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# Chapter 13
# Advancing ESG through 4IR technologies: Innovating for a sustainable and inclusive future

**Abstract:** The integration of Environmental, Social, and Governance (ESG) principles with Fourth Industrial Revolution (4IR) technologies have gained traction recently with several debates suggesting AI integration into ESG may offer transformative potential for sustainable development. On this premise, this chapter explores the transformative role of 4IR technologies in enhancing ESG principles by examining how the 4IR technologies can be leveraged upon to address critical sustainability challenges and foster inclusive development for all. We acknowledged that the integration of ESG principles with AI will drive innovation, improve transparency, and enable effective decision-making across industries. We equally highlighted that 4IR technologies integration into ESG initiatives are not without challenges especially on issues pertaining to data integrity, privacy, bias, transparency, accountability and over-reliance on AI. Hence, we noted that strong regulatory framework and collaborative efforts among stakeholders are essential to mitigate risks of over-reliance on AI, ensure responsible AI usage and maximizing its impact. This chapter therefore concludes that leveraging 4IR technologies to advance ESG initiatives is not merely a moral imperative but a strategic necessity to enhance ESG for any business as it presents an innovative pathway toward a sustainable and inclusive future.

**Keywords:** 4IR, environmental, social, and governance (ESG), sustainable development, ethics, stakeholders

## 13.1 Introduction

Over the years, climate change effect due to human induced activities has been waging unending war against humanity (Omotoso & Omotayo, 2024) having resultant impact like environmental pollution and ecological deterioration (Appiah et al., 2024), with the greenhouse gas emissions (GHGs) level in Africa growing to about 84% between 1970 and 2020 (Omotoso & Omotayo, 2024). This concern have heightened the urgent need to embrace sustainable practices (Greif et al., 2024). This need is further exacerbated by numerous initiatives to mitigate the GHGs. For instance, an initiative recently signed into law in South Africa is the Presidential Climate Committee (PCC) towards a Joint transition that aims to transition the country into a low-carbon econ-

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omy by reducing its GHGs, and build a climate-resilient future while targeting net-zero emissions by 2050 (Bascomb, 2024).

The achievement of the goals of any climate initiative according to Greif et al. (2024) requires three prominent strategies to be ensured. These strategies are: Efficiency (i.e., effective resources usage to minimise waste and increase productivity), sufficiency (i.e., consumption level reduction through improved lifestyle to promote more sustainable levels of resource usage), and consistency (better interaction with nature and technology to create an environmentally friendly circular economy) (Greif et al., 2024). Although, research have shown that sufficiency and consistency strategies can offer significant improvements for transition into a low-carbon economy. Yet, technological expertise and more efficient technologies are still required to develop immediate and longtime solutions (Nishant et al., 2020) and for building a climate-resilient future (Greif et al., 2024).

Given the foregoing, a prominent technology that offers promising solution is the Artificial Intelligence (AI), wherein machines learn based on their experience, adjust to new inputs, and perform human-like tasks (Duan et al., 2019). AI technologies given their potentials can offer three core essential attributes (Nishant et al., 2020). They have the ability to automate essential yet repetitive and time-consuming tasks, offering human time and energy to focus on higher-value work; they can extract valuable insights from massive amounts of unstructured data like videos, images, reports, business documents, social media posts, and emails that previously required human analysis; and they can integrate thousands of computing resources to solve highly complex world problems (Nishant et al., 2020). These abilities underscore their need to be leverage upon for possible ways to mitigate climate induced threats.

Although, research has shown that 4IR is transforming disciplines. For instance, within the domain of accounting, AI-driven tools is significantly enhancing audit quality and risk assessment capabilities (Al-Omush et al., 2025) chiefly due to the increasing demands for accuracy, efficiency, and reduced human error. Additionally, recent research has also shown that AI advancement is triggering profound transformations across regions, especially as they relate to sustainability (Nishant et al., 2020), and Environmental, Social, and Governance (ESG) principles (Bibri et al., 2024). For instance, the integration of AI into ESG principles can impact risk management because generative AI can be employed to simulate various ESG scenarios, helping financial institutions to visualize potential future landscapes and adjust their strategies (Lim, 2024). Also, by using AI-powered risk assessment tools that integrate ESG considerations, financial institutions can identify and mitigate potential risks associated with environmental and social factors, like climate change, labour practices, and human rights violations (Apel et al., 2023; Patterson et al., 2022). Hence, assisting financial institutions to reduce their exposure to financial and reputational risks, likewise contribute to sustainable and responsible business practices (Lim, 2024).

