

# Technology Megatrends for Sustainable Business



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**Abstract** In this work, we cover technological megatrends for sustainable business with a focus on the notion of sustainability and trending technologies for energy efficiency, waste management, supply chain management and operations, sustainable manufacturing, and predictive maintenance. Topics of coverage under this chapter include product-based, customer-based Vs. scenario-based Fintech 4.0, Fintech evolution from gen 1.0 to 4.0, Financial Technologies as a tool, service, or a system, the impact of Fintech 4.0 on key functions of the financial system, and operations. The chapter further navigates through the benefits and challenges and further explores the human factor in Fintech 4.0 through the lens of Industry 5.0. While the advancement on the sustainability front is promising, sustainable digitalization of practice can be impacted by various factors, including but not limited to lack of awareness, limited resources, financial constraints, and outdated infrastructure and replacement costs. Steady, sustainable digitalization requires support not just from local governments but the involvement of international bodies advocating for climate change.

## Introduction

Sustainability is defined as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). Sustainability is a holistic approach that entails making an informed decision to balance economic, social, and environmental factors. According to Elkington (1999), sustainability is “a business approach that creates long-term value by embracing opportunities and managing risks deriving from economic, environmental, and social developments.”

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In the era of disruptive innovations, organizations need to be proactive and adaptive to the innovations to stay in the global competition; companies such as Apple, Coca-Cola, and Proctor & Gamble have continuously changed their business strategies to stay ahead in the market. According to a recent survey by Gartner, 83% of corporate executives view investment in sustainability as having created both short- and long-term benefits for their business. A sustainable organization adopts practices keeping the environment, society, and the global economy in consideration and successfully handle the constant changes in technology, customer expectations, and the global business environment (Jarvis & Palmes, 2018).

Since the beginning of Industry 3.0, organizations jumped on the bandwagon of digitalization and innovation to improve their business practices (Bijker et al., 1987). However, not all the technological innovations were sustainable, in fact, many caused serious harm to the environment. Businesses engaged in large-scale production, leading to huge wastes, high levels of carbon consumption to keep the manufacturing/production plants up and running, and over-reliance on paper-based office administration practices. These practices endangered the ecosystem and future generations.

Consequently, the term “sustainable business practices” was coined to emphasize a much-needed shift in business practices to adopt greener technologies while parting ways from digitalization that was not environmentally friendly. The emergence of technology mega trends (such as renewable energy, circular economy, energy efficiency, waste management, transparency in the supply chain, remote work, sustainable manufacturing, and predictive maintenance) accelerated the drive for sustainable growth of businesses and the economy.

Examples of sustainable practices could be using renewable energy resources instead of fossil fuels and adopting a circular economy, reducing environmental impact by reducing waste and keeping resources in use for longer durations (Berg et al., 2018). Another example is sustainable agriculture practices, which adopt organic farming, crop rotation, and integrated pest management to minimize negative environmental impact (Yunlong & Smit, 1994). Further, Sustainable transportation involves minimizing the harmful impact of vehicles on the environment by adopting a more sustainable mode of commuting, such as using public transit, cycling, and walking (Brunn, 2019). Furthermore, sustainable building designs include reducing carbon emissions, installing energy-efficient equipment, and improving indoor air quality (Wang & Adeli, 2014). To secure a more livable future for us, future generations, and the planet Earth, we must design and adopt more sustainable practices in our everyday lives and businesses.

## A Shift from Digital Transformation to Sustainable Digitalization

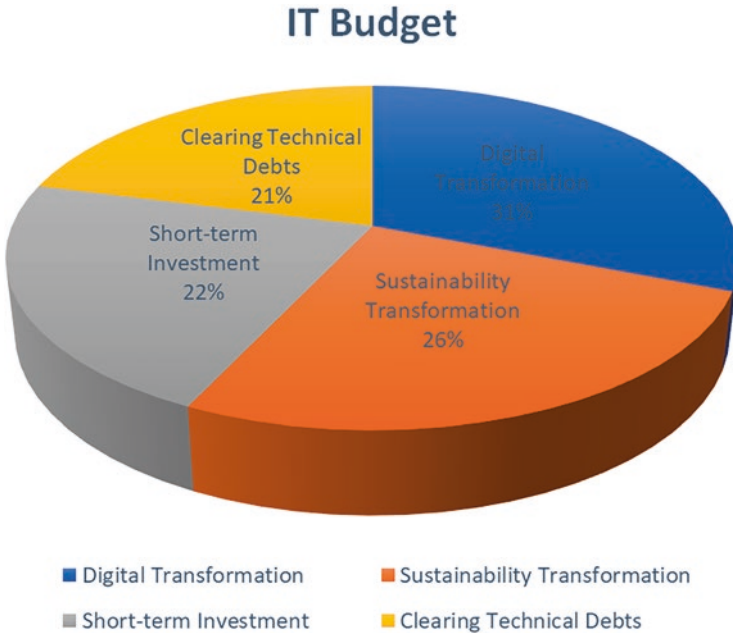
Although the digital transformation of businesses is a long-standing practice, sustainable digitalization is a relatively new concept (Cofino, 2013). Sustainable digitalization refers to the adoption of green technologies that are long-lasting, organic, and environmentally friendly. Previously businesses viewed all technological innovations as the same while ignoring their long-term impacts on the planet and the people (Font et al., 2008). For instance, the invention of supersonic flights was once considered a major technological breakthrough as it presumably reduced flying time by half. One notable partnership of supersonic crafts was between the British and French “Concorde Project” between 1976 and 2003 (Campagna, 2011; Gillman, 1977). Together, they created aircraft capable of traveling long distances in the shortest possible time. Although they were banned from flying over the land as they caused extreme air pollution (greenhouse gas emission, sonic booms, shock waves, and noise), they still had clearance to fly over oceans.

