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Digital Inequality and Sustainable Development

Nierówności cyfrowe i rozwój zrównoważony

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Abstract
Digital inequality represents a critical challenge in the pursuit of sustainable development, as disparities in access to and proficiency with digital technologies hinder equitable growth, social inclusion, and environmental sustainability. This article examines the multifaceted relationship between digital inequality and sustainable development, highlighting how unequal access to information and communication technologies (ICTs) impacts economic opportunities, educational outcomes, healthcare access, and environmental protection. It underscores that digital disparities often mirror and exacerbate existing socio-economic inequalities, particularly affecting marginalized groups based on income, education, age, and geography. The analysis demonstrates that addressing digital inequalities is essential for unlocking the full potential of digital technologies to contribute to pillars of sustainability and Sustainable development goals.

Key words: digital inequality, sustainable development, digital inclusion, environmental sustainability

Streszczenie
Nierówności cyfrowe stanowią krytyczne wyzwanie w dążeniu do zrównoważonego rozwoju, ponieważ dysproporcje w dostępie do technologii cyfrowych i biegłości w ich używaniu utrudniają sprawiedliwy wzrost, inkluzję społeczną i zrównoważony rozwój środowiskowy. W tym artykule zbadano wieloaspektowy związek między nierównościami cyfrowymi a zrównoważonym rozwojem, podkreślając, w jaki sposób nierówny dostęp do technologii informacyjno-komunikacyjnych (ICT) wpływa na możliwości ekonomiczne, wyniki edukacyjne, dostęp do opieki zdrowotnej i ochronę środowiska. Podkreśla się, że nierówności cyfrowe często odzwierciedlają i pogłębiają istniejące nierówności społeczno-ekonomiczne, w szczególności dotykając zmarginalizowane grupy ze względu na dochód, wykształcenie, wiek i lokalizację geograficzną. Analiza pokazuje, że zajęcie się nierównościami cyfrowymi jest niezbędne do uwolnienia pełnego potencjału technologii cyfrowych w celu przyczynienia się do osiągnięcia Celów zrównoważonego rozwoju.

Słowa kluczowe: nierówności cyfrowe, rozwój zrównoważony, inkluzja cyfrowa, równowaga środowiskowa

Introduction

In today's interconnected world, digital technologies play a crucial role in driving progress and innovation. However, the benefits of these technologies are not universally accessible, leading to significant digital inequalities. These disparities manifest in varying levels of access to and proficiency with information and communication technologies (ICTs), impacting individuals' ability to participate fully in the digital economy and society.
Digital inequality poses a significant barrier to sustainable development, as it exacerbates existing socio-economic disparities and hinders efforts to achieve equitable growth and social inclusion. The divide is often most pronounced along lines of income, education, age, and geography, where marginalized groups have limited access to digital resources and skills. This lack of access restricts their opportunities for education, employment, and civic engagement, creating a cycle of disadvantage that undermines the pillars of sustainable development.

The relationship between digital inequalities and sustainable development is complex and multifaceted, influencing various domains such as economic growth, education, health, and environmental sustainability. For instance, limited digital access can impede economic opportunities and innovation, while in education, it can result in unequal learning outcomes and restrict access to information and resources. Similarly, in healthcare, digital disparities can hinder access to vital services and information, affecting public health outcomes. Moreover, the inability to leverage digital tools for environmental monitoring and protection can impact efforts toward sustainability and climate resilience.

Addressing digital inequalities is therefore critical to ensuring that technological advancements contribute to a more inclusive and sustainable future. This article explores the intersection of digital inequality and sustainable development, examining how disparities in digital access and skills impact various dimensions of sustainable development and highlighting the need for targeted policies and interventions to bridge the digital divide.

Definitions and categories of digital inequality

Digital inequality is a multifaceted concept that has evolved alongside advancements in technology and has been interpreted in various ways across academic literature. At its core, digital inequality refers to the disparities that exist between individuals, households, businesses, and geographic areas at different socio-economic levels regarding their opportunities to access information and communication technologies (ICTs) and their use of the Internet for various activities.

Initially, digital inequality was primarily associated with physical access to technology, often referred to as the *digital divide*. This divide highlighted the gaps in access to computers and the Internet between different regions and demographic groups (Norris, 2001). Access was typically measured by ownership of digital devices and connectivity to broadband Internet services. This perspective dominated early studies, which focused on the infrastructural and economic barriers preventing equitable technology access. As technology became more ubiquitous, the notion of access evolved to include not just the availability of devices and Internet connectivity but also the quality and affordability of these resources. Researchers began to recognize that mere access to technology did not guarantee effective use or meaningful engagement, leading to the introduction of the concept of the *second-level digital divide*.

