Impact of Low Earth Orbit Satellite (LOES) on Mobile Telecommunications Industry in Southern Africa & Societal Development: Case Study of Zimbabwe.

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ABSTRACT

The study aimed to develop insights into the impact of the Low Earth Orbit Satellites (LEOS) in the Zimbabwe telecommunications Industry and the broader impact on societal development in line with the Sustainable Development Goals in Southern Africa, with Zimbabwe as a case study. The mobile industry significantly contributes to sustainable development and attaining the Sustainable Development Goals (SDGs). Studies indicate that enhanced connectivity through satellite communications can stimulate local economies by fostering entrepreneurship and attracting foreign investment (Deloitte, 2020). Furthermore, access to high-speed internet facilitates educational opportunities and improves healthcare

delivery via telemedicine applications (Mutasa & Chivanga, 2021). The study employed qualitative methodology to gather insights from key stakeholders within the telecommunications sector, including government officials, industry experts, and community leaders. Findings reveal that while LEO technology presents significant opportunities for improved connectivity and economic growth, regulatory frameworks, affordability, and digital literacy must be addressed to maximise its benefits. The findings suggest that while there is considerable excitement surrounding the introduction of LEO satellites into Zimbabwe's telecom landscape, the realisation of their full potential hinges upon overcoming specific obstacles, including regulatory adaptations, affordability measures, and investments aimed at improving digital skills among users. Addressing these factors collaboratively among stakeholders will enhance both immediate outcomes explicitly related to expanding network coverage while contributing positively to longer-term socio-economic advancements. The study proposes a framework that guides the industry in the adoption of the LEOS in the telecommunications ecosystems and contributes to the societal development in Southern Africa through the attainment of the SDGs and the African Union Agenda 2063, which are predicated on the growth of telecommunications services as drivers of internet and connectivity growth (Morrison et al, 2020; GSMA, 2025).

Keywords: Low Earth Orbit Satellites; Telecommunications; Societal Development; Zimbabwe; Southern Africa

JEL Code: (according to the JEL Classification System)

1.0 Introduction and research problem

This paper explores the complex effects of Low Earth Orbit (LEO) satellites on the mobile telecommunications sector in Southern Africa, particularly in Zimbabwe. The advent of LEO satellite technology presents opportunities and challenges for the current mobile telecommunications sector, necessitating an in-depth analysis of its potential impacts (Kala, 2023). The paper's primary objective is to understand how the emergence of LEO satellites influences competitive dynamics, service delivery methods, and regulatory frameworks within the region's mobile telecommunications sector. This involves evaluating the capacity of LEO satellites to address existing gaps in mobile network coverage, particularly in rural and underserved areas, and their potential to enhance the resilience and stability of telecommunications infrastructure. A crucial aspect of the study is to assess the implications of the societal development of mobile telecommunications services enabled by LEO satellites. This includes examining how improved connectivity might foster economic growth, increase access to education and healthcare, and empower individuals and communities through digital inclusion. The study also explores policy and regulatory challenges from integrating LEO satellites into the mobile telecommunications framework. This evaluation will consider the need for updated licensing frameworks, spectrum management guidelines, and data protection regulations to address the unique characteristics of LEO satellite technology, ensuring fair competition and consumer protection. The demonstrated ability of

mobile technologies to promote development by improving information access in regions with similar infrastructural challenges, such as rural Bangladesh, underscores the importance of assessing the potential impacts of LEO satellite integration in the Southern African context (Ashraf, 2015).

Few studies examine the overall effect of LEO satellites on the mobile telecommunications sector and societal advancement in Southern Africa, particularly in Zimbabwe. A thorough investigation of how LEO satellites could enhance connectivity, especially in remote and underserved regions of Zimbabwe where conventional terrestrial infrastructure is lacking, is essential (Samson et al., 2017).

2.0 Research Objectives

The study seeks to address the following research objectives:

1. To assess the mobile telecommunications infrastructure, coverage, and service quality in Zimbabwe.
2. To evaluate the capacity of LEO satellites to enhance mobile telecommunications in Zimbabwe, particularly in underprivileged regions.
3. To ascertain the challenges and opportunities of integrating LEO satellites within Zimbabwe's telecommunications infrastructure.
4. To evaluate the potential of LEO satellites in improving Zimbabwe's economy, education, healthcare, and information accessibility.
5. To propose policy and legislative frameworks for deploying and utilising LEO satellite mobile telecommunications in Zimbabwe.

