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REVIEW ARTICLE

The Effects of the Fourth Industrial Revolution on Malaysia's Marginalized and Vulnerable Communities

Haezreena Begum binti Abdul Hamid[1*]

[1]Faculty of Law, Universiti Malaya, 50603, Kuala Lumpur, Malaysia
Email: haezreena@um.edu.my

CORRESPONDING AUTHOR (*):
Haezreena Begum binti Abdul Hamid
(haezreena@um.edu.my)

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ABSTRACT

This article examines the impacts of the Fourth Industrial Revolution (4IR) on vulnerable and marginalized groups in Malaysia such as the poor, women in poverty, children, the elderly and persons with disabilities. Drawing on data from written documents, reports, and digital sources, the article provides a critical evaluation of Malaysia's National 4IR Policy, which seeks to merge the physical, biological, and digital spheres through four main approaches which includes enhancing human capital with 4IR competencies; expanding digital infrastructure; modernizing regulatory frameworks; and promoting innovation and technological uptake. While the 4IR policy seeks to support national development, address technological risks, and promote digitalization, there seems to be a lack of laws and legal safeguards for the rights of the vulnerable and marginalized people. As a result, this groups faces multiple challenges such as job displacement, increased poverty rates, widening gender gaps, and wastage of resources. The article concludes by providing recommendations on 4IR policies, programs, and practices, evaluating their current and potential impacts on these groups.

Contribution/Originality: The paper's primary contribution is highlighting gaps in Malaysia's National 4IR Policy, which prioritizes innovation and infrastructure but lacks legal safeguards for vulnerable groups. It reveals that the policy fails to address socio-economic disparities, potentially exacerbating challenges for the poor, women in poverty, children, the elderly, and persons with disabilities.

1. Introduction

The Fourth Industrial Revolution (4IR) signifies the integration of physical, digital, and biological realms, fueled by swift data growth, improved connectivity, advances in data analysis, strengthened human-machine collaboration, and cutting-edge developments in robotics (Fanoro et al., 2021). As outlined in the National Fourth Industrial Revolution Policy (4IR), this technological shift has the potential to enhance income levels, foster social cohesion, improve efficiency, offer greater convenience, and contribute to the conservation of scarce natural resources (Economic Planning Unit Prime Minister's Department, 2022). Fundamental aspects of 4IR involve big data, AI, augmented reality

(AR), and machine learning (Siimsen et al., 2023). The Malaysian government is committed to implementing the 4IR agenda, harnessing technological advancements to drive socioeconomic progress. However, concerns remain regarding whether these innovations will effectively benefit vulnerable and marginalized communities in Malaysia.

According to reports, the vulnerable and marginalised groups were extensively affected by Covid-19 pandemic lockdowns between 2020 to 2022 (Siimsen et al., 2023). Many fell into extreme poverty, faced food shortages, became unemployed, suffered severe loss of income, and experienced a myriad of social, economic and health problems. Vulnerable groups in the Malaysian context would include women in the B40[1] category; the poor and economically vulnerable; children (under 18); senior citizens (60 above); people with disabilities;[2] migrant workers; ethnic minorities; youth (15-30); and the natives of Sabah and Sarawak (collectively referred to as "vulnerable groups") (MAMPU, 2021). However, for the purpose of this article, discussions will only revolve around the poor; the B40 category; women; children; the elderly or senior citizens; and Persons with Disabilities; as well as the youth due to the lack of data on other groups. While the article may present specific keynotes on each group, these groups may also be conflated due the lack of specific data attributed to these groups. For instance, students would include children, women as well as youth; poor might also include B40 group, children, women, and youth.

2. Literature Review

2.1. The 4IR Context in Malaysia: Economic and social development

The Malaysian government seeks to build a dynamic ecosystem that attracts manufacturers, innovators, suppliers, and service providers, especially within the ASEAN region. To realize this vision, Malaysia is focusing on advancing five key 4IR technologies such as artificial intelligence (AI), the Internet of Things (IoT), blockchain, advanced materials and technologies, and cloud computing alongside big data analytics. With 4IR expected to enhance productivity by 30% across all industries by 2030, the government is also dedicated to expanding the digital economy to uplift vulnerable and marginalized groups, including underserved rural communities, in an effort to close the digital divide (Economic Planning Unit Prime Minister's Department, 2022).

