advances in generative AI enable the automation of non-industrial work functions, including reasoning, communication, coordination, and planning [2] [31]. Because of the unique capabilities of AI systems and their rapid advancements, work areas that were unaffected by previous waves of automation may now be at risk.

It is important to identify whose livelihoods may be affected by the advent of these new technologies [1] [2]. While previous technological advancement predominantly affected jobs in industrial production, digitalization is now impacting roles in accounting, sales, logistics, trading, and certain managerial occupations [2]. A projection by Goldman Sachs estimates that AI could affect over 300 million jobs in the coming decade, with the most vulnerable positions being office and administrative support, as well as legal work [28]. A report by McKinsey, meanwhile, estimates that automation could leave up to 800 million people without jobs by 2030 [45]. While as much as 80% of the U.S. workforce could be affected by the adoption of AI tools, workers in higher-income jobs face ‘potentially greater exposure’ to these effects [20].

Nonetheless, prior innovations have led to job displacement, which has often been counterbalanced by the emergence of new job opportunities. This can be partly attributed to what is known as the ‘reinstatement effect’, which occurs when innovation leads to job displacement [2]. However, it remains uncertain whether the job displacement brought about by digitalization will have characteristics that are different from those seen in previous waves of displacement and reinstatement.

Taking a broader view, it is important to note that digitalization also creates new job opportunities. The overall impact of digitalization on employment may be less significant than some alarmist predictions indicate. For instance, the World Economic Forum anticipates a net positive impact on labor demand from ' most technologies’ over the next four years, particularly in the rapidly growing sectors related to technology and digitalization [75].

Market concentration

Market concentration around digital technologies is another significant economic impact. A handful of powerful technology organizations dominate the landscape of digital technologies and associated services. For example, Meta owns several popular platforms, including Facebook, Instagram, Threads, and WhatsApp, boasting a combined subscriber base of over 8 billion. This gives Meta an ‘overwhelming dominant position’ in the social media market [43].

In a recent ruling, a federal court in the United States found that Google has maintained an unlawful monopoly over internet search services and text search advertisements. This ruling highlights how Google has used its dominant market position to suppress competition and limit consumer choices within the internet search industry. With Google accounting for nearly 90% of all internet searches, the court's case described how the company manipulated its market position by charging advertisers excessively high prices [60]. Google is expected to contest this ruling, but it may have far-reaching consequences for the technology sector. Other dominant players are likely to face increased scrutiny over their business practices, both from legislators and stakeholders. This situation underlines the need for clearer reporting standards to disclose potentially anti-competitive behaviors [56].

As digital technologies become more integrated into daily life, market concentration in cybersecurity holds significant implications. Major cybersecurity firms, such as CrowdStrike and Cloudflare, protect a substantial portion of global digital infrastructure. For example, CrowdStrike provides cybersecurity services for Microsoft, the second-largest cloud service provider, while Amazon Web Services leads the market and Google ranks third. These organizations collectively control over two-thirds of the cloud services market. Despite the seemingly disconnected nature of digital technologies, the reliance on a few key players for its main infrastructure, cloud computing, makes the entire digital ecosystem vulnerable. Although these systems have robust safety mechanisms in place, a successful breach or an internal malfunction could lead to catastrophic impacts on the global economy. In July 2024, a global disruption affecting nearly nine million devices worldwide occurred due to a failed CrowdStrike update for Microsoft-powered devices[26]. The disruption caused ripple effects across many sectors, including public services, healthcare, and transportation, leading to the cancellation of over five thousand flights.

Impacts on the environment

Digitalization has significant environmental impacts by changing the ways in which people, organizations, and society as a whole interact with their surroundings [67]. While emerging digital technologies present numerous opportunities to enhance environmental protection and reduce greenhouse gas (GHG) emissions, they also contribute to their own environmental impacts. The infrastructure and combined technologies necessary to maintain the digital landscape result in impacts on natural resources, including land, energy, and water use [47].

