Challenges, Prospects, and Strategic Directives for African Countries to Harness the Disruptive Capabilities of the Fourth Industrial Revolution (4IR)

Gaelle Fitong Ketchiwou* Patrick Ngulube**

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Abstract

The Fourth Industrial Revolution (4IR) has been at the center of several economic and political debates in recent years. This is because of its capacity to significantly disrupt every life, economic sector, and industry. The problem is that when compared to the West, there has been limited literature on 4IR in Africa, and the continent has yet to embrace the revolution in full. The purpose of this article is to explore the challenges, prospects, and strategic directives for African countries to harness the disruptive capabilities of the 4IR. This qualitative study used a narrative literature review approach. Journal articles constituted the sample for the study. A manual thematic analysis approach was used to analyze data. Findings reveal that despite the social, institutional, economic, and environmental challenges, the 4IR comes with a myriad of social, institutional, economic, and environmental benefits for Africa. However, for Africa to overcome existing challenges and harness the opportunities of the 4IR, employers, educational institutions, and governments in the continent need to play a strategic role. This study contributes to the limited academic literature on the 4IR in Africa. Findings from this article can inform policies around the 4IR in African countries. Results also provide practical strategic directives for African employers, educational institutions, and governments to harness the disruptive capabilities of the 4IR.

Keywords: *Fourth Industrial Revolution, Strategic Directives, Disruptive Capabilities, Africa*

Introduction

The heated global debate around the 4IR is warranted by its noticeable impact on different aspects of human life (World Economic Forum, 2023). Even though knowledge about the 4IR is

* Central University of Technology, South Africa. E-mail: fitong@unisa.ac.za

** University of South Africa. E-mail: ngulup@unisa.ac.za

currently primitive and immature in many sectors, the 4IR is gaining traction across different sectors (Masinde & Soux, 2020), causing immense disruption to skills (Chamola *et al*., 2020; Dagnaw, 2020). The 4IR is in motion, hence businesses and policymakers across the world are responding to it so that they will not be left behind (Mentan, 2018; Soh & Connolly, 2020). African countries have begun to embrace the revolution, and governments are working with private sector players to prioritize the 4IR within their economies (Bayode *et al*., 2019; Manda & Dhaou, 2019).

Research Problem, Objective, and Research Questions

Prior research reveals that both developed and developing countries are unprepared for the vast socioeconomic disruptions accompanying the 4IR (Rotatori, Lee, & Sleeva, 2021; World Economic Forum, 2023). However, when compared to Western countries, Africa lags in the transition to the 4IR (Mamphiswana & Bekele, 2020; Oxford Insights, 2023) and is not yet prepared to face the 4IR revolution (Arakpogun *et al*., 2021; Uleanya & Ke, 2019). Developed countries intend to sustain their economies, find markets, and create space for their populations through the capabilities of the 4IR, a move which, similarly to previous revolutions, has no African as an equal counterpart (Saidi, 2022; Uleanya & Ke, 2019). During earlier revolutions, developed countries created an uneven platform where developing countries had to rely heavily on them for finance, markets, technology, and survival (Saidi, 2022). This resulted in Africa's overreliance on advanced economies. The failure of previous global moves to improve the largest parts of Africa indicates an urgent need for informed and critical rethinking in the current revolution (Mentan, 2018; Saidi, 2022). The narrative needs to change. Indeed, Europe and America will amass immediate gains from the 4IR (Schwab, 2016; World Economic Forum, 2023). Unless African countries use proactive approaches to face the 4IR, they may not be able to leverage its benefits.

The purpose of this article is to explore the challenges, prospects, and strategic directives for African nations to harness the disruptive capabilities of the 4IR. This narrative literature review article answers three broad research questions (Synder, 2019): What challenges hinder African countries from embracing the 4IR? What opportunities does the 4IR present for African countries? What are the future directives for African countries to fully leverage the 4IR?

The following section situates the study in a theoretical context. This is followed by a literature review and methodology. After that, the findings are presented and discussed, and concluding remarks are made. Finally, the paper ends with the study's contribution, limitations, and recommendations for further studies.

Literature Review

Theoretical Underpinning

The diffusion of innovation theory provides a theoretical background for this paper. This theory seeks to explain how, why, and at what rate technology and new ideas spread. The diffusion of innovation theory helps to predict how people make decisions to adopt an innovation through their adoption patterns and their understanding of its structure (Rogers, 1995). The theory encapsulates specific characteristics of innovation and its benefits, which are used to explain why users adopt innovation or how they decide to adopt it (Durac *et al*., 2023; Indah & Abdul, 2023; Min *et al*., 2018). This theory is ideal for this article because it provides the lens to understand the rationale for spreading and adopting innovative technologies in Africa, which is critical for harnessing opportunities of the 4IR in the continent. This section discusses 4IR technologies and skills, challenges, opportunities, and approaches to leveraging their benefits.

The 4IR technologies and skills

The world has experienced four major revolutions (Schwab, 2016), each building on the development of the preceding revolution with more significant socioeconomic and political implications for Africa. The First Industrial Revolution happened around the 18th century and was characterized by mass production through the application of science and technology to the natural and raw resources obtained by the West through the conquest of underdeveloped countries of Asia and Africa. The Second Industrial Revolution began around the 19th century with the development of new energy sources to support the exploitation of mineral resources and the growth of international trade and collaborations. Machines increasingly replaced workers, and the transition from subsistence crops to cash crops had significant socioeconomic implications on populations (Xu, David & Kim, 2018), including Africa (Dagnaw, 2020; Mamphiswana & Bekele, 2020). Around the 1950s, the knowledge-based industrial revolution emerged. This Third Industrial Revolution was characterized by the internet, semiconductors, the

use of electronics, computing, and the development of nuclear power, which emanated from previous technological developments in manufacturing, energy discovery, and distribution (Schwab, 2016).