The ESG principles being a set of criteria or metric employed to assess company's activities and performance encompasses three critical dimensions (Nitlarp & Kiattisin, 2022) highlighted below:

1. **Environmental:** This facet evaluates how an organization manages the impact of its operations and its overall environmental responsibilities (Nitlarp & Kiattisin, 2022). This comprises metrics like carbon emissions mitigation strategies, energy usage/consumption, waste management practices, and resource or biodiversity conservation. Lately due to global concerns, organizations are now facing increasing scrutiny to embrace sustainable practices to minimize environmental footprint arising from the company activities (Gold & Taib, 2023).
2. **Social:** The social facet has its focus on how companies interact and manage their relationships with employees, suppliers, customers, and communities. The core consideration here includes labour practices, community engagement, diversity and inclusion efforts, as well as adherence to policies on human rights and overall corporate social responsibility (CSR) (Nitlarp & Kiattisin, 2022).
3. **Governance:** This facet involves the internal systems that control organizational behaviour like board composition, diversity, compensation structures for executives, shareholder rights, and compliance with regulations and ethical standards. Strong governance practices are essential for ensuring accountability and ethical conduct within the organizations.

The technological advancements has therefore led to the emergence of the Fourth Industrial Revolution (4IR) where Artificial Intelligence (AI) is the focus of significant attention (Bibri et al., 2024). The 4IR is a buzz word that has gained traction across different sectors of the economy as it is perceived as a fusion of many technologies having the potential to blur the boundaries between the physical, digital, and biological spheres (Oke & Fernandes, 2020).

The 4IR is poised to offer innovative solutions to mounting environmental challenges confronting nations (Ketchiwou & Ngulube, 2024; Nishant et al., 2020) as it has the potential to unlock avenues for improving resource efficiency, reducing energy consumption (Ukoba et al., 2024), streamlining waste management (Ebekozien et al., 2024), enhancing transportation management (Ajayi et al., 2024), conserving biodiversity, and mitigating environmental impacts.

In a nutshell, the foregoing debates are suggestive that 4IR holds the power to reshape development landscape for the future as they have the potential to tackle sustainability issues (Nishant et al., 2020) and steer environmental consciousness especially when integrated into ESG principles. To this end, this chapter seek to explore the transformative role of 4IR technologies in enhancing ESG principles as it explores how the 4IR technologies can be leveraged upon to address critical sustainability challenges and foster inclusive development. To achieve this objective, the chapter proceeded with the below highlighted discussions.

i. Why ESG is crucial today
ii. The concept of 4IR and technological advancements
iii. Roles of 4IR in enhancing ESG vis-à-vis the five core aspects for achieving the governance of 4IR
iv. Ethical considerations for 4IR usage in ESG reporting
v. 4IR Governance
vi. Examples of AI-powered ESG Applications; and
vii. Ways through which 4IR may contribute to risk mitigation strategies in ESG

It is our hope that at the end of this chapter, we are able to proffer ways to harness the transformative capabilities of 4IR technologies that steer environmental consciousness, whilst proffering new opportunities that drive the achievement of sustainable development goals (SGDs), propel economic growth, and forge a more resilient and equitable future for all.

## 13.2 Why is ESG crucial today?

The essence of ESG in today's business world cannot be overemphasized as it has surged recently due to increased awareness of climate change, social justice movements, and corporate accountability (Zhang & Zhang, 2023). Reporting based on ESG is crucial because it involves disclosing data pertaining to an organization's performance in terms of its environmental stewardship, social responsibility, and governance practices (Nitlarp & Kiattisin, 2022). ESG reporting is important for diverse stakeholders needs such as investors, customers, employees, and regulators as they often seek transparency regarding a company's sustainability initiatives and ethical impact. Hence, investors are now increasingly using ESG metrics to screen potential investments portfolios, recognizing that companies with strong ESG practices are more resilient and better positioned for long-term corporate success. Besides, for accounting and management disciplines, advancing ESG is underpinned by several compelling interrelated factors, that individually plays a crucial role in shaping the discourse around this vital area. Companies, as major contributors driving these issues (Gold et al., 2022), bear a moral and ethical obligation to reduce their ecological footprint (Nair et al., 2024). Additionally, recent reports noted that about two-thirds of investors now contemplate ESG metrics for their investment decisions, indicating that strong ESG strategies can enhance an organization's reputation and financial performance while decreasing associated risks with regulatory compliance and reputational damage (British Business Bank, 2024). Furthermore, as highlighted by the European Institute of Management and Finance, effective disclosure provides insights into a firm's operations and helps to assess their long-term sustainability strategies (EIMF, 2024).

## 13.3 Concept of 4IR and technological advancements

The implementation of AI has had a significant influence on industrial systems which is now popularly referred to as the fourth industrial revolution (4IR) (Nitlarp & Kiattisin, 2022). The 4IR denotes the ongoing transformation brought about by technological advancements, one that combines different aspects of physical, digital, and biological spheres, enabled by technologies like Artificial Intelligence (AI), blockchain, nanotechnology, biotechnology, robotics, Internet of Things (IoT) and other emerging technologies (Haenlein & Kaplan, 2019; Ukoba et al., 2024). Unlike traditional technologies that transformed mainly the industries, 4IR impacts every facet of the society, from education to healthcare and governance. 4IR presents significant opportunities for enhancing ESG practices for organizations that leverage on it by improving their ability to monitor environmental impacts, engage with stakeholders effectively, and ensure compliance with evolving regulations. As firms navigate this new landscape, integrating AI particularly 4IR strategies into business processes is pivotal to advance ESG considerations as they are crucial for achieving sustainable growth and maintaining competitive advantage in an increasingly conscientious market. However, despite the profound potential of these technologies, they still bring with them series of challenges such as ethical dilemmas, regulatory gaps, and environmental concerns that must be proactively addressed to ensure responsible and sustainable AI implementation (Crawford et al., 2019;Gupta & Agarwal, 2024).

