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Article

Assessing the prospects of digital infrastructure in promoting rural economic development in South Africa

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Abstract: The prospects of digital infrastructure in promoting rural economic growth and development are by and large immense. The paper found that rural development is considerably important for economic development and for achievement of sustainable livelihoods that increases people's ability to achieve good health and wellbeing that enable the achievement of sustainable development. The paper found that digital imbalance and digital illiteracy in the rural areas hinder implementation of digital infrastructure to lead to rural economic growth. Digital infrastructure is the source of economic opportunities that enables local people in the rural areas to be more creative in achieving development success. It enables them to have a unique sense of place and fashioning of vibrant economic and financial opportunities that ensure the achievement of sustainable rural economic development. However, the paper found that the application of digital infrastructure to South Africa's rural areas in the bid to promote rural economic growth has been hindered by factors like the digital divide, financial constraints, digital illiteracy and the failure to own a smart phone. These factors hinder digital infrastructure from leading to sustainable rural economic development and growth. The paper used secondary data gathered from existing literature. The use of qualitative research methodology and document and content analysis techniques became vital in the process of collecting and analyzing collected data.

Keywords: digital infrastructure; economic development; rural communities; good health and well-being; sustainable development and South Africa

1. Introduction

The aim of this paper is to assess the prospects of digital infrastructure in promoting rural economic development in South Africa. South Africa's rural communities have been experiencing poverty caused by slow and sometime failure of rural economic growth. As opposed to urban areas where digital infrastructure has boosted the urban economy, rural areas suffer from lack of connectivity that makes digital infrastructure not to be able to lead to electronic business that would promote rural economic growth. Scholars argued that rural environment do not benefit from a robust digital and internet connections that would enable the operationalization of the digital infrastructure (Strover, 2003; Velaga et al., 2012). Digital infrastructure used in service delivery has potential to promote poverty reduction and as such leads to sustainable development. Digital infrastructure used in service delivery improves people's livelihoods and wellbeing and is a major contributor to sustainable rural economic growth and development. However as remarked in South Africa's rural areas, digital infrastructure has not been able to empower rural people to fight and reduce poverty rates. Digital infrastructure has deepened divisions which are still

serving as contributors to chronic poverty. World bank (1990) report shows that in rural communities digital infrastructure instead of promoting poverty reduction has deepened poverty and unequal access to basic services. For this reason, South Africa's rural communities are characterized by chronic poverty that results from unequality caused by digital infrastructure.

Irwin, Isserman, Kilkenny and Partridgeet (2010) argued that rural communities face financial inequality and economic income disparity. These communities also face population decline which affects labour force because significant people migrate towards urban areas in the search of economic opportunities (Irwin et al., 2010). this migration has thus led to the erosion of digital skills and awareness leaving rural communities vulnerable to chronic poverty (Steiner and Atterton, 2015). Taking digital infrastructure and establishing robust internet connections together with raising people's awareness on the digital tools to rural communities paves ways towards achieving economic growth and thus sustainable development in those communities. Hence, the paper sought to answer the following question: what is the role of digital infrastructure in promoting rural sustainable economic development in South Africa. To answer this question and achieve the aim, the paper is structured as follows. While the first section was an introduction, the second section is a research methodology that was adopted in this study. The third section is a literature review that explains and explore the potential of digital infrastructure in promoting rural economic development in Africa. The fourth section is a discussion of findings while, the fifth section is a conclusion and proffers recommendations.

2. Methodology

The paper adopted a qualitative case study research methodology with a focus on South Africa's rural economy and communities. A qualitative case study in this paper explored phenomenon within the contexts of digital infrastructure and rural economic development in South Africa through the use of numerous data collected from secondary sources. This approach ensured that the digital infrastructure and rural economic development are not explored through one lens, but rather a variety of lenses which allows for multiple facets of the phenomenon to be revealed and understood (Baxter and Jack, 2008). The rural economy and communities became the paper's case study approach. The case study approach was used in this paper because it helped develop understanding of the difference between the rural economy and urban economy and the factors making digital infrastructure promote economic growth in urban and those ones hindering economic growth in rural communities. Creswell (2013) presented that the use of the case study approach involves comparing real-life events and cases that occur over time and have affected the society. South Africa's rural communities used as case study helped to understand key factors hindering digital infrastructure to promote rural economic growth. Factors like digital divide, internet connectivity, financial constraints, digital illiteracy, and social inequalities across the rural communities were found to inhibit digital infrastructure from promoting economic growth in rural communities.