The second-level digital divide refers to disparities in digital literacy and skills among different groups. This dimension of digital inequality examines how individuals use digital technologies and whether they possess the necessary skills to benefit fully from them (Hargittai, 2002). Studies in this area emphasize the importance of digital skills training and education as crucial components of bridging digital inequalities. Differences in skills can affect individuals' ability to seek information, engage in online transactions, and participate in digital communication, impacting their overall quality of life and opportunities.

More recently, scholars have explored the *third-level digital divide*, which considers the varying outcomes of technology use among different groups. This perspective focuses on how individuals and communities derive benefits from their digital engagements, examining the socio-economic impacts of digital inclusion (Van Deursen & Helsper, 2015). For instance, access to digital technology can lead to improved educational outcomes, better job prospects, and increased civic participation. However, if certain groups are unable to leverage these technologies effectively, digital inequality can exacerbate existing socio-economic disparities.

The concept of digital inequality emerged in the late 20th century, coinciding with the rapid expansion of the Internet and personal computing technologies. Initially, the focus was on infrastructural barriers – how geography, income, and education influenced the ability to access computers and the Internet. Policymakers and researchers aimed to address these disparities by increasing access to technology in underserved communities through public initiatives such as community technology centers and subsidized Internet access programs (Servon, 2002).

As access to technology improved in many parts of the world, the focus of digital inequality research shifted to include issues of digital literacy and competency. Researchers recognized that having access to digital technology did not necessarily equate to the ability to use it effectively (DiMaggio & Hargittai, 2001). This realization led to increased emphasis on education and skills training as necessary components of digital inclusion strategies. During this period, the concept of digital inequality began to encompass a broader range of factors, including cognitive and cultural barriers to effective technology use. Studies highlighted the role of social support networks, cultural capital, and personal motivation in shaping digital skills and engagement levels (Robinson et al., 2015).

In recent years, the discourse on digital inequality has further expanded to consider the quality and outcomes of technology use. Researchers have investigated how different groups benefit from digital technologies, considering factors such as online participation, content creation, and the development of digital identities (Ragnedda & Muschert, 2013). This shift reflects a growing awareness of the complex ways in which technology intersects with social, economic, and political structures. Additionally, the rise of big data, artificial intelligence, and platform-based economies has introduced new dimensions of digital inequality. Issues such as data privacy, algorithmic bias, and digital labor exploitation have emerged as critical areas of concern (Eubanks, 2018). These developments

highlight the need for a nuanced understanding of digital inequality that accounts for both traditional access issues and new forms of digital exclusion.

Digital inequality is a pressing issue that encompasses various dimensions of access to technology. At the heart of this issue is the digital divide, which highlights the disparity between individuals who have access to digital technologies and those who do not. This divide is not merely about having physical access to technology but also encompasses the quality of access, digital literacy, and the ability to effectively use these technologies.

Internet access is a crucial factor in determining an individual's ability to participate in the digital world. Studies have consistently shown that internet access is unevenly distributed across different socioeconomic groups. For instance, individuals from higher-income households are more likely to have consistent and high-speed internet access compared to those from lower-income households. This disparity impacts their ability to access educational resources, employment opportunities, and other digital services. Furthermore, education levels significantly influence internet usage, with individuals possessing higher educational qualifications more likely to engage in digital activities.

In addition to internet access, ownership of digital devices such as smartphones, tablets, and computers is essential in understanding digital inequality. Research indicates that device ownership is strongly correlated with socioeconomic status, age, and education. While smartphones have become more prevalent and offer internet access to a broader population, the quality and type of device can still create disparities in how individuals engage with digital content. The type of device owned significantly influences the quality of internet access, as smartphones may not offer the same functionality for complex tasks as computers or tablets do. This distinction affects the kind of activities users can perform online, such as job searching or completing educational coursework.

Geographical and demographic differences further exacerbate digital inequality. Urban areas typically benefit from better infrastructure, allowing for faster and more reliable internet connections. Conversely, rural areas often face challenges such as limited infrastructure and higher service costs, restricting internet access and device availability. These geographical disparities are evident not only in developing countries but also in developed nations. For example, in the United States, noticeable differences exist in internet access between urban and rural areas, with rural residents often having fewer options for high-speed internet.

Demographic factors such as age, education, and income level also significantly influence access to technology. Older adults generally exhibit lower levels of internet use and digital literacy compared to younger individuals, due to factors like lack of digital education, financial constraints, and lower perceived utility of internet use. Similarly, individuals with higher educational attainment are more likely to use digital technologies and possess the necessary skills to leverage these technologies effectively. Income disparities further exacerbate digital inequalities, as lower-income individuals often face financial barriers to acquiring and maintaining digital devices and internet subscriptions.

Digital inequality is a complex and multifaceted issue that involves a range of factors including geographical location, socioeconomic status, age, and education. Addressing these disparities requires comprehensive policies focused on improving infrastructure in underserved areas, enhancing digital literacy across all age groups, and ensuring affordable access to technology for low-income households. As digital technologies continue to evolve, ongoing research and policy interventions will be essential to bridging the digital divide and fostering an inclusive digital environment.