At the dawn of the 21st century, a more impactful, aggressive, and far-reaching revolution began called the Fourth Industrial Revolution (Schwab, 2016). This revolution denotes a system of devices that are linked through the internet to convey data autonomously (Mhlanga, Ndhlovu & Hofisi, 2021). This revolution combines physical and digital advancements in technologies and technological developments at an unprecedentedly exponential pace (Anderson, 2018; Dagnaw, 2020; Qi, Chen, Li, Cheng & Li, 2019) with positive spins on all key industries (Adams, 2018; Xu, David & Kim, 2018). It also connotes new opportunities, ideas, and inventions that promise to solve societal challenges through emerging technologies (Micheni *et al*., 2021; Schwab, 2016). Modern industry 4.0 technologies include the Internet of Things, big data, simulation, cloud computing, blockchain, augmented or virtual reality, additive manufacturing, automation, artificial intelligence, internet, and cyber-physical systems (Bayode *et al*., 2019; Micheni *et al*., 2021; Ndhlovu & Dube, 2023; Yusuf, Abubakar & Baba, 2020). These technologies are often referred to as "smart" (Dagnaw, 2020; Distor, Campos Ruas, Isagah & Dhaou, 2023; Signé, 2022). The use of emerging technologies requires versatile skills such as agility, adaptability, critical thinking, cognitive abilities, problem-solving, information, communication and technology, automation, coding and programming, system thinking, data analysis, social media skills, creativity, innovation, analytical thinking, active learning, emotional intelligence, computer-based competencies, and teamwork (Chaka, 2020; Chopra & Purohit, 2022; Reaves, 2019; Schwab, 2016; World Economic Forum, 2023). These are imperative skills for the 4IR and are classified as the 4IR skills.

Challenges of the 4IR

The African continent faces several economic, socio-cultural, legal, environmental, political, and institutional challenges in its quest to embrace the 4IR (Distor *et al*., 2023). As technology, machines, and digitization replace low-skilled and low-pay jobs, the workforce becomes obsolete (Barclay, 2018; Mamphiswana & Bekele, 2020), leading to segregated job markets (Mpungose, 2020a), mass job displacements (Arakpogun *et al*., 2021) and increased unemployment within the continent (Barclay, 2018). As jobs become scarce (Mamphiswana & Bekele, 2020), workers

become prone to stress and pressure (Barclay, 2018). Job losses also perpetuate existing inequalities, threaten social cohesion (Arakpogun *et al*., 2021; Mamphiswana & Bekele, 2020), and further marginalize the poor (Barclay, 2018). These factors are magnified by the political instability and limited support from political leaders in the continent (Distor *et al*., 2023).

When compared to other continents, the deindustrialization of the African economy has retarded the continent's adoption and use of 4IR technologies (Mamphiswana & Bekele, 2020). Also, there is a lack of skill required to develop and implement technologies of the 4IR (Bayode *et al.*, 2019; Distor*et al*., 2023). This is coupled with the lack of finance to acquire the 4IR technologies (Andreoni & Anzolin, 2019; Bayode *et al.*,2019), as well as the limited financial viability of governments to fund the 4IR projects (Distor *et al*., 2023). People are also resistant to new technologies within the workplace (Bayode *et al.*,2019) due to the lack of trust in systems and risk aversion mindsets (Distor *et al*., 2023). In addition, there is a lack of governance policies, models, strategies, and institutional capacity to implement the 4IR technologies, especially for start-ups in Africa (Arakpogun*et al*., 2021; Mhlanga *et al.*, 2021), as there are often limited collaboration networks with more experienced firms (Distor *et al*., 2023).

The development and deployment of technologies are slow in developing countries (Oxford Insights, 2023), and some technologies have been said to be biased and discriminatory against Africans due to their absence in technology development processes (Mitchell, 2019). Likewise, the adoption and spread of the 4IR technologies have been constrained by limited access to resources such as technological devices, data, and data-sharing platforms (Dagnaw, 2020; Mamphiswana & Bekele, 2020), electric power, and the internet, (Bayode *et al.*,2019; Yusuf *et al*., 2020). Although internet connectivity is vital for the use of modern technologies, sub-Saharan Africa has one of the lowest mobile penetration rates globally (Mamphiswana & Bekele, 2020). There are also limited broadband and ICT infrastructure, and the existing digital divide poses a significant challenge in Africa (Andreoni & Anzolin, 2019; Arakpogun*et al*., 2021; Bayode *et al.*, 2019), resulting in limited access, affordability, and ability to use (Distor*et al*., 2023). Moreover, the increasing use of interconnected technological devices has created data breaches and loss of control over networks, exposing individuals, organizations, and countries to hacking and cybersecurity concerns (Ajibade & Mutula, 2020; Bayode *et al*., 2019).

The 4IR technologies have a negative impact on humans and the environment (Distor *et al*., 2023; Liu & Stephen, 2019) that may leave Africa more vulnerable than it already is. Several African countries are still trying to adapt to the 4IR; hence, the legal and regulatory guidelines are not yet clear, resulting in legal, ethical, and implementation hurdles (Arakpogun*et al*., 2021; Dagnaw, 2020).

Opportunities of the 4IR

Notwithstanding its challenges, the 4IR allows African customers to access a variety of customized and affordable high-quality products and services that solve local problems (Ajibade & Mutula, 2020; Andreoni & Anzolin, 2019; Dagnaw, 2020; Mamphiswana & Bekele, 2020; Owoseni & Twinomurinzi, 2020) and improve living standards (Arakpogun *et al*., 2021).

The 4IR also has the potential to stimulate the development of vital 4IR skills (Saidi, 2022; Mpungose, 2020a). It creates jobs for emerging careers (Mamphiswana & Bekele, 2020; Saidi, 2022), thereby guaranteeing dependable income and purchasing power and reducing poverty and inequality on the continent (Andreoni & Anzolin, 2019; Arakpogun *et al*., 2021; Manda & Dhaou, 2019).

Moreover, the adoption of emerging technologies contributes to data availability, and data generation and improves business processes, thereby enhancing productivity, profitability, efficiency, and effectiveness (Ajibade & Mutula, 2020; Dagnaw, 2020; Distor *et al*., 2023; Mamphiswana& Bekele, 2020; Owoseni&Twinomurinzi, 2020). This, in turn, reduces costs and ensures sustainability (Andreoni & Anzolin, 2019; Owoseni & Twinomurinzi, 2020). The use of modern technologies can give companies access to new markets and industries (Dagnaw, 2020; Mamphiswana & Bekele, 2020). Modern technologies can also help minimize waste and preserve the environment (Andreoni & Anzolin, 2019). Therefore, the 4IR has the potential to drive socioeconomic development within the African continent (Arakpogun*et al*., 2021; Dagnaw, 2020; Mamphiswana & Bekele, 2020).

Leveraging the benefits of the 4IR

To leverage the 4IR in Africa, governments need to plan, budget, finance, and execute 4IR technologies and projects (Dagnaw, 2020; Distor *et al*., 2023; Mpungose, 2020b; Owoseni & Twinomurinzi, 2020). Likewise, there is a need for multi-sectoral collaboration and leadership at

different levels to promote emerging technologies, innovation, and 4IR projects (Arakpogun*et al*., 2021; Distor*et al*., 2023). African governments should also invest in research and development to build capacity for the 4IR (Ajibade & Mutula, 2020; Arakpogun*et al*., 2021). This may require the identification of promising sectors to invest in and protect them while developing skills for emerging sectors (Mamphiswana & Bekele, 2020; Saidi, 2022). There is also a need to develop enabling infrastructures (e.g., ICT, internet, electrical power, technological devices) to accommodate digital transformation in education and industry (Bayode *et al.*, 2019; Mpungose, 2020b; Yusuf *et al*., 2020).