A qualitative case study methodology was adopted in this paper. It helped exploring differences within and between cases that were used in study. It also helped

gather data from key cases that enabled the researcher to predict similar results across cases (Yin, 2003). The case study that was used is the South African state and it was used to describe phenomenon and the real-life context (Yin, 2003), in which digital infrastructure has been used to promote rural economic development thus sustainable development. The case study approach further enabled to explore and understand those benefits of digital infrastructure in promoting rural economic development are not clearly understood in South Africa. Coombs (2022) argued that a case study is a key methodological research approach in social sciences because it helps researchers to generate an in-depth understanding of a contemporary issue that are affecting the world. Coombs (2022) further argued that case study approach enables researchers to carry out a critical investigation about an individual and events to gain an understanding of a real-life phenomenon. In this study, its use aimed at reviewing complex issues surrounding digital infrastructure and provided insights into its role in promoting rural economic development in South Africa.

It has been noted that a case study is mostly applied and used in qualitative studies that belong to social sciences (Bloomberg and Volpe, 2022). The approach is useful because it enables researchers to obtain in-depth findings on issues and events in their natural real-life context (Crowe et al., 2011). Stake (2010) argued that case study approach to research provides researchers with an opportunity for greater depth of understanding of events or phenomenon. The case study approach enabled the researcher to collect an in-depth insight on the role of digital infrastructure in promoting rural economic development. It also helped to answer as how digital infrastructure promote rural economic development why this digital infrastructure is needed for South Africa to achieve a rural economic development that promote the achievement of sustainable development. Yin (2018) argued that the use of a case study in social sciences enables researchers to understand why events occurred, how they occurred and what lessons can be learnt from them. It has been noted that the use of case study helps illustrate issues or concerns that are affecting the society in helpful manner (Creswell and Poth, 2018). The study moreover, adopted multiple cases approach. The aim was achieved multiple findings from those cases and identify common patterns, relationships, or similarities. As Yin (2018) argued, the use of a multiple case study in this research led to the collection of similar and diverse secondary data, but the paper consistently looked for patterns or relationships across cases.

Gopaldas (2016) said that qualitative methodology means a range of data collection and analysis techniques that use secondary data from the existing literature. The paper relied on the exiting literature published in the public domain, and this led to the collection of secondary data. Secondary data was used to gather data that enabled the achievement of the purpose and objective of this paper. According to Boslaugh (2007), secondary data is understood as a data sets available in social sciences which has been made public and easily accessible. The secondary data involved the existing data that can be relevant or applied to answer a research question that is different from the previous research work (Vartanian, 2010). The use of this secondary data was useful because it helped economize time and funds. This is because secondary data was collected without purchasing it as it was available in the library and internet sources.

Collected secondary data aimed at establishing conceptual and substantive reasons for the prospects of digital infrastructure in promoting economic growth whether in rural or urban areas. Soiferman (2010) argued that the fundamentals of conducting qualitative research and provided an overview of the literature which then guided the path of the study and linked the researcher to intended research problem. It allowed the researcher to read and review the data multiple times while analysing it. Collected data from literature review was initially interpreted through qualitative document analysis technique. Bowen (2008) argued that document analysis technique refers to the process of evaluating literature that is found in the public domain. This literature reviewed included both printed and electronic documents on digital infrastructure, rural communities, economic and sustainable development in South Africa. The use of document analysis to interpret collected data enabled the collection of insights and knowledge that conceptualized the prospects of digital infrastructure in promoting rural sustainable economic and development in South Africa.

Collected secondary data was also interpreted via qualitative content analysis technique. This is because it is a method that enable researchers to analyse data and interpret its meaning in convincing manner (Schreier, 2012). In this paper, such technique became flexible and enabled the description of cases of digital infrastructure and their roles in promoting rural economic development. Scholars argued that content analysis is beneficial when one wants to interpret and explain textual materials that are collected from the documents or literature review (Akşan and Baki, 2017; Hsieh and Shannon, 2005). Hence this technique helped in extracting meaningful information pertinent to rural communities, the digital infrastructure in South Africa and their potentials in promoting economic growth. The technique enable one to achieve critical knowledge and insights on the role of digital infrastructure and its role in increasing the potential to achieve rural sustainable economic development in South Africa

3. Literature review

Rural economic development consists of every effort directed towards economic and social objectives with the aim to promote economic growth and sustainable income in the areas outside cities (Atkinson, 2017). The concept rural means areas that are located in the villages outside of the townships. Rural area is many times linked to rural activities such as agriculture and farming that normally take place outside the cities. however, due to modern technological innovation rural agricultural and farming activities are transformed from traditional to modern living (Friedland, 2002).