While it was public knowledge that the supersonic flights were harmful to the environment and there was never a convincing business case for supersonic airlines, yet the “Concorde Project” continued for 27 years mainly because of the huge investment from the British and French partners (Campagna, 2011). From the case, one can assume that previously, companies deliberately ignored or greenwashed their digital transformation projects to protect their personal gains. The manufacturer’s “profit over everything else” mentality was supported in part by the lenient penalties, or lack thereof, in case of non-compliance with sustainability measures.

With time, companies realized their customers were becoming increasingly aware of the concepts such as sustainability, and environmental damage. As a result, manufacturers also shifted their focus to sustainable digital technologies in order to gain customer acceptance, especially from the younger audience, for soft image building (Cote, 2020; Peters, 2019).

According to Software AG’s white paper published in 2023, “How sustainability is (or should be) shaping IT decisions in 2023,” “If you’re doing business in 2023, you can’t escape the topic of sustainability. The pressure is on for businesses to act more responsibly.” The foundation of sustainable digital transformation is based on the triple pundit principle—people, planet, and profit.

In recent times, the drive for digital transformation has increased manyfold, and companies are adopting the digitalization of business processes to achieve competitive advantage (Bijker et al., 1987); manufacturers are now rethinking their technological choices and their impacts on the environment, society, and workforce (Font et al., 2008). To this end, megatrends in Industry 4.0 and Industry 5.0 have been personalized customer care and experience via constant connectivity (mobile, internet, AI-based agents, chatbots, etc.), intensive automation of manufacturing processes, and care for the ecosystem. Although these megatrends offer great value propositions, unifying them in a seamless way remains a challenge. Nonetheless, a visible change, as can be seen from the graph below, has been companies’



**Fig. 1** IT budget allocation by the organizations. *Source:* Author's Creation based on Software AG. 2023 [white paper]. <https://www.softwareag.com/content/dam/softwareag/global/resource-library/software-ag/white-paper/sustainability-research-situation-report/01-situation-report-average-it-budget-split.svg>

investment in both digitalization and sustainability initiatives (Software AG, 2023). The manufacturers have attempted to combine sustainability and technology concepts to achieve many advantages. We will now describe some of the key drivers of sustainable technologies.

Figure 1 clearly indicates a shift in organizational preferences from profit to sustainable investments. On average, organizations are allocating 31% of their budget to digital transformation and 26% to sustainable transformation initiatives. We will now discuss the factors primarily responsible for favorably reshaping organization and management attitudes toward sustainable digital investments (Software AG, 2023).

### ***Reducing the Environmental Footprint***

Companies are now realizing that their past manufacturing activities have played havoc with the ecosystem. The manufacturers are now concerned with the impacts of pollution, greenhouse gas effects, and the depletion of natural resources on the planet. Sustainable technologies are being viewed as a viable solution to combat and reverse environmental damage (Marques & Fuinhas, 2011).

Since 2012, IKEA has been investing in renewable energy sources such as solar panels, windmills, and turbine technology (IKEA, 2023). The company aims to operate 100% on renewable energy by 2020. Moving to renewable sources reduces the carbon footprint as well as traditional energy consumption costs. The company is also investing in sustainable methods including the circular economy model that helps create lasting products that can be repaired and recycled for reuse. IKEA's environmentally friendly approaches have been widely recognized and positioned the company as a leader in the industry for sustainability (IKEA, 2023).

### ***Innovation and Competitiveness***

Sustainable technologies are not only environmentally friendly but also great for innovation and competitiveness (Cote, 2020). Adopting newer and more efficient technologies can help companies be more competitive while maintaining their growth targets.

Amazon's fulfillment centers are revamping warehouse operations using automation in collaboration with human labor (Mims, 2022). Amazon uses moveable robotic shelves capable of stacking multiple products simultaneously and bringing them to the workers for packing and shipping by moving around the warehouses. This innovative technology helps Amazon cut the time required by a worker to stack and pick up the products manually, speeds up the product delivery process, and reduces inventory costs. In short, this strategy helps Amazon achieve its people, planet, and profit objectives (Mims, 2022).

### ***Cost-Effective Approach***

One of the key drivers behind a sustainable digital shift is the recognition that sustainable technologies are cost-effective. For instance, the adoption of personalized/customized manufacturing as opposed to mass production and storage of products stops the wastage of resources and raw materials and encourages the recycling of used materials and products. Similarly shifting to renewable energy platforms results in energy saving.

Companies such as Tesla, Google, and IKEA have heavily invested in alternative sources of energy. Where Tesla is aiming to achieve its target for renewable energy by 2030 (Tesla, 2021), Google and IKEA have already met their renewable energy goals in 2019 and 2020, respectively (Anon, 2020; IKEA 2023). Both companies claimed to generate more energy than what they consumed. Amazon has also invested in wind farms and solar plants to achieve net zero emission targets by 2040 (Douglas, 2019). Many clothing brands are now using sustainable sourcing and recycled raw materials to produce clothes (Sustainable Apparel Coalition, n.d.). These attempts are not only useful in reducing carbon emissions but also in achieving cost efficiencies.

## ***Reputation and Branding***

Modern-age customers are aware of environmental concerns and are making their buying choices wisely (Lakhan, 2016). They prefer to invest in items that can either be reused or are already recycled. They also prefer buying products from companies with good social and environmental images. Companies that are helping societies, have charitable associations, and contribute to good causes such as environment protection initiatives do not have to spend a lot of money in marketing themselves. Investing in sustainability is considered as investing in a company's brand and reputation and an effective way of differentiating a company from its competitors.