3.0 Research questions:

The study seeks to answer the following research questions:

1. What is the status of Zimbabwe's mobile telecommunications infrastructure, coverage, and service quality?
2. In what ways can LEO satellites enhance mobile telecommunications in Zimbabwe, particularly in underserved regions?
3. Incorporating LEO satellites into Zimbabwe's telecommunications framework: challenges and prospects?
4. In what ways might LEO satellites contribute to the enhancement of Zimbabwe's economy, education, healthcare, and access to information?
5. What policies and regulations are necessary for the deployment and utilisation of LEO satellites for mobile telecommunications in Zimbabwe?

4.0 Significance of the study

The paper addresses a gap in the literature about the impact of LEO satellites on the mobile telecommunications market in Southern Africa, namely in Zimbabwe.

This study demonstrates how LEO satellites may enhance connectivity, coverage, and innovation in mobile telecommunications, hence fostering regional economic and social advancement.

The study's results can guide satellite and mobile telecommunications policy and regulation, promoting investment and innovation.

The case study method facilitates understanding of the challenges and opportunities associated with integrating LEO satellites into Zimbabwe's telecommunications infrastructure.

Telecentres in rural South Africa enhance women's information skills, economic standing, social ties, and ICT literacy (Alotaibi et al., 2021).

The results may assist mobile network operators in leveraging LEO satellite services to enhance their competitiveness and market presence.

5.0 Literature Review

The proliferation of mobile phones is rapidly transforming Africa's telecommunications sector, particularly in developing countries (Ashraf, 2015; Curwen & Whalley, 2011). This expansion provides individuals with unprecedented access to modern communications (Kalil, 2009). Mobile communication has supplanted fixed-line networks in many areas due to its affordability and convenience (Tran et al., 2015). Over the past decade, mobile phone coverage has significantly expanded across Sub-Saharan Africa, Asia, and Latin America (Nunavath et al., 2020). However, the growth of mobile networks necessitates substantial initial investments, which can elevate costs for end-users. In emerging sectors where cost is a primary concern, this may restrict accessibility and innovation (Meddour et al., 2011). The effective deployment of mobile communication technology requires the establishment of fiscal regulations, consumer protection measures, and technological standards (Hemeson, 2006). In an increasingly interconnected world, users of mobile communications may encounter privacy violations without adequate policy frameworks and infrastructure (Hussain & Ullah, 2012).

Low Earth Orbit satellites will enhance connectivity and reduce the digital divide in Southern Africa, particularly in Zimbabwe. LEO satellites have the potential to provide cost-effective broadband internet in sparsely populated areas where infrastructure installation is prohibitively expensive (Ogutu, 2023). LEO satellites are well-suited for remote and rural regions as they cover larger areas than terrestrial networks (Ogutu, 2023). LEO satellites improve real-time applications such as video conferencing and online gaming due to their lower orbit and reduced latency (Bhaskar et al., 2020). Zimbabwe, a landlocked nation with a significant rural population, stands to benefit considerably from LEO satellite technology in its mobile telecommunications framework. LEO satellites can enhance mobile broadband access in underserved areas, promoting economic growth, education, healthcare, and social progress.

The digital divide in Southern Africa hinders progress as many individuals lack access to essential online services (Fourati et al., 2022). Establishing remote telecommunications infrastructure is often two to three times more expensive than in urban areas, with revenue considerably reduced due to the low purchasing power and sparse population of rural residents (Cavalcante et al., 2021). Mobile network operators face difficulties providing internet services in rural areas due to infrastructure limitations, pricing issues, digital literacy gaps, and inappropriate content. Enhancing infrastructure, affordability initiatives, digital literacy programs, and relevant materials are crucial for addressing these challenges. Governments should promote collaboration between mobile network operators and local access providers to share infrastructure and reduce deployment costs to bridge this gap. Investments in rural network infrastructure can be incentivised through subsidies and tax benefits.