3.1. Characteristics of rural areas

Rural places or environment are characterized by poverty caused by lack of jobs and movement for business. Rural area experiences heavy population decline because many people migrate from it to urban area in the search for employment and better living (Irwin et al., 2010). Population decline therefore constitutes one of the critical threats to the achievment of sustainable development. This means that rural area is characterized by a shrunk population with less innovative skills to carry out digital infrastructure. Niyitunga (2022) argued that lack of population is a threat to sustainable development because it negatively affects economic growth and prevents people from

achieving sustainable livelihoods. Niyitunga and Musya (2024) argued that the main effects of population decline are the fact that it creates harsh economic conditions, worsen people's living standards, increases high costs of life. This therefore means that rural areas experience high population decline which comes with infrastructure challenges because of lack of development projects, loss of skilled workers because they migrate towards urban areas. The rural areas also experience lack of socio-economic opportunities environmental pollution and as well as dependency syndrome which is a threat to economic development and growth (Niyitunga and Musya, 2024). Niyitunga (2022) argued that transportation and housing are major challenges encountering rural areas. Niyitunga (2022) further argued that the inhibiting the use of digital health and blockchain in rural hospitals is the lack of parity in digitalization and as well as the digital illiteracy, and the failure to be in a position to have access to robust internet connections.

3.2. Cases of digital infrastructure

Digital infrastructure is made of two words. Infrastructure is understood in this study as the basic physical and organizational structures needed for promoting service delivery and necessary for an economy to function and be improved (Tilson et al., 2010). Digital on the other hand means any connections that uses internet or bundles in the daily business. For example, scholars have argued that digitization has become a powerful instrument in our daily activities as it not only enables the usage of automation but also tracks and keeps information for future reference and use (Agrawal et al., 2018; Zuboff, 1988). It creates and stores records that provide crucial opportunities to improve processes and predictions about future events (Agrawal et al., 2018; Zuboff, 1988). For example, digitization has the ability to codify human tasks in software and as well as creates jobs that enable people achieve a financial income that improve their lives (Helper et al., 2021).

Per definition, Tilson et al. (2010) said that digital infrastructure means the use of the basic information technologies and organizational structures, along with the related services and facilities necessary for an enterprise or industry to function. They further argued that such infrastructures enable global, national, regional, industry, or corporate infrastructures to function (Tilson et al., 2010). This makes digital infrastructure to be understood as shared, unbounded, heterogeneous, open, and evolving sociotechnical systems that comprise an installed base of diverse information technology capabilities with the abilities operate and design communities (Hanseth and Lyytinen, 2010). It may include but not limited digital technologies such as the internet of things, blockchains, additive manufacturing, big data, artificial intelligence, cloud computing, and augmented and virtual reality (Rindfleisch et al., 2017). Digital infrastructure also comprises components such as hardware, software, networks, data centers, cloud computing and cyber-security systems (Rindfleisch et al., 2017).

When it comes to the opportunities, digital infrastructure acts as a very important driver of growth, particularly in rural areas where traditional barriers are more acute. High-speed internet and broadband connectivity can drastically bring down transaction costs, promote access to markets, and facilitate business operations. For rural areas, where such economic barriers are more acute, reliable digital networks

open up prospects for e-commerce, access to information, and entrepreneurial activities. This infrastructure facilitates telework, strengthens communication channels, and integrates rural economies into national and global markets. Therefore, establishing robust digital infrastructure is central to bridging the digital divide and creating an all-inclusive digital economy that would spur economic growth (Schwab, 2016).

Of all the benefits of digital infrastructure in terms of economic development and planning, the most important is in reducing transaction costs significantly. This is achieved by adopting such digital tools as online payment systems, e-commerce platforms, and electronic invoices. These greatly improve the efficiency and cost-effectiveness of business operations. In the rural setting, where these traditional barriers to economic activity are most glaring, digital infrastructure has a far greater impact.

For instance, e-commerce online settlement systems offer better ways of making financial transactions in that businesses are able to process payments quickly and safely without handling cash physically and without the tedious bank procedures involved. This not only reduces time and costs for managing transactions but also improves the way one manages their finances. E-commerce platforms further amplify the effect by allowing them to break the shackles of a local market. The e-commerce platforms allow rural enterprises to reach out to the national and global markets, thereby potentially increasing their sales and revenue streams manifold. Special market access through these means allows businesses to gain new customers, increase revenue sources, and lessen dependence upon geographical markets (Laudon and Traver, 2024).