In today's rapidly evolving digital landscape, possessing digital skills is crucial for active participation in both the information society and the digital economy. However, significant disparities exist in digital competence levels across various social groups, exacerbating existing social and economic inequalities. These differences are primarily influenced by factors such as age, education level, income, and geographical location.

One of the most pronounced disparities is found between age groups. Research indicates that older adults generally have lower levels of digital skills compared to younger individuals. This disparity arises from a lifetime of reduced exposure to new technologies and limited opportunities for digital education (Hill et al., 2008). As a result, older individuals often struggle to adapt to rapid technological changes, which impacts their ability to effectively utilize online services and other digital resources (Friemel, 2016). This gap in digital skills can lead to a sense of disempowerment and exclusion from the digital society, further isolating older adults from social and economic opportunities.

Education plays a critical role in shaping digital competence. Individuals with higher education levels typically possess better digital skills due to greater access to educational resources and training opportunities (Helsper & Eynon, 2010). Education not only provides technical knowledge but also fosters critical thinking skills essential for navigating the dynamic digital environment (van Laar et al., 2020). Consequently, those with advanced education are better equipped to leverage digital technologies for economic and social advancement.

The influence of income on digital skills is another significant factor contributing to disparities. Higher-income individuals often have greater access to advanced technologies and training opportunities, enabling them to develop and update their digital skills (Robinson et al., 2015). Conversely, those in lower-income brackets frequently face financial barriers that limit their access to digital devices and educational opportunities, resulting in digital

marginalization (Scheerder et al., 2017). This income-based digital divide not only perpetuates existing inequalities but also limits the economic mobility of disadvantaged groups.

Addressing these disparities requires targeted interventions in education and training. Formal education systems are increasingly integrating information and communication technology (ICT) education into their curricula, preparing students for life in a digital society. By introducing technology in schools and higher education institutions, we can foster digital skills development from a young age, thereby enhancing adaptability in the job market (Passey et al., 2018).

Professional training and continuing education courses are essential for workers to keep pace with technological changes. Organizations that invest in developing their employees' skills can boost productivity and mitigate workplace digital inequalities. E-learning platforms and online courses offer flexible learning opportunities accessible to a wide audience, thus democratizing access to digital skills (Büchi et al., 2016).

Social initiatives and government programs promoting digital education play a vital role in leveling the playing field for groups at risk of digital exclusion. These projects, often targeting older adults, the unemployed, and ethnic minorities, provide access to technology and digital skills courses, enabling these groups to participate more fully in social and economic life (van Dijk & Hacker, 2018). By addressing the digital divide through such initiatives, society can promote a more inclusive digital economy where all individuals have the opportunity to thrive.

Digital technologies have become integral to modern society, influencing various aspects of daily life, work, and education. However, the way different social groups engage with these technologies varies significantly, reflecting disparities in access, skills, and utilization. Understanding these differences is crucial for addressing digital inequality and ensuring that all groups can benefit from technological advancements.

Socioeconomic status plays a crucial role in determining how individuals and groups use digital technologies. Higher-income individuals often have more access to advanced technologies, allowing them to use a broader range of digital services. These individuals are more likely to engage in complex online activities such as e-banking, online shopping, and accessing high-quality digital content (van Deursen & van Dijk, 2014). In contrast, lower-income groups may primarily use digital technologies for basic communication and entertainment, reflecting a narrower scope of digital engagement due to financial constraints and limited access to resources (Robinson et al., 2015).

Age is another significant factor influencing technology use. Younger generations, often referred to as digital natives, tend to adopt new technologies more rapidly and integrate them more seamlessly into their daily lives. They use digital tools for social networking, entertainment, and learning, demonstrating a high level of comfort with various digital platforms (Correa, 2016). This generational divide highlights the challenges older adults face in using digital technologies due to a lack of familiarity and confidence, often limiting their engagement to basic functions such as email and web browsing (Hunsaker & Hargittai, 2018).

Cultural and educational backgrounds also shape technology use. Individuals with higher educational attainment are generally more adept at utilizing digital technologies for diverse purposes, including professional development and lifelong learning. They are more likely to engage in information-seeking behaviors and use technology as a tool for enhancing productivity and creativity (Zillien & Hargittai, 2009). Cultural values and norms can influence technology adoption and use, with some groups prioritizing specific applications that align with their social practices and community needs (Eynon & Geniets, 2016).

The integration of digital technologies into various domains has transformed how people live, work, and learn. In daily life, digital technologies have reshaped communication, entertainment, and personal management. Smartphones and social media platforms enable instant communication and information sharing, facilitating connections across geographical boundaries (Ling, 2012). Streaming services and digital media offer diverse entertainment options, while apps for personal finance, health monitoring, and home automation enhance convenience and efficiency in daily routines (Rainie & Wellman, 2012).