Many companies are leveraging their drive for sustainability to portray themselves as socially responsible enterprises. Starbucks's usage of LED lights, reusable and compostable cups, and commitment to recycling programs have had a positive impact on its customers (Garnick, 2018). Coca-Cola's strategy of starting plant-based packaging, making bottles from recycled ocean plastic, and water-saving approach at its bottling facility has helped improve its public image (Heyden, 2019). Levi Strauss & Co's unique idea of making jeans from recycled cotton and plastic bottles has helped the brand image overall (Better Cotton Initiative, 2015). The Body Shop's fair trade and packaging waste reduction techniques are proof of the company's commitment to promoting ethical and sustainable practices (Prance-Miles, 2019).

## ***Regulatory Compliance***

Federal and local governments, in many countries, have put in place regulatory measures for manufacturers to control the environmental damage of industrial activities (Joseph & Stavins, 2007). These measures outline standards to ensure the safe and ethical use of technologies and include fines and even production closure in case of non-compliance. In North America and Europe, the governments have introduced the environment handling fee or eco fee that passes the cost of using, recycling, and disposing of the electronics to producers and customers (Lakhan, 2016). Using these measures is helpful in many ways.

- It creates awareness in society about the impact of electronic/technological devices on the environment and ensures safe usage.
- It encourages thoughtful/long-term use of electronic items including technological products.
- It transfers the accountability for the entire product life cycle (including the end, when the product is no longer in use) to the manufacturers and the ultimate users (Huenteler et al., 2016).

## *Sustainable Technologies*

Technology plays a vital role in the design and deployment of sustainability measures. Sustainable technologies are created and developed to have the least detrimental effect on the environment, society, and economy while supporting long-term viability. They are critical for accomplishing Sustainability goals and tackling global concerns such as continuous resource depletion, climate change, and biodiversity loss (Van Oers & Pereira Roders, 2014). Figure 2 illustrates the list of contemporary sustainable technologies such as renewable energy technologies, circular economy, supply chain transparency, energy-efficient buildings, sustainable transportation, sustainable agriculture, water management, remote work, predictive maintenance, blockchain, edge computing, and the Internet of Things. Let us understand these technologies in more detail.



**Fig. 2** Types of sustainable technologies. *Source: Authors' creation*



## *Renewable Energy Technologies*

Pursuing global sustainability goals requires greater emphasis on renewable energy sources. Utilizing green energy sources like solar, wind, hydropower, and geothermal energy can help lower greenhouse gas emissions and lessen the effects of climate change. A study by the Intergovernmental Panel on Climate Change (2014) stated that by 2050, between 70% and 85% of the world's power might come from renewable energy sources, resulting in a 35%–50% decrease in carbon dioxide emissions compared to 2010 levels. Reducing greenhouse gas emissions is crucial to alleviate the effects of changing climate, resulting in extreme weather conditions, rising sea levels, and higher global temperatures. Adopting renewable energy sources can help alleviate energy poverty and improve access to energy in poor and developing countries (UNDP, 2014). Energy is essential for economic growth and a higher standard of living. Utilizing renewable energy sources leads to enhanced energy security, a decreased reliance on imports of fossil fuels, and increased energy independence (IRENA, 2016). Dependence on imported fossil fuels may compromise energy security, as was the case during the oil crisis of the 1970s. To sum up, renewable energy is essential to achieving sustainability goals and creating an equitable future.

## *Circular Economy*

In our existing ecosystem, we utilize resources from the Earth, manufacture things from them, and finally discard the by-products as garbage—the process is linear. In contrast, in a circular economy, we prevent waste from being created in the first place. The circular economy runs on the principle of reducing, reusing, and recycling. A circular economy encourages using renewable resources such as solar and wind energy, which have a more negligible environmental effect than fossil fuels. On the economic front, the circular economy can provide new business possibilities, such as creating new technology, goods, and services and cutting costs by optimizing resource usage. However, building a circular economy might be challenging. For example, the design of items and materials must be reassessed to guarantee that they can be readily dismantled and recycled. Furthermore, new business models and supply chains must be built to support a circular economy, which may need substantial investment and stakeholder cooperation.

Despite these challenges, numerous industries such as construction, electronics, automobiles, and textiles have already begun to embrace circular economy ideas. For example, in the construction business, circular economy ideals may be implemented by designing structures for disassembly, using recycled materials, and recycling building components at the end of their life. Similarly, companies like Philips take back the product when their life ends to refurbish them and eliminate waste. The automobile industry also considers using recycled materials such as plastics and metals in car manufacture (Bocken et al., 2014). BMW collects old car parts



and recycles them. The fashion sector is adapting circular business models, where using rental and resale services extends the life of goods and minimizes waste. H&M collects old clothes from customers and recycles them to make new products. By adopting circular economy practices, businesses reduce their environmental impact, enhance resource efficiency, and generate new economic possibilities. As stated by Geissdoerfer et al. (2017), “Circular economy is not just about recycling or waste reduction, but about a systemic shift towards a sustainable economic system.”

### ***Supply Chain Transparency***

Transparency in the supply chain has grown in relevance recently as customers, and stakeholders demand greater responsibility from businesses. Transparency may assist in establishing trust and promoting sustainability by providing customers with the information they need to make educated purchasing decisions. Supply chain transparency is releasing and sharing information about the manufacture, transport, and distribution of goods and services within a supply chain. This information might contain details regarding the source of raw materials, the environmental and social effects of manufacturing processes, and the working conditions of individuals involved in manufacturing and transportation. According to one Harvard Business Review research, organizations prioritizing supply chain openness are more likely to succeed and have a better brand reputation. Organizations with transparent supply chains are better equipped to manage risk and respond to emergencies like natural disasters or human rights violations.