In the modern age, digital infrastructure assumes center stage in giving contour to the economic landscape, more so in rural areas that have been relegated to very low levels of development. Capacity and the spread of digital technologies are increasingly instrumental in dictating economic development and planning in these regions. The integration of digital infrastructure, broadband internet, mobile networks, and digital platforms presents opportunities for transforming economic activities, smoothing out agricultural practices, improving market access, and engendering new entrepreneurial ventures (Burch, 2001). For digital infrastructure to promote sustainable economic and development in rural areas particular set of challenges such as connectivity gaps, digital illiteracy, digital inequality and the weak internet infrastructure need to be addressed. The need to invest in digital technology has become unavoidable for those countries heading towards achieving sustainable development. It has been noted that effective economic planning that leads to sustainable rural economic development and growth depends on the use of digital technology in service delivery (Atkinson and Castro, 2023).

The case of digital infrastructure in Kenya and in Morocco showed that digital infrastructure leads to digital economy which contributes economic growth and enables financial stability (Wangui, 2020). The cases of digital infrastructure in the East Africa showed that the use of digital infrastructure has led to the growth of technological innovation which forms the basis for economic growth. Cirera and Maloney (2017) noted that developed countries have benefitted from technological innovation to achieve sustainable economic growth. Bernard and Jones (1996) cited

in Jammeh (2022) found that technological innovation increases the speed of labour productivity facilitates smooth delivery of products and goods. Solow (1957) cited in Jammeh (2022) found that technological innovation contributed to economic growth in the United States (US) to 87.5% GDP. Geroski (1989) cited in Jammeh (2022) noted that innovation has promoted economic productivity growth in the United Kingdom (UK) firms leading to sustainable financial income. It has also been found that innovation contributed in the UK economy growth as domestic firms' productivity rates arose to 50% of total factor productivity and 30% of the entry of firms (Jammeh, 2022). Bayarcelik and Taşel (2012) noted that technological innovation affected economic growth in Turkey. Maradana et al. (2017) found that there is a strong link between innovation and per capita economic growth in the long run. Maradana et al. (2019) found that there is relationship between innovation and economic growth. Vuckovic (2016) noted that technological innovation promotes economic growth by increasing foreign direct investment and reducing unemployment.

GAO (2023) found that the flourishing of the electronic economy significantly promotes common wealth and manufacturing processes upgrading. Li (2023) found that digital infrastructure investment improves the quality of the economy by means of factor analysis methods. Digital infrastructure has promoted and enhanced the quality of economies in China's provinces (Li, 2023). Lu et al. (2021) noted that digital technology and its derivatives of the digital economy has expanded China's economy. It has increased and promoted digital marketplace from 2.6 trillion to 35.8 trillion in 2019, and the computerized economy accounted for a share of the GDP also soared from 14.2% to 36.2% (Lu et al., 2021).

The Digital China Development Report (2022) spelled that through digital infrastructure digital market grew up and promoted economic growth (Weina et al., 2023). The use of digital infrastructure has deepened China's digital economy shows a spatial distribution pattern and has positively correlated with the economic development of each region in China (Mao, 2023). Mao (2023) found that digital infrastructure the growth rate of the online economy index was high in all regions, especially in the western and central regions, amounting to more than 20 percent. It has been noted that digital infrastructure in China presented a positive economic growth resulting from digital economy (Baoping and Haifeng, 2023). Digital infrastructure has been based on the blockchain technology and cloud computing (Wenrong et al., 2022).

Digital infrastructure promotes investment at long-term and stable economic and financial income by promoting jobs opportunities (Zhang, 2023). Digital infrastructure promoted tens of thousands of employments, which became driving force for economic growth (Wu et al., 2021; Zhang, 2023). The construction of new facilities for digital infrastructure such as high-speed broadband, 5G networks, data centers have potential to deepen digital economy, improve economic efficiency, and facilitate industrial upgrading and transformation (Mao, 2023). Digital infrastructure strengthens any country's informatization economic ability, improves the level of informatization (Mao, 2023). It promotes growth of the informatization industry, and optimize the allocation of social resources (Mao, 2023). American economist Rosenstein (1943) cited in Mao (2023) found that great promotion of economic investments that accelerate economic growth depends on the digital infrastructure.

Digital infrastructure promotes economic growth and financial income at long-term rates thus promoting the achievement of sustainable economic development. Hirschman (1958) cited in Mao (2023) noted that the development of infrastructure promotes digital market and intensify financial business that promote economic growth. Digital infrastructure can thus be said to be the fundamental of economic growth in today's society. Rostow (1962) found that digital infrastructure remains the basis for rapid productivity growth and economic growth.

