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IoT Adoption in Botswana's SMEs: Technological Readiness and Government Initiatives

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Abstract

As Botswana seeks a more diversified and developed economy, fostering a robust Small and Medium-sized Enterprises (SME) sector is paramount. Consequently, integrating Industry 4.0 technologies, particularly the Internet of Things (IoT), presents a promising possibility for stimulating SME growth. Nonetheless, successful IoT adoption hinges on understanding Botswana's technological landscape. This study employed a Systematic Reviews and Meta-Analyses (PRISMA) guideline to survey the existing literature (academic and grey literature) published between 2015 and 2024 on Botswana's digital readiness. The review examined several areas of technological readiness, including e-commerce legislation, Information and Communication Technology (ICT) education, infrastructure investment, government online services, e-participation initiatives, internet costs, policy framework, cybercrime threats, and overall technology adoption. Results showed that while Botswana has made progress in digital integration, its digital maturity is still evolving. Strengths were found in areas including; e-commerce legislation, ICT education and infrastructure investment. However, weaknesses persist in areas including; limited government online services, limited e-participation initiatives, high internet subscription costs, inadequate policy framework, cybercrime threats, infrastructure limitations, and overall low technology adoption. These findings will equip SME decision-makers and policy makers with valuable insights to assess their digital preparedness for IoT adoption, while also considering Botswana's digital environment.

Keywords: Technological Readiness, Internet of Things (IoT), Industry 4.0, SMEs, Botswana

1. INTRODUCTION

The digital transformation of manufacturing and related industries, known as Industry 4.0 (4IR), has brought about ground-breaking evolutions in the way businesses function. This paradigm shift is fronted by breakthrough technologies including cyber-physical systems, the Internet of Things (IoT), cloud computing, and artificial intelligence (AI) [1]. 4IR aims to create a highly interconnected, automated, and data-driven industrial environment, enabling organizations to optimize their operations, enhance productivity, and unlock new opportunities for

innovation and growth [2]. Subsequently, the disruptive potential of 4IR has evolved from a mere suggestion to a critical vitality for businesses and economies globally [3]. Therefore, by strategically adopting 4IR solutions, organizations worldwide can expect substantial improvements in revenue streams and return on investment (ROI) [4].

Within the 4IR framework, the IoT stands as a powerful instrument. Often characterised as the next phase of internet evolution, IoT enables communication between machines [5]. It comprise of interconnected objects, sensors, communication infrastructure, cloud-based processing units, and decision-making systems [6]. Essentially, IoT bridges the physical and virtual worlds by connecting real-world objects equipped with identifiers like Radio Frequency Identification (RFID) tags to the internet via sensor networks [7]. This pervasive network of interconnected devices holds immense potential for driving digital revolution within Small and Medium-sized Enterprises (SMEs). For instance, IoT-enabled sensors can provide real-time monitoring of production processes, allowing businesses to optimize efficiency, minimize waste, and enhance product quality [8].

In the global economic milieu, resource-dependent economies like Botswana are actively seeking strategies to foster economic diversification and a strong manufacturing sector [9]. The Botswana government acknowledges the transformative potential of integrating information and communication technologies (ICT) into the nation's development. This recognition is explicitly articulated within key frameworks, such as the National Development Plan and the Maitlamo National ICT Policy [10]. These frameworks emphasize the crucial role of ICT integration in charting a sustainable path towards a knowledge-based economy for Botswana by the year 2036 [11].

While many economies worldwide are rapidly adopting 4IR technologies, developing nations like Botswana, face unique challenges in navigating this digital revolution. Yet, despite governmental efforts to encourage ICT adoption, the uptake of innovative technologies within Botswana remains notably low, particularly among SMEs [12], [13]. This has hindered Botswana's efforts to diversify its economy and transition to a knowledge-based society through effective ICT integration [14]. Moreover, reluctance of SMEs to adopt emerging technologies may indicate a deficiency in their understanding of Botswana's technological readiness to support disruptive innovations. As Nylén and Holmström [15] emphasize, it is crucial to evaluate digital readiness before implementing new technologies to mitigate the risk of failure and enhance adoption. Similarly, Mutula and Van Brakel [16] and Shonhe and Kolobe [17] underscore the significance of comprehending Botswana's digital landscape for fostering widespread adoption of emerging technologies. This study aims to bridge a research gap by analysing existing literature on Botswana's digital readiness for

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IoT adoption within the 4IR framework. Specifically, it examines several areas of technological readiness, including e-commerce legislation, ICT education, infrastructure investment, government online services, e-participation initiatives, internet costs, policy framework, cybercrime threats, and overall technology adoption.

By focusing on Botswana, this research offers valuable insights into the unique technological readiness barriers and opportunities faced by developing economies, thereby providing broader lessons and strategies for successful IoT adoption in similar contexts. Additionally, the study aims to empower SME decision-makers and policymakers by providing them with actionable insights to strategically prepare for Industry 4.0. This knowledge will enable SMEs to assess their digital readiness for IoT adoption. Ultimately, this study will contribute to fostering a more advanced and competitive SME sector in Botswana's digital economy.

2. METHODS

2.1. Literature Review Methodology

This study adheres to established best practices for conducting systematic reviews, as outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, published in 2009 [18]. This structured and systematic approach ensures a comprehensive and transparent review of the literature [18]. Our investigation included both academic and grey literature published between 2015 and 2024. The subsequent sections explain the systematic literature review (SLR) process. It begins by articulating the primary research question that guided the literature analysis, followed by secondary research questions. Furthermore, the study discusses the stages involved in the SLR and presents the PRISMA flow diagram.

2.1.1. The main research question

This study aims to comprehensively assess Botswana's technological readiness for IoT adoption and the government's initiatives supporting IoT adoption by SMEs. To achieve this, the study defines technological readiness and its key components. It then analyses Botswana's technological environment, considering factors such as technology readiness rankings, mobile technology penetration, national vision, development plans, ICT strategy, and network infrastructure investments. Furthermore, the research examines the relationship between the government and the SME sector, and the potential benefits of IoT adoption for Botswana SMEs. Finally, the study conducts a thorough analysis of Botswana's technological readiness, identifying its strengths, weaknesses, and the governmental initiatives in place to support IoT adoption. Thus, the primary research question is:

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"What is the current state of Botswana's technological readiness for adopting Internet of Things technologies, and what are the key governmental initiatives supporting IoT adoption for Small and Medium-sized Enterprises in the country?"