Governments and employers need to create awareness and educate people on the importance of 4IR technologies to promote adoption and use (Ajibade & Mutula, 2020; Dagnaw, 2020; Mamphiswana& Bekele, 2020; Mpungose, 2020a). Emphasis should be on lifelong learning initiatives that will help Africans solve contemporary challenges ethically (Ajibade & Mutula, 2020; Marwala, 2019; Molele, 2019; Owoseni&Twinomurinzi, 2020; Yusuf *et al*., 2020). For this to happen, the education sector has a key role to play. There is a need to continuously reconceptualize teaching towards quality outcome-based education that meets market requirements (Bayode *et al.*, 2019; Mpungose, 2020b; Yusuf *et al*., 2020). It is also important to decolonize the African curriculum and incorporate artificial intelligence in all courses (Molele, 2019). Partnerships between educational institutions and local or international entities (public or private) can help learning institutions access a variety of technologies and develop 4IR competencies needed to meet industry demands (Arakpogun *et al*., 2021; Mpungose, 2020b; Ogbuanya, Njoku, Kemi & Ogunkelu, 2018; Saidi, 2022).

It is important to create a sound political (Saidi, 2022), economic and social environment (Mamphiswana & Bekele, 2020) where 4IR businesses can strive. Government support for innovation and digitalization has become vital in this era (Ajibade & Mutula, 2020). It is equally important for African governments to promote local content for indigenous technologies and local innovations that solve African problems (Arakpogun *et al*., 2021; Saidi, 2022). Institutional policies and models should be adopted to support the 4IR technologies in Africa (Arakpogun *et al*., 2021). Relevant policy reforms and governance guidelines are needed to promote the ethical use and implementation of the 4IR technologies (Bayode *et al.*,2019; Distor *et al*., 2023;

Owoseni & Twinomurinzi, 2020), protect vulnerable human industries, and promote social justice (Saidi, 2022).

Research Methodology

This section covers the research design, population, sample, data collection, and data coding and analysis.

Research design

The choice of a qualitative methodology using an interpretive paradigm (Creswell & Creswell, 2018; Neuman, 2014) allowed the researchers to understand linkages and knowledge related to the challenges, opportunities, and directives for African countries in the 4IR (Marshal *et al*., 2022). A narrative literature review method was employed in this study.

A narrative review follows an informal process that is not constrained by predetermined selection criteria (Fan *et al*., 2022) but adapts a process of discovery (Snyder, 2019) that assists in answering the research question. A rigorous literature review should include the purpose of a review, data selection process, assessment and synthesis approach, and reporting and findings (Kunisch *et al*., 2018; Synder, 2019). The following two sections describe this in detail. Narrative reviews are appropriate when reviewing a topic across diverse settings, domains, silos, and disciplines (Breslin & Gatrell, 2020; Hoon & Baluch, 2020; Synder, 2019; Wong *et al*., 2013) to identify common directions, paths, and patterns across the different literatures for integration (Elsbach & van Knippenberg, 2020) within a limited timeframe (Creswell & Creswell, 2018; Marshal *et al*., 2022). This approach allowed us to review only articles that are relevant to answer the research questions more powerfully than single studies would have. This presents risks of implicit author biases, systematicity, and thoroughness, potentially resulting in flawed arguments or selective assumptions (Fan *et al*., 2022; Snyder, 2019). To address these limitations, the researchers stressed that accuracy, precision, trustworthiness, and replicability (Snyder, 2019) reflect credibility, rigor, transparency, generativity, and scope (Fan *et al*., 2022). Accuracy and procedural justification were ensured by describing the research steps in detail to ensure reproducibility and transparency. Using a predesigned codebook ensured consistent coding across the board, ensuring quality and reliability. Although the inclusion and exclusion criteria could exclude relevant studies, leading to flawed conclusions, the methodological transparency and rationale enable readers to understand the processes followed in the

identification, analysis, synthesizing, and reporting, thus ensuring trustworthiness (Synder, 2019; Wong *et al*., 2013). Unlike other literature review approaches, much still needs to be learned about the methods to be employed by narrative review scholars; however, its current limitations could be addressed through the adoption of a transparent and reflexive approach (Fan *et al*., 2022), as described in the following two sections.

Population, Sampling, and Data Collection

Considering the primacy of methodological transparency in literature reviews, we present our search and selection criteria in terms of steps, decisions, and judgment during the scientific study (Fan *et al*., 2022). The sample for this literature review is articles collected through a database (Synder, 2019). We used the Google Scholar database, a reliable and accessible web search engine that indexes scholarly literature from various publishers and disciplines. As advised by Synder (2019), a pilot test was conducted (on five articles) to test the search terms and criteria. Thereafter, the search terms were refined, together with the order of analysis and codebook. The final search terms used were "opportunities" or "advantage," "challenges" or "problems," "future" or "directive" or "recommendation," and "fourth industrial revolution" and "Africa" or "African country." This yielded search results of about 1,500 articles. The inclusion criteria (Synder, 2019) were open-access articles written in English and published in peer-reviewed journals from 2018 to 2023. Exclusion criteria (Synder, 2019) were books, conference proceedings, working papers, non-journal articles, articles not written in English, and articles published before 2018 or after 2023. When refined to specifically include articles that addressed the research objectives, such as challenges, opportunities, and directives for the 4IR in Africa, the potential articles narrowed down to 375 articles. Synder (2019) recommended that the reviewers read the titles and abstracts of articles to ascertain relevance before proceeding to read the full text. Finally, 26 articles were accessible for selection for the study that met the criteria stipulated above and were supported by the researchers' judgment that these articles would help them answer the predetermined research questions (Synder, 2019). See Table 2 of the Appendices.

Data Coding, Synthesis, and Analysis

We used a thematic analysis method for identifying, analyzing, and reporting patterns ideal for narrative reviews (Synder, 2019). Data extracted from the final sample (Synder, 2019) included authors' names, article titles, years of publication, journal names, challenges, opportunities, and recommendations on the 4IR. Findings were then coded using a codebook to ensure consistency in coding and theme formation (Fan *et al.*, 2022; Synder, 2019). We used an incremental expansion of knowledge approach through a snowballing approach during the review process (Fan *et al.*, 2022), which led to the researchers answering the research questions by drawing similarities (see Table 3) to form themes presented in Figure 1 and discussed in the discussion section.