Below we explain some notable and most prominent 4IR technologies:

1. **Artificial Intelligence (AI)**: AI refers to the capability of a machine or computer system to emulate and execute tasks that would generally necessitate human intelligence like logical reasoning, learning, and problem-solving (Greif et al., 2024). AI encompasses machine learning (ML) algorithms that enable systems to learn from data and make decisions without any human influence. Thus, within the context of ESG, AI can enhance data analysis for better environmental monitoring and reporting.
2. **Internet of Things (IoT)**: IoT refers to interconnected devices that gather and exchange data over the internet. In environmental applications, IoT devices can monitor resource usage in real-time, providing valuable insights for sustainability considerations.
3. **Blockchain**: This is a decentralized ledger technology that enhances transparency by recording transactions in a well-secured environment across multiple parties. Blockchain can be used in supply chain management to ensure ethical sourcing and traceability of materials.
4. **Biotechnology**: Innovations in biotechnology can lead to sustainable agricultural practices and the development of environmentally friendly products.

Now, let's examine the roles of 4IR in enhancing ESG

## 13.4 Roles of 4IR in enhancing ESG

As ESG concerns has become a critical global issue, AI has demonstrated significant potential in tackling these concerns (Greif et al., 2024). More so, as firms strive to improve their ESG performance frameworks amidst increasing regulatory pressures, the integration of 4IR technologies has emerged as a transformative solution. As a result, integrating ESG principles with 4IR has gained traction since the technologies are presumed to assist in reshaping corporate practices across industries (Pandey & Thampi, 2024). This is further driven by the increased awareness about sustainability and ethical considerations among numerous stakeholders, as well as the role firms can assume in addressing societal issues (Saxena et al., 2023). To address societal concerns, the need to integrate 4IR into ESG reporting becomes inevitable. This is crucial as AI technologies can enhance ESG data collection, analysis, and reporting by automating processes, thus saving time, uncovering trends and patterns to assist in making an informed decision, and providing real-time insights that enables organizations to make timely adjustments to their sustainability (Ahmad et al., 2023). This synergy will assist to boost transparency, accountability, and sustainability.

Besides, ESG reporting serves as a basis for the evaluation of organization's impact on its society and the environment in general. Hence, integrating AI technologies like blockchain, big data analytics, and robotic process automation (RPA) into the accounting profession is crucial for automating routine accounting tasks, such as providing real-time insights into financial data, and improving the accuracy of financial reporting (Ahmad et al., 2023; Al-Omush et al., 2025). This capability allows organizations to provide more reliable disclosures that meet stakeholder expectations for transparency. Additionally, it will further provide a comprehensive view of the firms' long-term viability and ethical stands. According to Gillis et al. (2024), ESG encompasses various sustainability and ethical issues that influence business practices, offering a means to assess risks and opportunities related to these factors. Although, the foundation of ESG can be traced as far back to the era of socially responsible investing (SRI), one that started out as a means of excluding organizations from investment portfolios based on ethical concerns. However, due to evolving demands, the focus has now shifted towards recognizing companies that are engaged in environmentally friendly activities, thereby integrating these factors into mainstream investment analysis (Bergman et al., 2020).

## 13.5 4IR Governance

There are indications that effective governance of 4IR technologies can significantly enhance ESG outcomes for businesses. This is true because 4IR governance is not merely about mitigating risks, rather it is about harnessing technological innovation

to create a sustainable, equitable, and prosperous future. Therefore, businesses, policymakers, and civil society need to collaboratively design governance systems that balances technological potential with ethical responsibility, ensuring that the 4IR catalyses positive change for all.

Strong governance of 4IR technologies can also foster alignment of technological capabilities with ESG goals, as it can drive sustainable business practices (Nishant et al., 2020) and better financial and societal outcomes (Lim, 2024). As such, 4IR governance is not only a moral imperative but a strategic necessity for business's ESG requirements.

Consumer trust and loyalty are increasingly tied to perceptions of behaviour, as evidenced by studies indicating that consumers are more likely to support companies they view with strong governance (Salesforce, 2019). As regulatory landscapes are now evolving rapidly, with governments and international organizations introducing guidelines and standards to oversee AI deployment (OECD, 2018), businesses without strong AI governance risk reputational damage, legal liabilities, and diminished competitiveness that may impact on their ESG goals (Crawford et al., 2019).

4IR technologies tend to offer a myriad of unique opportunities to enhance ESG practices across various disciplines. For instance, organizations that have begun leveraging advanced data analytics, machine learning (ML) algorithms, and natural language processing (NLP) are now able to process large volume of ESG-related data effectively and efficiently than they could have achieved using the traditional methods. In addition, the benefits of AI integration into ESG range from enhanced accuracy, prediction models, better scalability, to sustainable innovative culture (Gupta & Agarwal, 2024). Similarly, AI tend to offer avenue for recognizing patterns and trends that inform strategic decision-making, thus, offering businesses the opportunity to assess their ecological footprints and social impacts more accurately (Adelakun et al., 2024).