In the workplace, digital technologies have driven significant changes. Remote work and telecommuting have become increasingly common, enabled by high-speed internet and collaboration tools such as video conferencing and cloud-based applications (Allen et al., 2015). These technologies have increased workplace flexibility and allowed for more diverse work arrangements. Additionally, automation and artificial intelligence are transforming industries by improving efficiency and productivity, although they also raise concerns about job displacement and the need for new skill sets (Brynjolfsson & McAfee, 2014).

In education, digital technologies have opened up new avenues for teaching and learning. E-learning platforms and massive open online courses (MOOCs) provide access to educational resources worldwide, breaking down traditional barriers to education (Means et al., 2014). Technology-enhanced learning environments support personalized and interactive learning experiences, allowing students to learn at their own pace and explore subjects in depth (Collins & Halverson, 2018). However, disparities in access to digital tools and the internet remain challenges that need to be addressed to ensure equitable educational opportunities (Selwyn, 2016).

Economic dimension

Digital inequality, defined as the disparity in access to, use of, or impact of information and communication technologies (ICTs), has profound implications for sustainable economic development. The economic dimension of sustainable development emphasizes equitable growth and resource distribution to enhance productivity and improve living standards. Digital inequality can hinder this dimension by limiting access to economic opportunities, affecting productivity, and ultimately impacting overall economic growth. This exploration delves into how digital inequality influences productivity and economic development and examines the role of technological innovations in reducing economic disparities.

Digital technologies have become integral to modern economic activities, significantly influencing productivity by automating processes, improving communication, and facilitating innovation. However, digital inequality can lead to a productivity gap between individuals, businesses, and countries with differing access to technology. Unequal access to ICTs leads to variations in productivity levels, with regions having better access to high-speed internet and advanced ICT infrastructure experiencing higher productivity gains. For example, research indicates that broadband internet expansion has contributed significantly to GDP growth across OECD countries, highlighting the link between internet access and economic performance (Czernich et al., 2011).

In addition to infrastructure, digital inequality manifests as a skills gap. Individuals lacking digital skills are less likely to participate in high-productivity jobs, which increasingly require digital competencies. This skills gap can exacerbate economic inequalities, as those with digital skills often command higher wages and contribute more effectively to economic growth (Wei, 2017). The importance of digital skills is further underscored by their role in fostering innovation and entrepreneurship, as digital access provides the tools necessary for developing new products and services. Regions with high digital inequality often see lower rates of innovation, which can stifle economic growth, as observed in studies examining entrepreneurial activity and new business ventures (Faggio & Overman, 2014).

Digital inequality also affects broader economic aspects, such as economic inclusion. It can restrict access to online financial services, e-commerce, and remote work opportunities, reducing the economic potential of disadvantaged groups and reinforcing existing disparities (Hargittai, 2008). Additionally, the digital divide correlates with regional economic disparities, where urban areas with advanced digital infrastructure attract more investment and talent, while rural or underserved areas lag, creating an uneven economic landscape (Forman, Goldfarb, & Greenstein, 2012).

On a global scale, digital inequality affects a country's competitiveness. Nations with limited digital infrastructure and skills are less able to participate in the global digital economy, reducing their economic growth potential (Qiang et al., 2009). However, technological innovations play a crucial role in bridging the digital divide and reducing economic inequalities. Expanding internet access and improving ICT infrastructure are fundamental steps toward achieving this goal. Initiatives such as low-cost internet services and investment in broadband infrastructure can enhance access to digital technologies, particularly in underserved areas (Prieger, 2013).

To address the skills gap, educational programs aimed at increasing digital literacy are essential. Governments and organizations are increasingly recognizing the importance of digital skills training to empower individuals and improve their economic prospects. Programs that provide training in digital skills can help reduce unemployment and increase economic participation (Van Deursen et al., 2011). Supporting innovation and entrepreneurship through digital platforms can reduce economic inequalities. Digital technologies enable the creation of new business models and services that can reach broader markets, thus promoting economic growth. Policymakers can encourage this by providing incentives for startups and investing in digital innovation hubs (Nambisan et al., 2017).

Technological innovations also have the potential to promote inclusive growth by creating solutions tailored to the needs of disadvantaged communities. For instance, mobile banking and e-commerce platforms have provided financial services to unbanked populations, improving their economic inclusion and opportunities for growth (Demirguc-Kunt et al., 2018). Technological innovations also have the potential to significantly reduce economic inequalities, contributing to more inclusive economic growth. Across different regions, numerous initiatives have been implemented that leverage digital technologies to bridge economic disparities.

One such example is the adoption of mobile banking in Sub-Saharan Africa, particularly through the M-Pesa platform in Kenya. Launched by Safaricom in 2007, M-Pesa allows users to store and transfer money via mobile phones. This innovation has significantly increased financial inclusion by providing banking services to the unbanked population, thereby enhancing their economic opportunities (Jack & Suri, 2011). Access to mobile banking has not only improved household consumption, savings, and investments in small businesses, but has also contributed to poverty reduction and economic growth in the region (Suri & Jack, 2016).