2.1.2. The secondary research questions

To address the primary research question, this review process focused on the following secondary research questions:

1) What are the various definitions of technological readiness and its key dimensions?
2) How does Botswana's current technological environment, including its technology readiness rankings, mobile technology growth and penetration, national vision, development plans, ICT strategy, and network infrastructure investments, align with the country's goals for adopting IoT technologies?
3) What is the nature of the relationship between the Botswana government and the SME sector in fostering technology adoption?
4) What are the key strengths and weaknesses associated with Botswana's technological readiness, and governmental initiatives supporting IoT adoption for SMEs?

Adhering to the PRISMA guideline, our search strategy predominantly concentrated on English-language publications from 2015 to 2024, while also considering earlier works of significant importance. Table 1 provides a detailed overview of the PRISMA protocol followed by the study, outlining key stages such as inclusion and exclusion criteria, source identification, database selection, search strategy formulation, and classification analysis.

Table 1. The SLR process adopted by the study

Stage	Description
Inclusion criteria	1) Academic Literature: Peer-reviewed research articles, books, and conference proceedings published in English. 2) Grey Literature: Government reports, policy documents, industry reports, theses, and trusted technology portals published in English. 3) Publication Dates: January 2015 to July 2024, with exceptions for highly influential earlier studies. 4) Focus: Studies on Botswana's technological readiness, SME IoT adoption, SMEs and Industry 4.0, and technological readiness in developing economies.
Exclusion criteria	1) Academic Literature: Studies not published in full text or in academic journals/proceedings.

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Stage	Description
	2) Academic Literature: Studies without a direct focus on IoT adoption in SMEs, technology readiness in Botswana or developing economies. 3) Grey Literature: Studies not published in Botswana or from government or technology untrusted sources. 4) Publication Dates: Studies published before January 2015, unless deemed highly relevant.
Identifying Sources and Databases	1) Key databases and sources include academic journals, books and conference proceedings (e.g. Scopus, Web of Science, IEEE Xplore, University of Botswana Library catalogue, and Google Scholar). 2) For grey literature Google was used for broader coverage, to identify relevant sources in government portals and trusted technology websites (e.g., industry associations, research institutes)
Formulating Search Strategies	1) Core search terms combined "Botswana" with synonyms for technology readiness, such as "Technology readiness," "Digital readiness," "e-readiness," "ICT readiness," and "network infrastructure", "Information and Communication Technology readiness" 2) Additional keywords included: "Small and Medium-Sized Enterprises" (or "SMEs"), "IoT" (or "Internet of Things"), "emerging technology," "disruptive technology," "4IR," "Industry 4.0," and "Vision 2036." 3) Furthermore, keywords related to government initiatives and national development plans were incorporated: "Government," "National development plan," "NDP 11," "Sustainable development goals," "economy," "Maitlamo," "ICT policy," "ICT Vision," and "Government initiatives."
Performing Classification Analysis	1) Duplicate entries were removed using Mendeley software. 2) Two independent reviewers screened the remaining studies using the predefined selection criteria. Any disagreements were resolved through discussion until a consensus was reached.

An initial search yielded a large number of publications (n = 3203). Two independent reviewers then assessed each publication against pre-defined inclusion/exclusion criteria to ensure a focused and objective selection. This rigorous process resulted in 22 research publications deemed most relevant for further analysis (refer to Figure 1).

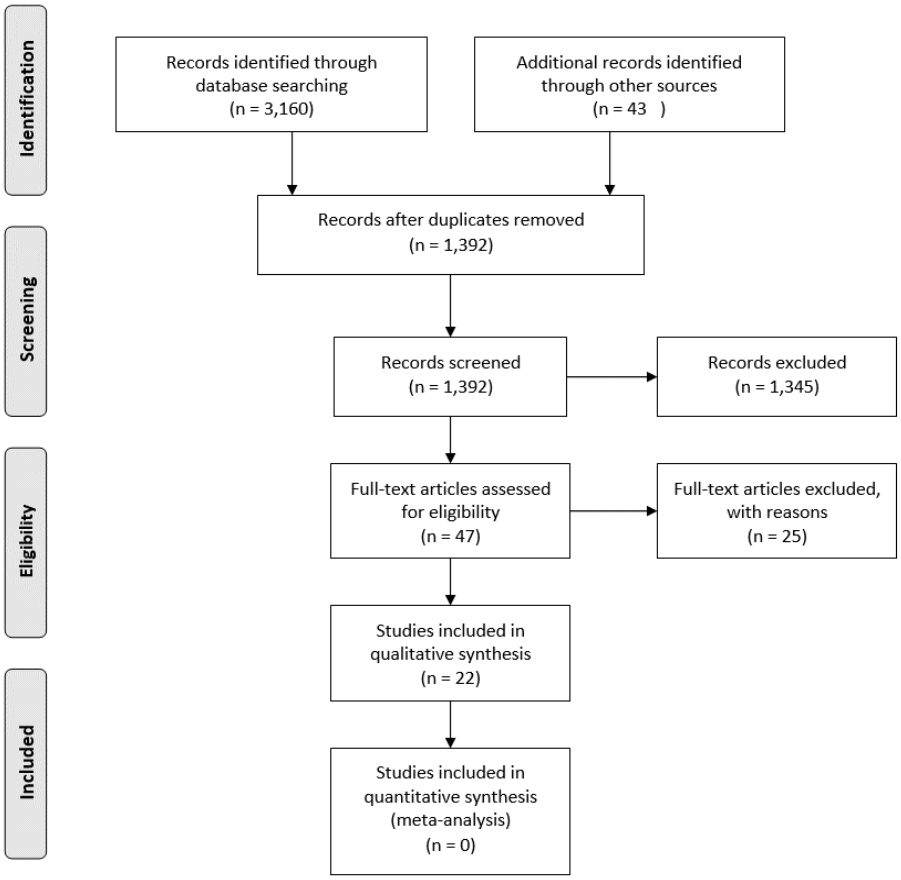

Figure 1. The PRISMA flow diagram, adapted from Moher et al. [18]

3. RESULTS AND DISCUSSION

This section presents a summary of the key findings from the systematic literature review on Botswana's technological readiness. Notably, the terms "technology readiness", "e-readiness" and "digital readiness" are used interchangeably throughout this study due to their minimal conceptual distinction in this specific context. A detailed discussion of these findings is provided in sections 3.1 to 3.5.