To maximize the benefits of 4IR, the government introduced the National 4IR Policy on 1 July 2021, designed to facilitate the adoption of emerging technologies such as AI, big data, and blockchain. A governance structure, led by the National Digital Economy and 4IR Council, has been established to oversee and coordinate initiatives across multiple ministries and agencies (Economic Planning Unit Prime Minister's Department, 2022). The 4IR Policy, alongside the Digital Economy Blueprint (DEB), serves as a strategic framework to help citizens harness the potential of 4IR.

The policy is guided by three key objectives: (i) leveraging the growth opportunities presented by 4IR; (ii) creating an enabling environment to address the challenges associated with 4IR; and (iii) fostering trust in an inclusive digital society. It focuses on

[1] The B40 category refers to the bottom 40% of households across the country with a monthly net income of less than RM4,850.
[2] In Malaysia, Persons with Disabilities (PWD) encompass individuals with hearing, visual, speech, physical, learning, mental, or multiple impairments or disabilities.

10 key sectors such as (i)manufacturing; (ii) transportation and logistics; (iii) healthcare; (iv) education; (v) agriculture; (vi) utilities; (vii) finance and insurance; (viii) professional, scientific, and technical services; (ix) wholesale and retail trade; (x) tourism (Economic Planning Unit Prime Minister's Department, 2022). It also include six supporting sectors such as (i) construction services; (ii) arts; (iii) entertainment and recreation (iv) real estate, mining, and quarrying; (v) information and communication services; and (vi) administrative and support services (Economic Planning Unit Prime Minister's Department, 2022). By integrating these sectors into its 4IR strategy, Malaysia aims to drive technological transformation, enhance economic growth, and ensure that all segments of society benefit from digital advancements.

2.2. Usage of Internet

The most recent findings from the Department of Statistics Malaysia (DOSM) show that household connectivity to the internet reached 96% in 2022, an increase from 94.9% in 2021 (Ignatius, 2023). Ownership of mobile phones, radios, and televisions among households remained consistently high, exceeding 95 percent. DOSM further highlighted that internet engagement among Malaysians aged 15 and above rose to 97.4% in 2022, compared to 96.8% the previous year, with social networking continuing to be the most common online activity (Ignatius, 2023).

Moreover, there has been a significant upward trend in Malaysians turning to online platforms for information gathering, communication, civic participation, digital government services, entertainment, online shopping, and other digital interactions. The frequency of internet-related activities expanded by over 3 percentage points, with several areas registering notable gains. These include researching products or services (92.5%), uploading original digital content (17.6%), managing personal websites (10.3%), generating income via digital platforms (15.5%), internet-based banking (74.8%), streaming radio content (72.8%), watching television broadcasts online (68.1%), and purchasing goods or services via online marketplaces (70.4%) (Ministry of Economy: Department of Statistics Malaysia, 2023).

Furthermore, proficiency in essential ICT tasks has strengthened, with 97% of individuals capable of copying or moving files, 96.3% adept at using copy-and-paste within documents, and 89.4% able to send emails with attachments. More advanced digital abilities have also gained traction, such as applying basic formulas in spreadsheets (67.1%) and writing code using programming languages (23.5%) (Kementerian Ekonomi: Jabatan Perangkaan Malaysia, 2022). Additional skills that have grown include setting up and connecting new devices (79.2%), searching for, downloading, configuring software (72.5%), and creating electronic presentations via computer applications (62.9%) (Kementerian Ekonomi: Jabatan Perangkaan Malaysia, 2022).

As internet dependency continues to rise, the Malaysian government has accelerated initiatives to strengthen the nation's digital ecosystem through the Pelan Jalinan Digital Negara (JENDELA) framework (MyGovernment, 2020). For more than two decades, the Malaysian Communications and Multimedia Commission (MCMC) has been responsible for overseeing mobile network services such as 3G, 4G, and 5G, in accordance with global benchmarks (MyGovernment, 2020). The Ministry of Communication and Multimedia (MCM) reports that rural internet penetration has reached 83.9% (Official Portal Ministry of Communications, 2023). In addition, under the Twelfth Malaysia Plan

(2022), the Ministry of Rural Development received RM10.53 billion, with RM3.52 billion allocated for operational costs and RM7.01 billion earmarked for development initiatives (Digital Nasional, 2021).