Findings and Dicussions

Findings reveal that the 4IR presents social, institutional, economic, and environmental challenges and opportunities in Africa. Directives for the future, presented in Figure 1, point to the important role of employers, educational institutions, and governments in harnessing the capabilities of the 4IR in Africa.

Figure 1. Challenges, opportunities and strategic directives for Africa to harness the disruptive capabilities of the 4IR

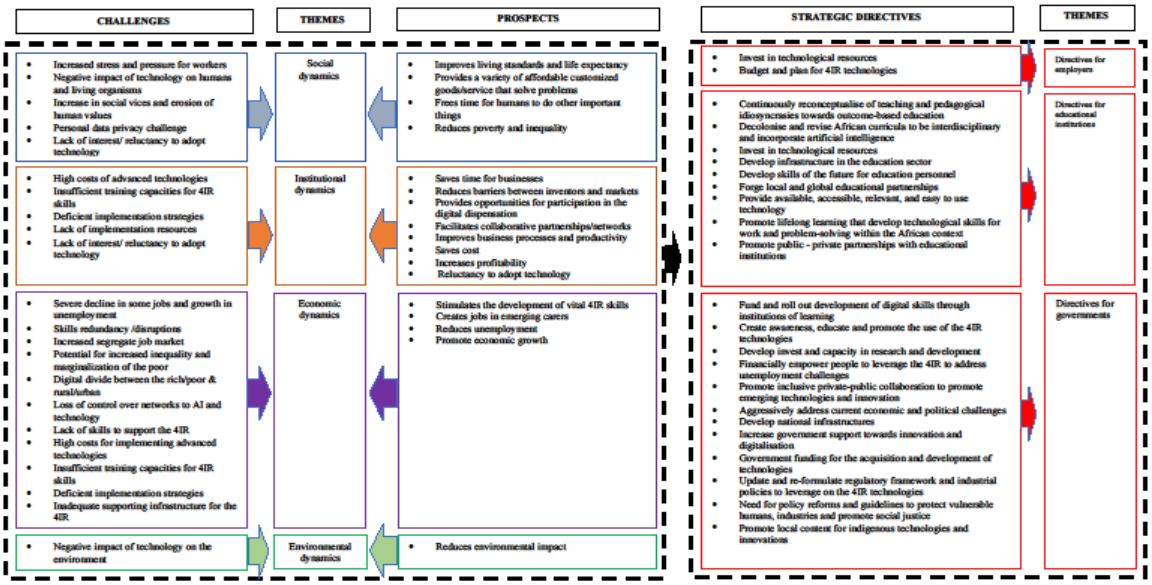

Figure 1 was developed by authors

Discussion

The purpose of this paper was to explore the challenges, prospects, and strategic directives for African countries to harness the disruptive capabilities of the 4IR. Findings reveal that Africa still experiences social, institutional, economic, and environmental challenges in embracing the 4IR. However, several opportunities can be leveraged if employers, educational institutions, and governments strategically promote the 4IR agenda in the continent. This section discusses the themes presented in Figure 1 in the context of existing academic discourse.

Challenges of the 4IR

Social challenges

Findings from this review reveal that the disruptive nature of the 4IR poses threats to the mental health of workers through increased pressure and stress. Prior research confirms that transformation in the workplace affects the mental wellbeing of workers (Arakpogun *et al*., 2021; Barclay, 2018; Mamphiswana & Bekele, 2020). Likewise, findings from this article show that technological experiments and mutilations could hamper living organisms and create genetic diseases and malformations, negatively impacting living beings. This has been confirmed by previous research claiming that the 4IR technologies can negatively impact humans and the environment (Distor*et al*., 2023; Liu & Stephen, 2019). In addition to the above, this article finds that the increasing use of technology promotes social vices and erodes human values. Past researchers affirm that the 4IR threatens social cohesion (Arakpogun *et al*., 2021; Mamphiswana & Bekele, 2020). Moreover, the data privacy challenge revealed in this study is in line with previous research confirming that the interconnectedness of technological devices creates a loss of control over networks, thereby subjecting individuals, organizations, and countries to cyber security concerns (Ajibade & Mutula, 2020; Bayode *et al.,* 2019). At the same, this review also highlights the lack of interest and reluctance to adopt emerging, which was confirmed by Bayode *et al. (*2019) and Distor *et al. (*2023). Overexposure, overreliance, addiction, and loss of human control of technology can hamper the social and mental wellness of humans on the continent.

Institutional challenges

This study highlights the high costs of advanced technologies, deficient implementation resources and strategies, and reluctance to adopt the technology. Prior research confirms that insufficient

finance limits the acquisition, adoption, and spread of 4IR technologies in Africa (Andreoni & Anzolin, 2019; Bayode *et al.,* 2019; Distor *et al. (*2023). Arakpogun *et al. (*2021) also confirm the lack of institutional capacity to implement 4IR technologies, while Arakpogun *et al. (*2021) and Dagnaw (2020) confirm implementation hurdles linked to resources and capacity. Bayode *et al. (*2019) and Distor *et al. (*2023) also affirm the reluctance to change and new technologies. African institutions cannot fully optimize and capitalize on the benefits of AI technologies.

Economic challenges

Our results highlight a severe decline in some jobs and higher levels of unemployment, job segregation, skills disruptions, increased inequality, digital divide between the rich and the poor and rural and urban areas, loss of control over networks, inadequate skills, insufficient training capacity, high cost of advanced technologies, deficient implementation strategies and limited infrastructural support for the 4IR. Previous scholars confirm that the 4IR could increase unemployment levels (Arakpogun *et al*., 2021; Barclay, 2018; Mamphiswana & Bekele, 2020), segregate job markets (Mpungose, 2020a), thereby perpetuating (Arakpogun *et al*., 2021; Barclay, 2018; Mamphiswana & Bekele, 2020). Likewise, Bayode *et al. (*2019) and Distor *et al. (*2023) confirm the lack of skill required to develop and implement advanced technologies of the 4IR. Other academics also acknowledge the lack of strategy and capacity to implement the 4IR technologies in Africa (Ajibade & Mutula, 2020; Arakpogun *et al.,* 2021), while some scholars express their concerns about data vulnerability and cybersecurity threats to economies and governments (Bayode *et al.,* 2019; Distor *et al.*, 2023). Previous academic discourse confirms the infrastructure challenge, the digital divide (Andreoni & Anzolin, 2019; Arakpogun *et al*., 2021; Bayode *et al.*,2019), and the lack of government funding, which limits the expansion of 4IR technologies and 4IR skills in Africa (Dagnaw, 2020; Distor *et al*., 2023; Mpungose, 2020b). Economic dynamics present major constraints for African countries to leverage the disruptive capabilities of the 4IR.

