

EXAMINING BEST PRACTICES FOR LOCAL GOVERNMENT REFORM IN THE FOURTH INDUSTRIAL REVOLUTION



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Abstract

The Fourth Industrial Revolution (4IR) is characterised by disruptive technologies such as artificial intelligence, the Internet of Things, and blockchain, which present significant opportunities to transform governance, enhance service delivery, and foster community development.

This article explores best practices for local government reform, with the focus on integrating 4IR technologies to advance governance and sustainable development.

The research is situated within the context of South Africa's local government framework and juxtaposed with international benchmarks to provide actionable insights.

The study utilised a qualitative research approach in the form of secondary data analysis, whereby academic literature, policy documents, case studies, and reports were reviewed. This methodology enabled a comprehensive examination of international best practices and their applicability in the South African context. The analysis was guided by theoretical frameworks, including the diffusion of innovation and stewardship theories, to provide insight into the adoption and implementation processes of 4IR technologies in governance.

The findings reveal that the adoption of 4IR technologies in local government necessitates inclusive governance, robust policy frameworks, and substantial investment in digital infrastructure to bridge the digital divide.

Integrating 4IR technologies into local government operations can significantly enhance service delivery and governance; however, achieving this requires addressing systemic challenges such as policy gaps, infrastructure deficiencies, and inequities in access.

This article contributes to the discourse on governance innovation by offering a comparative analysis of best practices and strategic recommendations tailored to the South African context.

1. Introduction

The Fourth Industrial Revolution (4IR) represents a significant shift in the technological landscape. It is characterised by the fusion of digital, physical, and biological systems. This revolution promises to transform the way governments operate and engage with citizens, with technologies such as artificial intelligence (AI), robotics, and the Internet of Things (IoT) offering unprecedented opportunities for enhancing public sector efficiency. However, the adoption of 4IR technologies in developmental local government faces several challenges, particularly in countries like South Africa, where digital infrastructure remains underdeveloped and municipal officials often lack the necessary skills and resources to implement such

technologies (Nelwamondo & Njenga, 2021, p. 7). Dlodlo et al. (2012, p. 1) identified several challenges facing rural areas in South Africa, including the underutilisation of natural resources, inadequate socio-economic infrastructure and services, limited access to public amenities and government services, insufficient water resources for households and agriculture, and low literacy and skill levels.

Phetha and Ndlovu (2023, p. 77) found that local government in South Africa undoubtedly faces various challenges in delivering services, including slow response rates to citizens' requests and long distances to reach government offices (particularly in rural areas). Poor information technology (IT) systems also create

problems of inefficiency and ineffectiveness at this level (Mawela et al., 2017, p. 159). For example, rural areas require special attention to address the digital divide that still persists if information and communication technologies (ICTs) are to be used to change citizens' lives. Constraints include issues of distance, and a lack of electricity and connectivity remains pertinent (Mawela et al., 2017, p. 159).

A possible cause of the local challenges is that local government IT infrastructure is not up to standard and is insufficient, as the 4IR relies on a backbone of advanced technology. When ICT infrastructure is deficient, e-government development is inhibited, which limits the proportion of citizens that can be served. As the 4IR seeks to expand into rural areas, issues concerning the provision of infrastructure and access to services become more critical, as most 4IR technologies require physical infrastructure to operate (Mhlanga et al., 2021, p. 1012).

Lele and Goswami (2017, p. 7) conducted research in India on rural challenges in 4IR integration, especially in the agricultural sector. India facilitates citizen engagement and awareness programmes to better support rural inclusive growth and has proven that digital platforms can provide for this via "smart physical systems", which can be used to create more skilled jobs in rural areas, particularly in the agriculture, energy, and infrastructure sectors. This indicates that "pro-rural digital policies" require "bottom-up" and "top-down" approaches to successfully integrate 4IR opportunities. However, such research has not yet been conducted in the South African context. This study aimed to bridge this gap by advocating measures for good practice in 4IR integration. The purpose of this is to afford recommendations on effective means for pro-rural digital policies between municipal officials and community members.

In an effort to advance developmental local government to play an important role in encouraging and raising standards of living and creating new opportunities for individuals to flourish, the South African government has acknowledged the importance of the 4IR. Unfortunately, local government is not yet fully integrated into the 4IR. The argument is that the 4IR is not yet upon local government, and there is little evidence that it is on the horizon (Moll, 2021, p. 2). This statement is supported by Marwala (2020, p. 1), who points out that one issue of contention is that South Africa has lagged in the first three industrial revolutions. This is evidenced by the fact that, on many occasions, municipalities have fallen behind in their ability to adapt and respond to industrial revolutions (Marwala, 2021, p. 10). Rossouw and Lourens (2019, p. 92) argue that a particularly salient example of this disingenuity was President Ramaphosa's invocation in his 2019 State of the Nation Address regarding

building new "smart cities", while most South African municipalities struggle with crumbling infrastructure, water and electricity supply, crippling debt, overpopulation, and violent crime.

Prior research has underscored the potential of the 4IR to drive innovation in public governance, with studies indicating that smart cities, digital governance, and AI-driven solutions can significantly enhance service delivery, accountability, and public trust. Despite this potential, many municipalities struggle to integrate these technologies due to a variety of factors, including inadequate policy frameworks, poor infrastructure, and resistance to change (Khemka, 2020, p. 4). This paper examines the key barriers to 4IR adoption in South African municipalities and proposes a comprehensive policy framework that incorporates international best practices for technology integration in local government settings.