Emissions impacts

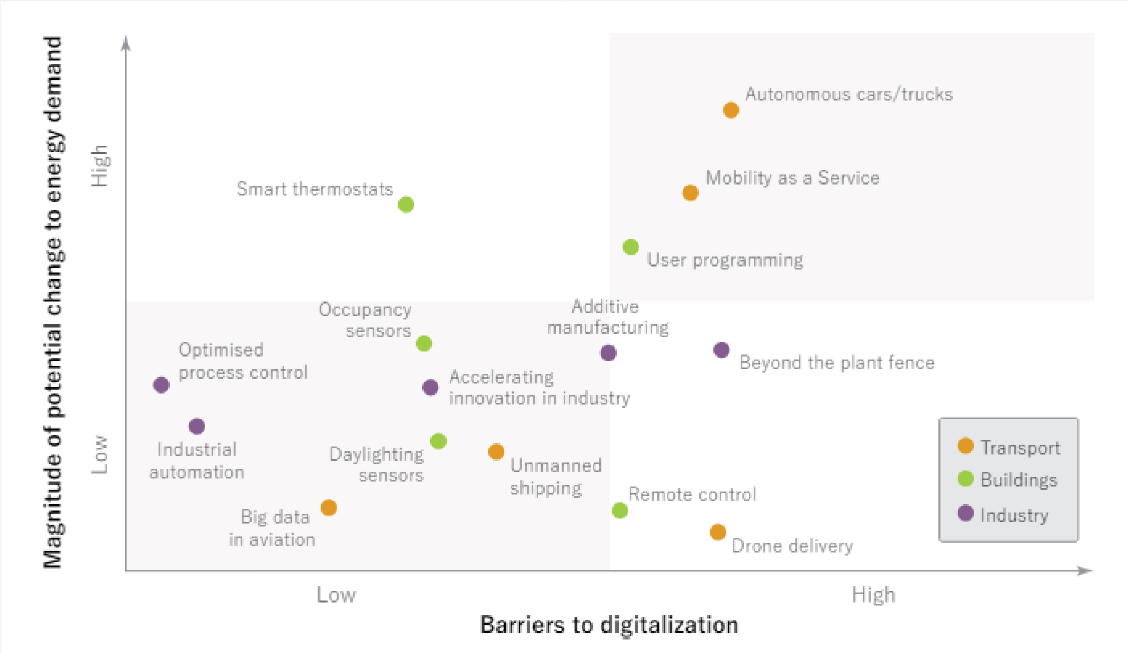
The adoption of digital technologies is often promoted as a means to reduce global GHG emissions [4] while ensuring long-term economic growth [76]. These digital technologies can potentially reduce emissions in various industries and encourage a reduction in material consumption [30]. However, the positive impacts on GHG emissions are generally indirect; digital technologies facilitate a shift away from practices that may harm the environment. This transformative potential is limited without targeted regulation and policy [42]. For instance, new digital technologies are being deployed to improve biodiversity monitoring, allowing for more frequent and reliable information on existing risks to biodiversity. However, better information alone does not address the fundamental causes of these risks [42]. Therefore, while there is potential for positive impacts, their realization depends on a range of factors.

In the transportation sector, the International Energy Agency (IEA) estimates that advancements in automation and electrification could either halve energy use or more than double it. This outcome will depend on the interplay between technological developments, adoption rates, policy responses, and human behaviors [35]. Without advances in energy efficiency, the implementation of smart energy technology may not yield overall reductions in energy use and could even negate potential decreases. A comprehensive study examining the prospects for energy savings through digitalization by 2050 indicates that without robust advancements in energy efficiency to mitigate the effects of digitalization, energy consumption could increase by 42% compared to the baseline established in the study [12].

Additionally, it is important to consider the rebound effect associated with adopting digital technologies. This phenomenon occurs when the adoption of digital technology leads to reduced environmental impacts – such as the dematerialization of goods or decreased transportation needs - while simultaneously increasing energy consumption from electronic devices. For instance, the growth in digital products such as hardware, along with energy-intensive services like cloud computing and data center operations, can offset the efficiency gains realized through the practices of the digital economy [6] [27] [37].

The dual impact of digitalization on energy demand is depicted in Figure 5 by examining the barriers to digitalization in three energy-intensive sectors: transportation, buildings, and industry. For instance, the barriers to adopting digital technologies in industrial automation are relatively low, making it easier for organizations to implement these solutions compared to the transportation sector. Nevertheless, the overall impact of such digitalization in terms of energy demand may still be limited, despite the energy efficiencies gained in industrial production.

Figure 5. Potential Impact of digitalization on Transport, Buildings, and Industry (IEA, 2017)



Key message: Digital technologies and applications face a variety of barriers to adoption and use, and their impacts on energy use differ across demand sectors.

Notes: The digitalization trends/strategies included in this figure are not intended to be exhaustive. "Magnitude of potential change to energy demand" indicates the potential impact of digitalization on energy demand in absolute terms, which may be positive or negative. "Barriers to digitalization" include technological, regulatory and public perception components. The quadrants are illustrative only and intended to give a sense of relative magnitude.

Capturing the emissions impacts associated with digitalization has also proven to be a challenge in scientific literature. Data gaps concerning the energy consumption of digital technologies, the dynamic and open-ended nature of digital innovation, and poor track records of digitalization projects contribute to the 'unknowable' climate impact of these technologies [30]. The gaps in available data on emissions force researchers to make various assumptions about key variables in their research design. These variables include estimates of the lifetime and energy efficiency of digital devices, the extent to which digitalization changes consumption behavior, and the number of users of both material and digital products.