3.1. Defining Technological Readiness and its Dimensions

The concept of technological readiness, introduced in the late 1990s to assess the disparity in digital advancement between developed and developing countries [16], has evolved into a critical factor in today's world [19]. While the precise definition remains debated [16], one perspective views technological readiness as the level of ICT development within a society [20]. This definition emphasizes not only the

availability of technologies but also the skills and attitudes needed for their effective use. Makame et al. [21] inflate on this concept, framing technological readiness as the interplay between human resource capital, financial resources, government policies, ICT infrastructure, and e-government services. Formerly, Singh and Maurya [22] presented a broader perspective, encompassing both technological adoption and ICT use within a country. Their definition considers factors like the availability of advanced technologies, technology absorption by firms, and internet penetration rates. Alzhanova et al. [23] emphasized the effective utilization of technology, including infrastructure accessibility and user proficiency. Parasuraman and Colby [24] define technological readiness as the willingness and competence of individuals to embrace new technologies in their personal and professional lives. Supriyanto and Mustofa [25] offer a multi-dimensional perspective, encompassing telecommunications infrastructure, human resources, legal frameworks, and the overall economic and political environment that facilitates ICT adoption.

Since the introduction of the Technology Readiness Level (TRL) methodology by National Aeronautics and Space Administration (NASA) in the 1970s, a multitude of digital readiness assessment tools and indexes have been developed [26]. Notably, technology readiness can be evaluated using dimensions, incorporating individuals, workgroups, organizations, industries, and even entire nations [26]. Agriculture and Food Canada, cited by Mutula and Van Brakel [16] highlights different degrees of technological readiness within organisations. This included activities like using email as the primary communication method, utilising websites for internal and external communications, selling goods and services online, making travel arrangements through online services, purchasing computer equipment and software online, sending electronic invoices, and making electronic payments. In Table 2 the study presents the selected renowned technology readiness assessment frameworks [26]. These frameworks are recommended for assessing existing national capabilities, and identifying digital strengths and weaknesses in prior research [26] .

Table 2. Technology readiness frameworks, key dimensions and maturity

Framework	Dimension	Stages of maturity	Literature source
Government AI Readiness Index	Government, Data and Infrastructure, Technology sector	N/A	[27]
Network Readiness Index	Technology, people, Governance, Impact	N/A	[28]
Digital Maturity Assessment Tool	Governance and leadership, People and culture; Capacity and capability, Innovation, Technology	Minimal, Informal and reactive, Transitional,	[29]

Framework	Dimension	Stages of maturity	Literature source
		Customer-driven, Transformed	
Country Digital Readiness-CISCO	Technology adoption, Start-up environment; Human capital, Technology infrastructure, Business and government investment, Ease of doing business, Basic needs	Activate, Accelerate, Amplify	[26]
E-government Development Index	Normalized composite index of 3 indices—Online Services Index (OSI), Telecommunications Infrastructure Index (TII), Human Capacity Index (HCI)	Low, Middle, High, Very High	[26]
Digital Adoption Index	People, Government, Business	0 – 1 scale	[26]
Digital Maturity Model 5.0	Culture, Technology, Organization, Insights	Skeptics, Adopters, Collaborators, Differentiators	[26]

Source: Adapted from Assefa et al. [26] and modified by the author

In analysing the Table 2, is evident that the specific dimensions used to assess a country's technological readiness can vary. However, most frameworks converge on the following key dimensions; a) Technology: This dimension evaluates the presence and advancement of technology infrastructure. This could include aspects like internet penetration, mobile network coverage, and cloud computing availability. b) People: This dimension assesses the human capital available to effectively leverage technology. It considers factors like the workforce's skills and digital literacy, along with the availability of training programs to address skill gaps. c) Government: This dimension evaluates the government's role in promoting digital adoption and readiness. This could include factors like government investment in digital infrastructure, the existence of clear digital policies and regulations, and the effectiveness of e-government services. d) Business environment: This dimension assesses the overall business climate and its support for digital adoption. This could include factors like ease of doing business, access to financing for technology investments, and the presence of a vibrant startup ecosystem.

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3.2. Analysis of Botswana's Technological Readiness Environment

Since gaining independence in 1966, Botswana has witnessed significant economic growth primarily driven by its beef and mining sectors [30]. However, the recent years have seen a growing recognition of the need to diversify the economy and lessen dependence on these sectors [9]. In this context, ICTs are now recognised as the catalyst for the next stage of economic development [14]. Their potential lies in integrating all citizens and sectors into the global digital economy, fostering widespread benefits [11]. One key strategy for economic diversification focuses on the adoption of disruptive technologies like the IoT [31]. Muchuchuti et al. [32] underline the importance of active participation in 4IR for African nations, particularly Botswana. The National Employment Policy [33] reinforces this notion by highlighting the necessity for proactive government action to ensure Botswana's adoption of 4IR technologies. Such measures are crucial to prevent the country from being left behind in the rapidly evolving global technological landscape [32], [33].