2. Literature Review and Theoretical Framework

This section discusses the applications and influences of the 4IR on local government, as well as the theoretical frameworks that underpinned the study.

2.1. Applications and Influences of Fourth Industrial Revolution (4IR) Technologies on Local Government

4IR technologies, including the IoT, AI, machine learning, and advanced robotics, are discussed in detail below, along with their positive impact on the functioning of local government (Xing & Marwala, 2017, p. 11).

2.1.1. The Internet of Things (IoT)

One of the most discussed technological developments of the 4IR that impacts local government is the IoT. The IoT refers to the connection between sensors or devices and the Internet. It consists of major features and built-in intelligence that enable communication protocols and distributed intelligence for smart objectives via wired and wireless sensors and actuators. Furthermore, identification, location tracking, and monitoring of subjects are some IoT functionalities (Bkheet & Agbinya, 2021, p. 160). Malinga (2019, p. 1) states that the IoT can be used to gather data in real time for local government decision-making processes.

Water scarcity is also a growing concern for municipalities in South Africa; as such, IoT devices equipped with sensors can monitor water flow and detect leaks. By leveraging real-time data and advanced analytics, municipalities can identify inefficiencies, automate water flow adjustments, and prevent wastage. More

specifically, IoT-driven smart water management systems promote sustainability, enhance water conservation efforts, and contribute to preserving this precious resource (Tsiukhai, 2022, p. 1). This statement is supported by Pretorius (2019, p. 25), who points out that the IoT has also been employed in the United States of America to minimise water loss due to pipe leakages and to reduce household water consumption.

2.1.2. Artificial Intelligence (AI)

One of the most important role players in the 4IR is AI, or “smart” machines that mimic human intelligence, perform complex tasks with little or no human intervention, and are capable of self-learning (Leonhard, 2016, p. 1). Rossi (2019, p. 127) agrees that AI “is a scientific discipline aimed at building machines that can perform many tasks that require human intelligence”. According to Baruffaldi et al. (2020, p. 8), AI “is a term commonly used to describe machines performing human-like cognitive functions (e.g., learning, understanding, reasoning and interacting)”. Kim (2017, p. 1) proposes that AI can be seen as a 4IR tool for enhancing human knowledge, by involving different insights through stimulating creative thinking and achieving better results. The AI Group of Experts at the Organisation for Economic Co-operation and Development (OECD) defines an AI system as “a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments” (cited by Lancrin & Van der Vlies, 2020, p. 7). AI is therefore essential for making decisions and predictions. AI is a subfield of computer science, with the sole purpose of giving human-like intelligence to machines or robots to enable them to become self-reliant platforms that can carry out smart decisions autonomously (Toor, 2017, p. 1).

AI-based applications are emerging across a broad range of expert domains. There are two types of AI: narrow AI, which relates to applications that humans use to perform tasks in specific domains, and “strong AI”, which refers to artificial general intelligence (AGI) that is still under development (Adendorff & Putzier, 2018, p. 1). Moreover, the concept of AGI is broad and deep. It comprises features that surpass human intelligence in many dimensions, such as analytical speed, memory, multitasking, pattern recognition, and the ability to adapt to newly learned information. According to Kasvosve (2017, p. 1), AI encompasses three broad areas: cognitive science applications, robotics applications, and natural interface. Figure 1 depicts an overview of AI with the relevant applications in each of the domains.

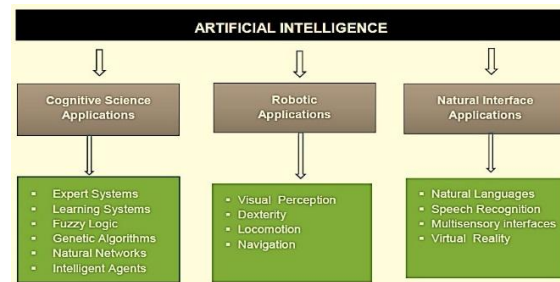


Figure 1. AI overview: Three main application domains

Source: Adapted from Kasvosve (2017, p. 1)

AI has the potential to improve human welfare, contribute to positive, sustainable global economic activity, increase innovation and productivity, and help to address key global challenges such as climate change, health crises, resource scarcity, and discrimination. Moreover, AI is rapidly opening up a new frontier in the fields of business, corporate practices, and governmental policy. AI also holds significant potential to advance the agenda towards meeting the Sustainable Development Goals (SDGs) because it can be leveraged for social good and to further the SDGs in areas such as education, health, transport, agriculture, and sustainable cities; among others (Blinken, 2023, p. 1).

AI is rapidly becoming an integral part of local government and is revolutionising the way municipalities are managed and services are delivered. From streamlining processes to improving decision-making processes, AI offers numerous benefits to local government. By leveraging AI technologies, local government can automate administrative tasks, such as data collection and analysis, thereby freeing up valuable time and resources. This, in turn, allows municipal officials to focus on more complex and strategic issues, which can lead to increased efficiency and productivity in local government operations. Furthermore, AI implementation in local government can enhance the quality and effectiveness of municipal services. For instance, AI technologies, such as chatbots, are proven tools that offer efficient and automated solutions for managing resident inquiries and providing real-time assistance to residents seeking digital news, information, services, and resources from their local government at all hours of the day and night (Leslie et al., 2021, p. 1).