Additionally, since 4IR plays a pivotal role in automation processes, particularly streamlining compliance with ever-evolving regulatory requirements especially those pertaining to sustainable practice adoption, through automative data collection and analysis, businesses can now ensure timely and accurate disclosures of relevant data that conform to stakeholders' expectations for transparency. We believe this functionality and capability is especially critical in today's rapidly changing regulatory landscape, where businesses face increasing scrutiny to demonstrate their commitment to sustainable practices.

Here are other key insights from recent literatures:

1. **Enhanced ESG integration through 4IR technologies:** Effective governance for 4IR technologies allow organizations to monitor and manage ESG metrics more comprehensively. For instance, AI-powered tools can track carbon emissions or analyse supply chain sustainability, leading to improved environmental performance. Besides, proper governance ensures these technologies are deployed sufficiently and effectively, addressing ESG concerns like data privacy and social equity (Sarkis et al., 2023).

2. **Sustainability and financial performance:** Research also highlights that companies adopting advanced governance practices for 4IR technologies often perform better financially and in terms of ESG compliance. For example, a study focusing on Brazilian companies found that adherence to ESG principles, supported by advanced digital tools, positively influences corporate value and investor confidence (Souza et al., 2021).
3. **Stakeholder engagement and decision-making:** Properly governed 4IR tools enhance stakeholder engagement by providing transparent and real-time data. These fosters trust and aligns corporate actions with ESG objectives. For instance, blockchain can create tamper-proof records for sourcing, ensuring accountability and improving governance ratings (Kouhizadeh & Sarkis, 2024).

Based on the foregoing, this chapter now proposes five key aspects that must be addressed to achieve governance of 4IR. We believe this will foster alignment of technological capabilities with ESG goals in business.

### 13.5.1 Five core aspects for achieving governance of 4IR

**a. Transparency**

Transparency in AI is defined as the degree to which businesses disclose relevant information pertaining their AI operations. This includes reporting on the decision-making processes and allowing independent entities to monitor these processes. Transparency ensures that AI systems are understandable and that their functionality is clear to stakeholders (Hood, 2006; Margetts, 2011). In a nutshell, it is the accessibility of AI systems and their workings to users and stakeholders (Radanliev, 2025).

***Factors that Give Rise to Transparency Concerns***

Research have shown that lack of transparency is one of the primary causes of public distrust in AI systems (Radanliev, 2025), and the main factor driving transparency concerns is the unexplainable nature of AI algorithms. As AI technology evolves, particularly with the advent of deep learning, many AI systems function in ways that are not easily explainable to humans. One of such concern is the "black-box" effect, a common concern with AI methodologies that makes it challenging for businesses and regulators to understand how decisions are made by these systems (Burt, 2019). Moreover, the rise of complex machine learning (ML) models has led to systems that autonomously make decisions based on patterns that may be unclear even to their creators. Thus, it is sometimes presumed that algorithms are protected as trade secrets by companies, contributing to the opacity of AI decision-making processes (Burrell, 2016).

***Governance Considerations to address transparency concerns***

To address transparency concerns, businesses need to implement measures such as explainable AI, where algorithms are designed to be interpretable and understandable. Supporting this argument, Radanliev (2025) noted that setting up regulations or developing frameworks that place explicit demands on AI systems to be explainable and open to public scrutiny is essential for AI transparency. A typical example can be found in the European Union's General Data Protection Regulation (GDPR) and AI Act. Independent audits of AI systems when conducted regularly is also essential to ensuring the systems are functioning as expected. Furthermore, businesses disclosing technical limitations of their AI systems to stakeholders and engaging with third-party observers to assess the AI system's functionality and decision-making processes (Deloitte, 2019) shows transparency. Additionally, to balance transparency with the protection of proprietary information, policies must be established to determine which AI-related information need to be disclosed and under what circumstances. Overall, transparency will be enhanced through the use of explainable AI (XAI) techniques (Radanliev, 2025).

**b. Machine Bias**

Machine bias refers to the unfair advantages or disadvantages that AI systems may introduce due to the biases present in the training data or design (Murikah et al., 2024). Biases can result from historical data that reflects societal prejudices, leading AI to make discriminatory decisions against certain groups (Wachter, Mittelstadt, & Floridi, 2017).

***Factors that Give Rise to Machine Bias***

Several factors contribute to machine bias, including historical bias, representation bias, and measurement bias (Murikah et al., 2024). Historical bias arises from datasets that reflect past prejudices, such as biased hiring or criminal justice decisions. Representation bias occurs when certain groups are underrepresented in training datasets, leading to inaccurate predictions for these groups. Additionally, data manipulation or improper data collection methods can exacerbate these biases, also algorithmically design choices that prioritize certain features over others (Binns, 2018).