Ding (2024) found that digital infrastructure is of immeasurable value in helping people respond to emergencies and in switching to online office or teaching activities. Mao (2023) noted that digital infrastructure enhances the scale of mobile online education thus promoting economic growth. Digital infrastructure can also improve the availability and utilization of factors, and innovate the forms of labor, capital and finance (Ding, 2024). It has been noted that the construction of digital infrastructure can promote urban rural economic and financial income (Zhao and Li, 2022). It has been proved that the impact of digital economy on urban-rural financial and income is widely acknowledged in China (Zhao and Li, 2022). Digital infrastructure creates a range of new channels and styles for digital tourism, offering new economic growth potential (Ding, 2024). Tourism promotes rural economic development because it enhances foreign exchange reserves (McKinnon, 1964), stimulates investments in new infrastructure, human capital and increases competition (Blake et al., 2006), promotes industrial economic development (Lee and Chang, 2008). Tourism also promotes rural economic development because it promotes job creation and thus increases financial and economic income (Lee and Chang, 2008). In the cases of emergency situations such as pandemic diseases or disasters, digital infrastructure enables the continuation of economic and business activities through online transactions thus moving from traditional way to new way that increase economic growth. In China, it is noted that cloud vacations based on online businesses are growing rapidly and have increased economic and financial growth (Yan et al., 2022). Digital tourism relies on digital technology to manage tourism-related content, provide digital cultural services, and facilitate China's economic recovery in the post-pandemic era.

4. Discussions

Digital technology used in service delivery brings about operational efficiency that promote sustainable development because it reduces administrative overheads with minimized errors. Automation in basic services such as financial transactions would increase the velocity of the billing cycle, assure timely payments, and improve cash flow management (Laudon and Traver, 2024). In effect, digital infrastructure gives a more productive and profitable environment that needed to achieve sustainable economic growth and development whether in urban or rural areas. These technologies enable an environment for economic development through reduction in transaction costs and innovation of business processes. The adoption of digital tools in rural businesses could result in more efficient operations, increased competitiveness, and hence sustainable economic growth. In addition, less physical movement and direct interactions are required which are mostly costly and time consuming. To a great extent, operational costs can be lowered down by means of online communication and

transactions in business. Besides, digital infrastructure enhances logistic capabilities, it will be easier to track the shipment, manage stock, and reduce delays. All these improvements will save money and expedite processes. (Dutton, 2014). Digital infrastructure expands the access to financial services, such as digital banking and mobile money platforms. Through these facilities, rural businesses can participate in digital loans, be able to open savings bank accounts, and make various investments in growth and development. Moreover, with the availability of digital tools, gathering valuable data for market trends analysis, consumer behavior, and operational performance becomes possible and provides better decision-making ability and strategic planning.

The findings of this paper showed that transiting to digital infrastructure enhances literacy and the skilled labor force through training and acquisition of skills. Digital tools can stimulate innovation and entrepreneurship among rural entrepreneurs in developing new services and products that bring economic diversification. In addition, it is a means to connect rural businesses with government services, support programs such as grants, subsidies for easier access to resources, and bureaucratic processes (Rainer and Cegielski, 2011). Improved digital infrastructure enhances market accessibility for firms in the rural areas. High-speed internet and broadband connectivity would allow businesses in such places to find a wider and more varied market, using e-commerce portals, social media, and online advertising. This increased access provides more opportunities for sales and enables rural businesses to sell their products and services to specialized/niche markets and customers around the world. Digital technologies simplify business operations, hence making them efficient because of the automation and effectiveness involved in their processes. Cloud-based solutions help businesses in dealing more effectively with inventory, sales monitoring, and customer relationships. Digital tools also allow telework and collaboration, hence enabling a business to adapt to changes in the market and improve productivity, which enhances the business's ability to reach the full potential of its people (Siebel, 2020).

The findings of this paper showed that the incorporation of high-speed internet and broadband connectivity increases dynamism and competitiveness in businesses. From a broader perspective, through reduction in transaction costs, enhancing market access, and easing operations, digital infrastructure serves as a catalyst to economic growth and development, hence lifting rural communities over traditional barriers and toward a more inclusive economic landscape. It is in this context that evidence from various rural regions in the United States and Europe underlines how high-speed internet changes the nature of economic activity. In the United States, several studies and reports underpin a significant uplift in business performance following on from the introduction of broadband services. For instance, it has been established that e-commerce has been among the leading drivers of the growth in the ability of local retail and service businesses to expand beyond their borders within their respective geographical locations. Such extended access to markets has been seen as leading to increased sales, higher customer engagements, and broader economic opportunities for such enterprises (Bonomo and McDonough, 2020).