Similarly, broadband expansion has been a critical factor in reducing economic inequalities. For instance, research has shown that the expansion of broadband infrastructure in Brazil has led to substantial improvements in local economic development, particularly in rural areas. Increased access to broadband has allowed for the growth of small businesses and improved access to education and healthcare services, thereby creating greater economic

opportunities for previously underserved populations (Gomez-Barroso et al., 2020). This underscores the crucial role of broadband infrastructure in driving economic growth and reducing regional disparities.
These examples demonstrate how technological innovations can effectively reduce economic disparities and promote inclusive growth. By expanding access to digital technologies and providing digital skills training, policymakers can help bridge the digital divide and ensure that all individuals have the opportunity to participate in and benefit from the digital economy.

Social dimension

Digital inequality, defined as the disparity in access to, use of, and impact from information and communication technologies (ICTs), significantly affects the social dimension of sustainable development, particularly in education. As education increasingly relies on digital technologies, disparities in access and digital skills can lead to unequal educational opportunities and outcomes. This section explores how digital inequality impacts access to education and the quality of education provided, drawing on examples from literature to highlight differences in educational outcomes.
Digital inequality profoundly influences access to education and the quality of learning experiences. In an era where digital tools and internet access are integral to education, those without access face significant disadvantages. Students in digitally under-resourced areas often lack access to online learning platforms, digital textbooks, and other educational resources that are commonplace in digitally equipped schools (Mossberger et al., 2003). This lack of access hinders their ability to participate in remote learning opportunities and extracurricular activities that enhance learning experiences.
The COVID-19 pandemic has exacerbated these disparities, highlighting the crucial role of technology in education. Schools worldwide shifted to online learning, making internet access and digital devices essential for continued education (Dorn et al., 2020). However, students from low-income families and rural areas were disproportionately affected due to limited access to necessary technology and connectivity. This digital divide has resulted in significant educational setbacks for disadvantaged students, widening existing achievement gaps (Van Dijk, 2020).
Digital inequality also affects the quality of education by limiting teachers' ability to incorporate digital tools into their teaching practices. Educators in under-resourced schools often lack the training and resources needed to effectively integrate technology into their curriculum, resulting in a teaching approach that may not fully leverage digital tools to enhance learning (Ertmer & Ottenbreit-Leftwich, 2010). This disparity in technological integration can lead to significant differences in students' educational experiences and outcomes.
Numerous studies illustrate the impact of digital inequality on educational outcomes, providing evidence of how disparities in access and digital skills contribute to educational inequities. For example, a study by Warschauer (2004) explored how digital access affects students' learning opportunities, finding that students with more access to digital resources and support systems achieved better academic outcomes. Similarly, research by OECD (2015) highlights the positive correlation between students' digital competencies and their performance in subjects like mathematics and science.
Moreover, digital inequality often intersects with other socio-economic factors, exacerbating educational disparities. For instance, students from minority and low-income backgrounds frequently face additional barriers, such as a lack of supportive learning environments and limited exposure to digital technologies at home (DiMaggio et al., 2004). These factors further hinder their ability to develop digital skills and leverage technology for educational success.
In contrast, schools with robust digital infrastructure and support systems can offer enriched educational experiences. They provide students with access to a broader range of resources, personalized learning opportunities, and collaborative tools that can enhance engagement and learning outcomes (Redecker & Punie, 2017). Such environments not only improve academic performance but also prepare students for the digital demands of higher education and the workforce.
Addressing digital inequality in education requires comprehensive strategies that focus on increasing access to technology and improving digital literacy. Policies aimed at providing affordable internet access, distributing digital devices to underserved communities, and integrating digital literacy programs into school curricula are essential for reducing educational disparities (Livingstone & Helsper, 2007). Additionally, professional development programs for teachers can equip them with the skills needed to effectively incorporate digital tools into their teaching practices, thereby enhancing the quality of education.
Collaboration between governments, educational institutions, and the private sector is crucial to bridge the digital divide in education. Initiatives that focus on creating inclusive digital environments can ensure that all students have equal opportunities to succeed in a technology-driven world. By addressing digital inequality, societies can foster more equitable educational outcomes, contributing to the broader goals of sustainable development and especially Sustainable Development Goal 4: good quality education.

Digital inequality, characterized by disparities in access to information and communication technologies (ICTs), significantly impacts the social dimension of sustainable development, particularly in the context of health services and public health. Access to technology has the potential to transform healthcare delivery and improve health outcomes. However, digital inequality can exacerbate existing health disparities and impede access to health services for underserved populations. This section examines how access to technology influences healthcare services and public health, and explores the role of e-health in reducing social inequalities.