Environmental challenges

This article highlights the negative impact of technology on the environment, as found by previous scholars (Distor*et al*., 2023; Liu & Stephen, 2019). These elicit major concerns for African countries that cannot afford to add this challenge to their numerous economic, social, and political struggles.

Prospects of the 4IR

Social opportunities

Findings from this review reveal that technological developments can enable Africans to access a variety of quality goods and services and free time for humans to carry out activities that boost their happiness levels and morale. This highlights the potential to improve living conditions and life expectancy. These results are in synchrony with previous research affirming that technological developments of the 4IR provide access to a broad range of goods and services (Ajibade & Mutula, 2020; Dagnaw, 2020; Owoseni & Twinomurinzi, 2020) and improve living standards (Arakpogun *et al*., 2021).

Likewise, findings, as indicated in Figure 1, provide evidence that the 4IR has the potential to create employment, reduce social inequalities, and reduce poverty. This revelation ties in with previous research that commends the role of the 4IR in creating jobs, promoting social equity, and boosting the financial autonomy of individuals and communities (Andreoni & Anzolin, 2019; Manda & Dhaou, 2019). Africa is known for its high levels of deplorable living conditions, low life expectancy, and inequality, yet the 4IR offers opportunities for a different narrative.

Institutional opportunities

Figure 1 reveals that the 4IR presents prospects for improved business processes that can increase productivity, increase profitability, save time, and reduce cost. Distor *et al*. (2023), as well as Mamphiswana and Bekele (2020), confirm that adopting emerging technologies improves the efficiency and effectiveness of business processes and consequently enhances productivity and profitability. Andreoni and Anzolin (2019) and Owoseni and Twinomurinzi (2020) also attest that modern technologies can reduce costs and ensure business sustainability. Moreso, there is evidence from this study that the different avenues and technologies of this dispensation reduce barriers between inventors, collaborators, and markets. This is in line with previous research claims that modern technologies can enable innovative partnerships and collaborations (Arakpogun *et al*., 2021; Distor *et al*., 2023) and facilitate access to new markets (Dagnaw, 2020; Mamphiswana & Bekele, 2020). Hence, the 4IR technologies enable businesses to be profitable, sustainable, and competitive in a dynamic environment.

Economic opportunities

We also found that the 4IR can stimulate the development of vital skills relevant to this dispensation, create jobs, and reduce unemployment, thereby promoting economic growth. Previous scholars concur that the 4IR drives skills development (Saidi, 2022; Mpungose, 2020a), creates jobs (Mamphiswana & Bekele, 2020; Saidi, 2022), and reduces unemployment and inequality (Andreoni & Anzolin, 2019; Manda & Dhaou, 2019). Hence, 4IR can drive economic development within the African continent (Arakpogun *et al.,* 2021; Dagnaw, 2020) and offers Africa an opportunity to exit from economic stagnation, regression, and unsustainability.

Environmental opportunities

Using 4IR technologies can reduce the environmental impact of human and industrial actions. Andreoni and Anzolin (2019) confirm that modern technologies are efficient in minimizing waste and preserving the environment (Andreoni and Anzolin, 2019). Technology is increasingly being used to promote green initiatives (e.g., greenhouses, green production), energy conversion, and address issues around waste management, pollution, and climate change, which could benefit the continent.

Strategic directives

Directives for employers

This review stresses the need for employers to budget, plan, and invest in technology.

Previous research findings discovered the vital need for employers to create awareness and promote the adoption and use of emerging technologies (Mpungose, 2020b; Mpungose, 2020a) invest in technologies (Bayode *et al.,* 2019) and plan for the continuous development of relevant skills to support technology (Owoseni & Twinomurinzi, 2020; Yusuf *et al*., 2020). Acquiring technology and enabling employees to use and work with the 4IR technologies in this era are essential.

Directives for educational institutions

We find from this narrative review that institutions of learning need to reconceptualize teaching and pedagogies to be multidisciplinary and incorporate technology and artificial intelligence to solve African problems ethically. Results also show that private and public educational institutions need to invest in acquiring technology, facilitating learners' access to technology, supporting infrastructure, and upskilling the education personnel to be on par with the ongoing revolution. Previous scholars confirm the need to reconceptualize teaching to achieve quality outcome-based education in line

with market requirements on the continent (Bayode *et al.,* 2019; Molele, 2019; Mpungose, 2020b; Yusuf *et al*., 2020).

Also, we find evidence for the relevance of local and global partnerships between educational institutions and public, private, or other institutes of learning. Prior research confirms the vital role of global partnerships between educational institutions, public and private, in the 4IR (Arakpogun *et al*., 2021; Ogbuanya *et al*., 2018; Saidi, 2022). It is critical to align education with the demands of the era, industries, and continent.

Directives for African governments

Lastly, this review emphasizes the role of governments in funding, facilitating research and development, acquiring technologies, developing skills for this technological dispensation, creating awareness and promoting the 4IR technologies, fostering collaboration and partnerships, promoting local content, developing infrastructures, and empowering people to leverage the 4IR to address unemployment challenges. Past academics confirm the strategic need for African governments to finance and support innovation and digitalization (Dagnaw, 2020; Mpungose, 2020b), invest in research and development (Ajibade & Mutula, 2020; Arakpogun *et al*., 2021), create awareness and promote the use of technologies (Bayode *et al.*,2019; Mamphiswana & Bekele, 2020; Mpungose, 2020a), develop skills (Mamphiswana & Bekele, 2020), develop enabling infrastructures (Distor*et al*., 2023; Mpungose, 2020b; Yusuf *et al*., 2020), and promote the development of indigenous Technologies and innovations that solve African problems (Arakpogun *et al*., 2021; Saidi, 2022). Past research also emphasizes multi-sectoral collaboration at different levels to promote emerging technologies and innovation (Distor *et al*., 2023; Owoseni & Twinomurinzi, 2020).

Findings from this article highlight the need to put more effort into addressing economic and political challenges on the continent, as well as regulatory issues around the 4IR. Previous research confirms the relevance of sound political and economic environments (Mamphiswana & Bekele, 2020; Saidi, 2022), the need for African governments to create conducive environments where businesses can strive (Saidi, 2022) and robust legal and regulatory policies to guide the use and creation of 4IR technologies ethically and inclusively (Arakpogun *et al*., 2021; Bayode *et al.*,2019; Distor *et al*., 2023; Owoseni & Twinomurinzi, 2020; Saidi, 2022). The role of African governments

is paramount in the inclusive adoption of the 4IR and its technologies in this technological dispensation.