Despite the benefits of sustainable supply chain transparency, many businesses confront difficulties in efficiently adopting it. The complexity of global supply chains can make tracking sustainability performance and identifying sustainability risks and opportunities challenging (Sarkis, 2012). Sustainability data may be difficult to obtain, and there is a need for standardized metrics and reporting systems to enable effective benchmarking and comparison of sustainability performance. However, increasing collaboration among supply chain partners and integrating technology can improve transparency. Big companies such as Nike and Unilever releases annual sustainability report mentioning what efforts these firms are making to make the supply chain more transparent for all stakeholders and maintain fair labor standards (Unilever, 2022 & Nike, 2022).

### ***Energy-Efficient Houses***

The building sector is responsible for around 40% of worldwide energy consumption and about 30% of greenhouse gases release. To produce more sustainable houses, the construction industry is adopting measures such as innovative designs and installing equipment that consumes less energy. A United Nations Environment

Programme (2017) study estimated that sustainable construction practices can reduce carbon dioxide emissions by up to 1.5 billion tonnes by 2030. Energy-efficient housing is featured to increase the amount of natural daylight to decrease the dependency on other light sources. In addition, instead of traditional bulbs, CFL and LED bulbs are used that consume 75% less energy. Indoor air quality is improved, and buildings are thermally insulated to decrease the dependency on Air conditioners and heating systems (European Commission, 2016). These measures can significantly reduce the units of energy used and lower the cost associated with energy consumption. A report by the American Council for an Energy Efficient Economy claims that energy-efficient buildings yield a return on investment of up to 50% during their lifecycle (ACEEE, 2018).

### ***Sustainable Transportation***

Transportation significantly contributes to world air pollution. A study by the International Energy Agency (2021), revealed that the transport sector accounts for about 37% of worldwide energy-related CO<sub>2</sub> emissions. According to a UN Environment Programme (2017) study, sustainable transport systems such as electric automobiles, hybrid cars, bicycles, and public transit could reduce global greenhouse gas emissions by up to 1.7 gigatons per year by 2050. Furthermore, sustainable mobility saves money and promotes social fairness.

The biggest challenge for adopting sustainable transportation practices is the hefty expenditure to make infrastructure to support energy-efficient transportation systems. Due to their large initial expenses, these investments may be difficult to justify in the short term, despite their long-term benefits. Individual and organizational reluctance to change is another barrier to sustainable transportation. Many people are reticent to change their travel habits, and organizations may be cautious about investing in sustainable transportation projects due to the unknown return on investment. A few strategies can be adopted to make the transportation system more reliable and cost-effective, such as more reliance on public transit, building cycling and walking infrastructure, and switching to electric vehicles.

### ***Sustainable Agriculture***

Sustainable agriculture entails crop rotation, covering crops, conservation tillage, and agroforestry. Crop rotation includes planting several crops on the same ground over time. This strategy aids in soil fertility enhancement, insect and disease management, and erosion reduction. Crop rotation can boost yields by up to 25% (Cui et al., 2018). Under the Cover crops technique, plants are grown between main crops to protect and replenish the soil. Conservation tillage minimizes the quantity

of tilling done on farmland to reduce fuel, labor, and equipment demand, making farming more efficient, and cost-effective. Agroforestry consists of growing trees, crops, and livestock on the same plot of land, which enhances soil health, more biodiversity, and less pesticide and fertilizer usage. According to Mbow et al. (2014), agroforestry can improve crop yields by up to 50%.

## ***Water Management***

UNICEF estimates that by 2025, 66% of the world's population will be water stressed (UNICEF, n.d.). Water management could be a long-term solution to this problem. The process of controlling the usage, storage, and distribution of water resources is referred to as water management. Water conservation, wastewater treatment and reuse, and infrastructure investment are all components of effective water management. Water conservation measures include minimizing wastage by altering the habits of using water and reducing water usage in irrigation. Drip irrigation can save up to 60% of water consumption compared to traditional flood irrigation (Molden et al., 2010). Recycling wastewater is another technique where wastewater is treated to remove toxins and pollutants to make it available for industrial processes and agriculture purposes. Water reuse can cover up to 20% of worldwide agricultural water demand (Qadir et al., 2010).

The most critical part of water management is investing in water infrastructure, including constructing and maintaining dams, reservoirs, pipelines, and treatment facilities. On the other hand, water infrastructure may be expensive, and many regions struggle to finance such improvements. Climate change is one of the most pressing issues in water management. Climate change is projected to induce more frequent and severe droughts, floods, changes in precipitation patterns, snowmelt timing, and groundwater recharge rates, all of which will affect water supply and quality. Water governance is an additional issue in water management. Water governance encompasses the rules, organizations, and processes that regulate the use and management of water resources. Many regions face inadequate governance systems, corruption, and a lack of transparency, leading to water allocation conflicts.

## ***Remote Work***

The COVID-19 epidemic has exacerbated the development of remote work in recent years. This change has provided flexibility, enhanced production, and sustainability benefits. According to Global Workplace Analytics (2022), if the US workforce worked from home just half of the time, it would reduce greenhouse gas emissions by the equivalent of removing nine million cars off the road. Remote work eliminates the need for actual office space, which can result in significant cost savings

and environmental benefits. According to a Dell Technologies (2021), remote work can save an average of \$12,000 in office space expenditures per person per year. This reduction in workplace space also reduces energy consumption, water consumption, and garbage generation. Besides these environmental benefits, remote work can enhance social sustainability by allowing employees to work from anywhere globally. It is crucial to highlight that remote work is not a panacea for long-term sustainability. Employees may use more energy for heating, cooling, and lighting when working from home, which might increase energy usage. Furthermore, remote work might lead to social isolation and poor mental health.