Access to technology plays a crucial role in shaping healthcare delivery and public health outcomes. Digital tools and technologies enable healthcare providers to deliver more efficient and effective care, enhancing both the quality and reach of health services (Lupton, 2014). Telemedicine, for example, allows patients in remote and underserved areas to access healthcare services without the need for travel, thus overcoming geographic barriers to care (Krupinski & Weinstein, 2013). Moreover, digital health records and information systems facilitate better coordination of care, reducing medical errors and improving patient outcomes (Bates et al., 2018).

Despite these advantages, digital inequality poses significant challenges to equitable healthcare access. Individuals without reliable internet access or digital literacy are less likely to benefit from digital health services, potentially widening health disparities between different socio-economic groups (Mossberger et al., 2003). Rural populations, low-income households, and older adults often face barriers to accessing digital health technologies, limiting their ability to participate in e-health initiatives (Ragnedda & Muschert, 2013).

The COVID-19 pandemic has underscored the importance of digital technology in maintaining healthcare services during public health emergencies. With the shift to telehealth services, patients with internet access could continue receiving medical care, while those without such access faced disruptions in their healthcare continuity (Nouri et al., 2020). This divide highlights the urgent need for policies and interventions aimed at reducing digital inequality to ensure that all individuals have equal access to healthcare services.

E-health, encompassing a range of digital health services and technologies, has emerged as a powerful tool for reducing social inequalities in healthcare. By leveraging ICTs, e-health initiatives can expand access to healthcare services, particularly for underserved and marginalized populations. For instance, mobile health (mHealth) applications provide health information and services to individuals in remote areas, helping to bridge gaps in healthcare access (Free et al., 2013).

Research demonstrates that e-health can improve health outcomes by enhancing patient engagement and empowerment. Digital platforms enable patients to access health information, track their health metrics, and communicate with healthcare providers, fostering a more proactive approach to health management (Kumar et al., 2013). This empowerment can lead to better health behaviors and adherence to treatment plans, ultimately improving health outcomes and reducing disparities (Fischer et al., 2014).

Moreover, e-health can address social determinants of health by facilitating access to resources and services that contribute to well-being. For example, telehealth services can connect patients with mental health professionals, addressing barriers to mental healthcare in areas with limited access to specialists (Fisher et al., 2020). Additionally, digital health interventions can target specific populations with tailored health messages and interventions, promoting health equity and reducing disparities (Norman & Skinner, 2006).

However, realizing the full potential of e-health to reduce social inequalities requires addressing the digital divide. Ensuring equitable access to digital health technologies necessitates investments in infrastructure, such as expanding broadband access and providing affordable digital devices to underserved communities (Robinson et al., 2015). Furthermore, digital literacy programs are essential to equip individuals with the skills needed to navigate and utilize digital health tools effectively (Friemel, 2016).

Digital inequality's impact extends beyond education and healthcare, permeating various aspects of social life, such as civic participation, access to public services, and social integration. As societies increasingly rely on digital platforms for communication, governance, and service delivery, those without adequate access or skills are at a significant disadvantage, not only in their ability to engage fully in civic life but also in their capacity to integrate into the broader social fabric.

One critical area where digital inequality manifests is in civic participation. Access to digital platforms has become essential for engaging in many forms of political and civic activities, from voting and participating in public consultations to engaging with local government representatives. Studies have shown that digital literacy significantly influences the extent and effectiveness of civic engagement. For instance, individuals with higher digital skills are more likely to participate in online petitions, social media campaigns, and digital town hall meetings, which are increasingly popular methods of civic participation (Hargittai & Shaw, 2013). Conversely, those with limited access to digital tools or insufficient digital literacy are often excluded from these processes, which can lead to a decrease in overall civic engagement and the reinforcement of existing social inequalities.

Access to public services is another domain heavily influenced by digital inequality. Many governments around the world have digitized public services to increase efficiency and reach. However, this shift has inadvertently marginalized populations that are digitally excluded. For example, access to services such as tax filing, social welfare programs, and even job applications increasingly require some level of digital proficiency. Research in the

European context indicates that older adults and low-income groups are particularly disadvantaged by this digitalization of public services, as they often lack the necessary skills or resources to navigate online platforms effectively (Friemel, 2016). This digital divide not only limits access to essential services but also exacerbates socioeconomic inequalities, as those unable to engage digitally are left behind in accessing the support they need.

Furthermore, social integration is deeply affected by digital inequalities. In a world where social interactions increasingly occur online, those who are digitally excluded find themselves isolated from broader social networks. This isolation can have profound implications for social cohesion and community building. Studies have demonstrated that individuals who are more engaged online are more likely to have broader social networks, participate in community activities, and feel a sense of belonging (Wellman & Haythornthwaite, 2002). On the other hand, those who lack digital access or skills often experience social isolation, which can lead to a sense of exclusion from the digital society.