In a review of 31 studies of the emissions impacts of digital technologies (specifically digital goods)[7], researchers identified significant variations in the estimates of energy use impacts attributed to these

[7] E-books, e-magazines, e-journals (grouped under e-publications), e-news, e-business, e-music, e-videos, and e-games

technologies [15]. Different accounting metrics produce varied figures regarding the emissions cost of digitalization. An academic study indicates that if we only consider the emissions produced by the electricity usage of data centers, they would account for 0.3% of global carbon emissions [47]. This figure increases to 2% when we include emissions from networked devices such as laptops, smartphones, and tablets. Other estimates suggest that global emissions created by digital services fall between 2-3% of all global emissions [4]. The United Nations Environment Programme attributes 4% of all direct GHG emissions to the ICT sector, comparable to the emissions of the entire aviation industry [67].

Energy impacts

Digitalization has a significant impact on energy consumption, leading to increased energy use by both households and businesses due to higher reliance on digital technologies and electronic devices. Scholars and experts point out that machine learning processes – integral to the development and use of many AI systems deployed in recent years – are particularly energy-intensive [47] [40].

New generative digital technologies such as ChatGPT and AI tools developed by companies like Google, Samsung, Yahoo, and Microsoft require substantially more energy for operation compared to traditional internet searches [44]. A review of current evidence on carbon emissions and water use shows that generative AI technologies are 'distinctly resource intensive' [40].

Furthermore, the maintenance of data centers is energy-intensive. In 2022, the International Energy Agency (IEA) estimated that the energy demand from data centers, AI technology, and cryptocurrency applications accounted for 2% of global electricity demand [37]. The IEA has warned that data centers are becoming major contributors to rising electricity demand in many regions. They predict that over one-third of the projected increase in U.S. energy consumption from 2024 to 2026 will be attributed to the growth of the data center sector [37]. The report also cautions that without crucial regulatory interventions and technological advancements, electricity demand from data centers could more than double by 2026, reaching consumption levels similar to those of Japan [37].

According to the U.S. Department of Energy, energy usage from information technology equipment has increased by over 35% since 2005, largely due to increased internet use by individuals and organizations [70]. Microsoft's 2023 Sustainability Report indicates a 30% rise in the company's CO_2 emissions compared to 2020 due to indirect emissions (Scope 3) associated with the construction and maintenance of data centers [46]. In contrast, their reported Scope 1 and 2 emissions decreased by 6.3% in the same period. To meet potential increases in energy demand from the expanding data centers and the additional load of AI systems on their servers, Microsoft has started to consider a nuclear energy strategy [46].

Data centers generate heat, creating a need for cooling systems to prevent overheating. These cooling systems operate continuously, even in the most advanced and energy-efficient data centers. It is estimated that 25-40% of electricity demand from data centers is related to cooling systems [70]. Efforts have been made to mitigate this issue, such as redirecting heat generated from data centers to heat homes or generate electricity [61] and even relocating data centers to colder climates for natural cooling [47]. However, these solutions may not be scalable, as smaller data centers may face challenges to transition [71] [47]. Additionally, the necessary technological and physical restructuring to these changes could create their own impacts [27].

Impacts on water use

Activities involved with sourcing material for technological devices, maintenance of data centers, and production of devices impact water use. The impact of mining on water consumption has long been noted [3] [16] [29] [38] [40].

Digitalization's most substantial water consumption impacts outside of water impacts from mining are tied to the maintenance of data centers. Cooling systems to prevent overriding servers, data storage systems, and routers rely on water use, which has impacts on water resources and security. Up to 9 liters of water is evaporated for every kWh of energy used in data centers [29]. One unrealized data center project in Luxembourg would have consumed up to 10 million liters of water per day, around 10% of the water consumption of the entire country [42]. Utah Data Center, used by the US National Security Agency, consumes 6.4 million liters of water daily, contributing to water shortages when combined with periods of drought [63] [34].

Land impacts

Data centers impact land use due to their size and the infrastructure required for their operation. This includes cooling systems, servers, and backup energy supplies.

For instance, the Switch SuperNAP data center is situated on a campus in a 190,000 m^2 field in Nevada, United States. In Virginia, another US state, there has been rapid growth of data centers. Since 2019, the total has increased from 186 to 467, making Virginia the largest data center market in the United States [74]. Digital Realty operates Virginia's largest data center, which occupies 278,000 m^2; currently, about one-third of this space is actively used, while the rest is reserved for future expansion [17]. The largest data center in the world is the China Telecom-Inner Mongolia Information Park, located in central Mongolia (Moss 2022). The complex is designed to cover over 1,000,000 m^2 and will include facilities for cloud services, call centers, warehouses, offices, and living areas [49]. The construction of the Inner Mongolia Information Park involved converting land primarily used for farming and livestock grazing. This land conversion has affected local communities and livelihoods, particularly various ethnic herder groups that still inhabit the area.

Figure 6. A cluster of data centers located in Northern Virginia, USA [8]

However, the majority of land use impact from digitalization occurs in the production phase of electronic technology. According to a study on the entire value chain of the German electronics industry, almost 90 % of land change and occupation takes place at the resource extraction level [51] [42].