Despite these efforts, OpenSignal, a global mobile analytics provider, highlights significant disparities in 4G-LTE connectivity between urban and rural areas. In 2019, urban residents were connected to 4G networks 83.7% of the time, while rural users had access only 44% of the time. The ultimate goal is to achieve full nationwide internet coverage, making JENDELA a crucial pillar of Malaysia's digital economy strategy, aiming to cover the remaining 3% of populated areas by 2025.

3. Methodology

For this article, data was gathered from both primary and secondary sources, including books, journal articles, legislation, published reports, newspaper and magazine articles, as well as websites of non-governmental organizations (NGOs) and government agencies, covering the period from 1986 to 2023. The most common keywords used for this analysis are terms and phrases which include: '4IR', '4IR in Malaysia','4IR and women', '4IR Policy', "4IR and the poor", "4IR and B40", "4IR and persons with disabilities", "4IR and the elderly", "4IR and vulnerable groups", "4IR and marginalised groups" and "4IR policies in Malaysia". Ensuring thorough coverage, varied use of the term '4IR' was applied to capture all relevant articles on 4IR, such as 'Fourth Industrial Revolution' or 'National 4IR Policy'. Most of the statistics and data in this report are taken from local newspaper reports as well as the relevant Ministry and government's website dedicated to 4IR. The National 4IR Policy available on the website and provides a comprehensive report on the policies, activities, and programmes of 4IR that has been and intended to be implemented on all fragments of society. However, there are limited data on how 4IR can impact and affect vulnerable groups.

4. Findings

4.1. Laws and policies that govern 4IR in Malaysia

Malaysia has yet to implement a specific legal framework dedicated solely to artificial intelligence (AI). Nonetheless, multiple existing statutes cover elements of data privacy and cyber-related crimes. The Personal Data Protection Act 2010 (PDPA) regulates the handling of personal information in business activities, while the Technologists and Technicians Act 2015 (Act 768) established the Malaysia Board of Technologists (MBOT) to oversee technology practitioners. Furthermore, the Communications and Multimedia Act 1998 (CMA) outlines rules and licensing requirements for the communications and multimedia industries. Although it addresses the role of online intermediaries, the CMA does not fully encompass the emerging complexities tied to the Fourth Industrial Revolution (4IR). Several government bodies and ministries contribute to crafting guidelines and policies related to digital technologies, including the Malaysian Communications and Multimedia Commission (MCMC). As a key authority, the MCMC supports the growth of a competitive, efficient, and progressively self-governing communications and multimedia sector that underpins Malaysia's economic and societal development.

4.2. Risks and vulnerabilities of 4IR

4.2.1. The Poor and B40 Groups

Malaysia's official poverty threshold is currently set at RM2,208, with 5.6% of households falling below this benchmark in 2020, according to World Bank statistics (Lim, 2020). Nearly four-fifths of the population reside in urban settings, where the poverty incidence is 3.8%, much lower than the 12.4% observed in rural regions (Lim, 2020). Despite being the second-largest state by both land size and population, Sabah continues to face widespread poverty (Mayan & Nor, 2017). In Sabah's countryside, where about 1.6 million people live, 5.3% are classified as "impoverished," marking the highest rural poverty rate nationwide (Mayan & Nor, 2017).

Malaysia's income distribution system segments households into three principal tiers (Carvalho, 2023). The B40 category comprises the lowest 40% of households earning under RM4,850 monthly. The M40 segment represents the middle-income 40%, with monthly earnings ranging from RM4,851 to RM10,960 (Carvalho, 2023). The T20 group accounts for the top 20% of households with monthly incomes exceeding RM10,960 (Carvalho, 2023). The estimated national mean disposable household income in 2022 stood at RM6,338 (Harun, 2023), though this figure fluctuates depending on the state. In Peninsular Malaysia, Selangor reported the highest average income, followed by Putrajaya, Kuala Lumpur, Penang, Johor, and Melaka, whereas Kelantan, Perak, and Kedah ranked lowest (iMoney, 2025). In the same year, the average monthly earnings for urban households reached RM9,430 (Siddharta, 2023), while rural households averaged RM5,150 (Siddharta, 2023), underscoring the income disparity between metropolitan and rural areas.

By 2022, Putrajaya achieved full internet connectivity for households, while Kuala Lumpur followed closely with a 99.8% penetration rate (Siddharta, 2024). However, Sabah and Sarawak continue to lag behind Peninsular Malaysia in terms of internet availability and digital infrastructure, including computer ownership and fixed broadband access. According to Fang et al. (2022), about 35% of rural Malaysians lack dependable internet connections, largely due to poor coverage or high costs. A pre-COVID-19 review also revealed that access to stable networks such as 4G remained deficient in economically underdeveloped states, falling short of the Digital Economy Blueprint's objective of ensuring universal 4G connectivity in schools (Khazanah Research Institute, 2021).