In Zimbabwe, LEO satellites could significantly impact socioeconomic development. LEO satellites can improve educational outcomes and digital literacy by providing reliable internet access to remote schools and educational institutions. LEO satellite links facilitate telemedicine, remote patient monitoring, and access to online medical information, thus extending healthcare services to underserved rural communities. LEO satellites can help Zimbabwean entrepreneurs and small business owners expand e-commerce and online enterprises by offering dependable internet connectivity in both urban and rural areas. This can accelerate the growth of the digital ecosystem, encourage innovation and entrepreneurship, and diversify both urban and rural economies. LEO satellites can boost agricultural productivity by supplying farmers with real-time weather data, market information, and extension services to support informed decision-making and the adoption of modern farming techniques (Alper & Miktus, 2019; Lusigi, 2019; Sigama & Kalema, 2022).

Businesses can enhance rural economic development; however, most Zimbabweans live in impoverished rural areas (Samson et al., 2017). Governments in Southern Africa must invest in ICT infrastructure and educate citizens on its use to bridge the rural-urban divide (Blom & Uwizeyimana, 2020). They should collaborate with the private sector to improve access to ICT training, provide targeted financial support to SMEs in the ICT sector, establish ICT zones or parks in rural areas, foster ICT partnerships with the private sector, and raise awareness among businesses about the importance of ICT (Beyers & Molala, 2016). Prioritised policies in Botswana focus on access to information, online employment, community development, healthcare, education, and government services (Uleanya & Prinsloo, 2024). Lesotho's institutional readiness for digital platforms is inadequate, particularly concerning Internet/mobile platform proficiency and the sustainability of ICT projects (“Lesotho Digital Economy Diagnostic,” 2020). Technology is crucial for education, healthcare, agriculture, and governance in Zambia, and initiatives such as the Virtual Doctor project can promote technology adoption by providing professional medical care to rural areas (Kala, 2023).

The effective integration of LEO satellites into Zimbabwe's mobile telecommunications infrastructure requires robust legal and policy frameworks. Regulations for spectrum allocation, satellite licensing, and data privacy must be clearly defined to ensure fair

competition and protect consumer interests. Spectrum allocation regulations should encourage expanding LEO satellite services in underserved areas and promote efficient spectrum utilisation. Government agencies, regulatory bodies, and industry stakeholders must collaborate to create a regulatory framework supporting investment in LEO satellite technology and telecommunications innovation.

The ICT infrastructure and skills in sub-Saharan Africa lag behind global standards (Lesame, 2014). Zimbabwe must pursue digital literacy and skills enhancement to capitalise on LEO satellite technology. These programs should educate individuals, communities, and enterprises on the use of digital technologies and their participation in the digital economy. Such initiatives can facilitate citizens' access to LEO satellite communication for online education, e-commerce, and telemedicine. Achieving this requires digital literacy, competencies, and policy alignment (Alper & Miktus, 2019; Lusigi, 2019). Virtual collaboration technology may enhance cooperation among Southern African nations despite geographical distances (Kabanda, 2008). Zimbabwe can leverage these technologies to overcome geographical limitations and engage in collaboration with regional partners.

Impact of LEO on Mobile Telecommunications

Technological advancements and shifting consumer expectations are revolutionising the mobile telecom industry (Kala, 2023). Low-Earth Orbit satellites present a viable alternative to terrestrial networks, particularly in areas with inadequate infrastructure (Zimba et al., 2021). Due to their extensive reach, significant bandwidth, and minimal latency, LEO satellites offer mobile operators an attractive option for improving their coverage and service delivery (Sigama & Kalema, 2022). LEO satellites and mobile telecommunications hold remarkable potential for socio-economic development, especially in underserved regions of Southern Africa.

LEO satellites integrated with mobile telecommunications networks have the potential to revolutionise connectivity in Zimbabwe, a nation characterised by inconsistent infrastructure and inadequate internet access. LEO satellites can connect rural areas and help bridge the digital divide by delivering mobile services. They can provide underserved schools, hospitals, and businesses with high-speed internet, enhancing education, healthcare, and economic opportunities. Mobile operators can leverage LEO satellites to improve network capacity and service quality in urban regions to meet the growing demand for data-intensive activities such as video streaming and online gaming. Policymakers must establish competitive and investment-friendly regulatory frameworks to support the implementation of LEO satellite technology in Zimbabwe. Spectrum allocation policies should promote efficient spectrum utilisation and ensure equitable access for all telecommunications market participants. Legal frameworks addressing data privacy, cybersecurity, and consumer protection must safeguard the rights and interests of Zimbabweans. A collaborative framework involving government ministries, telecommunications regulatory authorities, industry stakeholders, and international technological organisations is essential for facilitating the deployment of LEO satellites and fostering innovation in the telecommunications sector. This ecosystem would enable informed policy decisions, effective technology implementations, and significant

socio-economic benefits from improved connectivity (Morrison et al., 2020; Mutasa & Chivanga, 2021).

