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Item 04 – Digitalization impacts – Identifying emerging reporting challenges and needs

For GSSB discussion

Date	10 September 2024
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Project	Research project – Digitalization impacts
Description	This research paper has been drafted in response to the GSSB request for more research on the sustainability impacts of digitalization, data protection, cybersecurity, and data privacy. This paper consists of a survey of the most significant impacts related to digitalization and emerging reporting needs tied to them. It identifies gaps in the current GRI Standards and proposes updates to a number of relevant Topic Standards for the GSSB to consider.

Contents

Executive summary

Digital technologies are being adopted by businesses, governments, and people at unprecedented rates. The wider use of new digital tools and services will create – and in certain areas already creates – various sustainability-related impacts. To understand emerging sustainability reporting needs resulting from the wider adoption of digital technologies, peer-reviewed academic publications and resources from leading international organizations were consulted. Three actual and potential impacts were identified: environmental, economic, and human rights related. Existing GRI Standards were assessed against these impacts to understand how well they capture digitalization-related impacts. Actionable recommendations were then developed based on the most recent internationally recognized frameworks and guidelines around digitalization.

Environmental impacts around digitalization arise principally from the development, production, maintenance, and disposal of the physical infrastructure that enables and sustains digitalization. This infrastructure has become increasingly complex, robust, and expansive over time. It includes resource-intensive data centers, undersea and underground fiber optic cables, satellites, cell towers and base stations, and personal devices.

Digitalization affects economic variables such as productivity, competition, labor, and employment. Evidence shows that digitalization has had uneven productivity impacts across organizations, depending on the capacity of the organization to leverage digital technologies effectively. Regarding labor and employment impacts, new digital technologies are impacting lines of work differently from previous waves of automation. While digitalization has led to some job displacement in the economy, it is also creating new opportunities at an accelerated rate.

Digitalization creates human rights implications via collecting and using personal data and human interaction with digital services, including artificial intelligence (AI). The widespread collection and use of personal data pose privacy and protection risks, with current regulatory frameworks struggling to keep pace with technological advancements. Broader uptake of AI and algorithmic decision-making can lead to biases and discrimination in employment opportunities and access to essential services.

Despite widespread characterizations of digitalization as a transformative opportunity to achieve sustainable development, this opportunity depends on many other intervening factors. While digital technologies offer potential for advancing sustainable development, there is limited evidence that this potential has become a reality. On the contrary, available evidence suggests that increasing digital transformation has intensified resource consumption and adverse environmental impacts due to substantial increases in e-waste, energy and water use of data centers, and production of technological hardware. Regarding human rights impacts, the lack of transparency over data governance and AI systems underscores the need for robust governance and reporting frameworks.

The GRI Standards partially cover the broad impacts of digitalization. Environmental and economic Topic Standards are robust and comprehensive, and given the ongoing update of economic impact and labor-related Standards, it is possible to capture digitalization impacts under these categories.

More reporting guidance on these impacts would help reporters understand the effects of decisions to adopt digital technologies. The reporting gap is substantial regarding the more unique impacts of digitalization, such as questions around data governance, AI-use, and algorithmic decision-making. While some unique aspects, as in *GRI 418: Customer Privacy, are covered,* existing disclosures need updating, reporting expectations should align with internationally recognized frameworks, and new disclosures addressing AI deployment must be developed.

Globally, a rapidly evolving regulatory landscape is shaping the future of digital transformation, with efforts across various jurisdictions aimed at influencing its direction. It is evident that not only GRI, but also other internationally recognized sustainability reporting frameworks are lagging in setting reporting expectations around the adoption of digital technologies and the implications this transition brings.

Recommendations

Pursue a digitalization project – In light of the assessment of GRI Standards and a review of the emerging regulatory and policy landscape on digitalization impacts, it is proposed that the GSSB considers pursuing a digitalization project to reflect the current Standards' reporting needs. Topic Standards identified as needing an update are *GRI 405 Diversity and Equal Opportunity, GRI 406: Non-discrimination, GRI 417 Marketing* and *Labeling, and GRI 418: Customer Privacy.* The project should consider revising these Standards to address aspects of digitalization that the current GRI framework omits, including data governance, cybersecurity, and AI adoption.

Mainstream digitalization in other Topic Standards – This would require integrating impacts that arise from adopting digital technologies not only from a data governance and cybersecurity perspective but also to allow for integrating environmental and economic impacts more clearly. For instance, the ongoing revision of the pollution-related GRI disclosures can consider the environmental impacts associated with maintaining the digital world, such as high reliance on water and energy to sustain data centers. Regarding ongoing projects such as labor and economic impacts, the respective working groups can consider the relevant categories of impacts identified in this paper. Integrating impact considerations in new GRI Standards projects would help SMEs and non-tech organizations using digital technologies to address digitalization impacts during their materiality assessments.

Consider sector-specific impacts – Following up on our current research on the broader impacts of digitalization, sector-specific research is proposed for consideration, as each sector has unique characteristics, capacities, and opportunities that influence how digitalization unfolds. Digitalization can have different impacts on sectors depending on their level of technological adoption, regulatory environment, and market dynamics. Also, sectoral differences can mediate where impacts occur along the digitalization value chain. For instance, in manufacturing, digitalization might focus on automation and the Internet of Things (IoT), while in finance, it might center on blockchain, big data analytics, AI-driven analytics, and customer services. Sector-specific research helps identify these unique factors that would inform decision-making. Conducting sector-specific research on the tech industry is also important, as it is the digital service provider to the economy. Additionally, most environmental impacts arise within the tech sector, particularly through the maintenance of digital infrastructure.

Produce other documents – Producing documents or resources such as reporting guidance, publishing research papers, discussion notes, and training material could also help non-tech or smaller organizations better understand the implications of their choices in adopting digital technologies.

Monitor the evolving policy landscape – In light of the rapidly evolving regulatory, policy, and reporting landscape around digitalization, continued monitoring of this landscape should be considered. Staying informed about regulatory developments is crucial for GRI’s strategic positioning and adaptation in the face of policy shifts. This could be done by collaborating with GRI's policy, Standards, and research functions.

Introduction

Digitalization – defined as the use of digital technologies and data as well as interconnection that results in new or changes to existing 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, developing 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 technology sector boom is accompanying the digitalization boom. As of the writing of 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 [35]

By all accounts, the emergence of digital technologies and their transformation are likely to endure. In a few years, machine learning and big data advances have enabled the mass adoption of artificial intelligence tools [19]. The diffusion of digital technologies and the potential of digital transformation hold opportunities for developing nations to improve well-being, economic productivity, and growth [53]. Developing economies are adopting strategies to effectively leverage digital technologies to address governance and developmental needs [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 put the United States at the forefront of global technological innovation while establishing a robust regulatory framework to ensure innovations are secure, accountable, and explainable. The European Union's Digital Strategy aims to achieve digital transformation of the EU by 2030 while also promoting digital transformation to enhance the EU's global competitiveness [22]. Through its National Digital Plan, China seeks to expand its digital infrastructure and economy while taking a leading role in advancing digital innovation [66].

Adopting new tools and services made available through digital technologies is likely to create – and in certain areas already creates – various impacts. For example, energy companies are deploying smart power meters and household devices that adjust electricity usage based on supply and demand in the grid. In urban settings, cities use digital tools for predictive maintenance and optimize traffic flow through adaptive signal control systems. In manufacturing, increased data availability from interconnected sensors can lead to efficient resource use and customized production outcomes. Emerging technologies are unlocking new capabilities that enable monitoring of at-risk ecosystems [67].

Digitalization of various customer-facing services, including financial services, health services, retail, and others, has transformed these sectors while bringing to the forefront concerns around data privacy and security, as well as around potential bias and discrimination [7]. The environmental cost of digital transformation is also unclear, with digitalization having been described as a 'potential fire accelerant' [27], an environmental 'game changer' [59], or 'a core component of the green transition' [30]. Indeed, the transformative power of digital technologies poses significant opportunities for the sustainable use of resources. Meanwhile, subject matter experts and academic literature are approaching this transformative potential with a degree of caution, as the German Advisory Council on Global Change concludes, 'Technical innovation surges do not automatically translate into sustainability transformations but must be closely coupled with sustainability guidelines and policies' [27].

For GRI, digitalization represents an important issue with knock-on effects on some Topic Standards, as well as unique impacts underexplored in the current framework. The GSSB Work Program 2023-2025 identified digitalization, data protection, cybersecurity, and data privacy as a research priority, with the potential to explore the subject further to assess the need for developing a Topic Standard. Therefore, this research aims to provide an understanding of the impact of digitalization on the economy, the environment, and people, including their human rights. It also allows the GSSB to make an informed decision about the need to develop a Topic Standard for digitalization. This research paper consists of a survey of the most significant impacts related to digitalization.

The report is structured as follows: scoping and methodology and an overview of digital technologies, including the related physical infrastructure and services. The following sections identify and elaborate on the impacts of digitalization across three main categories, namely impacts on the economy, the environment, and people, specifically human rights implications. To understand the need for a Topic Standard, the following section assesses the fitness of relevant GRI Standards in capturing impacts previously identified. The final section provides an overview of existing reporting expectations around digitalization impacts, followed by the conclusion and actionable recommendations for the GSSB.