Impacts on waste

Digitalization creates waste impacts by increasing the demand for technological equipment. The wider adoption of digital technologies has been identified as a driver of higher turnover rates for technological hardware (German Advisory Council on Global Change 2019). Rapid product innovation in digital services often leads to more frequent hardware upgrades, as advanced software requires greater computational power to function. The median lifespan of a mobile phone was almost five years between 2000 and 2005 [5]. Within a decade, this dropped to around 2.5 years, with an average retention rate[8] of less than two years [9].

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[8] Number of years before people change their phones.

The trend towards shorter lifespans and more frequent upgrades of technological devices contributes to more than 62 million tons of global electronic waste annually [69]. Since 2010, total e-waste has surged by 82%, with projections estimating it could reach 82 million tons by 2030, indicating an additional 32% increase [69]. Current efforts to manage this waste are insufficient to address the growing consumption rates of electronic devices, with electronic waste rising five times faster than e-waste recycling [69].

Waste reduction and energy efficiency via circular economy

Digitalization also has the potential to facilitate positive environmental impacts by supporting various aspects of the circular economy. This approach is defined as achieving resource efficiency and economic processes related by reducing the rates of natural resource extraction and consumption throughout the value chain – or as the transition towards it [6]. The circular economy is receiving increased policy attention due to its potential to reduce environmental pressures and reliance on raw materials within various sectors [53]. However, the market share of circular business models - such as recycling, remanufacturing, repair, sharing spare capacity, and providing services instead of products - is limited [53]. By utilizing digital technologies like artificial intelligence, blockchain, the Internet of Things (IoT), and cloud computing, organizations can be better positioned to transition to more sustainable models of production and consumption. This shift can lead to a more resource-efficient and circular economy [53] [6] [76].

Impacts on people, including human rights

Digitalization has impacts on people, including on their human rights, particularly through personal data usage and interactions with digital services.

Risks to rights to privacy and data protection

Despite the increasing number of regulations and frameworks, there is no universally accepted approach to managing digital data. The United Nations notes the emergence of a ‘data market’ where companies collect, trade, and exchange data through third-party brokers. These brokers often operate in an opaque and unregulated environment. It may take years to establish clear legislation, not to mention a global agreement [32].

Organizations’ processes for data collection, fusion, trading, and usage remain largely opaque [62]. Frequently, organizations providing digital services, such as streaming platforms, online retailers, and news websites, offer seemingly free services while monetizing personal user data and behavior data. This practice infringes on individuals’ right to privacy [18] [68]. Decision-making regarding data processing and trading often lacks transparency and traceability, and individuals have limited control over their own data [27].

Over the past decade, exposure of sensitive information through leaks, cyber-attacks, or data theft has affected millions of people. One notorious case is the Cambridge Analytica scandal in 2018, where it was revealed that the company harvested data from approximately 87 million Facebook users without consent and sold it to political campaigns [14]. Additionally, the Equifax data breach in 2017 compromised the personal information of more than 150 million people, including social security numbers, addresses, and credit card details [25].

Algorithmic risks

Algorithmic risks arise as AI systems operate on the patterns identified in the data they are trained on without comprehending the underlying context. As AI systems have become increasingly effective at recognizing patterns, they generate outputs based on the specific algorithms used, making model training highly consequential. The tendency of AI systems to be indifferent to truth leads to what experts call the 'hallucination effect', where outputs are generated that do not reflect reality [33]. Without the capability to independently assess the validity or the context of data, AI systems can perpetuate and even amplify existing biases.

Algorithmic bias and discrimination can occur at various stages in the life cycle of digital technology. Bias during the design stage arises when an algorithm is introduced to prejudiced information. Incomplete or unrepresentative datasets can lead to a biased baseline, which can result in discriminatory outcomes. For instance, individuals can be unfairly denied services in banking, healthcare, educational or employment opportunities [18], or algorithmic services may produce outcomes that are discriminatory to marginalized communities [21].

Following an audit of a 'decision-support algorithm' used by the child protective services of the Danish government, researchers found significant methodological errors in the algorithm that generated inconsistent child-at-risk scores and age-based discrimination. The authors conclude that such algorithms should not be deployed in local governance functions [48].

Private sector organizations responsible for AI innovation and development often do not disclose enough information about their algorithms, citing trade secrets or claiming that publicly available data can be commercially exploited. Despite some initial steps towards regulation, meaningful and common guidelines have yet to be established [10].[9]

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[9] Digitalisation and Responsible Business Conduct – Stocktaking of policies and initiatives provides an overview of most of the early regulatory steps.

CHAPTER 3

Assessing GRI Standards against digitalization impacts

The previous section sought to provide a general account of digitalization's potential and actual impacts. This section will review the current GRI Standards against these impacts to assess potential reporting gaps.