The findings of this paper showed that rural businesses need to use high-speed internet to adopt sophisticated digital tools that have streamlined operational processes. Systems, including CRM and ERP software, have become core material in enhancing

operational efficiency, inventory management, and customer interaction. Such tools will allow firms to automate and optimize a number of functions, hence making or running more effective and efficient operations. It is in this respect that rural enterprises are empowered to give better services, manage resources effectively, and ultimately realize high levels of productivity and profitability. The benefits of high-speed internet, however, radiate from the individual business to the broader rural economy. Greater connectivity sustains a more dynamic and integrated economic environment that supports innovation and entrepreneurship. High-speed internet facilitates exchange in information, ideas, and resources that drive diversification and resilience in the economy (the possibility to recover from the negative impacts of economic challenges or shocks) by connecting these rural areas to larger national and global markets. Aiding workforce development further, online education and training resources tend to equip rural populations with relevant appropriate skills that are necessary for people to succeed in the digital economy (McKinsey and Company, 2021).

The findings showed for example that in Europe also, one finds that regional economic development has been contributed by such advancements in high-speed Internet. According to the European Commission, reports have indicated that improved digital infrastructure in rural areas has resulted in business growth and economic activity. The availability of broadband has created an atmosphere for the growth of startups and small enterprises, thereby diversifying the local economy and lessening its reliance on traditional industries. For instance, Sweden and Finland have managed to attract investment and create employment in their rural areas with robust digital networks. Further, digital infrastructure has sustained remote work opportunities, thereby enabling people living in small towns and rural areas to participate in the growth of and take advantage of the digital economy without having to relocate to metropolitan areas (European Commission, 2012).

These examples underline the fact that access to high-speed internet in rural areas is an important economic driver. High-speed internet works as an economic engine, increasing market reach and operational efficiency manifold. This virtual opening to wider markets can be leading in business transformation for many rural businesses. But this sort of connectivity stops not only at e-commerce and opening up supply chains globally; an increase in productivity is achieved via a myriad of digital tools and platforms. This eventually makes it easier to integrate into larger economic networks, and then the urban-rural gaps are closed, thus amplifying the economic prospects for underserved communities. The introduction of digital infrastructure to a rural area is transformative in huge ways that greatly help spur economic growth and development. Digital infrastructure enables the expansion of markets by facilitation of the ability of unreachable markets heretofore to gain access, allowing local businesses to engage in e-commerce and reach other customers apart from their immediate geographical location. Such expansion has increased potential for sales and revenues (Sellick, 2018).

It also increases business performance due to the innovation of modern digital marketing strategies and effective online transactions. The rural enterprises can utilize social media and other online tools in customer acquisition, getting noticed, and thereby retain them in order to compete with the urban businesses. Online transactions

make sales easier, reduce overhead costs, and provide better service to customers. Another major advantage brought by the digital infrastructure is economic diversification. Giving life to new sectors like technology services or remote work opportunities will reduce the dependence on the traditional sectors and hence make the rural economy resilient to shocks. Digital infrastructure promotes an entrepreneurial, vibrant atmosphere that would become attractive to investments and therefore spur economic activity.

The paper found that digital infrastructure extends educational opportunities, especially in rural areas where infrastructure is not that well developed. High-speed internet and digital tools allow for remote learning and access to every possible educational material, helping to close the gap between the urban and the rural. Digital education tools also help in nurturing significant skills that apply to modern economies. Online platforms provide courses, training in digital literacy, technical skills, and vocational areas that would be useful in equipping students with the capacity to face future employment and competition in the fast-changing job market. All of this access to education enables a skilled workforce and links to broader economic development in rural areas (Bates, 2015). It improves service delivery in healthcare by surmounting geographical barriers to give access to medical care. In the sector of healthcare, digital infrastructure promotes the delivery of electronic health services through -electronic consultations, electronic diagnostics, and electronic treatments. For example, digital infrastructure promote telehealth facilities which in turn promote the delivery of health services that lead to good health and wellbeing in the rural communities. Telehealth in this article is understood as the application of digital tools to increase the access to health services via online platforms (Fisk et al., 2020). One can see that digital infrastructure promote the delivery of sustainable health services in rural communities at low cost and in short time thus serve as a promoter of sustainable development. For instance, there have been successful cases of Telehealth programs in countries like Australia and Canada that have promoted the access to the efficient health services that have improved the achievement of sustainable development (Fisk et al., 2020). The use of digital infrastructure in health care has reduced time spent to access health services in the rural communities. It enhanced access to specialized care; and improved healthcare efficiency. Turning to this would have a better health outcomes heance leading to the possibility of achieving sustainable development in South Africa's rural communities.