AI-powered chatbots enable local government to respond faster to residents, which reduces response times and enhances overall customer satisfaction. These chatbots can also handle routine inquiries, which frees human resources for more complex tasks. For example, ChatGPT is an AI chatbot that uses natural language processing to create human-like conversational dialogue. The advanced conversational capabilities of this AI chatbot can address many questions that people have (Hetler, 2023, p. 1). According to the University of California, Randy Saffold (2023,

p. 1), Senior Management Analyst of Leadership, Performance Management, Innovation Technology, Business and Economic Development, and Workforce Training, asked ChatGPT how municipalities could use it to help their residents. He acknowledged that the answers were superior and that municipalities should seriously consider implementing them. Birchall (2023, p. 1) posits that ChatGPT, a powerful AI language model, can assist municipal officials in managing local government and providing more benefits in terms of accessibility, information dissemination, and citizen engagement. Additionally, AI algorithms can analyse vast amounts of data to identify patterns and trends, which will enable local government to make data-driven decisions in areas such as urban planning, public safety, and resource allocation (Leslie et al., 2021, p. 1). By harnessing the power of AI, local governments can optimise service delivery, enhance citizen satisfaction, and ultimately foster more sustainable and liveable municipalities (Chiancone, 2023, p. 1).

2.1.3. Machine Learning

Keserer (2022, p. 1) asserts that although AI and machine learning are often used synonymously, they are actually very different. AI refers to anything that enables a machine to perform tasks that typically require human intelligence, such as object or sound recognition, comprehension of natural language, or solving challenging probabilistic problems. Machine learning, on the other hand, is a field of AI that allows systems to learn and improve from experience without being explicitly programmed. Smith and Pourdehnad (2018, p. 22) confirm that machine learning refers to computers' ability to learn and improve themselves through the use of creative intelligence, without being specifically taught or programmed. The reason that machine learning is classified as AI is that it involves algorithms that are fundamental to the viability of AI. This statement is supported by Liu et al. (2018, p. 1), who point out that an important component of AI is machine learning, which is known for its language comprehension and pattern or image recognition abilities, which can create value for municipalities. In this regard, the capabilities of machine learning to modify and enhance services, if used wisely, can hold many beneficial prospects for municipalities. Rapid progress in machine learning plays a central role in social, economic, and political culture (Adendorff & Putzier, 2018, p. 1).

Athey and Imbens (2017, p. 1) emphasise that inferring and understanding new commands from data is the key strength of machine learning. It investigates and analyses data, performs calculations, learns from it, and uses it to make predictions depending on the situation. The machine is being prepared, or is indeed preparing itself, on the most proficient method to perform a task accurately, then learning from the data and building its own

logic in providing solutions. For local governments to automatically improve performance on assigned tasks, machine learning techniques must be incorporated into their operations. Machine learning predictions can, for example, significantly enhance local government anti-corruption efforts (Varian, 2014, p. 1). Moreover, a study conducted by De Blasio et al. (2022, p. 1) showed that corruption is predictable, with high accuracy, using a limited set of variables readily available to policymakers.

Furthermore, machine learning provides a simple rule for identifying areas likely to experience corruption episodes. Investigative and prosecution efforts should focus on these areas, rather than, as is currently the case, on presiding over areas that are not likely to have corruption problems (De Blasio et al., 2022, p. 1). In this regard, Chiancone (2023, p. 1) argues that machine learning algorithms can analyse financial data to detect anomalies and potentially fraudulent activities. Butler (2022, p. 1) further acknowledges this reality and points out that machine learning takes the patterns found by AI to create data models that predict the likelihood of an issue occurring based on past events. This is also evidenced by the study conducted by Xia et al. (2022, p. 1), which emphasised that waste management is a fundamental municipal service. Accordingly, machine learning can help municipalities to optimise waste collection routes by considering historical data on waste generation, traffic patterns, and vehicle capacity. This reduces fuel consumption, greenhouse gas emissions, and operational costs while ensuring that garbage collection is more efficient and timelier. Moreover, Aldoseri et al. (2023, p. 1) agree that the more data machine learning can access, the more accurate the predictions. Municipalities will thus be able to make evidence-based decisions for better asset optimisation by incorporating real-time data from sensors into their predictions, which will update continuously.

2.1.4. Robotics

According to Groover (2023, p. 1), robotics is the integration of mechanics, electronics, and control systems to perform work or tasks automatically. Kernaghan (2014, p. 488) posits that the field of robotics is "the science or the study of technology involved in the design, development and deployment of machines, known as robots, to perform tasks normally performed by human beings". The field of robotics is a vital sphere of influence in which the impact of the 4IR can be seen (Wessels, 2020, p. 10). However, Bort (2014, p. 1) argues that the growth of robotics has led economic experts to warn that mass unemployment will result. More specifically, Hu (2021, p. 1) contends that South Africa's President Cyril Ramaphosa incorporated the 4IR into his economic strategy, which provoked criticism for its neoliberal rhetoric that echoes the World Economic Forum (2016, p. 1) and concerns that it will not lead to job creation. The public sector

must therefore rethink its strategies and auto-cannibalise its organisational models. This is because robots are capable of performing tasks that people cannot. Diphoko (2021, p. 1) suggests that local government should allow technology to assist with tasks that humans cannot complete, as it can function in areas where humans are less effective. Municipal and public service robotics represent a vast area of application with numerous opportunities to explore.