Scoping and methodology

Scope

Digitalization is a complex topic with crosscutting impacts. The impacts of digitalization occur across the entirety of a digital technology's life cycle, from the initial design to its deployment, as well as after its retirement. Furthermore, digitalization is made possible through the interconnection of technological devices and digitized data facilitated by a robust physical infrastructure that underpins the entire digital ecosystem. While responsible design and development of new digital technologies is crucial, this research project reviewed the impacts of digital technology adoption. The research also focused on the physical infrastructure surrounding digital activity and its impacts on the economy, the environment, and people, including their human rights. This approach was selected because focusing solely on technology companies and the development phase of digital technologies would limit the investigation of the impacts of digital technologies across all sectors. Responsible design and development of digital technologies should be a separate research project focusing on the technology sector. This research was therefore carried out with a sector-agnostic approach.

Methodology

In order to prepare this research paper, the following research methodology was used:

Scoping – Conducted to determine what constitutes digitalization, specifically to separate the activities of organizations in the technology sector from the broader category of digitalization. This was done to guide research according to the existing GRI Sector and Topic Standards and to maintain a sector-agnostic approach.

Desk research – Conducted to identify relevant qualitative and quantitative data on the various impacts of digitalization. As shown in the bibliography section, this paper has identified and leveraged a wide range of sources through targeted searches within academic journals, scholarly search engines (Google Scholar, Scopus, and Web of Science), as well as websites of globally recognized organizations such as the United Nations, the Organization for Economic Cooperation and Development (OECD), the International Labour Organization (ILO), among others.

Frameworks analysis – 26 Existing frameworks, guidelines, principles, and regulations were reviewed to understand the regulatory and reporting landscape of digital technologies. The regulatory and policy landscape around digital technologies are inconsistent and scattered. Therefore, texts from a variety of regulatory jurisdictions were reviewed. This analysis informed the drafting of the report, and the database of these frameworks can be found in the project documentation.

External engagement – The principal researcher attended workshops and conferences on digitalization, technology policy, and tech ethics and held two consultation meetings with experts. One expert was from academia, whereas the other was from the NGO sector.

Overview of digital technologies

Describing digitalization

Digitalization refers to the growing application of information and communication technologies across the economy [35]. However, there is no consensus on the definition of digitalization. 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 the international authoritative instruments, the OECD has defined 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, namely data and interconnection, which enable widespread adoption. It also touches on the transformative nature of digitalization, a research focus, as the potential and actual impacts associated with adopting digital technologies were investigated.

Digitalization is made possible through digitization and interconnection, both of which are technological trends in their own rights [13] [6]. Digitization consists of transforming analog information such as sound, image, or printed text to digital data so that digital devices can interpret without degradation and at a very low cost. Without digitization, digital technologies would not have any data to function, and digital transformation would not be possible [13]. Interconnection (or connectivity, or interconnectivity) refers to integrating and communicating between various digital systems, devices, and technologies through digital communication networks [6] [53]. It enables real-time flow, exchange, and data processing across different technologies. Through leveraging interconnectivity and digitization, a range of new digital technologies have emerged over the years. The collection of these technologies and services largely drives digital transformation [6].

The increasingly complex, robust, and expansive physical infrastructure is central to digital transformation, ranging from 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 sustains them.

Artificial intelligence

Artificial intelligence (AI) is a crucial component of digitalization as the new wave of digitalization is partly driven by a growing interplay between AI systems and other digital technologies.

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

Despite lacking a commonly agreed-upon definition for AI, AI systems usually carry similar characteristics [50]. The closest consensus to the definition of an 'AI system' is provided by the OECD: '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 is a concept that involves a set of techniques that allows machines to improve their performance and usually generate models in an automated manner through exposure to training data, which can help identify patterns and regularities rather than through explicit instructions from a human [55]. Machine learning is integral to the life cycle of AI systems from development to the end-use phase.

Wider adoption of new digital technologies, such as artificial intelligence, incentivizes further widespread data collection, storage, and processing. AI-system training requires large datasets, thereby increasing the salience of reporting on AI use and development [68].

Big data analytics

Big data describes large datasets that are high in volume[2] and variety,[3] and are created and shared at high speeds. It also involves the collection of 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 is described as a set of tools and techniques deployed to process, analyze, and visualize data generated through the digitization of content, tracking of human activities, and connectivity of physical objects [41] [18] [27].

Cloud technology

Cloud technology enables the storage of digitized data over a connected network. 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

[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, including social media platforms, e-commerce platforms, educational forums, and collaborative workspaces, each designed to support specific types of 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

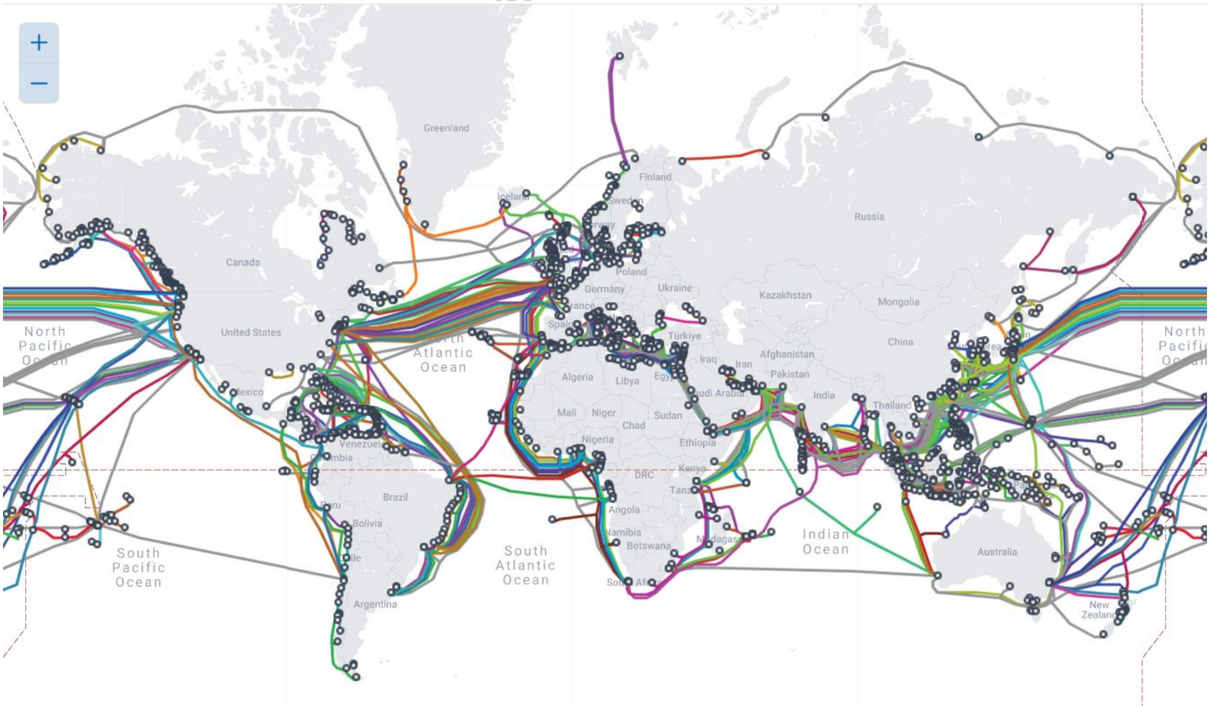
These facilities house servers and storage systems that process and store vast amounts of data. Data centers are the physical locations where cloud computing and storage services operate. Data centers enable all digital technologies that businesses and people rely on. Subcomponents of data centers are power supply and energy infrastructure, including backup power systems such as uninterruptible power supplies (UPS) and generators to ensure continuous operation. Cooling systems maintain appropriate working temperatures in data centers and other high-density electronic environments to prevent overheating and equipment failure.

Figure 2. Image of the Amazon data center in Oregon, United States

Fiber optic cables

Underground and submarine fiber optic cables are essential to the internet's physical infrastructure as they allow for transmitting data at high speeds across long distances. Submarine fiber optic cables connect grounded telecommunications and rapidly exchange large amounts of data globally.

Figure 3. Illustration of publicly available submarine cables [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. Digital services such as broadcasting, navigation, and global positioning systems (GPS) rely on satellite connections to transmit signals across devices.

Internet of Things infrastructure

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

Personal technology devices are also a key component of the IoT infrastructure as they serve as the primary interface through which individuals interact with digital technologies and data. Personal devices include smartphones, computers and laptops, tablets, wearable devices, and smart home devices.

Impacts of digitalization

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

The impacts of digitalization arise principally from the development, production, maintenance, and disposal of the aforementioned physical infrastructure. This involves information and communication technologies equipment, data centers, and data transmission networks, as well as developing and adopting 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 existing in the digital space, the physical infrastructure that enables digitalization, and the production of personal and commercial pieces of technology. Nevertheless, the impacts associated with using and maintaining digital technologies are crosscutting and multidirectional, making categorizing impacts into clearly divided categories challenging. For instance, capturing the carbon footprint of digital technologies throughout their lifecycle requires insights into the complex supply chain behind digital technologies,

[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.

including the relationship between the technology industry, the energy industry, and the extractives industry.