Conclusion

The purpose of this article was to explore the challenges, prospects, and strategic directives for African countries to harness the disruptive capabilities of the 4IR using the diffusion of innovation theory as a theoretical lens to understand the rationale for the spread and adoption of 4IR technologies in Africa. Although social, institutional, economic, and environmental challenges are related to the 4IR in Africa, there are attractive opportunities for people, organizations, economics, and the environment. To harness the disruptive capabilities of the 4IR, employers, institutions of learning and governments in Africa need to promote the use of technology, develop enabling infrastructure, fund and support the development of technologies,and developrelevant skills to match the demands of the revolution. This will require governments to address economic and political challenges and formulate regulatory and policy frameworks to guide the 4IR developments.

Contributions, Limitations and Recommendations for Further Studies

This article contributes to the limited academic discourse on 4IR in Africa and provides input into the research agenda. Practically, it provides strategic directives for African employers, educational institutions, and governments to harness the disruptive capabilities of 4IR, thus prompting policy reviews in African countries.

This study was a desktop review of literature, and the inclusion and exclusion criteria used in literature reviews could potentially exclude relevant studies, resulting in biased or false conclusions. Although a rigorous review approach was used, further research should consider empirically driven qualitative or quantitative approaches. Also, specific industries or countries could be investigated to confirm or refute the findings in this paper.

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Appendices

Table 1: Data (list of articles reviewed)

	Authors	**Year of Publication**	**Title**	**Journal**	**Volume (issue No), page number**
1.	Fomunyam, K.G.	2019	Education and the fourth industrial revolution: Challenges and possibilities for engineering education.	International Journal of Mechanical Engineering and Technology IJMET	10(08), 271-284
2.	Potokri, O. C.	2022	Positioning African women for the fourth industrial revolution (4IR) era: Insights for women students	Prizren Social Science Journal,	6(1), 84-9
3.	Kayembe, C. & Nel, D.	2019	Challenges and Opportunities for Education in the Fourth Industrial Revolution.	African Journal of Public Affairs	11(3), 79-94
4.	Venter, A.A.J., Herbst, T.H.H., & Iwu, C.G. SA	2019	What will it take to make a successful administrative professional in the fourth industrial revolution?	Journal of Human Resource Management/SA Tydskrifvir Menslikehulpbronbestuur,	17(0), 1-14
5.	Khoza, S. B.	2021	Can Teachers' Identities Come to the Rescue in the Fourth Industrial Revolution?	Technology, Knowledge, and Learning	28, 843–864.
6.	Oke, A. & Fernandes,	2020	Innovations in Teaching and Learning: Exploring the	Journal of Open Innovation:	6, 31, 1-22

	Authors	Year of Publication	Title	Journal	Volume (issue No), page number
	A.F.P.		Perceptions of the Education Sector on the 4th Industrial Revolution (4IR).	Technology, Market, and Complexity	
7.	Matotoka MD & Odeku K.O.	2021	Mainstreaming black women into managerial positions in the South African corporate sector in the era of the Fourth Industrial Revolution (4IR)	PER / PELJ,	2021(24), 1-35.
8.	Butler-Adam, J.	2018	The fourth industrial revolution and education.	South African Journal of Science	114(5/6)
9.	Sutherland, E.	2020	The fourth industrial revolution – The case of South Africa.	South African Journal of Political Studies	47(2), 233–252.
10.	Mahlatsi, M.	2020	The fourth industrial revolution: another industrial revolution leaving black women behind?	The Thinker	(83), 24-28
11.	Malomane, R. Musonda, I., Okoro, CS.	2022	The Opportunities and Challenges Associated with the Implementation of Fourth Industrial Revolution Technologies to Manage Health and Safety	Int. J. Environ. Res. Public Health	19(2)
12.	Oyebanjo, O.G. and Tengeh, R.K.	2021	Interrogating the challenges and opportunities for entrepreneurs in the Fourth Industrial Revolution: a developing country perspective	World Review of Entrepreneurship, Management and SustainableDevelopment	17(6), 883–896
13.	Serumaga-Zake JM, van der Poll JA.	2021	Addressing the Impact of Fourth Industrial Revolution on South African Manufacturing Small and Medium Enterprises (SMEs).	Sustainability.	13(21)
14.	Ndagi, A. & Salihu, A. A.	2018	4IR: Prospects and Challenges for Africa.	Dutse Journal of Economics and Development Studies	6(1), 189-198.
15.	Omonzejele, F.E. & Agu, C.O.	2023	The Opportunities and Challenges of the Fourth Industrial Revolution in Management Science.	Global Online Journal of Academic Research	2(1), 70-85
16.	Ayo-	2022	Human resources management	Journal of	6 (1), 131-

	Authors	Year of Publication	Title	Journal	Volume (issue No), page number
	Ayinde, A. I.		for secondary school quality in the 4th industrial revolution and the attainment of SDGs in Nigeria	Contemporary Issues in Education	140
17.	Adeosun, O.T., Shittu, A.I. & Owolabi, T.L.	2022	University internship systems and preparation of young people for world of work in the 4th industrial revolution.	Rajagiri Management Journal,	16 (2), 164-179
18.	Ebekozien, A. &Aigbavboa, C.	2021	COVID-19 recovery for the Nigerian construction sites: The role of the fourth industrial revolution technologies.	Sustainable Cities and Society	69 (2021), 1-10
19.	Onyeizugbe, C. U., Nnadi, T. A. & Enaini, S. O.,	2019	Re-engineering Nigeria economy through fourth IR: A case of Agro-Allied Firms in Nigeria.	International Journal of Applied Economics, Finance and Accounting	5(1), 14-30
20.	Akparobore, D., Omosekejimi, A.F. & Nweke, A.C.	2020	Librarians' Awareness, Positive Attitude, and ICT Skills: A Panacea for Effective Services Delivery in the Fourth Industrial Revolution (4th IR) Era in Academic Libraries in Southern Nigeria.	Library Progress (International)	40 (2)
21.	Okolie, U.C., Nwajiuba, C.A., Eneje, B., Binuomote, M.O., Ehiobuche, C. & Hack-Polay, D.	2021	A critical perspective on industry involvement in higher education learning: enhancing graduates' knowledge and skills for job creation in Nigeria.	Industry and Higher Education	35(1), 61-72
22.	Ajah, I. A. & Chigozie-Okwu, C. E.	2019	Exploring the benefits of the 4th IR: The Nigerian experience.	International Journal of Science and Technology	8(1), 23 – 32
23.	Jeche, V. R.	2023	The Fourth Industrial Revolution and Women in Zimbabwe:	Digital Policy Studies	1(2), 76–88.