3.2.1. Comparison of Botswana's technological readiness against global, regional, and least-performing nations

The Network Readiness Index (NRI) has emerged as a leading global framework for evaluating ICT development across various economies [34]. Established in 2002 by the World Economic Forum, this framework evaluates and ranks countries based on their capacity to leverage ICTs across four key pillars, namely; Technology, People, Governance, and Impact. Each pillar is further subdivided into three sub-pillars, resulting in a comprehensive analysis of a nation's ICT landscape through 58 distinct variables [28]. Consequently, by measuring ICT integration into society and the economy, the NRI aims to inform policy decisions that drive digital transformation and foster sustainable growth [35]. According to the 2023 Global NRI, Botswana ranks 110th out of 134 economies [28]. However, a comparative analysis with leading nations underscored a significant technological gap between Botswana and these countries. For instance, the United States leads with a technology score of 79.64, while Singapore follows with a score of 70.57. Finland hold a third position, by exemplifying a strong balance between technology and governance, with a technology score of 65.5 and a governance score of 89.94 [28]. In stark contrast, Botswana's technological ranking score of 25.75 and the governance score of 47.48 suggests a relatively strong regulatory environment, but it does not sufficiently offset its technological deficiencies [28].

When comparing Botswana's technological readiness with its African counterparts and neighbouring countries, the 2023 Global NRI results reveal a mixed performance. For instance, Botswana's technology rank score of 25.75 place it below top-performing African nations like South Africa, which ranks 59 with a

score of 41.75, and Kenya, ranked 65 with a score of 40.56, both demonstrating more advanced technological capabilities [28]. However when compared against its boarder-sharing countries, Botswana's performance is varied. Namibia, with a rank of 90 and a score of 33.04, surpasses Botswana in technology readiness, while Zimbabwe, ranked 118 with a score of 24.34, and Zambia, ranked 124 with a score of 20.2, trail behind [28]. Nonetheless, when compared to the lowest-performing country in Africa, Burkina Faso, ranked 134, Botswana has shown progress in technological development. In Table 3 a comparative analysis of Botswana's technological readiness in relation to the world's top-performing nations, its African counterparts, neighbouring countries, and the least technologically advanced country worldwide is presented.

Table 3. Comparative analysis of Botswana's technological rankings and score

Country	Ranking	Score
United States of America	1	79.64
Finland	3	65.5
Singapore	5	70.57
South Africa	59	41.75
Kenya	65	40.56
Mauritius	80	37.88
Namibia	90	33.04
Botswana	115	25.75
Zimbabwe	118	24.34
Zambia	124	20.2
Burkina Faso	134	12.14

Source: Adapted from [28], compiled and edited by the author

Despite its ranking in the global NRI, Botswana's potential for adopting emerging technologies like AI appears promising. For instance, the Government AI Readiness Index, a separate framework that evaluates government preparedness for AI implementation, positions Botswana at 98th globally [27]. This ranking suggests potential for growth. Moreover, Letsholathebe [31] highlights a more positive regional perspective, placing Botswana 9th position in terms of technology readiness within Sub-Saharan Africa. While these rankings may appear promising, significant obstacles persist that impede Botswana's overall digital readiness. For instance, an international comparison highlights a potential gap between Botswana's national technology readiness and its progress in integrating technology across various sectors [36]. Moreover, Shonhe and Kolobe [17] identify specific challenges hindering Botswana's advancement in adopting disruptive technologies, including; the absence of a national AI strategy, limited capacity for organizational change management, an immature domestic technology sector, inadequate skills, insufficient technological infrastructure, and limited data for training AI models. Unequal access to technology and its limited adoption across

the country also presents significant hurdles [14]. These faced by Botswana nation hinder economic progress. In particular, they limit the growth potential and opportunities for SMEs, ultimately hindering their ability to flourish in the global marketplace [11].

3.2.2. Mobile technology growth and penetration in Botswana

In recent years, Botswana has experienced a significant growth in ICT usage. This growth is primarily driven by the widespread adoption of mobile devices, with mobile phone subscription rates exceeding the total population [11], [37]. The high number of active mobile broadband subscriptions, which have exhibited steady growth since 2015 [38], exemplifies this trend. Furthermore, data from Statistics Botswana [39] confirms the continued growth of both mobile and fixed internet subscriptions in Q2 2023. This trend extends to mobile money, a technology enabling financial transactions via mobile phones, which is experiencing significant uptake [39]. Several service providers address this demand by offering convenient and accessible financial services. Additionally, nationwide mobile coverage has expanded, with advanced technologies like Third Generation (3G) and Fourth Generation (4G)/ Long-Term Evolution (LTE) reaching urban areas [11].

While mobile penetration is high, a significant portion of the population still lacks internet connectivity [39]. This digital divide highlights an area requiring focused attention. Moreover, social media usage, frequently viewed as an indicator of digital engagement, also falls below the level of mobile phone ownership [37]. These findings could suggest potential limitations in digital literacy or data plan affordability. This also suggests that addressing the digital divide and promoting broader internet access will be crucial for maximizing the benefits of this growing mobile technology landscape.

3.2.3. Botswana vision, national development plans and ICT strategy

The Botswana national master plan, Vision 2036, launched in 2016, serves as a roadmap for the nation's progress over the next two decades [14]. This strategic plan prioritizes achieving prosperity for all citizens by fostering investment in science, technology, innovation, research, and development [40]. Recognizing ICT as a key driver for economic diversification and sustainable development, Vision 2036 emphasizes enhanced ICT integration to transform Botswana into a high-income country by 2036 [14]. This focus aligns with "Maitlamo" the National ICT Policy [41], which aims to create connected communities and foster a knowledge society. Further supporting Vision 2036, National Development Plan 11 (NDP11), Sustainable Development Goals (SDGs), and the ICTPR e-commerce strategy was expanded to address key areas of Botswana's development agenda [11]. These include intensifying export markets, fostering private sector growth, empowering

citizens, creating jobs, boosting productive capacity, enhancing global competitiveness, economic diversification, and building a knowledge-based economy [11].