However, there have been several issues of internet connections and access in the rural communities in South Africa. This means that digital infrastructure in rural communities has not been embarrassed due to financial constraints and lack of stable internet connections and broadband. This has become a huge hindrance that has made rural people fail to turn to digital infrastructure when requesting or receiving services (Federal Communications Commission, 2022). The paper argues that for the enabling the use of digital infrastructure to permeate rural communities and bring about sustainable development, there must be a need to address financial constraint rural communities encounter and as well as establishment of robust internet infrastructure.

The findings of this paper showed that there is digital divide which constitutes a digital technological barrier and gap in skills among the people residing in rural areas.

Inadequate digital literacy and lack of technical skills are the problems that may arise while properly using digital infrastructure. It means that most rural communities have reported poor digital literacy, compared with most of their urban counterparts, constricting the adoption and use of the latter for digital technologies. For instance, survey research in India has shown that one of the key barriers to the use of digital services in rural communities is lack of sufficient technical skills. This therefore demands investment in digital literacy and training programs. Improved digital literacy in rural areas will mean that such populations can effectively use the digital infrastructure and participate more fully in the digital economy (Schrag, 2009).

There are also very significant challenges in the area of a regulatory and policy issue when it comes to deploying and scaling digital infrastructure. Unclear or non-existent regulatory frameworks in many cases often retard the development of a certain digital infrastructure project. Fragmented policies create a cause of inefficiency and delay, created due to either a weak regulatory standard or non-existing regulations to promote these. More regulation would deter investment, add another layer of risk, and complicate compliance. More than that, lack of harmonization between different jurisdictions may further compound the issues, increasing the administrative burden and costs. To that effect, inconsistent standards, legal uncertainties, and bureaucratic red tape ensuing from the absence of a coherent regulatory framework impede the expansion of digital networks. Analysis has shown that in most cases, fragmented regulations delay progress, increase costs, and create barriers to the deployment of broadband infrastructure. Streamlined development of digital infrastructure calls for coherent policy frameworks and regulatory standards. Enabling environments for such projects to be more effectively and efficiently implemented call for collaboration between different levels of government and regulatory agencies (Schrag, 2009).

A balanced approach to developing digital infrastructure should focus on opportunities and challenges. This is the reason integration of considerations of technological, economic, and policy nature secures the comprehensive development of a strategy that will maximize all the benefits and minimize probable drawbacks of the implementation. Evidence from successful projects related to digital infrastructure in the rural areas of South Korea and Finland has already highlighted how effective such holistic approaches are. These have illustrated how blending the harnessing of technology advancements and economic strategies together with conducive policies can result in huge accumulation of benefits. Collaboration between government, private sectors, and local communities is necessary for real sustainable and inclusive development. A holistic strategy for every aspect of digital infrastructure is most important to maximize its benefits while minimizing potential challenges (Schwab, 2016).

Critics involved in rural digital infrastructure projects usually emanate from the economic, policy analysis, and investment sectors. These critics argue about whether it is worth incurring the large costs of such projects against the expected economic benefits. They further argue that short-term returns from such high-cost projects may not be able to justify huge upfront and continuous expenses incurred by them. The skeptics view the high resource demands and the huge investments required for establishing and maintaining digital networks in rural areas with a lot of suspicion. Skeptics often refer to examples where huge investments in digital infrastructure

brought about only marginal benefits in terms of business efficiency and economic performance. For instance, a 2023 case study in the Harvard Business Review illustrated anticipated gains, where improved business connectivity and market access did not always materialize. It pointed out several rural areas in which such investments in digital infrastructure returned only very modest immediate results, thereby bringing out that the upfront costs and those for upkeep were disproportionate to the actual tangible benefits realized. This case thus brought out the need for more strategic planning and evaluation of such a project (Chang, 2023).

A 2022 report by the World Bank researched the economic viability of digital infrastructure projects in rural parts of developing countries. The report expressed concern over return on investment in areas of low population density where the initial demand for digital services was low. In this research, critics pointed out that huge investments made in digital networks are not proportionately rewarded economically. Further, there were many instances where the predicted improvement in connectivity and business operations wasn't seen; hence, skepticism plays a role when one evaluates the cost-effectiveness of these projects. Local needs and demands have to be assessed prior to committing huge resources for any digital infrastructure investments.