A significant proportion of broadband connections in developing countries are mobile (Cabrera-Castellanos et al., 2021). LEO satellite technology could facilitate Zimbabwe's prosperity by delivering essential services and enhancing economic growth. Remote education platforms provide high-quality learning resources to the most isolated students, telemedicine programs offer crucial healthcare services to marginalised populations, and e-government initiatives improve the efficiency of public service delivery and citizen participation. Numerous conflicting laws in Zimbabwe hinder the implementation of innovative financial services and products (Chitimira & Torerai, 2021). Individuals without banking access can engage in the formal economy and improve their livelihoods through LEO satellite communication.

LEO satellites have the potential to transform mobile telecommunications and enhance socioeconomic progress in Zimbabwe; however, there are hazards and challenges that must be addressed. Debris from low Earth orbit satellite constellations may jeopardise other satellites and space assets, exacerbate environmental concerns in space, and complicate space traffic management (Cavalcante et al., 2021). To ensure the long-term sustainability of space endeavours, the deployment of LEO satellite constellations must adhere to strict international standards and best practices for mitigating space debris. Cyberattacks on LEO satellites may disrupt communications and compromise critical data (Yue et al., 2022).

Zimbabwe's unique geographical and socio-economic context makes it an exemplary case study for analysing the impact of LEO satellites on mobile telecommunications and social development. LEO satellites have the potential to revolutionise agriculture, healthcare, education, and disaster management, thereby empowering individuals and fostering sustainable development. The nation's diverse terrain—urban areas, rural communities, and mountainous regions—provides a significant case study for the widespread connectivity of LEO satellites. Zimbabwe's initiatives for digital inclusion and closing the digital divide present an excellent opportunity to assess the effectiveness of LEO satellites in promoting growth. The desktop research outlines the social, political, and economic opportunities and challenges for rural banks in Zimbabwe (Matunhu & Mago, 2013). Rural areas can leverage LEO satellites to access internet markets, banking services, and various economic opportunities.

LEO satellite technology can support Zimbabwe in achieving its development goals in line with global frameworks such as the UN Sustainable Development Goals and the African Union Agenda 2063. The goals of Agenda 2063, which include eradicating poverty, promoting equitable growth, and ensuring access to quality education and healthcare, align with the potential benefits of LEO satellite connectivity. LEO satellites can enhance these initiatives by increasing information accessibility, fostering innovation, and optimising service delivery to marginalised communities. The strategic implementation and use of Information and Communication Technologies through LEO satellites can improve the quality of life for rural populations by facilitating precision agriculture through real-time data analysis, advancing healthcare delivery via telemedicine platforms, and enhancing

education through e-learning. LEO satellites provide reliable communication and data services during disasters, thereby strengthening community resilience and protecting vulnerable populations from climate change and natural disasters (Mupela et al., 2011).

LEO satellites can enhance communication between rural and urban areas, facilitate trade, and promote information transfer (Mercandalli et al., 2023). They can foster the prosperity of rural regions and reduce inequality by creating new economic opportunities, such as online agricultural marketplaces and remote work in the digital economy. LEO satellites can improve rural education by providing internet connectivity for online learning, research, and collaboration (Abdulai et al., 2022). Additionally, they facilitate telemedicine, remote monitoring, and access to medical information in rural areas (Yang et al., 2018). Telecommunication providers often avoid rural regions due to high infrastructure costs and low cell site revenue (Fourati et al., 2022). Cellular companies are hesitant to invest in rural telecommunications infrastructure because of these elevated expenses (Li et al., 2006). Community e-centers may promote e-commerce in rural areas (Islam et al., 2016). E-centers, staffed with trained personnel to instruct rural populations in ICT usage, would enhance services (Verma & Singh, 2014). Rural areas benefit from mobile banking, digital transactions, and financial services enabled by LEO satellites. This technology transforms Zimbabwe's approach to achieving Sustainable Development Goals, particularly in remote and marginalised regions.