4.2.2. Women

The World Economic Forum estimates the loss of about 5.1 million jobs between 2015 and 2020 of which 2.45 million are held by women. With the implementation of 4IR, the majority of new jobs created will be in fields of science, technology, engineering, and mathematics (STEM). While STEM has been lauded as having a high job growth, there seem to be a low rate of female participation and difficulties in recruiting women (Umor, 2018). Globally, women are vastly under-represented in STEM (Umor, 2018). According to UNESCO, less than 30% of the researchers working in STEM are women. There are concerns that work that is largely done by women will be among the first to be automated, and that 4IR might make gender inequalities worse. Hence, women can be gravely impacted by the implementation of 4IR because many women are involved in administrative roles. The transition of the traditional work and business concept to

online would mean that women are at risk of losing their jobs and becoming unemployed. In addition, the high cost of hardware, software, internet access, the constant upgrade of software and programmes, as well as maintenance of the device may pose to be a challenge for them.

Generally, women may be affected because of the following reasons; (i) transition from manual (human) systems to online technology; (ii) the low interest and participation in working in the fields of architecture and engineering, computer, and mathematics which has a higher job growth; (iii) the ability to apply digital technology in all aspects of life; (iv) the fluctuation of women's labour. There are also concerns on biases and discrimination built into AI systems which can threaten gender equality. Since algorithms are developed by people, they often reflect embedded gender biases within their coding, including how language, metrics, and indicators are framed. Furthermore, performance evaluation systems driven by algorithms may overlook longstanding cultural, historical, and societal influences, such as the unequal distribution of work-life responsibilities that disproportionately affect women (European Union Agency For Fundamental Rights, 2022).

Despite notable gains in women's educational achievements, female representation in Malaysia's workforce remains behind that of their male counterparts (Syed Salleh & Mansor, 2022). The Department of Statistics Malaysia (2022) reported that women's labour force participation rate stood at 55% in 2021, whereas men's rate was significantly higher at 80.9%. Globally, women's internet usage trails that of men by 12 percent, with the disparity widening to 32.9 percent in less industrialized nations. This digital divide highlights a broader issue of the systemic exclusion of women and girls from technological access (Kabir, 2019). 4IR, and the mobility, flexibility, and adaptability it affords, has the potential to reduce this digital gender gap. The modern digital landscape empowers women worldwide by providing the flexibility to launch their businesses with minimal investment while leveraging digital platforms to market their products and services (Oliveros, 2021). In an increasingly digital society, many women prefer remote work or Work from Home (WFH) arrangements due to various advantages, including reduced expenses, the ability to balance family responsibilities, lower health risks, time efficiency, improved work-life balance, and greater control over their schedules (Oliveros, 2021).

4.2.3. Children

A 2020 survey involving 670,118 parents representing 893,331 students revealed that only 15% of learners owned personal computers (Ong, 2020). Around 5.8% had access to a tablet, 46.5% depended on smartphones, while 36.9% of students had no digital devices at all (Ong, 2020). Several schools have encountered difficulties in sustaining effective teaching and learning due to limited connectivity in outlying and underserved regions. An evaluation prior to the pandemic found that the availability of reliable internet, including 4G, was significantly lower in less-developed areas, falling short of the Digital Economy Blueprint's requirement for universal 4G access in all educational institutions. Additionally, insufficient long-term strategies—especially regarding upkeep—have resulted in schools continuing to use outdated ICT hardware (Kamaludin & Sundaresan, 2023). This digital shortfall is further worsened by a lack of qualified educators and disparities in the distribution of digital tools (Kamaludin & Sundaresan, 2023). Scholars also argue that inadequate ICT integration in classrooms may stem from

gaps in teacher training, limited collaboration among instructors, and classroom teaching methods (Simin Ghavifekr et al., 2016).