Several emerging robotics technologies are uniquely suited to municipal and civil applications, which may be helpful to South African municipalities that are struggling with, for example, ineffective waste management (Jewaskiewitz, 2021, p. 1). ZenRobotics technology has been tested in construction and demolition waste sorting, with rates of 2 000 picks per hour per gripper and purity rates of 98% in separated streams being achieved. This type of technology has demonstrated its capacity to separate bulky items weighing up to 30 kg, which indicates that robotics can revolutionise municipal waste sorting (Innovation Spotlight, 2019, p. 1). Diphoko (2021, p. 1) points out that there are now automated side-loaders in waste removal, which are equipped with fully digital platforms featuring remote diagnostics, real-time global positioning, full customer service data integration, 360-degree cameras, proof of service tools, and a full complement of safety equipment. This makes vehicle operators' jobs safer and more productive than ever before. These are examples of how automating some municipal functions can enhance efficiency while allowing humans to focus on more complex jobs.

It is evident that municipal infrastructure management and maintenance remain a challenge for many public institutions in practice. This is apparent in the South African context, given the continued structural deterioration of infrastructure and the encroachment on potential development land due to poor management and neglect (Palmer et al., 2016, p. 1). According to The Guardian (2015), Leeds University led a £4.2 million (approximately R90 million) project to create a fleet of robot repair workers that could identify infrastructure problems before they become disruptive, automate pothole repairs without digging up half the road, and patch cracks in utility pipes. The primary aim is to assign repetitive tasks to robots while humans are given flexible work assignments to improve a municipality's workflows. Some councils in other parts of the world are also beginning to apply robotic process automation, which mimics human interaction with computer systems, to repetitive tasks such as signing people up for administrative duties (Local Government Sector Education and Training Authority, 2020, p. 6). This would allow machines to complete tedious data entry tasks, which they generally perform faster and more accurately than humans.

Furthermore, humans should focus their time on improving front-line services that cannot be delivered by robots (Albukhitan, 2020, p. 1).

2.2. Theoretical Frameworks

The diffusion of innovation (DOI) and stewardship theories underpinned this research.

2.2.1. Diffusion of Innovation (DOI) Theory

The theory found to be most suitable as a framework for this study was the DOI theory, which is commonly referred to as Rogers' theory. Everett Rogers, an American theorist and sociologist, popularised this theory in 1962. The DOI theory underscores the social dynamics involved in the spread of new ideas, which emphasises the subjective perception of information in social networks. It posits that the adoption of a new idea, practice, or object follows identifiable channels and modes over time, which shapes its acceptance within both individual and organisational contexts. According to this theory, an innovation is an idea or technology perceived as new by the individual, and it proposes that this spread creates a distinct pattern of innovation adoption (see Figure 2). This pattern has led to the identification of five adopter categories in a social system: innovators, early adopters, early majority, late majority, and laggards (Sziklai & Lengyel, 2022, p. 9). Figure 2 illustrates the "S"-shaped curve that represents the cumulative rate of adoption (or diffusion curve), while the bell curve depicts the number of new adopters along the same timeline.

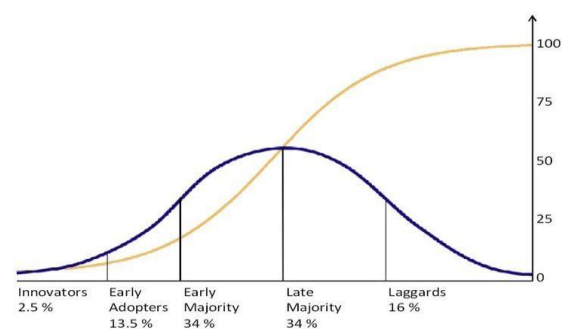


Figure 2. DOI theory process

Source: Rogers (2003, p. 14)

According to Rogers (2003, p. 14), the innovation-decision process suggests that diffusion occurs over time and can be seen as having five distinct stages: knowledge, persuasion, decision, implementation, and confirmation (see Figure 3). In other words, potential adopters of innovation must learn about the innovation, be persuaded of its merits, decide to adopt it, implement the innovation, and confirm (reaffirm or reject) their decision to adopt it. García-Avilés (2020, p. 2, citing Palm, 2022, p. 1) states

that this theory has been widely applied to technology. Moreover, Hassanien et al. (2021, p. 132) concur that the DOI theory is the most appropriate framework for investigating the adoption of technology in any organisation in terms of how and why innovations spread among people and at what rate.