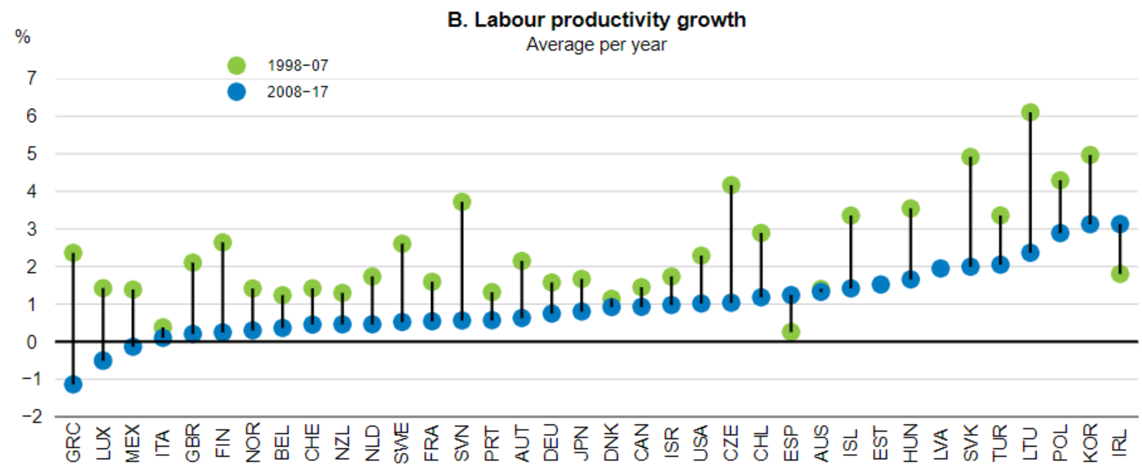
Impacts on the economy

Digitalization has impacts on the economy by affecting economic aggregates, mainly productivity, competition, labor, and employment. Digital technologies generate firm-level capacity for gathering and analyzing information that addresses various market inefficiencies [52] [53] [2]. Through monitoring, interconnecting, and manipulating physical modes of production, digital technologies enable the collection, management, and processing of data, leading to insights about materials, products, and processes [71] [6].

However, digitalization has had uneven economic impacts on organizations from a productivity standpoint. Despite spearheading the digital transformation, most OECD countries have seen a sharp decline in productivity growth over the past two decades [52]. While the declines in productivity growth in OECD countries depicted in Figure 4 are multicausal, productivity gains from digitalization have not been sufficiently large to offset other factors.

OECD suggests that declining or even gaining productivity is a result of organizations' uneven distribution of capabilities and resources [52]. Other research notes that small- and medium-sized enterprises (SMEs) and start-ups might face more difficulties accessing and using data, information, and knowledge generated by these technologies. This difficulty may prevent them from fully leveraging these technologies compared to firms with a more established technology experience [6]. OECD research indicates that firms with more resources to develop and use digital technologies have benefitted more from digitalization than others [52]. This suggests that productivity impacts brought about by digitalization may be more limited than previously thought.

Figure 4. Source: OECD (2019)



Labor and employment impacts

Adoption of digital technologies can impact employment and livelihoods. Job displacement is recognized as a potential negative impact of using artificial intelligence and automation by the IEEE, OECD, and the World Economic Forum [53] [65] [75]. Changes to business models triggered by the adoption of digital technologies can carry employment impacts across most sectors in terms of job creation, job displacement and job quality, and widening skills gaps [6]. Indeed, over 85% of organizations surveyed by the World Economic Forum believe increased adoption of new disruptive digital technologies such as AI is the most likely driver of organizational transformation, while 75% expect to adopt such technologies soon [75].

Wider adoption of AI-systems and advances in generative AI enable the automation of non-industrial work functions, such as reasoning, communicating, coordinating, and planning [2] [31]. Because of the unique abilities of AI systems and the rapid rate of advancement in their capabilities, work areas previously unaffected by former waves of automation may now become jeopardized.

So, it is important to clarify whose livelihoods may be affected by the advent of these new types of technology [1] [2]. While previous technological improvements altered jobs, mostly in industrial production, digitalization is targeting jobs in accounting, sales, logistics, trading, and certain managerial occupations [2]. A Goldman Sachs projection estimates that AI could affect over 300 million jobs in the coming decade, with most at-risk fields of work being office and administrative support jobs and legal work [28]. A McKinsey report meanwhile estimates that up to 800 million people could be left without a job due to automation by 2030 [45]. While as much as 80% of the United States workforce could have their work affected by the adoption of AI-tools, workers in higher-income jobs face 'potentially greater exposure' to their effects [20].

However, prior innovations have also led to job displacement, which was counterbalanced by the emergence of new jobs. This is partly due to the introduction of the innovation that led to displacement in the first place, described as the 'reinstatement effect' [2]. Furthermore, it remains unclear whether the job displacement brought about by digitalization will have characteristics unique from prior waves of displacement and reinstatement.

Taking a broader view and considering that new job opportunities arise due to digitalization as well, the overall impact of digitalization on employment may be less significant than predicted by the most alarmist accounts. The World Economic Forum, for instance, expects the impact of 'most technologies' on labor demand to be a net positive over the next four years because some of the fastest-growing job areas concern technology and digitalization [75].

Market concentration

Market concentration around digital technologies is another significant economic impact. A few powerful technology organizations dominate digital technologies and associated services. For instance, Meta owns products across several digital service streams, including Facebook, Instagram, Threads, and WhatsApp. Their collective subscription surpasses 8 billion, affording Meta an ‘overwhelming dominant position’ in the social media market [43].

A federal court in the United States recently ruled that Google has maintained an unlawful monopoly on internet search services and text search advertisements. The ruling highlights that Google used its dominant market position to suppress competition and restrict consumer options in the internet search industry. The case laid out how Google, which dominates nearly 90% of all internet searches, manipulated its position in the market by charging advertisers artificially high prices [60]. Google will likely challenge this ruling, although it will have far-reaching effects on the technology sector. Other dominant players now face increasing scrutiny over their business practices, both legislatively and from stakeholders. This underlines the need for concrete reporting expectations by disclosing behavior that can be deemed anti-competitive [56].

With the deeper integration of digital technologies in all aspects of daily life, market concentration around cybersecurity can have widespread implications. Major cybersecurity firms such as CrowdStrike and Cloudflare protect a substantial portion of the global digital infrastructure. CrowdStrike provides cybersecurity services for Microsoft, the world’s second-largest cloud service provider, with Amazon Web Services leading the market and Google following in third place. These organizations take up over two-thirds of the cloud services market. Despite the disconnected nature of digital technologies, the fact that its main infrastructure, cloud computing, is maintained by a few actors makes the entire digital ecosystem vulnerable. While these systems have robust safety mechanisms, a successful breach or an internal malfunction would create catastrophic impacts on the global economy. In July 2024, for instance, a global disruption to Microsoft-powered devices was caused by a failed update of CrowdStrike systems, affecting nearly nine million devices worldwide [26]. The disruption caused ripple effects across many sectors, including public services, healthcare, and transportation, including the cancellation of over five thousand flights.

Impacts on the environment

Digitalization creates environmental impacts by changing how people, organizations, and broader society interact with their environment [67]. Emerging digital technologies offer numerous options to enhance environmental protection and reduce greenhouse gas (GHG) emissions, although they also create their own environmental impacts. Digitalization has impacts on natural resources because of infrastructure and combinations of technology required to maintain the digital world [47]. These impacts arise from land, energy, and water use.

Emissions impacts

The adoption of digital technologies is presented as a way to reduce global GHG emissions [4] while also ensuring long-term growth [76]. Digital technologies can potentially reduce emissions in other industries and dematerialize consumption[30]. So, the positive impact on GHG emissions is indirect because digital technologies enable a change from existing practices that may damage the environment. However, their transformative power is limited without targeted regulation and policy