### ***Predictive Maintenance***

Predictive Maintenance is a proactive approach to equipment maintenance that employs data analysis and machine learning algorithms to forecast when a repair is required. This strategy can help reduce downtime, enhance productivity, and save money by predicting possible equipment faults before they occur. Neural networks, random forests, decision trees, and support vector machines are machine learning techniques that can be used for predictive maintenance. These algorithms can analyze data from sensors and other sources to find trends and abnormalities that indicate equipment faults. Manufacturers can use these algorithms to forecast when equipment maintenance is required, plan maintenance actions ahead of time, and avoid unplanned downtime. Examples of other predictive maintenance methods include deep learning techniques such as recurrent neural networks, convolutional neural networks, and autoencoders. These approaches have applications in various industries, including manufacturing, energy, and transportation.

Predictive maintenance is essential for increasing equipment reliability and lowering maintenance costs. However, maintaining data quality and integrating data from several sources are significant problems that must be solved to construct efficient predictive maintenance models.

### ***Blockchain Technology***

By enabling more efficient, transparent, and secure transactions, blockchain technology can significantly improve sustainability in various industries. Blockchain technology makes supply chains more efficient and transparent by recording and confirming the origin, movement, and quality of goods and resources. This can help organizations cut waste, assure regulatory compliance, and avoid fraud. For example, the food industry can utilize the blockchain to track the passage of items from farm to table, ensuring that they are sourced, transported, and sold sustainably. According to World Economic Forum (2019), blockchain has the potential to generate up to \$1.5 trillion in environmental and social benefits by 2030.

Blockchain technology can potentially make energy systems more efficient and transparent. Companies may decrease waste, boost efficiency, and enable more sustainable energy sources by utilizing blockchain to track and verify energy production, distribution, and consumption. Research by the International Renewable Energy Agency (2019) mentioned that blockchain can reduce energy-related greenhouse gas emissions by up to 15% by 2030. Blockchain technology has the potential to enhance sustainability significantly by enabling more efficient, transparent, and secure transactions across a wide range of businesses. However, blockchain systems can be more challenging to develop and manage than traditional systems, resulting in higher costs and significant security problems. Furthermore, blockchain may require specialized hardware or software, limiting its interoperability with existing systems.

### *Edge Computing*

In typical cloud computing models, data is processed and stored in centralized data centers, which consume much energy to run and maintain. On the other hand, edge computing systems process data locally, which can drastically minimize the energy required to transfer data across vast distances. According to an International Energy Agency (2021), edge computing can lower global data center energy consumption by up to 30%.

Edge computing systems can reduce the amount of data transmitted to centralized data centers, increasing network speed and decreasing the risk of data loss or corruption. Edge computing has many industrial applications, such as in transit systems; better traffic management can be accomplished with the help of real-time data. Decisions can be improved in agriculture using real-time information regarding soil, crop, and weather conditions.

### *The Internet of Things*

Internet of Things (IoT) is a system of networked objects that can communicate with one another and the Internet, enabling new possibilities and applications across various sectors. IoT sensors can record and analyze energy consumption data and assist in efficiently utilizing resources (Caragliu et al., 2011). IoT applications in multiple industries can reduce costs and enhance efficiency. In transportation, IoT devices can be used in transit to regulate traffic flow, resulting in efficient traffic management, which reduces fuel consumption. In agriculture, IoT applications can monitor variables such as soil moisture, crop health, and environmental conditions, allowing informed decisions regarding irrigation and fertilizers (Manavalan & Jayakrishna, 2019). IoT can help monitor real-time inventory movement and product quality in the supply chain (Abdel-Basset et al., 2018). The challenge associated

with IoT is the maintenance of a massive amount of data that needs significant energy consumption. And also, there is a concern for data security and privacy while handling huge amounts of data.

## **Investment in Sustainable Technologies—What Does the Future Hold?**

In our previous discussion in the chapter, we highlighted the numerous benefits of sustainable technologies for all stakeholders. Although digital technologies hold great value propositions, the future of the sustainable economy depends on timely investment decisions in long-term technology initiatives mainly in the infrastructure, manufacturing, finance, healthcare, and education sectors to guarantee sustainable growth. Hence, it is crucial to understand companies' and governments' viewpoints in terms of further investments in sustainable digitalization. A strong public and private sector partnership model will be needed to accelerate the implementation of sustainable technologies (Ahmad & Raza, 2020). The governments can support the private sector by incentivizing digital technology initiatives such as providing tax rebates and subsidies. Whereas the private sector can mobilize its resources, technical skills, and expertise to create innovative solutions to address the challenges of sustainability (Chunling et al., 2021).

Sustainable technologies have already proved useful in improving the living standard of people by making their jobs easier and taking over riskier tasks thus mitigating job safety concerns. Moreover, digitalization has played a vital role in addressing climate change concerns, such as mitigating the impact of natural disasters, reducing greenhouse gas emissions, effective waste management, and introducing recycled and reusable products. These technologies have also helped companies achieve energy and resource efficiency and reduce carbon footprints. The benefits of these technologies have also been noticed in improved education and health care, among others.