Addressing these multifaceted issues requires comprehensive social programs and initiatives aimed at reducing digital inequalities. Various countries have implemented such programs with varying degrees of success. For instance, in the United Kingdom, the *Digital Inclusion Strategy* aims to reduce digital exclusion by improving access to digital technologies, enhancing digital skills, and promoting the benefits of being online. This program specifically targets older adults, low-income families, and individuals with disabilities, recognizing that these groups are often the most digitally excluded (Helsper, 2012). Similarly, in Australia, the *Be Connected* program focuses on empowering older Australians to thrive in a digital world by providing free, personalized support and training to improve their digital literacy (Thomas et al., 2020). These initiatives highlight the importance of targeted strategies in addressing the digital divide and fostering greater social inclusion.

The effectiveness of these programs also depends on their ability to adapt to the specific needs of different communities. For example, in rural and remote areas, where infrastructure challenges often exacerbate digital exclusion, programs that focus solely on skills development may be insufficient. In these contexts, efforts must also include investments in digital infrastructure to ensure that communities have reliable and affordable access to the internet. The *Rural Broadband Initiative* in New Zealand is an example of such an approach, combining infrastructure development with digital literacy programs to ensure that rural populations are not left behind in the digital age (Howell & Grimes, 2010).

The social dimension of digital inequality encompasses more than just disparities in education and healthcare. It also affects civic participation, access to public services, and social integration, each of which is crucial for ensuring a cohesive and equitable society. By implementing comprehensive, targeted initiatives that address both the skills and infrastructure aspects of digital exclusion, societies can take significant steps toward closing the digital divide and promoting greater social inclusion.

Environmental dimension

Digital technologies have the potential to significantly enhance environmental sustainability by improving energy efficiency and facilitating environmental protection. As societies grapple with the challenges of climate change and resource depletion, digital tools offer innovative solutions for promoting sustainable practices. However, digital inequality can hinder the equitable distribution of these benefits, leading to disparities in environmental protection efforts. This section examines how digital technologies can support sustainable environmental practices and provides examples of their application in monitoring and protecting the environment.

Digital technologies are increasingly being utilized to support sustainable environmental practices, helping to optimize resource use and minimize environmental impacts. One of the key areas where digital tools have made a significant impact is in energy efficiency. Smart grid technologies, for example, enable more efficient management of electricity distribution by using real-time data to balance supply and demand, reduce energy losses, and integrate renewable energy sources (Gungor et al., 2012). By improving the efficiency of energy systems, digital technologies contribute to reducing greenhouse gas emissions and mitigating climate change (Faruqui et al., 2010).

In addition to energy efficiency, digital technologies play a crucial role in resource management. The Internet of Things (IoT) allows for the monitoring and optimization of water and waste management systems, reducing waste and conserving resources (Vermesan & Friess, 2014). By providing real-time data on resource usage, IoT technologies enable more informed decision-making and support the implementation of sustainable practices in industries and communities (Zhou et al., 2016).

Moreover, digital technologies facilitate the development of smart cities, where integrated ICT systems enhance urban sustainability by improving transportation, reducing energy consumption, and increasing the efficiency of public services (Kramers et al., 2014). These technologies enable cities to monitor and manage resources more effectively, leading to more sustainable urban environments (Allwinkle & Cruickshank, 2011).

Digital technologies offer powerful tools for monitoring and protecting the environment, providing critical data and insights that support conservation efforts. Remote sensing technologies, such as satellite imagery and drones, enable the monitoring of land use changes, deforestation, and habitat loss, providing valuable information for

conservation planning and policy development (Turner et al., 2015). These technologies allow for the early detection of environmental changes and the assessment of their impacts, facilitating more effective management and protection of natural resources (Pettorelli et al., 2014).

In addition to remote sensing, digital platforms are used to engage the public in environmental monitoring and conservation efforts. Citizen science initiatives leverage digital tools to involve individuals and communities in data collection and analysis, increasing awareness and participation in environmental protection (Conrad & Hilchey, 2011). These initiatives not only expand the scope of environmental monitoring but also empower individuals to contribute to conservation efforts and promote sustainable practices (Bonney et al., 2014).

The application of digital technologies in environmental protection also extends to pollution monitoring and management. IoT sensors and data analytics are used to track air and water quality, providing real-time information that can inform policy decisions and public health interventions (Li et al., 2016). By enabling continuous monitoring and rapid response to pollution events, these technologies help to reduce environmental risks and protect public health (Wang et al., 2017).

Digital inequality significantly shapes the capacity of individuals and social groups to engage in and benefit from environmental sustainability initiatives. While earlier analyses have focused on how technology facilitates environmental monitoring and management, it is crucial to recognize how disparities in access to and use of digital tools create uneven opportunities for participation in environmental efforts.