***Governance considerations to mitigate machine bias***

Governance strategies to mitigate machine bias include implementing debiasing techniques at various stages of the AI process, such as pre-processing, in-processing, and post-processing of data. Businesses should maintain comprehensive datasheets for algorithms, detailing their design, characteristics, and methods for detecting and reducing bias (Crawford et al., 2019). Furthermore, organizations should ensure that fairness and non-discrimination are integrated into AI workflows and continuously monitor systems for signs of bias. Businesses are also encouraged to engage third parties or internal teams to assess the accuracy and fairness of their datasets, as well as regularly reporting the results of these audits to stakeholders (Jobin, Ienca, & Vayena, 2019).

**c. Privacy**

Privacy concerns in AI governance refer to the need to protect personal and sensitive data from unauthorized use or access. This includes the rights to restrict the processing of personal data, rectify data inaccuracies, and request deletion of personal information (Gartner, 2020).

***Factors that Give Rise to Privacy Concerns***

Privacy concerns are primarily driven by the large datasets that AI systems require for training and operation. These datasets often contain sensitive personal information, which, if mismanaged, can lead to privacy breaches. Furthermore, the methods used to collect, store, and process data can inadvertently expose individuals to privacy violations, especially where data are shared across platforms or jurisdictions without adequate safeguards (Hill, 2017). The use of AI in surveillance and predictive policing also raises significant privacy concerns as these technologies may collect and analyze data without the informed consent of individuals.

***Governance considerations to address privacy concerns***

To address privacy concerns, businesses need to adopt privacy-by-design principles, one that ensures data protection is integrated into the AI system from the outset. This includes minimizing data collection to only what is necessary for the system's function and ensuring that all data is anonymized and encrypted where possible (Crawford et al., 2019). Additionally, businesses must perform thorough risk assessments to understand the potential impact of AI systems on privacy, particularly when handling sensitive personal data. As a result, businesses must comply with relevant privacy laws, such as the Protection of Personal Information Act (POPIA) in South Africa and the GDPR in the EU, to safeguard individual privacy rights (Binns, 2018).

**d. Beneficial AI**

Beneficial AI refers to AI technologies that are designed and used to positively impact society, ensuring that their deployment does not harm individuals or communities. Beneficial AI emphasizes human dignity, safety, sustainability, and overall societal well-being (Floridi et al., 2018).

***Factors that Give Rise to Concerns about Beneficial AI***

Concerns about the benefits of AI arise when AI systems are designed without fully considering their long-term societal impact. For example, AI applications in automation and robotics may lead to job displacement and exacerbate economic inequalities. Additionally, without adequate oversight, AI can be used for malicious purposes, such as surveillance or decision-making that disproportionately impacts marginalized communities (Rahwan, 2017). The rapid pace of AI development also creates uncertainty about its unintended consequences, which can undermine its potential benefits if not managed responsibly.

***Governance considerations to foster beneficial AI***

To ensure AI is beneficial, businesses should focus on human-centered design, ensuring that AI technologies prioritize the well-being of individuals and communities. This involves conducting thorough impact assessments to evaluate the potential social, economic, and implications of AI systems. Furthermore, businesses should engage with a diverse range of stakeholders, including those from marginalized communities, to ensure that AI benefits are distributed equitably. Financial wellness and job retraining programs should be considered to support workers displaced by AI technologies (Crawford et al., 2019). Lastly, AI systems should be continuously monitored to assess their long-term impacts on society and adjust as needed.

**e. Responsible AI**

Responsible AI refers to the use of AI technologies in a way that is accountable, transparent, and aligned with societal values. It emphasizes the importance of building trust in AI systems by ensuring that they are fair, explainable, and used in a manner that respects human rights and dignity (IEEE, 2019).

***Factors that Give Rise to Concerns about Responsible AI***

Responsibility concerns in AI arise from the lack of explainability and accountability in decision-making processes. Many AI systems operate as black boxes, where the rationale behind their decisions is not fully understood by developers, regulators, or the public. This lack of transparency makes it difficult to assign accountability when AI systems make harmful decisions or errors (Crawford, 2017). Additionally, as AI systems become more autonomous, it becomes increasingly challenging to determine who is responsible for their actions, particularly when AI systems interact with other technologies or systems (Elish, 2019).

***Governance considerations to achieve Responsible AI***

To ensure responsible AI, businesses must implement clear accountability frameworks that define who is responsible for the decisions made by AI systems. This includes establishing clear boundaries for AI use and ensuring that developers and business leaders understand their roles and responsibilities. AI systems should also be designed to be explainable, with transparent decision-making processes that can be easily audited by independent parties (Binns, 2018). Continuous monitoring and evaluation of AI systems are essential to ensure that they remain aligned with standards and societal expectations. Businesses should also provide regular reports on the performance and implications of their AI systems to stakeholders and regulatory bodies (Ananny & Crawford, 2018).