However, there are many critical decisions to be made before allowing the large-scale deployment of sustainable digital technologies. Firstly, it requires ongoing commitment and steady investment from the stakeholders. To this end, governments and companies have to upgrade the existing infrastructure, which adds time and money constraints (Chunling et al., 2021). Secondly, the institutionalization of sustainable technologies also requires careful consideration of issues such as privacy, security, and safe use of personal data gathered and stored by them. There is always a risk of leaking, misuse, or hacking of highly sensitive personal data. Finally, although technological advancements are known to make people's jobs easier, they have also been associated with the displacement of humans in many jobs, thus creating job loss, particularly in the manufacturing and service sectors. The low-skill workers' group is especially at risk of losing jobs to automation and the digitalization of businesses. Any future investment requires a careful review (in-depth risk

and benefit analysis) of the impact of digitalization on the future of the workforce and the economy. It is critical to ensure a responsible and ethical use of sustainable technologies to guarantee a lasting positive impact on both society and the environment. For instance, a more ethical practice will be to invest in the upgradation of employee skills so that they can work with more complex technologies without fear of losing their jobs.

## **Barriers to the Implementation of Sustainable Digital Technologies**

Although digital technologies promise a sustainable future economy, it is important to understand where the sustainability initiatives stand in the manufacturers'/producers' list of priorities. As of now, there are many hindrances that can impact the deployment of digital technologies across industries (Garrate, 2022; Zelenika & Pearce, 2011). Figure 3 illustrates the most common barriers businesses confront during sustainable technology implementation, such as financial constraints, infrastructure issues, lack of knowledge and awareness, resistance to change, and lack of public-private partnerships.

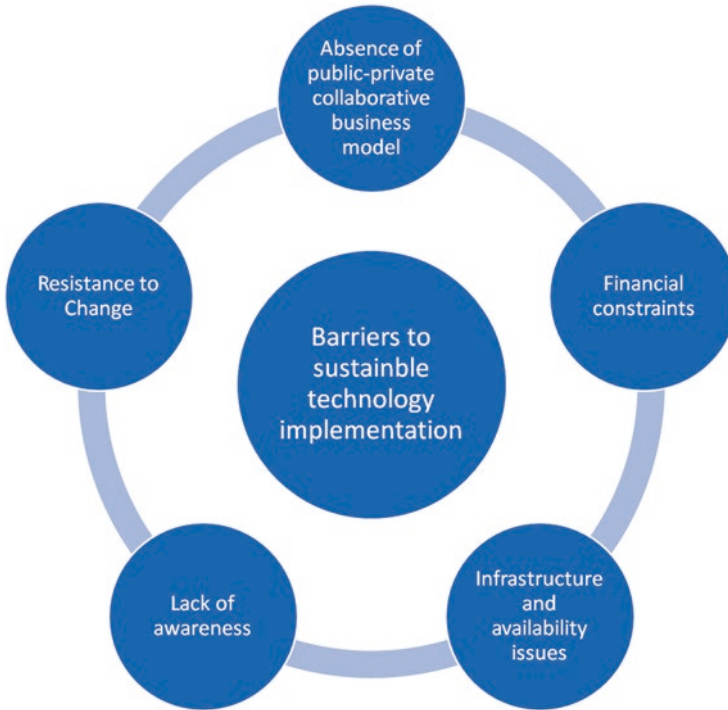
### ***Absence of public-private collaborative business model***

Any future investment in sustainable technologies requires the coordination of the main stakeholders. The lack of a public-private collaborative framework to streamline the processes and simplify outdated complex regulatory compliance requirements is impacting the widespread adoption of technologies (Ahmad & Raza, 2020; Chunling et al., 2021). The absence of a framework to combine public and private resources, capitalize on their unique offerings, and build on joint expertise has further widened the gap between industry and sustainable technologies.

### ***Financial constraints***

Although sustainable technologies guarantee cost efficiencies in the long run, rolling out sustainable technologies requires significant upfront costs (Hau et al., 2018). Large organizations may be able to use digital technologies to their advantage as they are more resourceful, but small and medium enterprises might struggle to adopt these technologies due to financial and budgetary constraints and the limited availability of external financing options.





**Fig. 3** Barriers to sustainable digitalization. *Source: Authors' development*

### ***Infrastructure and availability issues***

Noticeably, in some cases, technologies are fully developed but their use and applicability are impacted by a lack of supporting infrastructure or limited availability. For instance, the sale of electric vehicles will be impacted by the availability of electric charging stations in nearby locations even when people are willing to buy them (Singh et al., 2023). Similarly, although solar panels are widely adopted, and in demand, their usage is a problem in areas with adverse climates and limited sunshine.

Another issue is the incompatibility of sustainable technologies with the existing systems or processes of the company. The integration of sustainable technologies, in this case, will require upgrading or abandoning their previous systems; both options will require a substantial investment that companies may not be ready for.

### ***Lack of Awareness***

In the absence of proper education and awareness, companies and people can develop preconceived notions about the adoption of sustainable technologies (Cooney et al., 2022). Companies may view these technologies as added cost

centers only if they are ignorant about the long-term benefits and environmental impacts of using these technologies. Companies also overemphasize the amount of work and effort required to upskill their existing workforce to engage with sustainable technologies, particularly if they believe they do not have the required competencies at their disposal. According to its sustainability reports, the retail giant Walmart started its drive for sustainable technologies by educating and convincing its main stakeholders (workforce, buyers, and suppliers) about the potential benefits of shifting to greener technologies (Mandel, 2021).