The NDP11 emphasizes achieving "connected communities" to attain the knowledge society vision outlined in Maitlamo National ICT Policy. The Maitlamo National ICT policy framework is built on seven pillars: connecting Botswana, connecting communities, establishing enabling policies, delivering government services online, promoting ICT use in schools for lifelong learning and efficiency, and fostering innovation [14]. The Botswana government actively promotes ICT adoption through a multi-faceted approach. This includes initiatives designed to reduce the cost of ICT tools and implement tax breaks for ICT companies, particularly start-ups and SMEs [10]. Additionally, a comprehensive public awareness campaigns are launched, tailored to different demographics like youth, families, businesses, and seniors. These targeted campaigns ensure maximum impact in encouraging widespread ICT use across society.

3.2.4. Maitlamo national ICT policy

The Botswana's 2007 National ICT Policy "Maitlamo" guides the nation's social, economic, cultural, and political transformation [10]. Aligned with both Vision 2016 and Vision 2036 [14], Maitlamo translates national development goals into actionable strategies. This policy reflects Botswana's ambitious transformation from a manufacturing-based economy to an innovation-driven digital one. Subsequently, the ICT vision for development in Botswana is articulated as follows:

> *"Botswana will be a globally competitive, knowledge and information society where lasting improvement in social, economic and cultural development is achieved through effective use of ICT."*

To ensure the National ICT Policy's effectiveness, the government fostered a broad-based participation process involving over a thousand individuals [10]. Representatives from the public, private, and civil society sectors were included, along with specialist taskforces in key ICT application areas. These taskforces focused on key domains where ICT can be effectively applied, namely;

1) Community access and development.
2) Government services.
3) Education.
4) Healthcare.
5) Economic advancement and ICT growth sector.
6) Infrastructure and security.
7) Legislation and policy.

The National ICT Policy outlines three key outcomes to be achieved through its comprehensive approach. These are given as follows [10]:

1) Creation of an enabling environment for the growth of an ICT industry in the country.
2) Provision of universal service and access to ICT facilities in the country.
3) Making Botswana a Regional ICT Hub to make the country's ICT sector globally competitive.

To manage the complexity of achieving its ambitious goals, the National ICT Policy is structured around five key areas [10]:

1) Establishing the National ICT Vision, Goals and Objectives - to identify desired outcomes.
2) E-Readiness and Benchmarking - to establish the current level of ICT diffusion
3) National ICT Policy - to identify and explain the key programmes and projects that are required to achieve the National ICT Vision, Goals and Objectives.
4) National ICT Master Plan - to define the various programmes and projects in greater detail, identifying the project deliverables, timelines, resources, programme dependencies and preliminary cost estimates.
5) An ICT Monitoring and Evaluation Programme - to measure progress and benefits achieved.

Besides advocating for ICT integration across various sectors in both government and private domains, the Maitlamo national framework offers crucial guidance for implementing proposed programs and projects within its policy framework. This guidance is presented through illustrative examples and a set of guiding principles, as detailed in Table 4 [10].

Table 4. Maitlamo National ICT policy initiatives and goals

Initiative	Description	Goals
Connecting Communities Programme	Establishes Community Access Centres (CACs) in schools and libraries, providing affordable computers and internet access to all residents.	a) Bridge the digital divide. b) Ensure universal access for all, including individuals with disabilities.
Government-On-Line	Implements a comprehensive e-Government initiative offering various citizen and business services online.	a) Enhancing service quality b) Streamline processes c) Improving public service efficiency for citizens and businesses.
ThutoNet	Focuses on high-quality ICT education for children, with a	a) Equip future generations with ICT skills

Initiative	Description	Goals
	specific emphasis on science and engineering.	b) Foster national development through local skill development c) Achieve a "knowledge-based society."
E-Health Botswana Programme	Aims to revolutionize healthcare delivery through ICT investments.	a) Enhance quality, safety, timeliness, and efficiency of health services for all Batswana.
ICT and Economic Diversification	Leverages ICT to drive job creation through private sector growth and diversification	a) Attract investment in key sectors b) Strengthen traditional industries c) Boost tourism revenue.
Connecting Botswana	Proposes collaborative initiatives between government, private sector, and communities to strengthen technical infrastructure.	a) Support various ICT programs b) Foster entrepreneurship and citizen empowerment.
Connectivity Laws and Policies Botswana	Reviews current legislation and recommends policy actions for a secure and trusted digital environment.	a) Protect citizens' rights b) Foster a vibrant ICT sector c) Attract foreign investment and encourage domestic growth.

Source: Adapted from [10], compiled and edited by the author

3.2.5. Botswana network infrastructure investment

Notwithstanding the recent economic developments, Botswana remains steadfast in its commitment to alleviating poverty and inequality by fostering inclusive growth [14], [42]. In this context, the Botswana government has prioritized the development of a robust national ICT backbone by investing heavily in ICT infrastructure. This includes connections to major undersea cable systems like Southern African Submarine Cable System (EASSy) and West Africa Cable System (WACS). This provides high-bandwidth data transmission routes for regional and global connectivity [11]. Additionally, private initiatives with submarine cable systems like SEACOM and Telecomm Sat 3 further strengthen international connectivity of Botswana and the rest of the world [14].

Recognising the importance of domestic connectivity, Botswana established key entities like Botswana Fibre Networks (BoFiNet) and Botswana Telecommunications Corporation Limited (BTCL) to spearhead ICT development [14]. A significant achievement of BTCL is the Trans-Kalahari Fibre Optic Ring, a

cross-border network connecting Botswana to South Africa, Namibia, Zambia, and Zimbabwe [14]. This investment strengthens both national and regional connectivity. The equitable and affordable broadband access fuels innovation and creativity for businesses and individuals. Moreover, the high capacity and speed of undersea cable systems enable diverse data transmission with reliable redundancy routes, ensuring dependable communication [14]. This strong ICT infrastructure groundwork positions Botswana to leverage technology for further development and economic growth [43]. Figure 2 illustrates how the Eastern Africa Submarine Cable System (EASSy) and West Africa Cable System (WACS) cable systems connect Botswana to other African countries and various regions of the world.