	Authors	Year of Publication	Title	Journal	Volume (issue No), page number
			Threats and Opportunities.		
24.	Chinyamunjiko, N., Simon, C. Bhibhi. P.	2022	Rethink thinking Zimbabwean tertiary education in the Fourth Industrial Revolution: The case of a state university.	International Journal of Research Publications	103(1), 653-674
25.	Yingi, E., Hlungwani, P.M. & Nyagadza, B.	2022	The Fourth Industrial Revolution (4IR) in the Heart of the SDG Agenda: The Role of Education in Zimbabwe.	Africa Review	14 (2022), 213–229
26.	Moyo, Z.	2022	The Fourth Industrial Revolution: A Literature Study of Challenges Associated with Access to Education in Rural Schools in Zimbabwe.	Journal of Educational and Social Research	12(3), 125-136

Table 2: Data analysis

Description	References
Challenges of the 4IR	
Increased stress and pressure onworkers	Butler-Adam, 2018; Mahlatsi, 2020
Negative impact of technology on humans and living organisms	Fomunyam, 2019; Ndagi & Salihu, 2018; Omonzejele & Agu, 2023
Increased social vices and erosion of human values	Ayo-Ayinde, 2022; Moyo, 2022
Lack of interest/reluctancy to adopt technology (people and institutions)	Ebekozien & Aigbavboa, 2021; Malomane *et al*., 2022; Onyeizugbe *et al*., 2019
Severe decline in some jobs and growth in unemployment	Akparobore *et al*., 2020; Butler-Adam, 2018; Chinyamunjiko *et al*., 2022; Jeche, 2023; Mahlatsi, 2020; Malomane *et al*., 2022; Ndagi & Salihu, 2018; Serumaga-Zake & van der Poll, 2021; Yingi *et al*., 2022
Skills redundancy /disruptions	Ayo-Ayinde, 2022; Chinyamunjiko *et al*., 2022; Butler-Adam, 2018; Mahlatsi, 2020
Increased segregated job market	Fomunyam, 2019; Potokri, 2022
Potential for increased inequality through the marginalisation of the poor	Kayembe & Nel, 2019; Mahlatsi, 2020; Matotoka & Odeku, 2021; Moyo, 2022; Ndagi & Salihu, 2018; Oke & Fernandes, 2020; Omonzejele &

Description	References
	Agu, 2023; Serumaga-Zake & van der Poll, 2021
Digital divide between the rich/poor and rural/urban areas	Jeche 2023; Moyo, 2022
Loss of control over networks to AI and technology; i.e., hacking and cybersecurity concerns (for individuals, institutions and governments)	Fomunyam, 2019; Ebekozien & Aigbavboa, 2021; Kayembe & Nel, 2019; Omonzejele & Agu, 2023; Oyebanjo & Tengeh, 2021
Lack of skills to support the 4IR	Jeche, 2023; Malomane *et al*., 2022; Moyo, 2022; Oyebanjo & Tengeh, 2021
High cost of advanced technologies (institutions and governments)	Ebekozien & Aigbavboa, 2021; Malomane *et al*., 2022; Onyeizugbe *et al*., 2019 ; Serumaga-Zake & van der Poll, 2021
Insufficient training capacities for 4IR skills (institutional and government)	Malomane *et al*., 2022; Oyebanjo & Tengeh, 2021
Deficient implementation strategies (institutional and government)	Malomane *et al*., 2022; Oyebanjo & Tengeh, 2021
Lack of implementation resources	Malomane *et al*., 2022; Serumaga-Zake & van der Poll, 2021
Inadequate supporting infrastructure for the 4IR	Malomane*et al*., 2022; Oyebanjo&Tengeh, 2021; Serumaga-Zake & van der Poll, 2021
Negative impact of technology on the environment	Fomunyam, 2019; Ndagi & Salihu, 2018; Omonzejele & Agu, 2023; Potokri, 2022
Prospects of the 4IR	
Improves living standards and life expectancy	Fomunyam, 2019; Kayembe & Nel, 2019; Oyebanjo & Tengeh, 2021; Serumaga-Zake & van der Poll, 2021; Sutherland, 2020
Provides a variety of affordable customised goods and service that solve problems	Akparobore *et al*., 2020; Fomunyam, 2019; Kayembe & Nel, 2019; Malomane *et al*., 2022; Ndagi& Salihu, 2018; Omonzejele & Agu, 2023; Potokri, 2022; Serumaga-Zake & van der Poll, 2021
Frees time for humans to do other important things (e.g., spend time with family, leisure)	Fomunyam, 2019; Kayembe & Nel, 2019; Potokri, 2022
Saves time for businesses	Ebekozien & Aigbavboa, 2021; Khoza, 2021; Malomane *et al*., 2022; Ndagi & Salihu, 2018; Oke & Fernandes, 2020 Serumaga-Zake & van der Poll, 2021
Reduces barriers between inventors and markets	Oyebanjo & Tengeh, 2021; Ndagi & Salihu, 2018; Omonzejele & Agu, 2023; Serumaga-Zake & van der Poll, 2021
Provides opportunities for participation in the digital dispensation	Kayembe & Nel, 2019; Venter, Herbst & Iwu, 2019
Facilitates collaborative partnerships or networks	Akparobore, Omosekejimi & Nweke, 2020; Kayembe & Nel, 2019; Venter, Herbst & Iwu,