## 13.6 Examples of AI-powered ESG Applications

AI-powered ESG have been explored by several literatures and across different areas especially with companies and institutions leveraging AI to enhance sustainability. For instance, while investigating the applications of ML and AI in ESG Sector, Gupta and Agarwal (2024) argued that AI applications in ESG exist in optimizing processes for environmental performance, improving social/community performance, and good governance practices. Hence, integration of AI into ESG provides accurate carbon footprint management, resource utilization, community engagements in terms of diversity and inclusion, and regulatory compliance. Ukoba et al. (2024) examined the integration of 4IR and how it can be leveraged to achieve energy transitions and net-zero emissions. They found that 4IR presents a transformative opportunity to confront the dual challenges of achieving universal energy access and net-zero emissions goals. Lim (2024) explored the integration of AI in finance to ESG.

Furthermore, some prominent organizations that have leveraged AI to enhance their ESG initiatives are Googles, Unilever, Microsoft and KPMG. Marr (2024) mentioned that Google implemented AI to analyse satellite imagery for disaster response, as a result improving efficiency of relief efforts by generating accurate maps of areas affected by its activities. Microsoft leveraged AI-driven tools to track and reduce carbon emissions across its operations, tackle environmental challenges by designing projects that monitor biodiversity, optimize agricultural practices, and model climate changes (CSE, 2024) In addition, Unilever is able to minimize its environmental impact by integrating AI into its Sustainable Living Plan (SLP). The company employed predictive analytics, to optimize its supply chain processes, and as a result reduce its waste and water usage. They equally collaborates with startups like Sourcemap to utilize AI for tracking the sustainability practices of their suppliers, and with this they were able to address sustainability issues throughout their supply chain effectively (Unilever, 2023).

## 13.7 Ethical considerations for 4IR usage in ESG reporting

Ethical considerations of 4IR integration into ESG is crucial and as such goes beyond mere academic discourse as it can bear significant real-world repercussions. Moreover, despite the myriads of unprecedented promising benefits of integrating 4IR into ESG frameworks, numerous challenges still exist. Most prominent among these are issues surrounding data quality, regulatory compliance, and the technical expertise (Gupta & Agarwal, 2024). Equally important is the algorithm transparency and explicability of these algorithms, which are essential for sustaining public trust, especially in high-stakes disciplines like medicine or law. Another important area is the chal-

lenge of circumventing ingrained biases often found within the AI systems. These challenges must be addressed to ensure responsible and successful utilization. Given these discussions, the need for an ethical AI is driven not just by the mere imperatives of harm prevention and justice, but also by the strategic objective of nurturing sustainable, socially beneficial, and universally accepted innovation.

Below is a comprehensive explanation of these ethical issues:

**a. Data integrity and quality**

Data privacy is one of the most prominent issue often raised in AI integration within systems (Radanliev, 2025). The accuracy of AI-driven ESG assessments is strongly dependent on the quality of the data used. Poor-quality or inadequate data might produce biassed results, which may misrepresent a company's ESG performance. This is particularly concerning in emerging economies where data transparency is often deficient. Ethical constraints need rigorous validation techniques to verify and ensure that the AI models' data is reliable, accurate and complete. Organisations must create systems that will enable them to periodically analyse and enhance data quality in order to prevent misleading stakeholders and making ill-informed decisions.

**b. Bias in AI Algorithms**

Greif et al. (2024) noted that the results of complex AI algorithms can be strongly distorted by data bias because most AI applications especially those involving deep learning often function as "black boxes," a situation where the decision-making processes of the system are not transparent. Besides, Holzinger et al. (2019) had earlier mentioned that deep learning models though do achieve high performance, but their internal representations are often too complex for humans to understand, thus, making it difficult to interpret why a model arrived at a particular decision. It is equally important to bear in mind that AI systems can inherit biases from their training datasets, and this could lead to discriminating results. For example, if an AI model is trained on historical data that reflects existing social disparities, it may extend similar biases in its predictions and evaluations. This raises critical ethical concerns, particularly when assessing social responsibility measures within ESG frameworks. To reduce this risk, organisations need to prioritise fairness by employing diverse datasets and undertaking regular audits of their AI systems to detect and correct biases (Global Custody Pro, 2024).

Another issue pertaining to bias as observed by Holzinger (2018) is that most AI models are designed to optimize performance metrics like accuracy, at the expense of interpretability. This trade-off often makes it hard to offer explanations that are accurate and understandable in specific contexts, especially in areas of environmental sustainability where stakeholders need to see how different environmental factors interact and contribute to the model outputs (Greif et al., 2024).

Other AI algorithm biases can stem from data deficiencies – a bias that may arise due to errors or uncertainties in the data collection methods; demographic homogeneity – where models are trained on limited population diversity; spurious correlations –

a situation where proxy variables correlates with protected attributes; improper comparators – where unfair benchmarking groups reinforces disparities and cognitive biases – where the designers' skewed assumptions and thinking are embedded in systems (Murikah et al., 2024).