Proponents of rural digital infrastructure projects have really interesting counterarguments. For example, according to a case study on South Korea by the Ministry of Science and ICT in 2023, the implementation turned out to be successful in installing digital infrastructure in rural areas. Heavy investments in this study led to better business connectivity, economic growth, and easier access to quality education and healthcare. In South Korea, these successes were the outcome of a conceptually coherent and comprehensive package that integrated smoothly the efforts of the government, private sector, and local communities. Indeed, such context-specific investments, specifically designed for certain needs, led to an augmented degree of economic activity, productivity, and quality of life in rural areas. A 2022 case study from Finland, described by the Ministry of Transport and Communications, focused on how large-scale investments in digital infrastructure in rural areas impacted business operations, economic growth, and access to necessary services. The results returned were those of major improvement. This could be attributed to the fact that there was a comprehensive strategy that embraced technological development, economic planning, and facilitative policies. Despite the high upfront costs, some of the long-term benefits entailed improved economic opportunities, advanced connectivity, and access to services. The case showed that if executed properly, digital infrastructure projects could return very high in terms of economic and social value, thereby diminishing any initial skepticism.

These examples epitomize the vast chasm between critics and proponents of digital infrastructure projects in rural areas. They identify issues and successes that go with such investments, thus making the point that planning and evaluation must be very meticulous. A nuanced approach toward ensuring that benefits outweigh costs needs to consider local conditions, strategic planning, and the possibility of long-term gains. Successful and challenging experiences from both projects can be integrated to help guide future investments in maximizing the impact of digital infrastructure in rural development. This makes the economic impact of digital infrastructure a case very broad in tangible and intangible benefits: on the tangible side, productive business

activities, jobs, increased and better market access; on the intangible side, quality of life, education, and social inclusion. Critics also indicate that these intangible gains are difficult to measure and do not always meet the financial returns anticipated by investors. More importantly, the vast majority of digital infrastructure investments rely on rural population demand and uptake. With lower population densities and more limited initial demand, slower adoption could additionally delay the expected economic gains associated with these technologies. It is for these reasons that effective planning must be attuned to local needs and readiness to ensure investments in infrastructure align to community expectations and capacities.

The findings of this paper showed that while there may not be immediate financial returns for digital infrastructure projects in rural areas, they usually hold long-term socio-economic benefits. Therefore, it forms a basis for potential future economic opportunities and eventual access to global markets or innovation. The challenge is balancing short-term constraints of finance against long-term development potential. Cost sharing, access to expertise, and aligning investment strategies in public-private partnerships could reduce financial risks, improve feasibility, and orient the investment project towards broader economic development. One of the most critical aspects of planning and implementation would, therefore, be the assessment of how such partnerships aid in attaining desirable outcomes. This discussion is further complicated by the fact that there are concerns it might further exacerbate inequality. There is, in fact, huge fear that unequal benefits in digital infrastructure could probably deepen existing economic disparities. Digital resources, when accessed asymmetrically, can really enhance social inequalities and reduce participation in digital economy activities for the already disadvantaged. These are issues that effective economic planning must consider and deal with, ensuring that there is equity in the distribution of digital resources, bridging the digital divide, and hence fostering inclusive development. According to UNDP 2023, examples from uneven impacts of digital infrastructure projects bear testimony to disparities in access and benefits. Among others, targeted investments in underserved areas, inclusive policy design, and community engagement are some of the strategies for sharing the benefits equitably. These would address disparities and further the notion of inclusivity, avoiding deepening existing inequalities and ensuring that the benefits from digital infrastructures are shared in a fair and balanced way.

5. Conclusion

Rural economic in South Africa has encountered numerous challenges that have prevented the realization of sustainable rural economic growth. The paper found that digital infrastructure will have the potential to become an enabler in strengthening rural economic development, engendering economic growth, enabling more and better access to education and healthcare, and improving livelihoods. Such infrastructure would carry the prospect of closing connectivity gaps, thus making way for opportunities for those living in rural areas to participate further in economic activities and easier integration into larger national and global markets. It is difficult to implement and operationalize adequate digital infrastructure in rural areas, though, without many existing challenges. There is a need to adequately balance high costs,

technological barriers, and regulatory hurdles to ensure maximal benefits from the digital infrastructure. Therefore, measures towards overcoming these constraints are very crucial to setting out full potential for digital technologies in sustainable and inclusive rural development.

There is need to identify proper funding models to operationalize and support infrastructure deployment in rural settings when the ability to do so in digital terms is more realized. Strengthening initiatives that enhance digital literacy and competency levels in the general population will boost the full effect of these technologies. Promotion of regulatory frameworks that are enabling and inclusive, addressing issues of equitable access to digital resources, discrepant issues of how best to navigate the digital divide, disparities among rural communities, will need to be considered (Schwab, 2016). Policy initiatives must, therefore, account for inclusivity and fairness so that development in digital infrastructure can be realized to meet the diverse rural needs. We can hope to exploit the full potential of digital infrastructure for real and lasting economic progress in rural regions if stakeholders work collaboratively and involve comprehensive and forward-looking strategies.

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