4.2.4. Elderly

Advancements in technology create new opportunities for delivering broad and adaptable interventions for older adults. However, rapid technological changes can also lead to "technostress" (Thompson & Mayhorn, 2012). Difficulty in adopting new digital tools may impact older workers' confidence and ability to learn emerging technologies (Thompson & Mayhorn, 2012). Despite these challenges, numerous studies and real-world examples indicate that older workers are not only open to learning but are also increasingly dependent on digital technologies. For instance, during the pandemic, Telekom Malaysia reported a 2.95-fold increase in internet usage among Unifi customers aged 56 and above between November 2019 and 2021 (Tayep, 2022). Given this growing reliance, it is essential to provide older adults with proper training, guidance, and support to ensure seamless digital adoption.

4.2.5. Persons with Disabilities

As of 2022, approximately 2.4% of Malaysia's population which is equivalent to 633,653 individuals were officially registered as Persons with Disabilities (PWDs) under the Ministry of Women, Family and Community Development (MWFCD). However, disability-rights advocates estimate that the actual number of PWDs in Malaysia could be as high as 4.5 million (Isa, 2023). PWDs remain one of the most marginalized and discriminated groups in Malaysian society (Khoo et al., 2013). They are frequently overlooked and excluded, facing significant barriers to employment and workplace equality. As the Fourth Industrial Revolution (4IR) drives digital transformation, it is essential to ensure that PWDs are not left behind in the evolving workforce. According to Dell Technologies (2018), 85% of the jobs expected to exist by 2030 have not yet been created. To enhance employment opportunities, reskilling and upskilling PWDs with critical 21st-century competencies such as creativity, communication, and critical thinking can empower them to secure meaningful roles across various industries.

4.3. Opportunities and Challenges for marginalised and vulnerable groups from 4IR

4.3.1. Opportunities

A dedicated online platform will be launched to assist vulnerable groups—such as B40 communities, women, and persons with disabilities—in starting or expanding online businesses (Dell Technologies, 2018). The government has also established 911 PEDi centres nationwide, providing internet access, ICT facilities, and entrepreneurship training to uplift local economies, especially micro and small enterprises (New Straits Times, 2023). Initiatives like MyCraftShoppe by Kraftangan Malaysia and PUPUK by PEDi further support digital product marketing (Landau, 2021).

Advancements in assistive technologies are enabling greater inclusion for people with disabilities. Under the DEB framework, efforts to close the digital divide continue through initiatives like "My Ikrar," which promotes community-led digital training (Glennie & Klingler-Vidra, 2023).

For younger generations, digital literacy is essential. The PAK-21 initiative modernises school curricula, boosting students' exposure to technology and innovation (Safri & Jamaludin, 2022), while preparing them for a digital economy.

For senior citizens, Celcom and partners are developing non-intrusive digital monitoring platforms to enhance their well-being at home (Axiata, 2023). Public campaigns on fraud prevention further aim to reduce the risk of online scams (Axiata, 2023).

The 4IR policy also seeks to narrow urban-rural technology gaps by expanding digital marketplaces and promoting innovation-driven partnerships between micro-enterprises, SMEs, and entrepreneurs (Economic Planning Unit Prime Minister's Department, 2022).

4.4. Challenges

Malaysia has made progress in addressing 4IR-related challenges, yet several gaps persist as follows:

i. Digital Infrastructure Deficits – Connectivity remains limited in rural Sabah and Sarawak despite initiatives like JENDELA, hindering nationwide 4IR deployment (Yakin & Januin, 2024).
ii. Limited 4IR Readiness in Education – Teachers exhibit moderate preparedness for integrating 4IR into pedagogy (Nor Azizah et al., 2019), while many students lack awareness of 4IR workplace demands (INTI International University & Colleges, 2019).
iii. Regulatory Shortcomings – The PDPA restricts cross-border data flows without clear enforcement, prompting calls for a more flexible data transfer framework (Pillai et al., 2021).
iv. Educational Gaps and Infrastructure Deficiencies – Rural schools face unstable networks and limited access to ICT tools, contributing to a widening digital divide despite interventions such as the DELIMa program.
v. Widening Digital Divide – Urban-rural, gender, and income inequalities in digital access persist, disproportionately affecting the poor and limiting educational and employment prospects (Devisakti et al., 2023).
vi. Labour Market Displacement – Automation threatens low-skill jobs, especially in sectors dominated by women, highlighting the need for targeted reskilling to prevent gender imbalances.
vii. E-Commerce Barriers – Trust issues, fear of technology, and low digital literacy hinder online business uptake (Lee et al., 2018).
viii. Cybersecurity Awareness Deficit – Rising cybercrime, including RM1.3 billion in online fraud losses in 2023, reveals insufficient public vigilance (Zulkifli et al., 2020).