Prior conditions

1. Previous practice

2. Felt needs/ problems
3. Innovativeness
4. Norms of the social systems
5. Observability

Communication channels

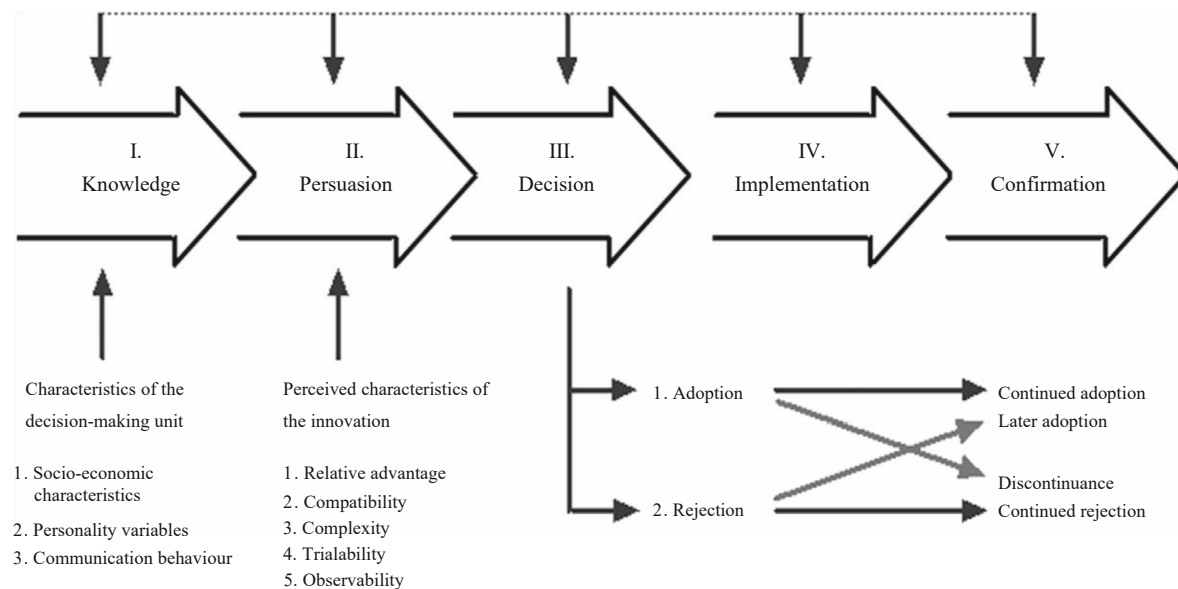


Figure 3. Decision process innovation model

Source: Genné-Bacon et al. (2020, p. 3)

El Malouf and Bahemia (2023, p. 1) highlight that the DOI theory is often regarded as a valuable change model for guiding technological innovation, where the innovation itself is modified and presented in ways that meet the needs of all levels of adopters. Moreover, previous studies, such as the one by Slinger et al. (2024, p. 4), have shown that the DOI theory allows researchers to study how innovation is adopted in society and to understand the influences related to the implementation of technology.

2.2.2. Stewardship Theory

According to Kgobe and Mamokhere (2021, p. 4), stewardship is an obligation to provide services effectively and efficiently, in order to meet the needs of the citizens of South African public service institutions without exception. The stewardship theory concerns being in control of something that has been entrusted to one's care but does not belong to the entrusted person (Motubatse et al., 2017, p. 95). Politicians and government administrators are entrusted with the care of the nation's resources placed under their control during their tenure in office. Good stewardship is best demonstrated through responsibility in serving community members (Motubatse et al., 2017, p. 95).

The stewardship theory can be used to assess developmental local government, as it provides a comprehensive framework for evaluating the performance and effectiveness of local government initiatives. At its very core, this theory underscores the responsibility of municipal officials to act as stewards or trustees of the resources entrusted to them while prioritising the long-term interests of the community above personal or partisan agendas. In applying the stewardship theory to assess developmental local government, several key principles emerge. First and foremost is the principle of accountability and transparency. Accordingly, municipal officials are expected to be transparent in their decision-making processes and ensure that the public remains informed and engaged (Mamokhere, 2022, p. 195).

In South Africa, municipalities have implemented various initiatives aligned with stewardship principles to address developmental challenges and promote sustainable development. Efficient resource management is another key aspect of assessing developmental local government through the lens of the stewardship theory. Moreover, municipal officials are tasked with managing financial, human, and infrastructure resources effectively to advance developmental goals and address the needs of the community. By optimising resource allocation and

promoting accountability in resource utilisation, officials demonstrate their commitment to stewarding public resources responsibly and achieving meaningful developmental outcomes. For example, Councillor Thabo Modise of the Mangaung Metropolitan Municipality advocated for the establishment of a community library and computer centre in his ward to improve access to educational resources and digital literacy skills. Through fundraising efforts and collaboration with local non-governmental organisations (NGOs), the project successfully provided residents with a space for learning and development. Such examples illustrate how South African municipalities are leveraging stewardship principles to address developmental challenges and promote sustainable development, thereby fulfilling their role as stewards of public resources for the betterment of their communities (Barendse et al., 2016, p. 3).

3. Methodology

This study adopted a qualitative desktop research approach to analyse secondary data from academic literature, policy documents, case studies, and institutional reports. This methodology enabled a comprehensive examination of international best practices and their applicability in the South African context.

A multiple case study technique was employed, which Vohra (2014) describes as an in-depth exploration of phenomena within their real-world context across several organisational settings. Similarly, Gustafsson (2017) defines a multiple case study as a method for investigating individuals, groups, or units with the aim of drawing broader generalisations. This approach is commonly used in the social sciences to identify similarities and differences across cases, which facilitates a deeper understanding of service delivery performance and the integration of 4IR technologies in local government settings.

The study utilised secondary data analysis, guided by thematic coding and comparative assessment frameworks. Quantitative information cited from reviewed sources, such as the European Union's (EU) eGovernment Benchmark, the OECD's Digital Government Reviews, and national statistics, was limited to aggregated findings, including mean scores, index values, or readiness rankings. Item-level data were not accessed or analysed, given the qualitative nature of the research design and the desktop-based data-collection approach.