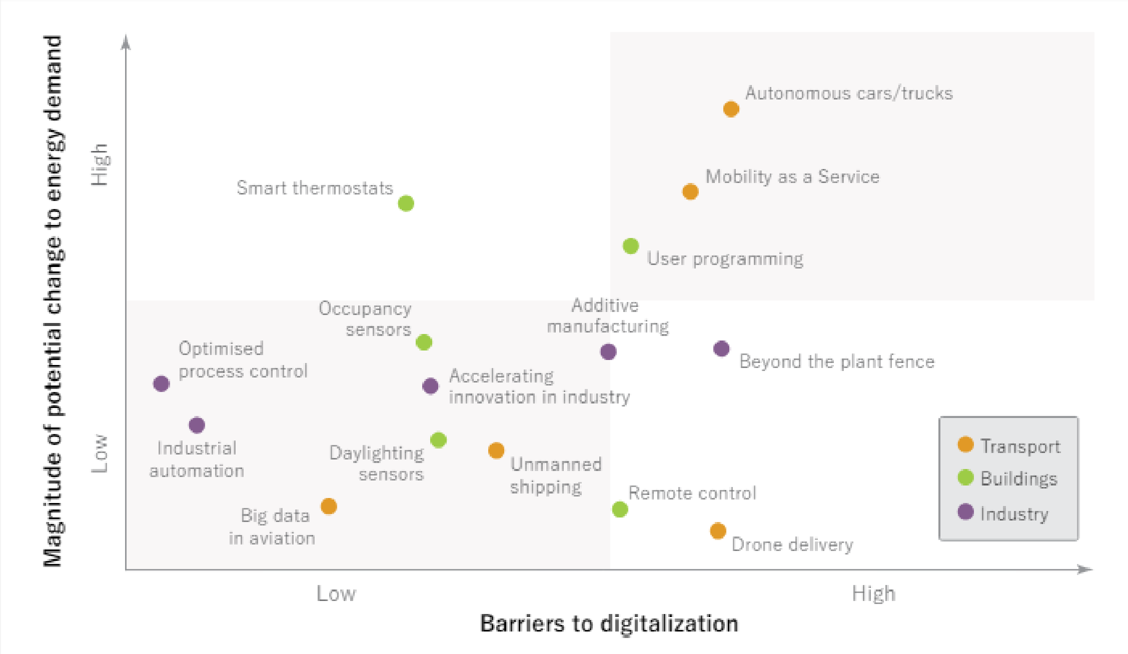
[42]. For instance, new digital technologies are being deployed to increase biodiversity monitoring, which provides more frequent and reliable information regarding ongoing risks to biodiversity. Nevertheless, better information does not provide the preconditions to alter the underlying causes that create the risks in the first place [42]. Therefore, positive impacts have the potential but depend on various factors to contribute meaningfully.

In transport, the IEA estimates that further automation and electrification could either reduce energy use in this sector by about half or increase it by more than double, depending on the interaction between technological advancements, the rate of adoption, policy responses, and human behavior [35]. Without advances in energy efficiency, implementing smart energy technology may not lead to overall reductions in energy use and could even offset potential decreases. A comprehensive study looking at the potential for energy savings by 2050 through digitalization finds that if strong energy efficiency advancements do not counteract digitalization, energy consumption could rise to 42% from the study's baseline [12].

The rebound effect associated with the adoption of digital technologies should also be considered. This phenomenon refers to how adopting digital technology can reduce environmental impacts, like dematerializing goods or lowering transportation needs, while increasing energy consumption from electronic devices. In other words, the growth in digital goods like hardware and energy-heavy services like cloud computing and data center maintenance can offset the efficiency gains from digital economy practices [6] [27] [37].

The potential dual impact of digitalization on energy demand is depicted in Figure 5 by considering the barriers to digitalization in three energy-intensive areas: transport, buildings, and industry. For instance, the barriers to digitalization in industrial automation are low, allowing organizations to adopt digital technologies more easily than in the transportation sector. However, this form of digitalization has minimal impact, which means that considering all the energy efficiencies gained by introducing digital technologies in industrial production, the overall effect on energy demand may nevertheless be limited.

Figure 5. Digitalization's Potential Impact 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 emissions impacts around digitalization has also proven to be a challenge in scientific literature. Data gaps in digital technologies' energy consumption, the dynamic and open-ended nature of digital innovation, and the poor track record of digitalization projects make their climate impact 'unknowable' [30]. The gaps in available data on emissions lead researchers to make various assumptions for key variables in their research design, such as estimates for the lifetime and energy efficiency of digital devices, the extent to which digitalization changes consumption behavior, and the number of users of material and digital products. After reviewing 31 studies on the emissions impacts of digital technologies (specifically digital goods)[7], researchers identified significant variances in the estimates of energy use impacts attributed to digital technologies [15].

Indeed, various estimates produce different pictures of the emissions cost of digitalization depending on the accounting metrics used. One academic study notes that only considering the emissions load of data centers' electricity usage would account for 0.3% of overall carbon emissions globally [47]. This figure increases to 2% of emissions if the accounting is expanded to cover networked devices like laptops, smartphones, and tablets. Other estimates put global emissions created by digital services between 2-3% of all global emissions [4]. The United Nations Environment Programme

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

attributes 4% of all direct GHG emissions from the ICT sector, almost as much as the entire aviation industry [67].

Energy impacts

Digitalization impacts energy use by increasing energy consumption at the household and business levels due to higher reliance on digital technologies and electronic equipment. Scholars and experts point to machine learning processes – integral to the development and use of many AI-systems deployed in recent years – as a particular energy-intensive area of digitalization [47] [40].

New generative digital technologies such as ChatGPT and AI-tools technology developed by companies such as Google, Samsung, Yahoo, and Microsoft are expanding and require substantially more energy to function outputs compared to traditional internet searches [44]. A review of the available 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 IEA estimated the energy demand from data centers and AI and cryptocurrency tech to be 2% of global electricity demand [37]. The IEA warned that data centers are becoming major contributors to rising electricity demand in many regions, with over one-third of the projected increase in US energy consumption for 2024-2026 attributed to the growth of the data center sector [37]. The report also warns that without crucial regulatory intervention and technological progress, the electricity demand for data centers could more than double by 2026, reaching the electricity consumption levels of Japan [37].

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

Data centers generate heat, creating a need for cooling systems to prevent overheating. These cooling systems work continually, even in the most advanced and energy-efficient data centers. It is estimated that 25-40% of electricity demand from data centers is tied to cooling systems [70]. Attempts have been made to address this system, such as redirecting the heat generated from data centers to heat homes or to generate electricity [61] and even relocating data centers to colder climates to provide natural cooling [47]. However, such efforts may not be scalable as smaller data centers may face barriers to transition [71] [47], while the necessary technological and physical restructuring to execute such transformation also creates its 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 create land use impacts due to their size, as their maintenance requires both physical technology and infrastructure to accommodate various technology combinations, such as cooling systems, servers, and backup energy supplies.

For instance, the Switch SuperNAP data center operates from a campus spanning a 190,000 m^2 field in Nevada, United States. Another US state, Virginia, has seen the rapid expansion of data centers. Since 2019, Virginia's number of data centers has risen from 186 to 467, establishing it as the largest data center market in the United States [74]. Digital Realty operates the largest data center in Virginia, and it has an allocated size of 278,000 m^2, with about a third actively used and the rest reserved for scaling [17]. The largest data center in the world is the China Telecom-Inner Mongolia Information Park, located in central Mongolia (Moss 2022). The project plans for the complex to cover over 1,000,000 m^2, including the machinery to run its cloud services, call centers, warehouses, offices, and living areas [49]. The construction of the Inner Mongolia Information Park involved converting land that was primarily used for farming and livestock grazing. This land conversion has affected local communities and livelihoods, particularly as the area is still home to various ethnic herder groups.

Figure 6. Data center complexes in Virginia. The left image depicts a data center with land conversion and deforestation. The right image shows data centers located in Virginia [8]

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

Impacts on waste

Digitalization creates waste impacts by driving up demand for technological equipment. The wider adoption of digital technologies has been noted as a driver of higher turnover rates for technological hardware (German Advisory Council on Global Change 2019). High product innovation rates in digital services encourage hardware replacement as more advanced software requires increased computational power to function. The median lifespan of a mobile phone was almost five years between 2000-2005 [5]. Within a decade, this decreased by half, around 2.5 years, with an average retention rate[8] of less than two years [9].

Shorter lifespans and more frequent upgrading of technological devices contribute to more than 62 million tons of global electronic waste generated annually [69]. Total e-waste has increased by 82% since 2010, with projections up to 82 million tons by 2030, which would be another 32% increase [69]. Current efforts are insufficient to meet the growing consumption rates of electronic devices, with electronic waste rising five times faster than e-waste recycling [69].

Waste reduction, energy efficiency via circular economy

Digitalization can facilitate positive environmental impacts by supporting various aspects of the circular economy – defined as achieving resource efficiency and economic processes related to lowering the rates of natural resource extraction and use throughout the value chain – or 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 for sectoral production [53]. However, the market share of circular business models such as recycling, remanufacturing and repair, sharing

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

of spare capacity, and the provision of services instead of products is limited [53]. By leveraging digital technologies like artificial intelligence, blockchain, the IoT, and cloud computing, organizations can be better positioned to transition to greener models of production and consumption, as well as 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, through the use of personal data and human interaction with digitalized services.

Risks to rights to privacy and data protection

Despite growing regulations and frameworks, there is still 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 operate in a space that is often opaque and unregulated. It will likely take years before clear legislation, let alone a global agreement, is in place [32].

Organizations’ data processing, collection, fusion, trading, and usage remain largely opaque [62]. Often, organizations that deploy digital services, such as streaming platforms, online retailers, and news sites, offer seemingly free services while commercializing personal user communication and behavior data, which interferes with the right to privacy [18] [68]. Organizational-level decisions around data processing and trading lack transparency and traceability, and individuals have limited control over their own data [27].

Over the past decade, exposure to sensitive information through leaks, cyber-attacks, or data theft has affected millions of people. One of the most infamous cases is the Cambridge Analytica scandal in 2018, where it was exposed that the company harvested the data of approximately 87 million Facebook users without consent and then sold it to political campaigns [14]. 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. AI systems have become increasingly effective at pattern recognition, so when introduced with enough data, they can identify patterns in data based on the specific algorithm they were built on, which makes training models for algorithms consequential. AI systems being indifferent to truth leads to what experts call the ‘hallucination effect’, where AI systems generate outputs that are not based on reality [33]. Without the ability to independently assess the validity or the context behind the data, AI systems can perpetuate and even amplify existing biases.