### ***Resistance to Change***

The phrase, “old habits die hard” explains the workforce’s resistance to change. The workforce may be reluctant to exchange their tried and tested methods with new technologies, especially if they do not know how to work with them (Henry & Jie mein, 2009). On the other hand, people may comprehend technology as a source of their displacement from the workplace instead of looking at it as an integrative tool installed to support their routine tasks. Kodak resisted upgrading to digital photography despite its sustainable implications. Kodak viewed the change as a potential threat to its profitable film business (Henry & Jie mein, 2009).

In conclusion, dealing with these barriers is possible with adequate support in educating governments, companies, and people about the benefits of sustainable technologies and how these technologies can be the key drivers of sustainable growth and economic success. Creating training and development programs, mobilizing monetary support from governments and other financial institutions, introducing large-scale infrastructural reforms, and implementing robust regulatory and compliance frameworks will help economies achieve their sustainability targets.

### ***Role of International Institutions in Promoting Sustainable Technologies***

Sustainability is a concept that bypasses national and geographic boundaries. Institutions at an international level are taking steps to create awareness about the adverse impacts of traditional technologies on the ecosystem. To this end, we have seen the establishment of various international bodies that promote the use of sustainable technologies globally to mitigate climate challenges and reduce carbon footprint and greenhouse gas emissions (Andresen & Hey, 2005). However, we have observed unequal sustainable development around the world mainly due to resource availability, lack of infrastructure, and absence of a strong regulatory framework; the use of sustainable technologies is not uniformly accepted and adopted across the globe.

While countries in North America and Europe are leading the sustainable technology movement, the concept is in its infancy in other countries (Singh et al., 2023). Resultantly, the development of international bodies aims to create

awareness of the long-term benefits of sustainable technologies for businesses and countries (Organisation for Economic Co-operation and Development, 2021). The role of international institutions in this context includes sharing knowledge, resources, financial and technical assistance, training, and development for capacity building, particularly for developing and under-developing economies to ensure a sustainable future for all (Andresen & Hey, 2005). We will now discuss some of the noticeable international sustainability initiatives.

United Nations is supporting the sustainability drive globally with multiple programs designed for developed and developing economies. United Nations Environment Programme (2017) advocates for a shift to renewable, energy-efficient technologies. United Nations Framework Convention on Climate Change (UNFCCC) initiative fosters collaboration between multiple stakeholders, i.e., the public and private sectors and members of society, on issues of the climate crisis, and sustainable technologies. Green Climate Fund (GCF) is another UN-supported program created under the UNFCCC. GCF provides financial support to developing economies to adopt carbon and energy-efficient technologies, particularly to the countries adversely impacted by climate change and natural disasters. It also supports the drive for using sustainable transportation and clean energy sources. United Nations Development Programme (UNDP), World Bank, and the Global Environment Facility (GEF) are also heavily investing in research and development programs to introduce affordable renewable technologies, waste management, and sustainable agriculture practices.

World Bank supports the implementation of sustainable digitalization in developing countries. World Bank has set up a Climate Technology Fund to fight and reverse the recent climate changes by controlling greenhouse gas emissions. International Energy Agency (2020) works to facilitate the provision of clean energy to its partnering countries with a focus on carbon capture, utilization, and storage (CCUS) (IEA, 2020).

International Renewable Energy Agency (IRENA) promotes the global availability and usage of renewable technologies. IRENA offers technical support and expertise in creating a compliance policy framework to encourage member countries to invest in renewable technologies (International Renewable Energy Agency, 2016). International Standards Organization (ISO) and the United Nations Industrial Development Organization (UNIDO) jointly set out policies, standards, and compliance frameworks for the creators of sustainable technologies (International Standards Organization, 2021; Jarvis & Palmes, 2018). These steps help regulate the safe, ethical, and effective use of sustainable technologies.

## **Recommendations**

Sustainability is not a one-time effort or a sequential procedure; it is a never-ending path companies pursue, envisioning a better future. Businesses must regularly analyze and reassess their systems and practices for constant development. Organizations can follow the below-listed recommendations to kick-start their sustainability journey.

### ***Conduct a Sustainability Audit***

It is crucial to find out the organization's current standing toward sustainability efforts in all the areas of its operation to find out the gaps, pain points, and overlooked places. The more comprehensive the initial audit is, the better clarity it will provide to devise a further action plan for the organization. The audit will help organizations identify areas to reduce environmental footprints.

### ***Integrate Sustainability into the Business Strategy***

Nowadays, businesses are looking for ways to reduce their carbon footprints and reduce negative environmental impacts. Organizations must understand that it is not the trend that every company has to follow; instead, it is our responsibility toward the upcoming generation. Even a small firm can take steps toward sustainability by realigning its goals and reinventing processes. Integrating sustainability with business strategy ensures that organizations contribute toward a sustainable future besides earning profits. To devise a plan, companies must assess their current performances in environmental, social, and governance areas to identify the domains that need the most attention and have most of the stakeholders involved. This prioritization is essential to avoid getting trapped in too many initiatives with little or no impact.

### ***Set Ambitious but Achievable Sustainability Goals***

Having established the thresholds at which an organization can pursue sustainable options, it is time to develop and prioritize goals. Setting sustainability goals will define the organization's aspirations and guide the efforts toward sustainability. Ensure to make Specific, Measurable, Achievable, realistic, and time-bound (SMART) goals. Stakeholders' involvement in designing and setting will also increase accountability. Establish long- and short-term goals to provide a clear vision and guide strategic decision-making.