A notable digital divide between younger (ages 18 to 35) and older (ages 55+) populations was consistently reported in these sources and was particularly evident in the Estonian case, where digital governance platforms serve users aged 16 to 85. These generational insights were derived from aggregated population-level indicators rather than individual-level responses. Consequently, structural equation modelling was not applied in this study. Where relevant quantitative results from other studies were referenced, they typically presented summarised indicators rather than raw survey items. This use of aggregated data aligned with the study's qualitative, cross-national comparative design and enabled conceptual integration and thematic synthesis without the need for respondent-level microdata. This approach supports policy-relevant generalisation across varied governance contexts.

4. Results and Discussion: International Comparisons and Best Practices

The study compared South Africa's 4IR adoption challenges with international best practices in order to draw insights from countries that have successfully integrated 4IR technologies into local governance.

Table 1. Comparison of international best practices and South African local government

International best practices				South African local government			
Interaction process	Economic impact/benefits	Social impact/benefits	Governance impact/benefits	Interaction process	Economic impact/benefits	Social impact/benefits	Governance impact/benefits
International best practice	Economic stimuli through AI-driven resource allocation and smart city initiatives, optimising water and energy usage	AI and the IoT improve quality of life by reducing environmental harm, improving living conditions, and preventing natural disasters	Enhanced transparency, accountability, and participation through smart governance platforms (e.g., <i>Decide Madrid</i>), open data, and AI-based crime prevention	Practice in South Africa	Economic stimuli through income generation	Effectiveness in service delivery and employee benefits	Transparency, accountability, rule of law, and participation
Smart water management	Reduced water wastage and infrastructure maintenance costs	More equitable access to water resources and reduced water shortages	Improved management of public utilities and resources	Smart water management	Reduced water wastage through monitoring and leak detection	Improved access to clean water for communities	Better monitoring and transparency in water service delivery
Environmental protection	Reduced costs of waste management and pollution control through automation	Improved health and quality of life and reduced environmental degradation	Enhanced governance in environmental protection through better monitoring	Environmental protection	Lower operational costs for waste management	Improved urban living conditions due to better pollution control	Better monitoring and enforcement of environmental regulations
Smart city initiatives	Economic growth through smarter infrastructure	Enhanced urban mobility, reduced traffic congestion,	Increased participation in urban planning	Smart city initiatives	Economic stimulus through infrastructure	Reduced traffic congestion and	Improved urban planning with

International best practices				South African local government			
Interaction process	Economic impact/benefits	Social impact/benefits	Governance impact/benefits	Interaction process	Economic impact/benefits	Social impact/benefits	Governance impact/benefits
AI in crime prevention and governance	investment and reduced costs Reduced crime rates and better management of law enforcement resources	and better quality of life Safer communities with lower crime rates, improving social cohesion and trust in law enforcement	and transparency in governance Increased transparency in crime prevention and governance through AI-powered fraud and corruption detection	AI in crime prevention and governance	investment and job creation Reduced crime-related economic losses and resource optimisation in law enforcement	improved public services Safer communities and better quality of life due to reduced crime	data-driven decisions Greater transparency in governance through AI fraud and corruption detection systems
Digital and e-governance for citizen engagement	Increased efficiency in government processes, reducing costs of public participation and decision making	Enhanced public trust and participation in decision making, fostering better community-government relations	Improved transparency and accountability through real-time data and open platforms for civic engagement	Digital and e-governance for citizen engagement	Lower costs of civic engagement and decision-making processes	More inclusive and participatory governance, improving trust between citizens and government	Enhanced transparency and accountability in governance through open data and digital platforms
Public service delivery	Reduced inefficiencies in service delivery, lowering operational costs for municipalities	Improved access to municipal services for citizens, promoting public satisfaction and well-being	Increased accountability and transparency in municipal service delivery	Public service delivery	Reduced operational costs through automation of municipal services	Better access to essential services and enhanced citizen satisfaction	Improved transparency and accountability in service delivery through automation
E-procurement	Lower transaction costs through automation and competitive bidding	Increased fairness in public procurement processes	Increased transparency and reduced corruption in procurement	E-procurement	Lower transaction costs in procurement	Poor competition among service providers	Lack of transparency and accountability in procurement processes
Learning networks	Increased capacity through knowledge-sharing and cost savings in government operations	Enhanced productivity and service delivery	Improved participation and accountability in governance	Learning networks	Lack of capacity and underutilised resources	Poor productivity and ineffective service delivery	Lack of participation and accountability in governance processes
Improved social and security benefits	Reduced costs associated with social safety net management and security operations	Enhanced social services, welfare distribution, and personal safety	Transparent management of social safety nets and security operations, fostering public trust in governance	Improved social and security benefits	Economic losses due to inefficient management of social welfare funds and increased costs for security operations	Social instability caused by insufficient distribution of welfare and ineffective security measures, increasing community unrest	Lack of transparency and accountability in the administration of social services and security operations, eroding public trust
E-citizens	New services tailored to citizens' needs improve economic opportunities	Easier access to government services and reduced service delivery times	Increased citizen participation through digital platforms enhances democracy	E-citizens	Inefficiency in targeting services to citizens leads to economic losses	Poor participation due to lack of digital infrastructure, resulting in exclusion from government services	Weak governance and lack of transparency in e-citizenship and digital services
Enabling policy and regulatory frameworks	Creation of economic conditions conducive to ICT investments and growth	Increased awareness of civil rights and improved accessibility to services	Enhanced transparency and compliance with legal and ethical governance standards	Enabling policy and regulatory frameworks	Lack of ICT infrastructure and enabling policies hinder economic opportunities in digital growth	Poor access to services due to inadequate policy frameworks leads to social exclusion	Weak governance structures are unable to enforce transparency and accountability without strong policy frameworks
Greater public participation in government affairs	Reduced costs for the government through digital public participation platforms	Easier public engagement in governance decisions, enhancing community trust	Enhanced democracy through public involvement and real-time feedback	Greater public participation in government affairs	Delayed corruption trials, rising xenophobia, and gender-based violence limit economic investments in public participation	Speedier process of public participation	Easier to be kept informed, as well as participation in governance
Public-private partnerships (PPPs)	Attracts technological innovation and investment in urban infrastructure, enhancing efficiency in public services through federal initiatives like the American Rescue Plan and Infrastructure Investment and Jobs Act	Improves access to essential services, including digital services that enhance public health and education outcomes for marginalised communities	Establishes clear frameworks for accountability and performance measurement in public service delivery	PPPs	Attracts investment for infrastructure development, especially in sectors like energy (e.g., renewable energy projects) and transportation (e.g., the Gautrain) to improve service delivery and stimulate economic growth	Enhances access to essential services such as water (e.g., water treatment plants), sanitation, and housing for underserved communities (e.g., the N2 Gateway housing project)	Establishes frameworks for accountability and transparency (e.g., the PPP Governance Framework) to help reduce corruption in public service delivery