**c. Privacy Concerns**

Privacy and data protection according to Radanliev (2025) are critical ethical considerations that must be considered during AI development since privacy is concerned with protecting personal and sensitive information from unauthorized access, and ensuring data are used responsibly. Regulations such as POPIA would play a critical role in shaping AI ethics by setting strict guidelines for data usage. Worthy of note also is that privacy, fairness, and user trust are interconnected. Hence, protecting user privacy is crucial in building and maintaining user trust, which is equally essential for the acceptance and success of any AI systems. Furthermore, ensuring the proper handling of data is vital for fairness, because data misuse can lead to biased outcomes. Besides, the gathering and sorting of large amounts of data often raises serious privacy concerns (Global Custody Pro, 2024). Moreover, AI systems often demand access to sensitive data, which can lead to misuse or unauthorised access if not adequately handled. As a result, ethical criteria must be set to preserve users' privacy rights while also allowing organisations to collect the data required for effective ESG analysis. This includes following standards like the POPIA Act and the European GDPR while still employing strong security measures to protect personal information (Global Custody Pro, 2024).

**d. Transparency, Explainability and Clarity**

Transparency is critical for establishing trust in AI-powered ESG assessments since AI algorithms are often thought of as "black boxes," making it difficult for stakeholders to comprehend how decisions are reached. Transparency can be a cornerstone of AI ethics because transparent AI systems will allow stakeholders to understand how decisions are made and ensure accountability. Transparency refers to the accessibility of the AI systems and their workings to users and stakeholders. While explainability refers to the ability of AI systems to be understood and interpreted by humans. Clarity on the other hand ensures that AI systems' purposes and outcomes are communicated in a straightforward and understandable manner (Radanliev, 2025). These factors are interconnected and must be prioritized when developing an AI system to ensure ethical development and deployment. Besides, the factors are crucial in building and maintaining user trust, ensuring that AI systems operate understandably and predictably. Besides, transparency and explainability play a pivotal role in establishing accountability, thus, ensuring that AI developers and users are held responsible for the outcomes of AI systems (ISO, 2023; MeitY, 2023; Radanliev, 2025).

Given the above, it is therefore important for companies to work by ensuring their AI processes are understandable by providing detailed documentation on the functionality of the AI algorithms, the data they use, and the reasoning behind their

decisions. Ensuring that stakeholders understand the decision-making process, develops trust while also allowing for the detection of potential biases or flaws in the system.

**e. Accountability**

As businesses increasingly rely on AI to perform ESG assessments, accountability becomes imperative, as there must be explicit lines of accountability for the outputs produced by AI systems. Why, because without clear accountability structures, it will be difficult to address failures or harms caused by AI systems (Mittelstadt, 2019). But where accountability exists, it would help to ensures that AI developers, operators and users are held responsible for the outcomes produced by the AI systems (Radanliev, 2025). However, in circumstances where AI-driven insights have negative repercussions, such as misrepresenting a business's ESG performance, companies must develop processes that would help to resolve these challenges and correct any harm instituted. This responsibility is critical to upholding ethical norms within corporate governance structures.

**f. Over-Reliance on AI**

Nishant et al. (2020) noted that over-reliance on historical data is a critical issue with AI applications, and such reliance can result to inaccurate prediction of future scenarios, leading to potential inaccuracies in applications (Greif et al., 2024). For instance, an anomaly detection algorithm intended to identify suspicious transactions could end up flagging a greater number of transactions from minority communities if the historical data shows racial disparities (Murikah et al., 2024). This may result to financial algorithms penalizing minorities, predictive policing systems targeting marginalized communities to a greater extent, and facial recognition misidentifying people of colour at significantly higher rates. While AI may boost decision-making processes, there is a risk that companies may become too dependent on these technologies and jeopardise human judgement. For example, over-reliance on AI systems that contains a training dataset that already reflect existing societal biases can spread discrimination (Murikah et al., 2024).

To address over-reliance challenges with AI integration, Radanliev (2025) noted that human oversight in AI decision-making is essential to prevent over-reliance on automated systems, particularly in critical sectors like healthcare and law enforcement. Other researchers who argued from the perspective of auditing stressed that solution to this challenge would require combining technical rigor and ethics to align AI with auditing's public interest duty (Koreff et al., 2023; Landers & Behrend, 2022; Murikah et al., 2024). In addition, Murikah et al. (2024) suggested leveraging more comprehensive data would help to mitigate biases from sampling and over-reliance on internal records.

## 13.8 Ways through which 4IR may contribute to risk mitigation strategies in ESG

4IR contributes substantially to risk mitigation measures in ESG frameworks by improving data analysis, tracking compliance, and enabling proactive decision-making. The following are some vital ways that AI might help mitigate ESG risks:

1. **Improved Data Analysis and Risk Identification**
   AI technology, especially machine learning (ML) algorithms, are adept at digesting large volumes of data from a variety of sources, including company reports, regulatory filings, news articles, and social media. This capacity enables businesses to efficiently detect and assess ESG-related risks. For example, AI can analyse historical data to spot patterns linked with climate change impacts or societal unrest, allowing firms to plan for possible disruptions and alter their strategy accordingly. AI helps organisations estimate risks associated with environmental changes or supply chain vulnerabilities, enabling for prompt responses when they leverage predictive analytics.
2. **Real-Time Monitoring and Compliance Tracking**
   AI systems can track regulatory changes globally and offer real-time updates on rules and regulations. This ongoing monitoring is critical for businesses functioning in dynamic regulatory settings where ESG criteria are ever evolving. AI automates compliance tracking, allowing firms to stay ahead of regulatory obligations and avoid potential penalties for noncompliance. Furthermore, AI can speed up internal audits by automating mundane operations, enabling for more regular and comprehensive reviews of ESG practices. This proactive approach guarantees that businesses may respond rapidly to any anomalies or risky areas.
3. **Scenario Planning and Risk Assessment**
   AI makes scenario planning easier by simulating many future scenarios based on current data patterns. This skill enables organisations to assess the robustness of their business plans against various ESG risks. For example, AI may simulate the effects of climate change on operations or quantify the financial consequences of possible regulatory changes. Organisations can improve resource allocation and implement tailored mitigation plans by prioritising risks based on their potential impact and likelihood.
4. **Customized Risk Management Solutions**
   AI enables the design of unique risk management solutions that address distinct sector issues associated with ESG concerns. By analysing company-specific data with market dynamics, AI can deliver actionable insights for efficiently minimising ESG risks1. Companies in high-polluting industries, for example, can use AI-driven data to optimise their operations and minimise their carbon footprint while staying on track with climate-related ESG targets.

5. **Stakeholder Engagement and Communication**
   AI improves stakeholder involvement by analysing communications and detecting areas where stakeholder rights are at risk. This analysis enables businesses to match their activities with ethical governance standards. Furthermore, AI can help with crisis communication management during ESG-related catastrophes by quickly generating communication strategies that retain stakeholder trust.
6. **Integration into Decision-Making Processes**
   The use of AI into decision-making processes aids risk mitigation by offering data-driven insights that guide strategic decisions. AI systems may simulate different risk scenarios and provide effective mitigation techniques based on comprehensive data analysis. This capacity enables decision-makers to make informed decisions which are consistent with both business objectives and sustainability goals.

## 13.9 Conclusion

The integration of ESG principles with advanced technologies marks a significant milestone in corporate responsibility and accountability. As stakeholders increasingly demand transparency regarding sustainability practices, organizations must adapt their reporting frameworks to reflect these expectations while leveraging technology to enhance their capabilities. Although, the journey towards effective ESG integration is not without challenges; yet it presents an opportunity for businesses to align their operations with broader societal goals while fostering long-term corporate performances. Besides, the Fourth Industrial Revolution (4IR) represents an unparalleled fusion of physical, digital, and biological systems, driven by technologies like Artificial Intelligence (AI), blockchain, robotics, and the Internet of Things (IoT). While these innovations offer transformative opportunities, they also present significant governance challenges, particularly concerning ethics, equity, and sustainability. Other challenges are the need for transparency in decision-making processes, bias in AI algorithms (i.e., machine bias), privacy concerns, and issues concerning data quality. Businesses must as a matter of cruciality navigate these complexities for aligning 4IR with existing governance structures while ensuring compliance with diverse regulatory requirements.

This chapter therefore highlights that integrating ESG principles into 4IR governance is not just a moral imperative but a strategic necessity to enhance ESG for any business. Hence, by prioritizing transparency, addressing machine bias, safeguarding privacy, and ensuring responsible and beneficial AI, businesses can align technological capabilities with sustainable development goals. As a matter of fact, ethical justifications necessitate that AI should enhance, not replace humans expertise in ESG assessments. It is imperative to note that an integrated approach that combines human

expertise with AI capabilities will assist to ensure that key details are not neglected when evaluating the ESG concerns.

Given this submissions and in response to the ethical considerations, an AI governance principles tailored towards the African context need to be developed in agreement with (Crawford et al., 2019). In fact, the governance principles should aim as follow:

1. Define the concerns associated with AI use, such as transparency, bias, privacy, and accountability (Mittelstadt et al., 2016).
2. Establish clear governance processes to address these concerns, specifying roles and responsibilities for monitoring and oversight, that will assist in aligning technological capabilities with ESG goals.

## Key takeaways:

1. *Transparency:* By fostering open disclosure and explainability, organizations can build trust and accountability around AI systems, mitigating the risks associated with opaque "black-box" algorithms.
2. *Bias Mitigation:* Proactive strategies to address bias in AI datasets and processes are essential for ensuring equitable outcomes, reducing societal inequities, and enhancing system fairness.
3. *Privacy Protections:* Embedding privacy-by-design principles into AI operations safeguards sensitive data, aligns with regulatory requirements, and strengthens consumer trust.
4. *Beneficial AI:* A commitment to societal well-being requires AI systems to focus on inclusive growth, equitable benefit distribution, and mitigating negative externalities such as job displacement.
5. *Responsible AI:* Accountability frameworks and regular audits ensure that AI applications are ethical, explainable, and aligned with stakeholder expectations.
6. *Strategic Implications*: As the regulatory landscape evolves and stakeholder scrutiny increases, organizations must prioritize ESG-aligned governance to remain competitive and resilient. Effective governance not only addresses risks but also enhances financial performance, bolsters investor confidence, and solidifies long-term societal value. Importantly, region-specific governance frameworks particularly in the contexts of Africa, they are crucial to addressing unique challenges and fostering inclusive growth.

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