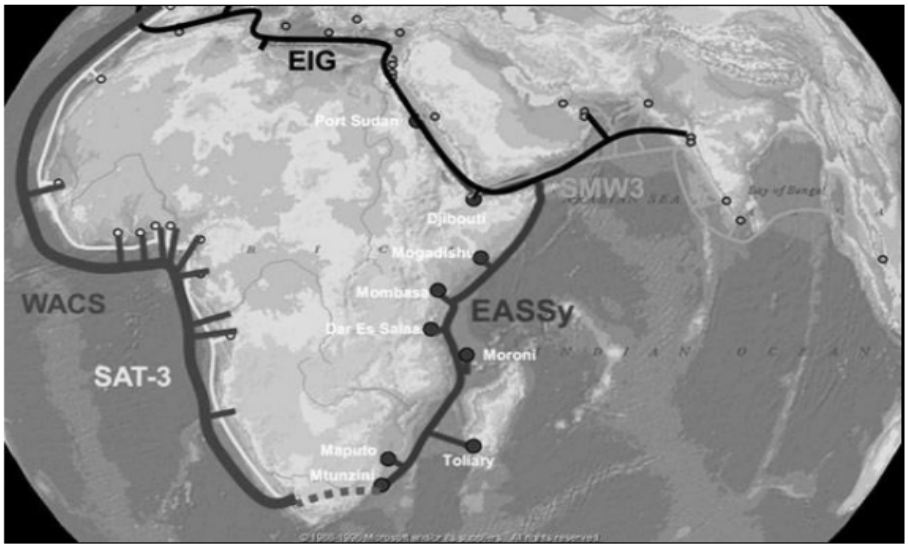

Figure 2. EASSy and WACS connecting Botswana to Africa and the world [43]

3.3. Botswana Government and the SMEs Sector

The government of Botswana recognizes SMEs as key drivers of economic growth and initiators of employment opportunities. In this context, the government prioritizes on empowering SMEs and boosting their competitiveness through facilitating capacity development and infrastructure development, including access to affordable technology and relevant industry skills [14]. Moreover, the government fosters SMEs collaboration within the local industry, and facilitating connections to large retailers and foreign partners. Furthermore, a new ICT licensing framework (2015) has been instigated which simplifies market entry and promotes market diversity for SMEs [11]. This initiative complements the SmartBots digitization strategy, launched in 2020, which aims to drive economic transformation across all sectors – economy, government, and society [44].

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The introduction of BoFiNet as a wholesale provider in the market has also contributed to continuous reductions in ICT service tariffs at about 70% in Botswana compared to regional and international rates [14]. Further, the company has in 2015 deployed wholesale Wi-Fi hotspots for the access of retail service providers in major towns and villages, a project subsidized by the Universal Access and Service Fund (UASF), to reduce investment costs for SMEs [45]. The presence of capacity from initiatives like EASSy and WACS has further led to reductions in internet subscription prices. This cost reduction has, in turn, empowered SMEs to invest in modern technologies, access digital resources, and expand their online presence [43]. With these concerted efforts, aligned with Botswana's national development goals, SMEs are better positioned to contribute to the nation's economic growth, innovation, job creation, and progress toward achieving broader societal and developmental objectives [11].

3.4. Why Should IoT Adoption Matter to Botswana SMEs?

Economic diversity is an ultimate goal of Botswana's Vision 2036 and NDP11 [14]. Therefore, to attain the nation's set objectives, digitalization plays a crucial role as a catalyst. Thus, by adopting emerging technologies like IoT, Botswana's SMEs can overcome existing limitations and unlock new opportunities for growth within the digital economy. According to Okafor [46] the integration of IoT in daily operations enables SMEs to differentiate them in the global marketplace. Through sensor-based monitoring, constringent quality control can be achieved, ensuring that products meet international standards. This builds trust and recognition for their brands, giving them a competitive edge [47]. Moreover, real-time data collection facilitated by IoT allows for data-driven decision-making, optimizing resource allocation and streamlining processes [48]. These efficiency gains translate to cost reduction and increased productivity, leading to improved profitability for SMEs [46]. Furthermore, IoT empowers SMEs to explore new markets and expand their customer base [49]. For instance, leveraging IoT-enabled logistics and supply chain management opens up opportunities for international trade [50]. This comprehensive approach to digital transformation contributes to national development in Botswana. In essence, a thriving SME sector, empowered by disruptive technologies like IoT, drives economic diversification, creates job opportunities, and strengthens the domestic economy [31]. Additionally, fostering a culture of innovation and technological adoption positions Botswana as a leader in the digital age, aligning with the strategic goals outlined in Vision 2036 and the NDP11 [14].

3.5. Analysis of Botswana Technological Readiness: Strength, Weakness, Government initiatives

Botswana boasts digital strengths in areas like; investments in infrastructure – international cables, nationwide fibre optics, and e-service upgrades – lay the foundation for enhanced connectivity [10], [14]. This improved connectivity also boosts businesses, access to global resources, and fuel economic growth in Botswana [11]. Additionally, the global NRI report postulates that the country excels in areas like e-commerce legislation, ICT education, and progress towards clean energy [28]. Table 5 illustrates some of Botswana technological strengths, and government initiatives.

Table 5. Botswana technological readiness strengths and government initiatives

Category	Strengths	Description
Infrastructure Investment	Government investment in infrastructure	a) Connection to EASSy and WACS Systems b) Rollout of fiber-optic cables nationwide c) Focus on developing e-services, broadband connectivity, and postal network
Broadband Connectivity Benefits	Increased connectivity and capabilities	a) Enables business and individual connection b) Access to global resources and capabilities c) Potential for export-led growth d) Boosts productivity in technology-driven sectors
Improved Education and Training	Significant investment and focus on reform	a) Over 25% of annual budget allocated b) Education and Training Sector Strategic Plan (ETSSP) for reform initiatives c) Curriculum revision d) Teacher up skilling e) Increased access to tertiary education f) Matching training with industry needs g) Increased use of ICT in education
Research, Innovation and Development	Planned research investment and collaboration	a) Focus on research relevant to economy and industry collaboration with regional research institutions b) Enhanced global competitiveness through innovation