For instance, individuals in economically disadvantaged communities often lack access to digital tools that could help them monitor local environmental conditions, such as air quality sensors or mobile apps that provide pollution alerts. These tools are increasingly essential for making informed decisions about personal and public health, especially in areas prone to environmental hazards. However, those without access to such technologies may remain unaware of local environmental risks, leading to greater exposure to harmful conditions and exacerbating existing health disparities (Mossberger et al., 2013). This gap in access to critical environmental information underscores the broader issue of environmental justice, where digital inequality compounds the challenges faced by marginalized communities.

Moreover, the potential for individuals to engage in sustainable practices, such as recycling or energy conservation, is often linked to their digital literacy and access to relevant technologies. Mobile applications that guide users through the process of sorting waste, finding recycling facilities, or managing energy consumption are powerful tools for promoting sustainable behavior. However, individuals who are digitally excluded are less likely to engage with these tools, leading to lower participation in sustainability initiatives. This digital divide can result in uneven environmental benefits, where more digitally literate and economically advantaged groups are better positioned to reduce their environmental footprint (Hargittai, 2010).

Education also plays a crucial role in shaping how individuals and communities interact with environmental issues. As digital platforms become more central to environmental education, students with limited access to technology are at a significant disadvantage. This digital divide in education means that students from under-resourced schools or low-income families may miss out on valuable opportunities to learn about sustainability and environmental science. The long-term consequence is a generation of individuals who are less prepared to address environmental challenges, both personally and professionally, reinforcing social inequalities (Selwyn, 2010).

Furthermore, digital literacy is increasingly necessary for participating in environmental advocacy and activism. Social media platforms, online petitions, and digital organizing tools have become indispensable for mobilizing public opinion and driving environmental change. However, effective participation in these digital spaces requires not only access to technology but also the skills to use it effectively. Those who are less digitally literate, such as older adults or people from lower socioeconomic backgrounds, may find themselves excluded from these important conversations, limiting their ability to advocate for environmental justice and contribute to collective environmental efforts (Robinson et al., 2015).

Finally, the adoption of smart technologies, such as smart meters or IoT devices, illustrates another facet of digital inequality. These technologies can significantly enhance energy efficiency and resource management, contributing to environmental sustainability. However, their benefits are often skewed towards those who can afford to invest in such technologies. Lower-income households, which could benefit most from reduced energy costs, are often the least likely to access these technologies. This creates a scenario where the advantages of environmental sustainability are not equitably distributed, further entrenching social and economic divides (Zhang et al., 2017).

Addressing these digital inequalities is crucial for ensuring that all individuals and communities can participate fully in environmental sustainability efforts. By improving access to digital tools and enhancing digital literacy across all social groups, we can promote more equitable participation in environmental initiatives and ensure that the benefits of sustainability are shared broadly and fairly.

Conclusion

The article investigates the impact of digital inequalities on sustainable development, emphasizing the profound consequences across economic, social, and environmental dimensions. This analysis elucidates that equitable access to information and communication technologies (ICTs) and the enhancement of digital skills are paramount not only for fostering economic growth but also for advancing social equity and promoting environmental stewardship.

Digital inequalities significantly impede economic development by creating substantial barriers to labor market entry, educational opportunities, and entrepreneurial endeavors. A deficiency in digital skills and limited access to technological resources serve to stifle innovation and exacerbate income disparities among different societal groups. To counter these challenges, it is crucial to escalate investments in digital infrastructure, particularly in underdeveloped regions, and to establish comprehensive training and educational programs that cultivate digital skills at all societal levels.

Digital disparities intensify social exclusion, preventing marginalized groups from participating fully in the digital and civic life of their communities. Such limitations restrict access to essential information, online education, healthcare services, and opportunities for digital civic engagement. Expanding digital inclusion through targeted public policies that guarantee equal access to technology and by embedding digital education within standard educational curricula can effectively mitigate these barriers, thus fostering a more inclusive society.

The unequal distribution of digital technologies also undermines the capacity to manage natural resources efficiently and to address the challenges posed by climate change. Advanced digital tools, like remote sensors and sophisticated monitoring systems, can dramatically enhance the management of environmental resources but their benefits are often not realized due to lack of widespread access. Promoting universal access to these technologies in communities around the globe is essential for achieving the objectives outlined in global Sustainable development goals, which include mitigating environmental impact and promoting sustainable resource use and especially is in compliance with goal no 4: Good quality education.

Addressing digital inequalities is imperative not only to achieve economic parity but also to enhance social cohesion and environmental protection. An integrative approach that encompasses coherent policies, strategic education initiatives, and substantial investments in digital infrastructure is essential to harness the full potential of technology for sustainable development. Consequently, tackling digital inequalities demands concerted policy efforts at both national and international levels, ensuring that technological advancements contribute equitably to the welfare of all societal strata and help in mitigating environmental degradation. This comprehensive strategy will enable a more equitable and sustainable future, leveraging technology to address major societal challenges effectively.

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