Algorithmic bias and discrimination can occur at various stages of the life cycle of a digital technology. Bias at the design stage refers to when an algorithmic system is introduced to biased information at the design level. Incomplete or unrepresentative datasets establish a biased baseline from which an AI system would emerge, which can lead to discriminatory outcomes in various contexts. For instance, people can be unfairly rejected from services (banking, healthcare) or employment and educational 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 that the algorithm had significant methodological errors, generated inconsistent child-at-risk scores, and exhibited age-based discrimination. The authors conclude that such algorithms should not be deployed in local governance functions [48].

Private sector organizations, which are in charge of AI innovation and development, do not disclose sufficient information on their algorithms, citing trade and commercial sensitivities or claiming that data on the public internet can be used for commercial purposes. Despite the early steps in regulating this field, no meaningful or common action guidelines have yet been established [10].[9]

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:

- ***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, reporting guidance that expands this expectation can be formulated. Also noteworthy is the ongoing project on economic impacts.
- ***GRI 206: Anti-competitive Behavior*** **–** contains a disclosure on legal actions for anti-competitive behavior, anti-trust, and monopoly practices, which can capture monopolistic and predatory behavior by major technology companies. For instance, Google's legal case would have to be disclosed under this disclosure.

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

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

- ***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 provision, among others. In its current form, this Standard contains no disclosures that can be directly linked to digitalization. GRI 3-3 can, to an extent, capture the negative impacts created by the adoption of automation or other new technologies. However, there are no specific disclosures on company policy to address concerns related to the growing adoption of digital technologies and the workforce resilience against it.
- ***GRI 402: Labor/Management Relations*** – contains a disclosure on minimum notice and consultation on operational changes, which could include changes due to automation and digitalization. However, this is not explicitly mentioned in the Standard, so additional reporting guidance would be needed.
- ***GRI 404: Training and Education*** – contains a range of disclosures on training and upgrading employee skills and performance reviews, which are crucial for workforce adaptation to new technologies. These disclosures are framed in a way that can capture training programs that aim to prepare the workforce for automation and digital transformation. However, no disclosures require reporting on company-provided training programs related to digitalization and automation or preparing employees to transition into new roles created by these technologies. For instance, no specific disclosures exist on reskilling employees to obtain digital skills. However, the framing of 'Disclosure 404-2 Programs for upgrading employee skills and transition assistance programs' can also be interpreted to include transitions due to digitalization. More concrete disclosures can be formulated on commitments to assisting, supporting, and preparing workers whose future in the organization may be jeopardized by digitalization and automation.

However, the ongoing revision and update of labor-related Standards have revamped the reporting expectations around digitalization impacts on workers. The proposed changes address various aspects of digitalization that can have impacts on workers, such as employee data protection and privacy and up-skilling and re-skilling of employees who were affected by significant organizational changes.

The revised draft Standards now have both topic management and topic disclosures on the handling of personal data by employers, including disclosures on several key issues identified in this research paper:

- Incidents relating to non-compliance or the unauthorized disclosure of private data of employees and workers who are not employees.
- Personal data protection and privacy policies.
- Obtaining explicit consent related to 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 covering various environmental impacts, including *GRI 305: Emissions*, *GRI 302: Energy*, *GRI 303: Water and Effluents*, and *GRI 306: Waste*. These Standards are comprehensive enough to capture the environmental impact of digitalization, particularly as it relates to energy and water use, land use change due to the growing 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:

- ***GRI 418: Customer Privacy –*** contains a single disclosure of identified cases of loss or theft of customer data. However, it is not detailed enough to satisfy reporting needs on the complex data privacy and governance landscape. It lacks reporting requirements on data protection and privacy matters for stakeholders beyond customers, such as employees and other partners in the supply chain. It also contains no disclosures on preventive measures being taken by an organization to ensure data privacy and asset security in cyberspace. There is also a need for disclosure on third-party data management, as companies outsource data management, storage, and processing services to third parties. There are also no disclosures on the obligations of companies to bolster cyber security or any measures in place to stress test defenses against cyber-attacks.

  Furthermore, the regulatory landscape has surpassed the requirement level in *GRI 418*. For instance, a GDPR-compliant organization would already report this information, meaning that this Standard would not be relevant for the reporting organization because it asks for fewer requirements. *GRI 418* needs an update to appropriately reflect all the major regulatory developments on data protection and cyber security matters. Instead of updating *GRI 418*, a more comprehensive digitalization standard could eventually be developed to represent the potential negative impacts that cannot be adequately reported in the current Standard.

- ***GRI 417: Marketing and Labeling*** – contains disclosures to ensure fair and responsible practices when organizations interact with customers through their marketing and labeling activities. '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. Considering the substantial use of digital tools for marketing purposes, for instance, in developing marketing strategies, using online platforms to carry out campaigns, and for targeted advertising, this Standard should be bolstered to create reporting expectations on the use of algorithmic systems for targeted advertising and use of customer data to create consumer profiles.

- ***GRI 2: General Disclosures –*** contains 'Disclosures 2-25 Processes to remediate negative impacts' that provide space for reporters to discuss their policy or strategy to address grievances due to cyber security breaches leading to loss or theft of data or assets. However, no clear link establishes a cyber security breach as a negative outcome to be remediated.

- ***GRI 410: Security Practices –*** is relevant as nearly all organizations using digital services need third-party cybersecurity services to ensure the information and, at times, assets are safe from cyber-attacks. However, the Standard is not equipped to create robust reporting on cybersecurity practices since the only disclosure is on human rights training of 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 as it relates to employment and not to other consequences of algorithmic bias.

Other human rights infringements across different AI use cases must also be considered. For instance, rapid technological advancements reduced the costs of implementing surveillance technologies, which can be deployed in ways that violate the right to privacy. The rise of social media platforms created new forms of online harassment and bullying and enabled the rapid dissemination of disinformation and hate speech. Integrating biometric technologies in governance and other types of service provision can create circumstances that lead to human rights violations. Users may deploy AI tools in ways unintended by their developers, leading to unintended negative impacts. The analysis of the current GRI Standards shows that these are not equipped to address the growing human rights considerations.

The assessment of existing GRI Standards offers an overall mixed picture regarding the broad impacts of digitalization. Environmental and economic Topic Standards are robust and comprehensive, and given the ongoing update of economic impact and labor Standards, it is possible to capture digitalization impacts under these categories. The reporting gap is substantial enough to warrant a revision of existing relevant Topic Standards regarding the more unique impacts of digitalization, such as questions around data privacy and security and AI use. While some unique aspects are covered, existing disclosures need to be consolidated, reporting expectations need to be increased, and new disclosures addressing AI development and deployment need to be developed. The current GRI Topic Standards are too thematically remote from the unique human rights issues posed by AI and other emerging disruptive technologies. AI use disclosures need to be developed to address this gap.

Current reporting expectations on digitalization impacts

Reporting expectations on digitalization impacts are still in the early phases of definition, although the regulatory landscape is rapidly evolving. The existing reporting tools can better capture some impact areas tied to digitalization. These areas are primarily tied to impacts on the environment, including but not limited to emissions, energy and water use, land change, and waste. Sustainability reporting frameworks on data security and privacy, use of AI, and cybersecurity are less defined and only partially covered by a patchwork of industry-specific standards. On the use of AI, no widely agreed-upon framework that sets disclosure expectations was found. A systemic review of reporting organizations in Western Europe identified no reference to a framework or reporting standard regarding voluntary disclosures on AI use, suggesting a significant gap [11].

This analysis included a review of ESRS, SASB, and CDP Standards, among the leading sustainability reporting frameworks. ESRS, given its recent launch and having published its first set of standards in December 2023, currently has no digitalization standard. Due to its focus on environmental components of sustainability, CDP also has no specific disclosures on the impacts of digital technologies. SASB, on the other hand, produced a standard targeting the software and information technologies industry. The standard focused on the emerging impacts of data privacy and security, the environmental footprint of digital technologies, intellectual property protection, and competitive behavior, as well as managing systemic risks posed by disruptions to digital technologies and services.

Given that SASB produced an industry-specific standard, more frameworks, guidelines, regulations, and other authoritative sources on various impacts associated with digitalization that GRI Standards do not already cover were reviewed. This was done to get a better thematic understanding of how issues around digitalization are covered under international authoritative sources that are not reporting standards. Therefore, this section includes a review of five authoritative sources chosen for their relevance and because these have informed legislation, policy, guidelines, and reporting expectations globally. These instruments are described and discussed as possible 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 specifically describes 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 software and IT industry organizations 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, 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 approach to identifying and addressing data security risks, include 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 match with a potential Topic Standard on digitalization, as the GRI Standard would not be sector focused. However, reporting expectations in the SASB standard align well with broad stakeholder expectations around digitalization impacts, as these impacts create financial risks and opportunities for the reporting organization.