4.5. Policy and programme recommendations

The main focus of Policy Thrust 1 of the 4IR Policy is to prepare citizens with knowledge and skill sets related to 4IR, education and talent management components. In the 12th Malaysia plan, the ICT development programmes were significantly highlighted. It also encompasses the entire current and future labour force including latent workforce such as the elderly, housewives and the disabled. Therefore, it is important to provide opportunities to all segments of society to equip themselves with the necessary

knowledge and skill sets in order to achieve this goal. This segment of society includes groups living in rural and marginalized areas. This skill set is essential for them to keep up with the rapid changes of technological advancements and meet the demands of the industry.

In searching for ways to maximise the inclusion of women in the economic benefits of 4IR, a robust policy framework need to be incorporated into education programmes to train more women in STEM (Khazanah Research Institute, 2023). Retraining programmes need to focus on placing women in renewable energy industries, and labour laws designed need to protect women from the negative impacts of 4IR. Special grants can also encourage the interest of women or young people to become researchers, engineers, or venture into the fields of medical science or health science in their career fields. In this regards, women need to recognized and rewarded for their involvement in these fields.

There is a need to increase digital literacy and educate the benefits of technology in outreach promotional activities. There is also a need to have technical competence in order to operate the computer in terms of hardware and software as well as information literacy (Mossberger et al., 2003). Cognitive abilities and specific digital literacy are required to operate the ICT and content exploitation. To address these issues, the Half Term Review of the 12th Malaysia Plan has identified '12 Major Shifts' to catalyze socioeconomic development in the final period of the 12th Malaysia Plan. One of the Major Shifts is the Technology-Based and Digital HGHV Industry and one of the main strategies or initiatives that will be implemented is the implementation of leadership programs and the improvement of digital skills at the national level.

The Fourth Industrial Revolution Center will be a platform for sharing experiences and views from expert policy makers and global best practices in aspects of digital transformation, GovTech and energy transition. In addition, a comprehensive review of existing initiatives outlined under the DEB and the National 4IR Policy will be carried out to identify gaps and strengthen implementation. Through these initiatives, the future available digital talent can be strengthened through:

i. Improvement of digital infrastructure, where laboratories and classrooms will be equipped with digital devices to provide a more conducive digital learning environment;
ii. Improvement of digital capabilities and capabilities, where an awareness program on digital and emerging technologies for counselors in the education system will be provided to enable counselors to advise and encourage students to pursue digital or technology-based careers; and
iii. Fostering interest in the field of technology among students, where interest in developing digital and creative content will be applied in schools through more practical activities involving students and clubs related to digital and technology such as robotics, coding and digital content will be included in the list co-curricular activities.

5. Conclusion

To fast-track Malaysia's transition into an advanced digital economy driven by innovation and green energy, the World Economic Forum and the Malaysian government established the Centre for the Fourth Industrial Revolution (Malaysia Centre for 4IR) in 2023. This initiative aims to harness technological advancements

while upholding human, social, and cultural values, aligning with the 12th Malaysia Plan and the Sustainable Development Goals. As the first of its kind in the ASEAN region, the centre represents a major step towards positioning Malaysia as a global leader in technology governance and innovation.

However, further efforts are needed to establish a fully 4IR-enabled government. Enhancing digital and technological adoption within the public sector is crucial, particularly in automating systems and processes for real-time responsiveness. Addressing the digital divide such as disparities in internet access, infrastructure, and IT skills among the poor and vulnerable is essential for inclusive progress. Overcoming these challenges and embedding strong governance within the 4IR framework can unlock significant benefits for the government. To bridge existing gaps in talent and infrastructure readiness, decisive leadership is required. Key priorities include equipping marginalised communities with 4IR-related skills, expanding digital infrastructure to foster nationwide connectivity, modernising regulatory frameworks to keep pace with technological advancements, and accelerating the adoption of 4IR innovations.

Ethics Approval and Consent to Participate

This research was conducted purely through desk-based analysis, relying on written documents, reports, and digital sources without direct interviews or participant involvement. Despite the absence of fieldwork, the study adhered to ethical research standards by ensuring accuracy, integrity, and responsible use of data while maintaining objectivity and academic rigour.

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Conflict of Interest

The author reported no conflicts of interest for this work and declare that there is no potential conflict of interest with respect to the research, authorship, or publication of this article.

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