International best practices				South African local government			
Interaction process	Economic impact/benefits	Social impact/benefits	Governance impact/benefits	Interaction process	Economic impact/benefits	Social impact/benefits	Governance impact/benefits
Collaboration between government and technology firms	Fosters economic growth and job creation in the tech sector through initiatives like the Digital Service, which supports local governments in adopting digital transformation	Promotes social equity by ensuring diverse community participation in governance and enhancing access to public transportation options	Enhances citizen engagement through data-driven insights that inform policy decisions and urban planning efforts, improving trust in government institutions	Collaboration between government and technology firms	Collaboration with firms like IBM on smart cities initiatives enhances infrastructure and public service delivery, promoting economic development	Enhances access to essential services such as water, sanitation, and housing for underserved communities through partnerships with NGOs and private companies	Establishes frameworks for accountability and transparency, helping to reduce corruption in public service delivery through initiatives like the Open Government Partnership

Source: Own creation

5. Key Findings

This section discusses identified areas that can be enhanced and a policy framework for improvement.

5.1. Identified Areas for Improvement

Based on international best practices, several key areas can be improved in South African local government:

- **ICT infrastructure:** Limited infrastructure for enabling technologies such as AI, the IoT, and digital platforms hinders progress.
- **PPPs:** While some successful PPPs exist, expansion into digital infrastructure, water, and social services is needed.
- **Citizen engagement:** South Africa lacks robust platforms for real-time citizen participation and transparency.
- **Service delivery automation:** Automation of services, such as waste management and water monitoring, is underdeveloped, which leads to inefficiencies.

- **Transparency and accountability:** Governance mechanisms for public procurement, service delivery, and social welfare management need enhanced transparency through digitisation.

Identifying areas for improvement led to the development of a benchmark of best practices (as shown in Table 2). This table analyses factors that influence the adoption of digital innovation. It is categorised into demographic variables (observable population characteristics) and psychological variables (attitudes, perceptions, and behavioural tendencies). Additionally, this table benchmarks best practices from international case studies against current South African practices to identify gaps and to provide actionable recommendations.

Table 2. A benchmark of best practices for digital innovation: Demographic and psychological variables analysis

DEMOGRAPHIC VARIABLES				
Variable category	International practice	South African context	Gap identified	Recommended improvement
Age demographics	Digital platforms designed for multi-generational use (Estonia e-governance serves 16 to 85 age groups effectively)	Digital divide evident between younger (18 to 35) and older (55+) populations in service adoption	Limited age-appropriate interface design and digital literacy support	Develop age-specific digital interfaces and provide targeted digital literacy training programmes
Education level	Services accessible across education levels with multilingual support (e.g., Singapore's Smart Nation initiative)	Higher education correlates with increased digital service usage; limited uptake among lower education groups	Educational barriers to digital service comprehension and navigation	Implement simplified interfaces, visual guides, and multilingual support systems
Income / socio-economic status	Universal access regardless of income through public digital infrastructure (e.g., Finland's digital services)	Higher-income groups show greater adoption; lower-income communities face access barriers	Socio-economic disparities in digital infrastructure access and device ownership	Establish public digital access points and subsidised connectivity programmes for low-income areas
Geographic location	Equal urban-rural digital service provision (e.g., Denmark's digital-first strategy covers remote areas)	Urban areas show higher adoption rates; rural communities face connectivity and awareness challenges	Geographic digital divide with limited rural infrastructure and service awareness	Expand rural broadband infrastructure and deploy mobile digital service units
Language / cultural groups	Multi-cultural digital platforms with native language support (e.g.,	Services primarily in English and Afrikaans;	Language barriers exclude non-English/	Develop multilingual platforms that support