OECD Guidelines for Multinational Enterprises on Responsible Business Conduct

The OECD Guidelines for Multinational Enterprises on Responsible Business Conduct are recommendations addressed by governments to multinational enterprises to enhance the business contribution to sustainable development and address adverse sustainability impacts associated with business activities.

The 2023 update to the OECD Guidelines brought about a significant change in the due diligence expectations regarding the use of technology. The updated guidelines now impose new due diligence expectations on the development, financing, sale, licensing, trade, and use of technology, including gathering and using data. Any enterprise engaged with digital technologies is thus expected to carry out risk-based due diligence with respect to actual and potential adverse impacts related to science, technology, and innovation. They must also ensure transparency around data access and sharing arrangements and adopt responsible data governance practices. The inclusivity here suggests that all organizations can be considered technology companies, as almost all entities in OECD countries leverage technology to some extent in their operations.

Furthermore, the OECD adopts a holistic and inclusive approach to capture the evolving nature of technologies. This would align with a topical approach to a digitalization standard from the perspective of GRI, as all reporting organizations would 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 using AI, the recommendation has informed various frameworks, guidelines, and principles since its release in 2019. This 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 also suggests a sector-agnostic approach that puts responsible business conduct expectations on not only the developers but also the users of AI systems. The principles focus on transparency and explainability regarding AI systems, as well as safe AI use and ensuring accountability, which implies more expectations for disclosure. These could include:

- **Transparency and explainability:** AI actors may be required to disclose more information about how their AI systems function and the degree of autonomy the system operates under.
- **Changes during the AI system lifecycle:** AI actors may need to inform stakeholders about potential risks and changes arising from regular maintenance, data collection, testing, deployment, and decommissioning throughout an AI system's lifecycle.
- **Safety and risk management:** AI actors may expect to disclose the safety measures and protocols in place, especially in cases where AI systems might cause harm or exhibit unexpected behavior. This might also involve disclosures related to the override mechanisms or the conditions under which an AI system can be decommissioned.
- **Transparency of data sources for AI training purposes:** AI actors may need to report on the data sources used for training AI systems. To determine intellectual property concerns, this would include whether the data was obtained from open-access materials, copyrighted content, or user-generated content. If training data includes content subject to intellectual property rights, AI actors would need to report whether proper licensing agreements are in place and ensure that the use of such data is lawful.
- **Intellectual property rights compliance:** AI actors may need to demonstrate compliance with intellectual property laws in their country of operation and disclose how they manage the use of copyrighted materials while training AI systems.
- **User consent:** AI actors may need to inform users of their products that the data users produce by interacting with services is used to train generative AI systems.

General Data Protection Regulation (GDPR)

The GDPR is a comprehensive data protection legislation developed by the European Union to protect user privacy and data online within the European Union. It sets requirements for organizations on how they collect, process, store, and share personal data, emphasizing principles such as lawfulness, fairness, transparency, data minimization, and accountability [24]. GDPR has been a global benchmark for digital privacy and data protection as it 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 by any organization that engages with online users. These expectations include but are not limited to:

- **Requirements relating to the processing of personal data:** data must be processed lawfully, fairly, and transparently, including the informed consent of data subjects (users).
- **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.
- **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.
- **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.
- **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.
- **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.
- **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 first international regulatory attempt on AI, the EU AI Act, was approved by the European Parliament in March 2024 [23]. The major contribution of this document is that it is the first of its kind as a legal framework on AI, which sets requirements and obligations regarding AI use for both AI developers and deployers. It also establishes a risk-level typology for AI systems and sets expectations on the type of AI system used based on the risks it poses:

- **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.
- **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.
- **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.
- **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 concludes that digitalization's impacts on the environment and the economy are conditional. Intervening factors could play a role in determining the impact of digitalization in achieving sustainable development. A widespread agreement has been established, at least from the perspective of governments and international organizations, that digital transformation has the potential to bring about substantial change and advance sustainable development. However, this promise, at least from an environmental sustainability perspective, has yet to bring any tangible break from existing, resource-intensive ways of production and consumption. On the contrary, available evidence suggests a negative trend, with substantial increases in e-waste, energy, and water use by data centers already pushing major tech companies away from their emissions reduction commitments, underlining the importance of reporting on impacts around digital transformation.

Nevertheless, nearly all organizations have either already fully transformed digitally or are in the process of defining the depth of digital change they want to undertake. This will create ripple effects across the economy and the environment, as the reliance on the physical infrastructure of digital technologies will markedly increase over the next few years, exacerbating the negative impacts of data center maintenance. GRI will likely need to confront growing challenges in sustainability development brought about by the ever-expanding digital world.

While impacts on the economy and the environment can be captured in the existing GRI framework, more reporting guidance on relevant Topic Standards could connect digitalization impacts to wider sustainability impacts. The relevant Topic Standards address emissions, energy, water, waste, labor, and economic impacts. Regarding the other unique impacts of digital technologies, such as AI development and use, algorithmic decision-making, data privacy, and security, a substantial reporting gap is observed, enough to warrant a revision of the relevant Topic Standards.

It is also found that AI systems are being adopted and new AI-based services are rapidly emerging. This is followed by considerations for the broader uptake of AI systems on the rule of law and various potential infringements on human rights through algorithmic bias and discrimination. With algorithmic data processing capabilities rapidly increasing, setting reporting expectations around AI use aligned with emerging international standards and guidelines remains paramount. With generative AI capturing attention and investment, the risk of market concentration by big technology firms, as well as various implications on information ecosystems, also needs to be considered.

Globally, a rapidly evolving regulatory landscape is shaping the future of digital transformation, with efforts across various jurisdictions aimed at influencing its direction. It is evident that not only GRI but also other internationally recognized sustainability reporting frameworks are lagging in setting reporting expectations around the adoption of digital technologies and the implications this transition brings. GRI could leverage this gap by setting clear reporting expectations around digitalization impacts. GRI's global outlook also enables it to address digital technologies' disconnected and dispersed nature.

This paper establishes some research gaps, for instance, regarding sectoral differences in digitalization impacts, reporting activities of technology firms, and reporting in sectors with a larger adoption rate of digital technologies. The first gap arises from scoping. The adopted scope enabled a sector-agnostic approach but prevented a thorough exploration of the sectoral implications of digitalization. The second gap regarding research on reporting activities around digitalization can be pursued based on feedback from the GSSB and emerging research needs.

The following section includes five actionable recommendations that the GSSB can consider. The proposed recommendations are not mutually exclusive and contain a range of actions that aim to address emerging reporting needs around digitalization impacts.

Recommendations

1) **Pursue a digitalization project –** In light of the assessment of GRI Standards and a review of the emerging regulatory and policy landscape on digitalization impacts, it is proposed that the GSSB consider pursuing a digitalization project to reflect the current Standards' reporting needs. Topic Standards identified as needing an update are *GRI 405 Diversity and Equal Opportunity, GRI 406: Non-discrimination, GRI 417 Marketing* and *Labeling, and GRI 418: Customer Privacy.* The project should consider revising these Standards to address aspects of digitalization that the current GRI framework omits, including data governance, cybersecurity, and AI adoption.
2) **Mainstream digitalization in other Topic Standards –** This would require integrating impacts that arise from adopting digital technologies not only from a data governance and cybersecurity perspective but also to allow for integrating environmental and economic impacts more clearly. For instance, the ongoing revision of the pollution-related GRI disclosures can consider the environmental impacts associated with maintaining the digital world, such as high reliance on water and energy to sustain data centers. Regarding ongoing projects such as labor and economic impacts, the respective working groups can consider the relevant categories of impacts identified in this paper. Integrating impact considerations in new GRI Standards projects would help SMEs and non-tech organizations using digital technologies to address digitalization impacts during their materiality assessments.
3) **Consider sector-specific impacts –** Following up on our current research on the broader impacts of digitalization, sector-specific research is proposed for consideration, as each sector has unique characteristics, capacities, and opportunities that influence how digitalization unfolds. Digitalization can have different impacts on sectors depending on their level of technological adoption, regulatory environment, and market dynamics. Also, sectoral differences can mediate where impacts occur along the digitalization value chain. For instance, in manufacturing, digitalization might focus on automation and the IoT, while in finance, it might center on blockchain, big data analytics, AI-driven analytics, and customer services. Sector-specific research helps identify these unique factors that would inform decision-making. Conducting sector-specific research on the tech industry is also important, as it is the digital service provider to the economy. Additionally, most environmental impacts arise within the tech sector, particularly through the maintenance of digital infrastructure.
4) **Produce other documents –** Producing documents or resources such as reporting guidance, publishing research papers, discussion notes, and training material could also help non-tech or smaller organizations better understand the implications of their choices in adopting digital technologies.
5) **Monitor the evolving policy landscape –** In light of the rapidly evolving regulatory, policy, and reporting landscape around digitalization, continued monitoring of this landscape should be considered. Staying informed about regulatory developments is crucial for GRI's strategic positioning and adaptation in the face of policy shifts. This could be done by collaborating with GRI's policy, Standards, and research functions.