Category	Strengths	Description
Cybersecurity	Planned cybersecurity legislation	a) Government acknowledges the importance and plans to implement laws to address cyber threats, creating a more secure digital environment.
Citizen Empowerment	Supportive legal framework for SME ICT integration	a) Planned legislation to empower SMEs in ICT and protect them from multinational corporations, fostering a more inclusive digital economy.
Regulatory Reform	Focus on efficiency and investment on Regulatory Impact Assessment (RAI) strategy	a) Implementation of a Regulatory Impact Assessment (RIA) Strategy b) Focus on investor-friendly regulations and minimizing burdens on businesses, encouraging investment and innovation.
Bridging the Digital Divide	Accessible internet hubs to connect communities	a) Programs like Connecting Communities Programme establish Community Access Centres (CACs) in schools and libraries, providing affordable computers and internet access for all residents, including those with disabilities.
E-Government for Efficiency	Streamlined government services	a) Government-On-Line offers various citizen and business services online, improving access and efficiency compared to traditional methods.
Building a Skilled Workforce	Focus on ICT Education	a) ThutoNet prioritizes high-quality ICT education for children, equipping future generations with the skills needed for a knowledge-based economy.
Transforming Healthcare	Improved ICT-enhanced healthcare service delivery	a) The e-Health Botswana Programme utilizes technology to improve healthcare delivery, leading to better quality, safety, and timeliness of services for all citizens.
ICT-Driven Economic Growth	Technology for job creation	a) Initiatives leverage ICT to create jobs through private sector growth and diversification, attracting investment and strengthening various sectors of the economy.
Collaborative Infrastructure Development	Focus on multi-stakeholder strategy	a) Connecting Botswana fosters collaboration between government, private sector, and communities to

Category	Strengths	Description
		strengthen technical infrastructure, supporting various ICT programs and citizen empowerment.
Secure Digital Environment	Improved connectivity legal framework	a) Connectivity laws and policies establish a secure and trusted digital environment, protecting citizens' rights and promoting investment and growth within the ICT sector.
E-Commerce	Improved E-commerce legislation	a) Botswana has a strong legal framework for facilitating secure e-commerce transactions
Clean Energy	Progress towards fulfilling Sustainable Development Goal (SDG) 7	a) Botswana is making strides towards achieving SDG 7: Affordable and Clean Energy, which can play a crucial role in supporting a robust digital infrastructure.

Source: Adapted from [10], [14], [28], compiled and edited by the author (2024)

Despite Botswana's investments in infrastructure and education, challenges persist in technological readiness and maturity (refer to Table 6). Areas requiring improvement include policy frameworks, infrastructure limitations, skill development, and low technology adoption rates. The NRI confirms these weaknesses, highlighting lower scores in government online services, e-participation, and internet subscription costs [28]. Addressing these barriers is crucial for advancing Botswana's digital capabilities, ensuring sustainable growth, and fostering a supportive environment for SMEs' digital transformation [14].

Table 6. Botswana technological readiness weaknesses

Category	Weakness	Description	Reference
Science, Technology and Innovation Policy	Redundant and conflicting policies	Lack of a unified policy, legislative, and regulatory framework discourages investment and hinders development.	[51], [52]
	Slow ICT integration	Policies and reforms are planned but implementation is slow, hindering ICT progress.	
Infrastructure	Limited electricity access	Lack of electricity in rural areas hinders internet connectivity and ICT usage.	[53]
	Last-Mile connectivity costs	High infrastructure costs and low population density make it difficult to provide affordable internet access in rural areas.	

Category	Weakness	Description	Reference
Digital Divide	Limited internet access	Over half the population lacks internet connectivity, with rural communities most affected.	[54]
	High cost of internet	High internet data costs limit access and usage, especially for e-commerce.	[11]
	Lack of basic ICT skills	Limited digital literacy and ICT skills hinder user adoption and application.	[53]
Technology Adoption	Low bandwidth speeds	Slow internet speeds limit online capabilities and hinder productivity.	[55]
	Weak intellectual property rights	Inadequate protection of intellectual property rights discourages innovation.	
	Low investment in technology	Limited government funding for technological development restricts progress.	
	Poor banking and financial services	Weak financial services infrastructure hinders e-commerce adoption.	
Emerging Technologies	Lack of AI strategy	Absence of a national AI strategy hinders adoption of artificial intelligence.	[17]
	Insufficient skills and infrastructure	Limited technical expertise, inadequate infrastructure, and lack of data impede AI development.	
E-commerce	Limited awareness and expertise	Businesses lack awareness and expertise to effectively utilize e-commerce.	[11], [56]
	Quality of service issues	Inconsistencies in internet service quality hinder e-commerce operations.	
	High internet data costs	High internet data costs remain a challenge for e-commerce growth.	
	Payment system limitations	The absence of a domestic payment switch limits e-commerce transactions, especially for digital products and services.	
	Limited access to Startup finance	Difficulty obtaining startup finance restricts the growth of e-commerce businesses.	

Category	Weakness	Description	Reference
	Domination by regional players	Large South African retailers and companies may dominate Botswana's e-commerce market.	[11]
Cybersecurity	Not party to key cybersecurity conventions	Botswana's lack of participation in conventions like the African Union Convention on Cyber Security hinders collaboration and legal recourse	[57]
	Non-harmonized cybercrime and data protection laws	Inconsistent laws across countries make investigating cybercrime in cyberspace difficult for Botswana	
	Limited capacity among stakeholders	Law enforcement, service providers, policymakers, and regulators require more training and resources to address cyber threats.	