	Canada's multilingual e-services)	limited indigenous language support	Afrikaans-speaking populations	all 11 official languages with cultural sensitivity
PSYCHOLOGICAL VARIABLES				
Variable category	International practice	South African context	Gap identified	Recommended improvement
Technology acceptance	High citizen confidence in digital systems through transparent, reliable services (e.g., Nordic countries)	Mixed acceptance levels; younger demographics more accepting than older generations	Generational and educational gaps in technology acceptance and comfort levels	Implement gradual technology introduction with extensive user support and training programmes
Trust in government	High digital service adoption due to strong institutional trust (e.g., Estonia, Switzerland)	Historical trust deficits impact willingness to engage with government digital platforms	Low institutional trust reduces digital service uptake and data-sharing willingness	Build trust through transparent governance, data-protection guarantees, and citizen feedback mechanisms
Innovation adoption attitude	Culture of early adoption and innovation embracement (e.g., South Korea, Japan)	Conservative approach to new technologies; preference for traditional service methods	Risk-averse attitudes towards new digital innovations and change resistance	Develop change management strategies with pilot programmes and success story demonstrations
Digital self-efficacy	High citizen confidence in personal digital capabilities (e.g., Scandinavian countries)	Variable self-efficacy levels; many citizens doubt their ability to use digital services	Low confidence in personal digital skills create avoidance behaviours	Create user-friendly interfaces with built-in help systems and confidence-building tutorials
Privacy concerns	Balanced privacy protection with service efficiency (General Data Protection Regulation) compliance in the EU	High privacy concerns due to historical surveillance experiences and data breaches	Privacy anxiety limits willingness to share personal information for service access	Implement robust data-protection frameworks with clear privacy policies and user control options

Source: Own creation

5.2. A Policy Framework for Improvement

The study's dual guiding research question, namely "What is the role of the 4IR in developmental local government, and what proposals can be made to improve the policies, governance structures, capacity, and service delivery to fully benefit from the 4IR?", was foundational to this research.

5.2.1. Development of a Policy Framework

In response to the challenges posed by the 4IR, the goal was to address the study's research objective, namely "Develop a policy framework to contribute to developmental local government to provide certain suggestions for improvement in municipalities to deal with challenges posed by the 4IR". This framework focuses on four key areas:

(a) Policy improvement

The framework recommends revisions to existing policies that hinder the adoption of new technologies. By establishing guidelines that promote innovation and the use of digital tools, municipalities can align their policies with the opportunities presented by the 4IR.

(b) Enhance governance structures

Effective implementation of the 4IR requires strong governance frameworks. The policy framework proposes collaborative governance models that engage various stakeholders to ensure

that decision-making processes are inclusive and responsive to community needs. This directly addresses the need for improved governance structures highlighted in the research question.

(c) Capacity building

A critical aspect of leveraging the 4IR is the capacity of municipal employees. The framework emphasises the development of training programmes and resources aimed at equipping staff with the skills necessary to effectively implement and manage new technologies. This directly links to the research question's focus on enhancing capacity in local government.

(d) Service delivery enhancements

The framework proposes innovative strategies for service delivery, such as employing data-driven decision making to optimise resource allocation and enhance community engagement. This approach directly addresses the research question's emphasis on improving service delivery through the integration of 4IR technologies.

5.2.2. Linking the Framework to the Research Question

By articulating these proposals, the policy framework provides a clear pathway for municipalities to navigate the challenges posed by the 4IR. Each component of the framework aligns with the

research question, which illustrates how municipalities can effectively leverage the 4IR to improve their operations and service delivery (see Figure 4).

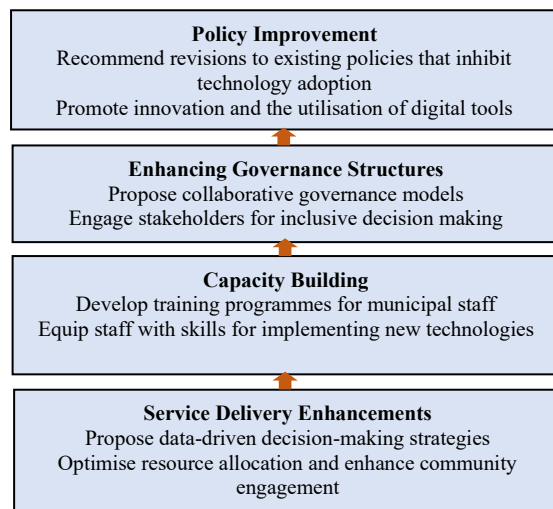


Figure 4. Policy framework

Source: Own construction

6. Limitations

This study's findings, while drawing from international best practices, are primarily contextualised within the South African local government framework. The applicability of these recommendations may vary across different cultural and institutional contexts. Specifically, the collectivist nature of many African societies may influence technology adoption patterns and community engagement strategies differently than in individualistic Western contexts. Similarly, in other collectivist societies such as Turkey, cultural norms around emotional expression (e.g., public displays of anger) may significantly affect community responses to technology-driven governance and participation models. These socio-cultural factors can mediate the acceptance, perception, and impact of 4IR technologies in local government systems.

Future research should examine how cultural dimensions, such as collectivism versus individualism, affect 4IR technology acceptance and implementation in diverse local government settings. Additionally, the economic disparities and infrastructure challenges specific to developing nations may require adapted implementation strategies that differ from those that are successful in developed economies. The digital divide remains a significant barrier that may not be equally present in all international contexts examined.

7. Conclusion

The integration of 4IR technologies into local government represents a significant opportunity to improve governance and

service delivery. However, without proactive measures, these technologies risk exacerbating socio-economic inequalities. This study concludes that South African municipalities must prioritise inclusivity, infrastructure, and capacity building to fully realise the benefits of the 4IR. The proposed policy framework aims to create an enabling environment for technology adoption to ensure that municipalities can leverage the 4IR to drive innovation, improve public services, and foster economic development.

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