Bibliography

1. D. Acemoglu, ‘The Simple Macroeconomics of AI’, *National Bureau of Economic Research*, vol. Working Paper, 2024, [Online]. Available: https://www.nber.org/system/files/working_papers/w32487/w32487.pdf
2. D. Acemoglu and P. Restrepo, ‘Automation and New Tasks: How Technology Displaces and Reinstates Labor’, *Journal of Economic Perspectives*, vol. 33, no. 2, pp. 3–30, 2019, doi: 10.1257/jep.33.2.3.
3. M. S. Al-Hwaiti, H. Brumsack, and B. Schnetger, ‘Heavy metal contamination and health risk assessment in waste mine water dewatering using phosphate beneficiation processes in Jordan’, *Environmental Earth Sciences*, vol. 77, no. 661, 2018, [Online]. Available: https://www.researchgate.net/publication/328006318_
4. I. Andersen, ‘With new pact, tech companies take on climate change’, *United Nations Environmental Programme*, 2021. [Online]. Available: https://www.unep.org/news-and-stories/story/new-pact-tech-companies-take-climate-change
5. C. Bakker, F. Wang, J. Huisman, and M. Hollander, ‘Products that go round: exploring product life extension through design.’, *Journal of Cleaner Production*, vol. 69, pp. 10–16, 2014, doi: 10.1016/j.jclepro.2014.01.028.
6. E. Barteková and P. Börkey, ‘Digitalisation for the transition to a resource efficient and circular economy’, OECD, Paris, OECD Environment Working Papers 192, 2022. doi: 10.1787/6f6d18e7-en.
7. Basel Committee on Banking Supervision, ‘Digitalisation of finance’, Bank for International Settlements, 2024. [Online]. Available: https://www.bis.org/bcbs/publ/d575.pdf
8. Baxtel, ‘Amazon IAD-55’. [Online]. Available: https://baxtel.com/data-center/amazon-iad-55
9. D. Benton, E. Coats, and J. Hazell, ‘A Circular Economy for Smart Devices’, Green Alliance, 2015. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S266678432400007X#bib15
10. E. Bonsón and M. Bednárová, ‘Artificial Intelligence Disclosures in Sustainability Reports: Towards an Artificial Intelligence Reporting Framework’, *Conference paper*, 2022, [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-030-94617-3_27
11. E. Bonsón, M. Bednárová, and D. Perea, ‘Disclosures about algorithmic decision making in the corporate reports of Western European companies’, *International Journal of Accounting Information Systems*, vol. 48, p. 100596, 2023, doi: 10.1016/j.accinf.2022.100596.
12. H. Brugger, W. Eichhammer, and E. Donitz, ‘Study on Energy Savings Scenarios 2050’, Fraunhofer Institute for Systems and Innovation Research ISI, 2019. [Online]. Available: https://www.isi.fraunhofer.de/en/competence-center/energiepolitik-energiemaerkte/projekte/energy-saving-scenarios-2050.html

13. E. Brynjolfsson and A. McAfee, *The Second Machine Age: Work, Progress, and Prosperity In A Time Of Brilliant Technologies*. Norton & Company, 2014.

14. C. Cadwalladr and E. Harrison-Graham, 'Revealed: 50 million Facebook profiles harvested for Cambridge Analytica in major data breach', *The Guardian*, 2018. [Online]. Available: https://www.theguardian.com/news/2018/mar/17/cambridge-analytica-facebook-influence-us-election

15. V. Court and S. Sorrell, 'Digitalisation of goods: a systematic review of the determinants and magnitude of the impacts on energy consumption', *Environmental Research Letters*, 2020, [Online]. Available: https://doi.org/10.1088/1748-9326/ab6788

16. A. Di Salvo, F. Agostinho, C. Almeida, and B. Giannetti, 'Can cloud computing be labeled as "green"? Insights under an environmental accounting perspective', *Renewable and Sustainabile Energy Reviews*, vol. 69, pp. 514–526, 2017.

17. Digital Realty, 'Digital Realty'. [Online]. Available: https://www.digitalrealty.com/data-centers/americas/northern-virginia/iad39

18. A. Duval, V. Rouas, and M. Ebdon, 'The Potential of Big Data Technologies for the Human Rights and Environmental Due Diligence Process', University of Amsterdam, 2023. [Online]. Available: https://pure.uva.nl/ws/files/126090183/giz2023_0121en_big_data_technologies_hredd_process.pdf

19. J. Eager, M. Whittle, J. Smit, G. Cacciaguerra, and E. Lale-Demoz, 'Opportunities of Artificial Intelligence', 2020, [Online]. Available: https://www.europarl.europa.eu/RegData/etudes/STUD/2020/652713/IPOL_STU(2020)652713_EN.pdf

20. T. Eloundou, S. Manning, P. Mishkin, and D. Rock, 'GPTs are GPTs: An Early Look at the Labor Market Impact Potential of Large Language Models (working paper)', 2023. [Online]. Available: https://arxiv.org/pdf/2303.10130

21. V. Eubanks, *Automating Inequality: How High-Tech Tools Profile, Police, and Punish the Poor.* St. Martin's Press, 2018.

22. European Commission, '*EU Digital Strategy*'. 2024. [Online]. Available: https://eufordigital.eu/discover-eu/eu-digital-strategy/

23. European Parliament, '*EU AI Act: first regulation on artificial intelligence*'. 2024. [Online]. Available: https://www.europarl.europa.eu/topics/en/article/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence

24. European Union, '*Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)*'. [Online]. Available: https://op.europa.eu/en/publication-detail/-/publication/3e485e15-11bd-11e6-ba9a-01aa75ed71a1/language-en

25. Federal Trade Commission, ‘Equifax Data Breach Settlement’. [Online]. Available: https://www.ftc.gov/enforcement/refunds/equifax-data-breach-settlement

26. G. Fraser, ‘CrowdStrike: Company to face questions over global IT outage’, *BBC*, London, 2024. [Online]. Available: https://www.bbc.com/news/articles/cr54m92ermgo

27. German Advisory Council on Global Change, *Towards Our Common Digital Future. Flagship Report.* Berlin, 2019. [Online]. Available: https://www.wbgu.de/fileadmin/user_upload/wbgu/publikationen/hauptgutachten/hg2019/pdf/wbgu_hg2019_en.pdf

28. Goldman Sachs, ‘Generative AI could raise global GDP by 7%’, Goldman Sachs. 2023. [Online]. Available: https://www.goldmansachs.com/intelligence/pages/generative-ai-could-raise-global-gdp-by-7-percent.html

29. L. Gordon, ‘AI Is Accelerating the Loss of Our Scarcest Natural Resource: Water’, *Forbes*, Mar. 07, 2024. [Online]. Available: https://www.forbes.com/sites/cindygordon/2024/02/25/ai-is-accelerating-the-loss-of-our-scarcest-natural-resource-water/

30. D. Gritsenko, J. Aaen, and B. Flyvbjerg, ‘Rethinking digitalization and climate: don’t predict, mitigate’, *npj climate action*, 2024. [Online]. Available: https://www.nature.com/articles/s44168-024-00127-z

31. M. Grobelnik, K. Perset, and S. Russel, ‘What is AI? Can you make a clear distinction between AI and non-AI systems?’, OECD, 2024. [Online]. Available: https://oecd.ai/en/wonk/definition

32. M. Heikkiläa, ‘How to opt out of Meta’s AI training’, *MIT Technology Review*, Jun. 14, 2024. [Online]. Available: https://www.technologyreview.com/2024/06/14/1093789/how-to-opt-out-of-meta-ai-training/

33. M. T. Hicks, J. Humphries, and J. Slater, ‘ChatGPT is bullshit’, *Ethics and Information Technology*, vol. 8, no. 26, 2024. [Online]. Available: https://link.springer.com/article/10.1007/s10676-024-09775-5

34. M. Hogan, ‘Data Flows and Water Woes: The Utah Data Center’, *Big Data & Society*, 2015, [Online]. Available: https://doi.org/10.1177%2F2053951715592429

35. International Energy Agency, ‘Digitalization and Energy’, 2017, [Online]. Available: https://iea.blob.core.windows.net/assets/b1e6600c-4e40-4d9c-809d-1d1724c763d5/DigitalizationandEnergy3.pdf

36. International Energy Agency, ‘Data Centres and Data Transmission Networks’. [Online]. Available: https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks

37. International Energy Agency, ‘Electricity 2024 - Analysis and forecast to 2026’, International Energy Agency, 2024. [Online]. Available: https://iea.blob.core.windows.net/assets/6b2fd954-2017-408e-bf08-952fdd62118a/Electricity2024-Analysisandforecastto2026.pdf

38. International Finance Corporation, ‘Water, Mining and Communities: Creating Shared Value through Sustainable Water Management’, 2014. [Online]. Available: www.commdev.org.