Impacts on the economy

Regarding impacts on productivity, the following Topic Standards could apply:

1. ***GRI 203: Indirect Economic Impacts*** – contains a disclosure on *significant indirect economic impacts,* which include 'changes in the productivity of organizations' or economic impacts of improving or deteriorating social or environmental conditions, which can capture productivity impacts due to wider adoption of digital technologies. However, additional reporting guidance could help expand this expectation. Also noteworthy is the ongoing project focusing on economic impacts.

2. ***GRI 206: Anti-competitive Behavior –*** contains a disclosure on legal actions related to anti-competitive behavior, anti-trust violations, and monopolistic and predatory behavior by major technology companies. For instance, Google's legal case would fall under this disclosure.

Regarding impacts on employment and workers, the following Topic Standards could apply:

1. ***GRI 401: Employment*** – contains disclosures on new employee hires and employee turnover, as well as benefits provided to workers, such as parental leave, life insurance, disability coverage, and retirement provisions. In its current form, this Standard contains no disclosures that can be directly linked to digitalization. GRI 3-3 can, to an extent, capture negative impacts created by implementing automation or other new technologies. However, there are no specific disclosures on company policy to address concerns related to the workforce's resilience amid the growing adoption of digital technologies.

2. ***GRI 402: Labor/Management Relations*** – contains a disclosure on minimum notice and consultation on operational changes, which could address changes due to automation and digitalization. However, this is not explicitly mentioned in the Standard so that additional reporting guidance would be needed.

3. ***GRI 404: Training and Education*** – contains a range of disclosures related to training and upgrading employee skills and performance reviews, essential for adapting to new technologies.

While the disclosures can capture training aimed at preparing the workforce for automation and digital formation, no specific requirements exist for reporting on training programs related to digitalization and reskilling employees for new roles created by these technologies. However, 'Disclosure 404-2 Programs for upgrading employee skills and transition assistance programs' can be interpreted to include transitions relating to digitalization. There is potential for more concrete disclosures regarding commitments to support and prepare workers whose future in the organization may be jeopardized by digitalization and automation.

The ongoing revision of labor-related Standards has transformed reporting expectations concerning digitalization's impacts on workers. Proposed changes address various aspects of digitalization that can have impacts on workers, including employee data protection and privacy, along with upskilling and reskilling initiatives for those affected by significant organizational changes.

The revised draft Standards feature both topic management disclosures and topic disclosures regarding handling personal data by employers, addressing key issues identified in this research:

- Incidents relating to non-compliance or unauthorized disclosure of private data of employees and workers who are not employees.
- Personal data protection and privacy policies.
- Requirement for obtaining explicit consent for data processing and monitoring activities from employees and workers who are not employees.

Environmental impacts

The GRI Standards contain a robust set of Topic Standards addressing various environmental impacts, including *GRI 305: Emissions*, *GRI 302: Energy*, *GRI 303: Water and Effluents*, and *GRI 306: Waste*. These Standards adequately capture the environmental impacts of digitalization, particularly regarding energy and water usage, land use changes driven by the increasing number and size of data centers, emissions, and electronic and digital waste generation and management.

Human rights impacts

Regarding potential negative impacts on the right to privacy, data protection, and cybersecurity, including asset protection, the following Topic Standards may apply:

1. ***GRI 418: Customer Privacy –*** contains a single disclosure of identified cases of loss or theft of customer data. However, it is not sufficiently detailed to meet the reporting needs on the complex landscape of data privacy and governance. It lacks requirements for reporting data protection and privacy matters concerning stakeholders beyond customers, such as employees and partners in the supply chain. Additionally, there are no disclosures on preventive measures organizations are implementing to ensure data privacy and asset security in cyberspace. There is also a need for transparency about third-party data management, especially with companies outsourcing data management, storage, and processing services to third parties. Furthermore, there are also no

disclosures on the obligations of companies to bolster cyber security or stress test their defenses against cyber-attacks.

It is important to note that the current regulatory landscape has surpassed the requirement level established in *GRI 418*. For instance, an organization compliant with GDPR would already be reporting this information; thus, this Standard is rendered less relevant for the reporting organization as its requirement expectations are lower. An update of *GRI 418* is necessary to reflect all major regulatory developments regarding data protection and cybersecurity. Instead of simply updating *GRI 418*, a more comprehensive digitalization standard could eventually be developed to capture better the potential negative impacts that cannot be adequately reported using the current Standard.

2. ***GRI 417: Marketing and Labeling*** – contains disclosures aimed at ensuring fair and responsible practices in marketing activities. Specifically, 'Disclosure 417-3 Incidents of non-compliance concerning marketing communications' requires an organization to report the total number of incidents of non-compliance with regulations and voluntary codes of conduct concerning marketing communications. Given the extensive use of digital tools for marketing purposes - such as developing strategies, using online platforms for campaigns, and targeted advertising - this Standard needs enhancement to establish reporting expectations concerning the use of algorithmic systems for targeted advertising and the creation of consumer profiles using customer data.