Description	References
	2019
Improves business processes and productivity	Akparobore, Omosekejimi and Nweke, 2020; Ebekozien & Aigbavboa, 2021; Jeche, 2023; Ndagi & Salihu, 2018; Malomane *et al*., 2022; Omonzejele & Agu, 2023
Saves cost	Khoza, 2021; Malomane *et al*., 2022; Oke & Fernandes, 2020; Oyebanjo & Tengeh, 2021; Serumaga-Zake & van der Poll, 2021
Increases profitability	Jeche, 2023; Malomane *et al*., 2022; Oyebanjo & Tengeh, 2021; Serumaga-Zake & van der Poll, 2021
Stimulate the development of vital 4IR skills	Adeosun *et al*., 2022; Ayo-Ayinde, 2022; Jeche, 2023; Khoza, 2021; Oke& Fernandes, 2020; Onyeizugbe, Nnadi &Enaini, 2019
Reduces poverty and inequality	Chinyamunjiko, Simon & Bhibhi, 2022; Ebekozien & Aigbavboa, 2021; Matotoka & Odeku, 2021; Omonzejele & Agu, 2023; Onyeizugbe, Nnadi & Enaini, 2019; Oyebanjo & Tengeh, 2021; Yingi *et al*., 2022
Creates jobs for emerging careers	Butler-Adams, 2018; Jeche, 2023; Ndagi & Salihu, 2018; Omonzejele & Agu, 2023; Potokri, 2022; Sutherland, 2020; Serumaga-Zake & van der Poll, 2021
Reduces unemployment	Ebekozien & Aigbavboa, 2021; Onyeizugbe, Nnadi & Enaini, 2019; Oyebanjo & Tengeh, 2021; Serumaga-Zake & van der Poll, 2021
Promote economic growth	Ndagi & Salihu, 2018; Malomane *et al*., 2022; Omonzejele & Agu, 2023; Oyebanjo & Tengeh, 2021
Reduces environmental impact	Ebekozien & Aigbavboa, 2021; Jeche, 2023; Ndagi & Salihu, 2018; Serumaga-Zake & van der Poll , 2021
Directives for the future	
Continuously reconceptualize teaching and pedagogical idiosyncrasies towards outcome-based education that blends academic and vocational competencies to meet market requirements	Adeosun *et al*., 2022; Ajah & Chigozie-Okwu, 2019; Ayo-Ayinde, 2022; Chinyamunjiko *et al*., 2022; Ebekozien & Aigbavboa, 2021; Fomunyam, 2019; Kayembe & Nel, 2019; Khoza, 2021; Moyo, 2022; Oke & Fernandes, 2020; Omonzejele & Agu, 2023
Decolonise and revise African curricula to be interdisciplinary and incorporate innovative artificial intelligence in all programmes	Adeosun *et al*., 2022; Butler - Adam, 2018; Chinyamunjiko *et al*., 2022; Ebekozien & Aigbavboa, 2021; Malomane *et al*., 2022; Moyo, 2022; Omonzejele & Agu, 2023 ; Yingi *et al*., 2022;

Description	References
Invest in technological resources (circular and educational institutions)	Fomunyam, 2019; Kayembe & Nel, 2019; Mahlatsi, 2020
Infrastructural development in education)	Ajah & Chigozie-Okwu, 2019; Ayo-Ayinde, 2022; Chinyamunjiko *et al*., 2022; Fomunyam, 2019; Jeche, 2023; Kayembe & Nel, 2019; Mahlatsi, 2020; Omonzejele & Agu, 2023; Moyo, 2022;
Forge local and global educational partnerships	Fomunyam, 2019; Jeche, 2023; Kayembe & Nel, 2019
Promote lifelong learning that develops technological skills for work and problem-solving within the African context in ethical and moral ways	Adeosun *et al*., 2022; Akparobore *et al*., 2020; Ayo-Ayinde, 2022; Butler-Adam 2018; Chinyamunjiko *et al*., 2022; Ebekozien & Aigbavboa, 2021; Jeche, 2023; Fomunyam, 2019; Kayembe & Nel, 2019; Makota & Odulo, 2021; Mahlatsi, 2020; Moyo, 2022; Potokri, 2022; Venter *et al*., 2019; Yingi *et al*., 2022
Fund and roll out the development of digital skills (through educational institutions)	Butler-Adam 2018; Fomunyam, 2019; Kayembe & Nel, 2019; Mahlatsi, 2020; Makota & Odulo, 2021; Mahlatsi, 2020; Moyo, 2022; Oke & Fernandes, 2020; Oyebanjo & Tengeh, 2021; Serumaga-Zake & van der Poll, 2021; Sutherland, 2020; Venter *et al*., 2019
Institutions of learning provide available, accessible, relevant, and easy-to-use technology	Khoza, 202; Potokri, 2022 ; Oke & Fernandes, 2020; Sutherland, 2020
Facilitate the development of skills of the future for education personnel	Adeosun *et al*., 2022; Ayo-Ayinde, 2022; Fomunyam, 2019; Kayembe & Nel, 2019; Moyo, 2022
Educate people on the importance of the 4IR technologies and promote awareness and attitude towards adoption and use (governments and institutions)	Akparobore *et al*., 2020; Ebekozien & Aigbavboa, 202; Malomane *et al*., 2022
Government should build capacity and invest in research and development	Ebekozien & Aigbavboa, 2021; Fomunyam, 2019; Jeche, 2023; Kayembe & Nel, 2019; Mahlatsi, 2020; Malomane *et al*., 2022; Ndagi & Salihu, 2018; Serumaga-Zake & van der Poll, 2021
Financially empower people to gain momentum in the 4IR and address its unemployment challenges	Fomunyam, 2019; Kayembe & Nel, 2019; Mahlatsi, 2020
Promote public-private partnerships with educational institutions to meet industries' demands	Adeosun *et al*., 2022; Chinyamunjiko *et al*., 2022; Jeche, 2023; Malomane *et al*., 2022 ; Moyo, 2022 ; Okolie *et al*., 2021; Yingi *et al*., 2022
Promote inclusive private-public collaboration to promote emerging	Adeosun *et al*., 2022; Ebekozien & Aigbavboa, 2021

Description	References
technologies and innovation	
Budget and plan for 4IR technologies (institutional)	Ebekozien&Aigbavboa, 2021;
Aggressively address current economic and political challenges (e.g., diversification of infrastructural and institutional insufficiencies, governance issues, and financial management systems)	Ajah & Chigozie-Okwu, 2019; Moyo, 2022; Omonzejele & Agu, 2023;
Develop national infrastructures (e.g. ICT, high-speed internet, electricity supply)	Malomane *et al*., 2022; Serumaga-Zake & van der Poll, 2021; Oyebanjo & Tengeh, 2021
Increase government support towards innovation and digitalization	Ebekozien & Aigbavboa, 2021; Ndagi & Salihu, 2018; Oyebanjo & Tengeh, 2021
Government funding for the acquisition and development of technologies needed to deliver in the 4IR era	Adeosun *et al*., 2022; Akparobore *et al*., 2020
Update and re-formulate regulatory framework and industrial policies to leverage 4IR technologies and promote their implementation	Ebekozien & Aigbavboa, 2021; Oyebanjo & Tengeh, 2021; Moyo, 2022; Ndagi & Salihu, 2018
Need for policy reforms and guidelines to protect vulnerable humans and industries and promote social justice	Fomunyam, 2019; Kayembe & Nel, 2019; Jeche, 2023; Mahlatsi, 2020; Matotoka & Odeku, 2021; Malomane*et al*., 2022; Moyo, 2022; Potokri, 2022; Yingi *et al*., 2022
Promote local content for Indigenous technologies and innovations	Adeosun *et al*., 2022; Jeche, 2023; Omonzejele, & Agu, 2023; Ndagi & Salihu, 2018;