39. J. Kesan, C. Hayes, and M. Bashir, 'A comprehensive empirical study of data privacy, security, and ownership issues in cloud computing', *Indiana Law Journal*, vol. 91, no. 2, 2016, [Online]. Available: https://web.archive.org/web/20170702070848id_/http://www.repository.law.indiana.edu/cgi/viewcontent.cgi?article=11194&context=ilj

40. T. Kneese and M. Young, 'Carbon Emissions in the Tailpipe of Generative AI', *Harvard Data Science Review*, 2024, [Online]. Available: https://doi.org/10.1162/99608f92.fbdf6128

41. M. Latonero, 'Big Data Analytics and Human Rights', in *New Technologies for Human Rights Law and Practice*, Cambridge University Press, 2018, pp. 149-161. [Online]. Available: https://www.cambridge.org/core/books/new-technologies-for-human-rights-law-and-practice/big-data-analytics-and-human-rights/AEFCC6D0B090A725742698E968E39431

42. R. Liu, P. Gailhofer, C.-O. Gensch, A. Kohler, and F. Wolff, 'Impacts of the digital transformation on the environment and sustainability', Institute for Applied Ecology, Berlin, Dec. 2019. [Online]. Available: https://www.researchgate.net/profile/Franziska-Wolff-2/publication/342039732_Impacts_of_the_digital_transformation_on_the_environment_and_sustainability/links/602819c7299bf1cc26c4154a/Impacts-of-the-digital-transformation-on-the-environment-and-sustainability.pdf

43. L. Lovdahl Gormsen and J. T. Llanos, 'Facebook's Anticompetitive Lean in Strategies', *SSRN Journal*, 2019, doi: 10.2139/ssrn.3400204.

44. A. S. Luccioni, E. Strubell, and Y. Jernite, 'Power Hungry Processing: Watts Driving the Cost of AI Deployment?', *ACM FAccT*, 2024. [Online]. Available: https://arxiv.org/pdf/2311.16863

45. J. Manyika, S. Lund, M. Chui, B. Jacques, and L. Woetzel, 'Jobs lost, jobs gained: What the future of work will mean for jobs, skills, and wages', McKinsey Global Institute, 2017. [Online]. Available: https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages

46. Microsoft Corporation, 'Accelerating a Carbon-Free Future - Microsoft Policy Brief on advanced nuclear and fusion energy', 2023. [Online]. Available: https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RW1fApf

47. S. G. Monserrate, 'The Cloud Is Material: On the Environmental Impacts of Computation and Data Storage', *MIT Case Studies in Social and Ethical Responsibilities of Computing*, 2022, [Online]. Available: https://mit-serc.pubpub.org/pub/the-cloud-is-material/release/2

48. T. Moreau, R. Sinatra, and V. Sekara, 'Failing Our Youngest: On the Biases, Pitfalls, and Risks in a Decision Support Algorithm Used for Child Protection', *The 2024 ACM Conference on Fairness, Accountability, and Transparency*, 2024, [Online]. Available: https://dl.acm.org/doi/pdf/10.1145/3630106.3658906

49. S. Moss, 'In search of the world's largest data center', *DataCenterDynamics*, 2022. [Online]. Available: https://www.datacenterdynamics.com/en/analysis/in-search-of-the-worlds-largest-data-center/

50. National Conference of State Legislatures, 'Approaches to Regulating Artificial Intelligence: A Primer', 2023. [Online]. Available: https://www.ncsl.org/technology-and-communication/approaches-to-regulating-artificial-intelligence-a-primer

51. M. Nill, N. Jungmichel, C. Schampel, and D. Weiss, 'Atlas on Environmental Impacts - Supply Chains – Environmental Impacts and Hot Spots in the Supply Chain', 2017. [Online]. Available: https://adelphi.de/en/publications/atlas-on-environmental-impacts-supply-chains

52. Organization for Economic Cooperation and Development (OECD), 'Digitalisation and productivity: a story of complementarities', OECD, Paris, 2019. [Online]. Available: https://www.oecd-ilibrary.org/economics/oecd-economic-outlook-volume-2019-issue-1_5713bd7d-en

53. Organization for Economic Cooperation and Development (OECD), 'OECD Going Digital: Shaping Policies, Improving Lives'. OECD, Paris, 2019. [Online]. Available: https://oecd-ilibrary.org/sites/9789264312012-n/1/2/7/index.html?itemId=/content/publication/9789264312012-en&_csp_=311fc743132502e5a98ac461d9bcb3d8&itemIGO=oecd&itemContentType=book#chap

54. Organization for Economic Cooperation and Development (OECD), *Recommendation of the Council on Artificial Intelligence*. 2019. [Online]. Available: https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0449

55. Organization for Economic Cooperation and Development, '*Explanatory memorandum on the updated OECD definition of an AI system*', OECD, Paris, 2024. [Online]. Available: https://www.oecd.org/en/publications/explanatory-memorandum-on-the-updated-oecd-definition-of-an-ai-system_623da898-en.html

56. G. Parker, G. Petropoulos, and M. V. Alstyne, 'Digital platforms and antitrust', *Bruegel*, 2020. [Online]. Available: https://www.bruegel.org/working-paper/digital-platforms-and-antitrust

57. A. Pauline, 'Digitalisation and Responsible Business Conduct'. *Organization for Economic Cooperation and Development (OECD),* Paris, 2019. [Online]. Available: https://mneguidelines.oecd.org/rbc-and-digitalisation.htm

58. SASB, *SASB Software and IT standard*, 2023.

59. P. Seele and I. Lock, 'The game-changing potential of digitalization for sustainability: possibilities, perils, and pathways', *Sustain Sci*, vol. 12, no. 2, pp. 183–185, 2017, doi: 10.1007/s11625-017-0426-4.

60. D. Shepardson and M. Scarcella, 'Google has an illegal monopoly on search, US judge finds', *Reuters*, 2024. [Online]. Available: https://www.reuters.com/legal/us-judge-rules-google-broke-antitrust-law-search-case-2024-08-05/

61. J. Shuja, 'Sustainable Cloud Data Centers: A Survey of Enabling Techniques and Technologies', *Renewable and Sustainable Energy Reviews*, vol. 62, pp. 195–214, 2016. doi: 10.1016/j.rser.2016.04.034.

62. U. Sivarajah, M. M. Kamal, Z. Irani, and V. Weerakkody, 'Critical analysis of Big Data challenges and analytical methods', *Journal of Business Research*, vol. 70, pp. 263–286, 2017. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S014829631630488X

63. O. Solon, 'Drought-Stricken Communities Push Back against Data Centers', *NBC*, 2021. [Online]. Available: https://www.nbcnews.com/tech/internet/drought-stricken-communities-push-back-against-data-centers-n1271344

64. Submarine Cable Map Project, 'Submarine Cable Map'. [Online]. Available: https://www.submarinecablemap.com/

65. The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems., 'Ethically Aligned Design: A Vision for Prioritizing Human Well-being with Autonomous and Intelligent Systems', 2019. [Online]. Available: https://standards.ieee.org/content/ieee-standards/en/industry-connections/ec/autonomous-systems.html

66. The State Council of The People's Republic of China, 'China unveils plan to promote digital development'. Accessed: 2024. [Online]. Available: https://english.www.gov.cn/policies/latestreleases/202302/28/content_WS63fd33a8c6d0a757729e752c.html

67. United Nations Environment Programme (UNEP), 'Sustainable Digitalization'. 2024 [Online]. Available: https://www.unep.org/topics/digital-transformations/sustainable-digitalization

68. United Nations High Commissioner for Human Rights (OHCHR), 'The right to privacy in the digital age Report of the United Nations High Commissioner for Human Rights', United Nations, 2021. [Online]. Available: https://documents.un.org/doc/undoc/gen/g21/249/21/pdf/g2124921.pdf?token=SByiggBI28u4ZxnQYk&fe=true

69. United Nations Institute for Training and Research, 'Global E-Waste Monitor 2024: Electronic Waste Rising Five Times Faster Than Documented E-Waste Recycling', 2024. [Online]. Available: https://www.unitar.org/about/news-stories/press/global-e-waste-monitor-2024-electronic-waste-rising-five-times-faster-documented-e-waste-recycling#:~:text=A%20record%2062%20million%20tonnes,met%20by%20e%2Dwaste%20recycling.

70. United States Department of Energy, 'Energy-Efficient Cooling Control Systems for Data Centers'. [Online]. Available: https://www.energy.gov/eere/iedo/energy-efficient-cooling-control-systems-data-centers#:~:text=The%20electricity%20consumed%20in%20these,increased%20demand%20for%20CRAC%20cooling

71. P. Valkokari, N. Tura, M. Stahle, J. Hanski, and T. Ahola, 'From Data to Wisdom: Approaches enabling circular economy', Tampere University, Finland, 2019. [Online]. Available: https://trepo.tuni.fi/bitstream/handle/10024/128511/Advancing_circular_business.pdf?sequence

72. P. Verhoef *et al.*, 'Digital transformation: A multidisciplinary reflection and research agenda', *Journal of Business Research*, vol. 122, pp. 889–901, 2021. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0148296319305478

73. World Bank, ‘Individuals using the Internet (% of population)’. 2022. [Online]. Available: https://data.worldbank.org/indicator/IT.NET.USER.ZS

74. World Data Center Project, ‘Data Center Map’. [Online]. Available: https://www.datacentermap.com/usa/virginia/

75. World Economic Forum, ‘Future of Jobs Report - 2023’, World Economic Forum, 2023. [Online]. Available: https://www.weforum.org/publications/the-future-of-jobs-report-2023/

76. World Economic Forum, ‘Accelerating Digital Transformation for Long Term Growth’. 2024 [Online]. Available: https://initiatives.weforum.org/digital-transformation/home