3*. GRI 2: General Disclosures –* contains 'Disclosure 2-25 Processes to remediate negative impacts', which allows reporters to outline their policies or strategies for addressing grievances related to cybersecurity breaches that result in data or asset loss or theft. However, there is no clear link that identifies a cybersecurity breach as a negative outcome requiring remediation.

4. ***GRI 410: Security Practices –*** is relevant as nearly all organizations using digital services need third-party cybersecurity services to protect information, and sometimes, assets, from cyber-attacks. Despite this relevance, the Standard is inadequate for robust reporting on cybersecurity practices; the only disclosure focuses on human rights training for on-site security personnel.

Regarding negative impacts arising from AI use - such as algorithmic bias and discrimination - *GRI 405: Diversity and Equal Opportunity* can apply, addressing employment-related aspects but failing to encompass other consequences of algorithmic bias.

Furthermore, other human rights infringements related to various AI use cases must also be considered. For instance, rapid technological advancements have reduced the costs of implementing surveillance technologies that can infringe upon privacy rights. The proliferation of social media has introduced new forms of online harassment and bullying, enabling rapid dissemination of disinformation and hate speech. The integration of biometric technologies in governance and service delivery can create circumstances that lead to human rights violations. Additionally, AI tools may be deployed in ways unintended by their developers, leading to unintended negative impacts. The analysis of the current GRI Standards shows that they do not adequately address these growing human rights considerations.

In assessing the existing GRI Standards, the overall impression regarding the impacts of digitalization is mixed. Environmental and economic Topic Standards remain robust and comprehensive. With the ongoing revisions of economic impact- and labor-related disclosures in the GRI Standards, there is potential to capture the impacts of digitalization under these categories.

However, the reporting gap is significant enough to warrant a revision of relevant Topic Standards to address the unique impacts of digitalization, such as data privacy and security, as well as AI usage. While certain unique aspects are covered, existing disclosures need consolidation, reporting expectations need to be heightened, and new disclosures addressing AI development and deployment must be introduced. Current GRI Topic Standards are too thematically remote from the distinctive human rights issues introduced by AI and other disruptive technologies. Therefore, specific AI use disclosures need to be developed to bridge this gap.

CHAPTER 4
Current reporting expectations on digitalization impacts

Reporting expectations for the impacts of digitalization are still in the early stages of development, although the regulatory landscape is evolving rapidly. Existing reporting tools can effectively capture some impact areas related to digitalization, primarily focusing on impacts on the environment, which includes emissions, energy and water use, land change, and waste. However, sustainability reporting frameworks addressing data security and privacy, the use of AI, and cybersecurity are less defined and are only partially covered by a patchwork of industry-specific standards. Notably, there is currently no widely accepted framework that sets disclosure expectations for AI use. A systemic review of reporting organizations in Western Europe identified no references to any framework or reporting standard concerning voluntary disclosures on AI use, highlighting a significant gap in this area [11].

This analysis considered leading sustainability reporting frameworks, including ESRS, SASB, and CDP Standards. ESRS, with the recent launch and publication of its first set of standards in December 2023, does not yet include a specific digitalization standard. CDP primarily focuses on environmental components of sustainability and lacks specific disclosures regarding the impacts of digital technologies. In contrast, SASB has developed a standard aimed at the software and information technology industry. The standard addresses the emerging impacts of data privacy and security, the environmental footprint of digital technologies, intellectual property protection, competitive behaviors, and the management of systemic risks posed by disruptions to digital technologies and services.

Given that the SASB standard is industry-specific, additional frameworks, guidelines, regulations, and other authoritative sources addressing various impacts associated with digitalization were reviewed. This was helpful for getting a better thematic understanding of how issues around digitalization are covered under international authoritative sources that are not reporting standards. Five authoritative sources that are relevant and have informed legislation, policy, guidelines, and reporting expectations globally are included in this section. These instruments are described and discussed as potential reporting expectations that can be derived from existing frameworks.

SASB Software and IT Standard

The closest equivalent of a digitalization standard within the current SASB framework is a standard that targets organizations in the software and IT services industry. SASB defines organizations in this industry as those offering ‘products and services globally to retail, business and government customers, and include entities that develop and sell applications software, infrastructure software, and middleware’ [58].

SASB identifies six topics for organizations in the software and IT industry to consider when disclosing information about sustainability-related risks and opportunities. These include:

- **Environmental footprint of hardware infrastructure**

  Specific disclosures on:

  1) total energy consumed;
  2) total water withdrawn and consumed, including percentage of each in regions with high or extremely high baseline water stress; and
  3) integrating environmental considerations into strategic planning for data center needs.

- **Data privacy and freedom of expression**

  Specific disclosures on:

  1) policies and practices relating to targeted advertising and user privacy;
  2) number of users whose information is used for secondary purposes;
  3) total amount of monetary losses as a result of legal proceedings associated with user privacy;
  4) number of law enforcement requests for user information, including percentage resulting in disclosure of information; and
  5) list of countries where core products or services are subject to government-required monitoring, blocking, content, filtering, or censoring.