### ***Communicate and Create a Sustainability Culture***

Organizations should regularly communicate their sustainability efforts with all the stakeholders, such as employees, customers, suppliers, and clients. Fortune 500 companies such as Walmart, Microsoft, Coca-Cola, General Motors, IBM, and Proctor and Gamble produce and share their Annual Sustainability Reports. This

report discloses their sustainability initiatives to reduce the negative impact on the environment, governance practices, and corporate social responsibility measures adopted by them. According to a study, 70% of employees report that robust sustainability efforts of a company influence their decision to stay longer in the organization.

### ***Invest in Renewable Energy Resources***

Organizations must take initiatives to minimize conventional energy sources and invest in renewable energy. Companies can adopt renewable energy sources, such as Installing Solar Photovoltaic (PV) Systems that convert sunlight into electricity. Walmart has been actively installing solar PV systems on the rooftops of its stores. Walmart's solar PV systems have reduced the company's dependency on fossil fuels and its emissions of greenhouse gases. The world's largest retailer has stated that it wants to end all emissions from its global operations by 2040.

### ***Adopt Energy-Efficient Technologies***

Organizations can invest in Energy Management Systems (EMS) to monitor, control, and optimize energy usage. EMS can identify energy-saving opportunities and maximize equipment performance using advanced analytics and automation. For example, Schneider Electric implemented an EMS in one of its buildings and achieved significant energy savings. According to a case study by Schneider Electric, the EMS reduced energy consumption by 20% through real-time monitoring and intelligent controls.

### ***Integrate Sustainability into Business Operations***

When priorities and goals are clearly stated, firms may begin planning to incorporate these objectives throughout the organization. Usually, it does not necessitate drastic action. Businesses can initially start with little adjustments when introducing new tools, concepts, and approaches to current business processes. Organizations can find more possibilities to change or enhance their current methods by keeping track of the outcomes of each intervention. Companies can create end-to-end transparency throughout supply chains, from sourcing to distribution. They can collaborate with suppliers to set standards, track and improve performance, and promote more sustainably developed environments. Businesses must reengineer their product designs to make their current items profitable. For instance, companies may redesign products using more environmentally friendly materials, cut back on

packing, and create refillable or compact versions that consume less water and less packaging while reducing the product's overall weight and, consequently, transportation-related carbon emissions.

### ***Partnerships and Collaborations***

Climate change cannot be stopped by one organization alone. Leaders must cooperate in setting clear goals, specifying the metrics they will use to gauge success, and reporting on their progress if they are to achieve the necessary radical changes. To achieve their goals for sustainability, CEOs are more willing to acknowledge the value of partnerships and collaboration. Governments, policymakers, industry peers, NGOs, consumers, clients, and suppliers are just a few examples of the various societal sectors that these connections span. Partnering with other companies fosters creative thinking, reduces risk, and boosts productivity. For example, the Sustainable Garment Coalition (SAC) is an industry cooperation of prominent garment companies, retailers, manufacturers, and non-governmental organizations (NGOs) seeking to improve the environmental and social performance of the apparel and footwear industry. The SAC created the Higg Index, a toolkit that allows businesses to monitor and assess the sustainability performance of their goods and supply chains.

### ***Evaluate Sustainability Efforts***

Tracking environmental performance indicators assist in assessing the organization's impact on natural resources and ecosystems. Common indicators include energy consumption, water usage, greenhouse gas emissions, and waste generation. The World Business Council for Sustainable Development (WBCSD) guides environmental performance measurement. External verification or certifications by independent organizations add credibility and assurance to sustainability efforts. These assessments can evaluate the organization's compliance with established standards and provide an objective performance assessment. The Leadership in Energy and Environmental Design (LEED) certification for buildings is a well-known example of external verification. Sustainability evaluation is a continuous effort that requires integration with all the sustainability-led processes and initiatives of the business.

## Conclusion

With the recent drive for sustainability governments, businesses, and people are aiming to conserve valuable resources for future generations. To protect the ecosystem, all the stakeholders (public sector, corporations, and people) have to collaborate and make informed decisions to balance economic, social, and environmental needs. This requires governments to incentivize and promote the implementation of sustainable technology, corporations to act more ethically and responsibly to reduce their carbon and greenhouse gas emissions and opt for renewable energy sources, and consumers to make informed and sustainable buying choices. When it comes to sustainable growth, all the stakeholders are in agreement that the adoption of sustainable technologies is the only way forward.

The implementation of multiple sustainable technologies ranging from renewable energy, circular economy, supply chain transparency, circular economy, sustainable transportation, sustainable agriculture, predictive maintenance, blockchain technology, and Internet of Things continue to reshape the future of the planet. Steady investment in these technologies will help reduce the carbon footprints by 35–50% and shift 75–80% of industrial activity to renewable energy by 2050. Adoption of sustainable technologies is not only an environmentally friendly approach but also helps organizations accelerate their growth, preserve resources, and achieve cost efficiencies.

Although there are many benefits of sustainable technologies their implementation is not a straightforward decision and is impacted by multiple factors including, upfront costs, lack or limited availability of external funding sources, particularly for medium-sized businesses, absence of public–private collaboration mechanism, lack of awareness, and resistance to change from both corporations and employees. Having said that, since sustainability is a global phenomenon better reforms are needed at international level to handle this social and environmental crisis.

In this regard, many international organizations have started initiatives to promote the use of sustainable technologies internationally. Organizations such as the United Nations, World Bank, International Energy Agency, International Renewable Energy Agency, and International Standards Organization in collaboration with their member countries are creating awareness about issues such as energy conservation and preserving resources by using renewable technologies and recycling approaches. These organizations are also supporting developing and under-developing countries financially and technically to adopt sustainable technologies. In conclusion, although we are far from achieving our sustainability targets the global response to sustainable technologies is promising and will only improve with the help of better reforms and support from the global stakeholders.



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