Source: Compiled and edited by the author

3.5.1. Implications of the technological readiness barriers for Botswana

The identified technological readiness barriers in Botswana have several significant implications:

1) Redundant and conflicting policies: Redundant and conflicting policies can lead to administrative inefficiencies and confusion, hindering coordinated efforts to advance technology adoption.
2) Slow ICT integration: Slow integration of ICT can impede overall economic growth and limit the competitive edge of businesses.
3) Limited electricity access: Inadequate electricity supply restricts the operation of digital devices and hampers technology adoption.
4) High last-mile connectivity costs: The high costs associated with last-mile connectivity can prevent rural and underserved communities from accessing the internet, perpetuating digital divides.
5) Limited internet access: Limited internet availability curtails opportunities for digital education, e-commerce, and other online services.
6) High cost of internet: Elevated internet costs make it difficult for SMEs and individuals to afford consistent access, limiting their ability to leverage digital tools.
7) Lack of basic ICT skills: Without fundamental ICT skills, the workforce cannot effectively utilize technology, hindering innovation and productivity.

8) Low bandwidth speeds: Low internet speeds impair the performance of digital applications, reducing efficiency and user satisfaction.
9) Weak Intellectual Property Rights: Inadequate protection of intellectual property can deter innovation and discourage investment in new technologies.
10) Low investment in technology: Insufficient funding for technological advancements stifles growth and development in ICT sectors.
11) Poor banking and financial services: Poor banking and financial services limit access to credit and other financial tools necessary for technological investments.
12) Lack of an AI strategy: The absence of a clear strategy for AI adoption prevents the country from fully exploiting the benefits of artificial intelligence.
13) Insufficient skills and infrastructure: Deficiencies in both human capital and physical infrastructure create barriers to effective technology utilization.
14) Limited awareness and expertise: A lack of knowledge and technical expertise inhibits the adoption and implementation of new technologies.
15) Quality of service issues: Poor service quality can lead to user dissatisfaction and reduced trust in digital services.
16) High internet data costs: Elevated data costs restrict internet use, especially for data-intensive applications, limiting digital engagement.
17) Payment system limitations: Inefficiencies in payment systems hinder e-commerce and other online financial transactions.
18) Limited access to start-up finance: Challenges in securing funding for start-ups impede innovation and entrepreneurial activities.
19) Dominance of regional players: The dominance of regional technology players can stifle local innovation and create dependencies.
20) Non-adherence to cybersecurity conventions: Exclusion from major cybersecurity frameworks leaves Botswana vulnerable to cyber threats.
21) Inconsistent legal frameworks: Non-harmonized cybercrime and data protection laws can cause regulatory uncertainty and security risks.
22) Limited capacity among stakeholders: A lack of capacity among key stakeholders prevents effective collaboration and strategy implementation.

4. IMPLICATIONS AND RECOMMENDATIONS

4.1. Implications of the Study

This critical literature analysis examines Botswana's technological readiness landscape, government initiatives, and available government resources. It offers valuable insights for both government and SME decision-makers as they navigate

the path towards an IoT-driven SME sector. By analysing the country's strengths and weaknesses in digital infrastructure, skills development programs, and policy frameworks, the study informs key strategies for both entities. For instance, for policymakers in Botswana government, the study identifies key areas that require improvement and focus. By addressing these key areas, the government can create a more supportive environment for SME adoption of IoT technologies. Moreover, recognising the resource constraints faced by many SMEs, the study empowers these businesses to make informed decisions regarding IoT adoption. The analysis encourages SMEs to assess their current technological readiness and become aware of relevant government initiatives and resources. This allows them to undertake a feasibility and practicality analysis of adopting IoT technologies in their respective organisations. Ultimately, this study equips both government and SMEs with insights to navigate the challenges and opportunities for widespread IoT adoption in Botswana's SME sector, aiming for a smooth transition towards 4IR.

4.2. Recommendations for Enhanced Support for SME IoT Adoption

Based on the findings, the following recommendations are suggested for enhanced support for Botswana's SMEs towards adopting IoT technologies, and to mitigate the technological readiness barriers. Consequently, Botswana government should:

1) Establish a clear and unified policy framework that specifically promotes SME adoption of IoT. This framework should address critical aspects such as data privacy, security, and standardization.
2) Simplify and expedite the implementation process for relevant policies and regulations to minimize delays and bureaucratic hurdles for SMEs.
3) Review and update outdated legislation to foster a more favourable environment for innovation and technology adoption within the IoT ecosystem.
4) Develop a national strategy outlining the development and implementation of IoT to support the growth of Botswana's digital economy.
5) Invest in expanding access to reliable and affordable electricity, particularly in rural areas. Additionally, upgrade existing infrastructure to provide businesses with faster and more dependable internet connections.
6) Establish mechanisms and partnerships to facilitate access to funding for SMEs seeking to adopt IoT technologies.
7) Explore strategies to lower internet data costs and make internet access more affordable for SMEs.
8) Design and implement training programs to equip the workforce with the digital skills required to effectively leverage IoT technologies.
9) Conduct national awareness campaigns to educate SMEs about the benefits of IoT adoption. Additionally, encourage workshops and conferences to promote knowledge sharing on IoT benefits.

5. CONCLUSION

This study comprehensively assessed Botswana's technological readiness to integrate the IoT in SMEs. A systematic literature review, focusing on studies published between 2015 and 2024, was conducted. Key findings revealed that scholars define technological readiness differently, but common dimensions include technology, human capital, government policies, and the business environment. While Botswana's technological readiness is evolving, it remains in its early stages. This is evidenced by its ranking of 110th out of 134 economies in terms of technological readiness and the rapid growth of mobile technology penetration since 2015. However, in recognising the pivotal role of SMEs for driving economic growth and job creation, the Botswana government has actively supported their digitalization through various initiatives. These efforts, including Vision 2036 framework, national development plans, the Maitlamo National ICT Policy, and investments in network infrastructure, have laid the groundwork for ICT adoption. While progress is underway, areas like e-commerce legislation, ICT education, and infrastructure investment show progress. Nevertheless, improvements are needed in areas including; government online services, e-participation, internet subscription costs, policy framework implementation, cybercrime challenges, infrastructure limitations, and overall low technology adoption. Nevertheless, future research should involve primary data collection, such as surveys or interviews, to gain a deeper understanding of the country's specific challenges and opportunities for IoT adoption. Additionally, replicating this systematic literature review methodology in a developed country could enable a comparative analysis, identifying best practices and contrasting them with Botswana's challenges.

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