- **Data security**

  Specific disclosures on:

  1) number of data breaches, including number of users affected; and
  2) description of the approach to identifying and addressing data security risks, including use of third-party cybersecurity standards.

- **Intellectual property protection and competitive behavior**

  Specific disclosure on:

  1) total amount of monetary losses as a result of legal proceedings associated with anti-competitive behavior regulations.

- **Managing systemic risks from technology disruptions**
- **Recruiting and managing a global, diverse, and skilled workforce**

  The SASB industry standard does not present a direct counterpart for a potential Topic Standard on digitalization, as the GRI Standard would not be sector-specific. However, the reporting expectations outlined in the SASB standard align well with broader stakeholder expectations concerning the impacts of digitalization. These impacts can create both financial risks and opportunities for reporting organizations.

OECD Guidelines for Multinational Enterprises on Responsible Business Conduct

The OECD Guidelines for Multinational Enterprises on Responsible Business Conduct provide recommendations from governments to multinational enterprises aimed at enhancing their contributions to sustainable development and addressing adverse sustainability impacts linked to their business activities.

The 2023 update to the OECD Guidelines introduced a significant change to the due diligence expectations regarding the use of technology. The updated guidelines now impose new due diligence expectations around the development, financing, sale, licensing, trade, and use of technology, including data gathering and usage. Any enterprise involved with digital technologies is expected to conduct risk-based due diligence regarding actual and potential adverse impacts related to science, technology, and innovation. Additionally, these enterprises must ensure transparency regarding data access and sharing arrangements and adopt responsible data governance practices. This inclusivity implies that nearly all organizations in OECD countries can be regarded as technology companies, as most utilize technology to some degree in their operations.

Furthermore, the OECD takes a holistic and inclusive approach to capture the evolving nature of technologies. This aligns with a topical approach to a digitalization standard from the perspective of GRI, whereby all reporting organizations need to consider the broader impacts of their use or transition towards digital technologies as part of their materiality assessment.

OECD Recommendation on Artificial Intelligence

Recognized as the first international and intergovernmental standard for AI use, this recommendation has informed various frameworks, guidelines, and principles since its release in 2019. The recommendation sets various expectations on all ‘AI actors’, defined as ‘those who play an active role in the AI system lifecycle, including organizations and individuals that deploy or operate AI’ [54]. This approach is sector-agnostic, placing expectations for responsible business conduct not just on AI developers but also on users of AI systems. The principles focus on transparency and explainability regarding AI systems, safe AI use, and accountability, which implies heightened expectations for disclosure. These could include:

1. **Transparency and explainability:** AI actors may be required to disclose more information about how their AI systems function and the extent of autonomy exercised by the system.

2. **Changes during the AI system lifecycle:** AI actors may need to inform stakeholders about potential risks and changes that arise during regular maintenance, data collection, testing, deployment, and decommissioning of an AI system.

3. **Safety and risk management:** AI actors may be expected to disclose the safety measures and protocols in place, particularly in scenarios where AI systems could cause harm or exhibit unexpected

behavior. This may also include disclosing information on override mechanisms or the conditions under which an AI system can be decommissioned.

4. **Transparency of data sources for AI training purposes:** AI actors may need to report on the data sources used for training AI systems. This would include clarifying whether data was sourced from open-access materials, copyrighted content, or user-generated content. If the training data includes content subject to intellectual property rights, AI actors would need to disclose whether proper licensing agreements are in place and confirm that the use of such data is lawful.

5. **Intellectual property rights compliance:** AI actors may need to demonstrate adherence to intellectual property laws in their country of operation and disclose how they manage the use of copyrighted materials during AI system training.

6. **User consent:** AI actors may need to inform users of their products that the data generated through their interactions with services is utilized to train generative AI systems.

General Data Protection Regulation

The General Data Protection Regulation (GDPR) is a comprehensive data protection legislation developed by the European Union to ensure the protection of user privacy and data online within the European Union. It sets requirements for organizations concerning the collection, processing, storage, and sharing of personal data, emphasizing key principles such as lawfulness, fairness, transparency, data minimization, and accountability [24]. The impact of GDPR has transcended Europe, setting a global benchmark for digital privacy and data protection. It has informed regulations in other regions and influenced how organizations approach data management and collection.

The requirements to be 'GDPR compliant' are substantial and comprehensive. The ripple effects of GDPR have elevated reporting expectations for any organization that engages with online users. These expectations include but are not limited to:

1. **Requirements relating to the processing of personal data:** data must be processed lawfully, fairly, and transparently, ensuring informed consent from data subjects (users).

2. **Purpose limitation and data minimization:** personal data must be collected for specified, explicit, and legitimate purposes and not further processed in a manner that is incompatible with those purposes.

3. **Privacy and confidentiality:** personal data must be processed in a way that ensures appropriate security, including protection against unauthorized or unlawful processing and accidental loss, destruction, or damage.

4. **Transparency expectations around processing, sales, copying, and storing data:** data collectors must provide data subjects with information when their data is collected. This includes

details such as the data controller's identity, the processing purpose, the legal basis for processing, and any data recipients.

5. **Right to access:** data subjects have the right to request and obtain information about whether their data is being processed and, if so, to access the data and obtain additional details like the processing purpose, the personal data categories, and the data recipients.

6. **Third-party data sharing –** if a user's data is shared with third parties, the data controller must inform the data subject about the recipients of the personal data. This applies to the sale of data as well.

7. **Data security management policy:**
    - **Data protection by design and default:** this principle refers to incorporating data protection measures into the design of systems and processes.
    - **Data protection officer:** some organizations are expected to appoint a data protection officer to ensure compliance with GDPR.
    - **Data transfers:** the GDPR imposes restrictions on transferring personal data outside of EU jurisdiction, which allows transferring user data only to countries deemed to provide adequate data protection.

EU AI Act

The EU AI Act represents the first international regulatory framework on artificial intelligence, officially approved by the European Parliament in March 2024 [23]. This groundbreaking legislation establishes a structured approach to AI by outlining specific requirements and obligations for both developers and deployers. Central to the Act is a risk-based classification system for AI applications:

1. **Unacceptable risk:** The highest risk level refers to AI systems such as social scoring and categorization of people. At this level of risk, the EU intends to ban these AI systems.

2. **High risk:** AI systems used in specific areas such as the operation of critical infrastructure, access to essential services, employment (including CV-sorting software during recruitment processes), credit scoring, migration, asylum, and border control management. The developers and deployers of such capabilities will have to satisfy risk assessment and mitigation system requirements, ensure high-quality training data and traceability, and ensure a high level of robustness and security.

3. **Limited risk:** Defines the need for transparency in AI tools that pose a limited risk, such as chatbots and generative AI. Developers and users of these tools must comply with transparency requirements to disclose when AI's content was generated and copyrighted data used for training AI systems.

4. **Minimal or no risk:** AI tools that pose little to no risk, such as those used in video gaming or spam filters, will be used freely.

Conclusion

This research finds that the impacts of digitalization on the environment and the economy are conditional and influenced by various intervening factors that can shape the role of digitalization in achieving sustainable development objectives. A broad consensus exists among governments and international organizations that digital transformation holds the potential to bring about substantial change and advance sustainable development. However, from an environmental sustainability perspective, this potential has not yet manifested in a meaningful departure from the current resource-intensive production and consumption practices. In fact, the data indicates a negative trend: substantial increases in e-waste and water and energy consumption by data centers are diverting major technology companies from their commitments to emission reductions, highlighting the importance of thorough reporting on the impacts of digital transformation.

Currently, nearly all organizations have either already fully transformed digitally or are in the process of outlining the extent of digital change they want to pursue. This shift is expected to create ripple effects across the economy and the environment, as reliance on the physical infrastructure of digital technologies is projected to increase significantly over the next few years, thereby exacerbating the negative impacts associated with data center operations.

While the impacts on the economy and the environment can be captured in the existing GRI framework, additional reporting guidance on relevant Topic Standards could link the impacts of digitalization to wider sustainability impacts. The relevant Topic Standards cover emissions, energy, water, waste, labor, and economic impacts, but they insufficiently address the unique impacts of digital technologies, such as developments in AI, algorithmic decision-making, data privacy, and security. There is a conspicuous gap in reporting related to these areas, warranting a revision of the relevant Topic Standards.

The research found that the adoption of AI systems is accelerating, along with the emergence of new AI-based services. This is accompanied by concerns regarding the implications for the rule of law and potential human rights infringements associated with algorithmic bias and discrimination. As algorithmic data processing capabilities rapidly expand, it is critical to set reporting expectations concerning AI usage in alignment with emerging international standards and guidelines. Additionally, growing interest and investment in generative AI highlight the risks of market concentration among major technology firms, as well as the various implications for information ecosystems.

This paper also identifies several research gaps, including discrepancies in digitalization impacts across sectors, the reporting activities of technology firms, and reporting in sectors with high digital technology adoption rates. The first gap pertains to the scoping of the research. The sector-agnostic approach adopted enabled a broad overview but limited a comprehensive exploration of the sector-specific implications of digitalization. The second gap relates to the investigation of reporting activities around digitalization, which could be pursued in future research.

On a global scale, a rapidly evolving regulatory landscape is influencing the future of digital transformation, with diverse efforts across jurisdictions aiming to steer its path. However, it is apparent that the GRI Standards and other internationally recognized sustainability reporting frameworks are lagging behind in setting reporting expectations for the adoption of digital technologies and the implications of the transition. GRI has the opportunity to fill this gap by implementing clear reporting expectations concerning the impacts of digitalization. Given its global perspective, GRI is well-positioned to address the fragmented nature of digital technology impacts, and provide leadership in the reporting of digitization impacts.

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