Zimbabwe faces recurrent floods, cyclones, and droughts, where LEO satellites can support disaster response efforts. LEO satellites enable real- time data gathering and communication for disaster assessment, relief operations, and coordination of emergency response teams (Schumann et al., 2018). This technology enhances the delivery of emergency medical supplies (Li et al., 2023). LEO satellites improve disaster preparedness by monitoring environmental conditions, providing early warning systems, and educating vulnerable communities (Voigt et al., 2016). They supply data for meteorological observation, climate modelling, and agricultural planning, facilitating informed decision- making and proactive adaptation to climate change. By using LEO satellites, Zimbabwe could build more resilient communities against natural disasters and climate change. Telemedicine and e- learning enable remote consultations and diagnoses while offering educational resources and online courses (Torabi et al., 2023).

LEO satellite technology holds significant promise for telecommunications and social development in Zimbabwe; however, its implementation and adoption face challenges (Abdellatif et al., 2023). These challenges must be addressed to optimise the potential of LEO satellites and ensure their sustainable and equitable use for the people of Zimbabwe. In developing nations like Zimbabwe, LEO satellite technology- which includes satellite deployment, ground infrastructure, and user equipment- can be prohibitively expensive. LEO satellites pose a risk to global indigenous innovation initiatives. Zimbabwe may lack skilled personnel to manage and maintain LEO satellite infrastructure as well as to develop satellite- based applications and services. Weather, atmospheric disturbances, and various factors can result in erratic or unreliable connectivity from LEO satellites, particularly in remote areas. The regulatory framework for LEO satellite operations in Zimbabwe may be unclear, presenting challenges for satellite operators and service providers (“Lesotho Digital

Economy Diagnostic," 2020). In Zimbabwe, it is crucial to protect critical data, infrastructure, and individuals from cyberattacks (Kabanda & Chingoriwo, 2022).

Despite the adoption of ICTs, only minimal modifications have been made to enhance digital record management (Chikomba et al., 2020). Zimbabwe lacks a cohesive legal framework for data protection, privacy, and cybersecurity, which complicates implementation efforts. Progress has been hindered by challenges in e-government infrastructure, necessitating the resolution of service deficiencies (Mahlangu & Ruhode, 2021). To maximise profits from LEO satellites, the satellite industry needs a supportive environment that fosters investment, innovation, and collaboration

Digital Divide in the Context of Zimbabwe

The digital divide in Zimbabwe can be bridged by LEO satellites providing affordable and reliable internet access to underserved communities. LEO satellites empower Zimbabwean communities to innovate applications, services, and business models, promoting entrepreneurship and innovation. They enhance secure and reliable communication between governmental entities and the populace, improve the provision of public services, and foster transparency and accountability in electronic governance. To avoid disappointments and engage with essential institutions, it is crucial to research key success factors for initiatives such as new dry ports (Taderera et al., 2023). LEO satellites will facilitate access to education, healthcare, and other essential services in remote areas, thereby boosting the quality of life and socioeconomic development.

Additionally, LEO satellites enhance resilience to natural disasters and climate change by delivering real-time data, communication services, and early warning systems. Despite governmental initiatives to offer complimentary e-Services, network accessibility, and ICT infrastructure, rural poverty and inequality persist (Blom & Uwizeyimana, 2020). Namibian libraries encounter challenges in delivering e-government services due to insufficient funding (Nengomasha & Shuumbili, 2020). The report advocates for government and institutional commitment, policy interventions, seizing opportunities, appropriate budget allocation for ICT development, enhanced internet penetration, and ongoing citizen education regarding ICTS and e-Government services.

The successful implementation and utilisation of ICT can enhance local municipalities' performance and service delivery (Oyelana & Thakhathi, 2015). Protests regarding service delivery in South Africa indicate that local government administration continues to inadequately serve its citizens, despite the potential of ICT (Oyelana & Thakhathi, 2015). The integration of ICT in public sector management is essential for e-government and citizen services (Mbangula, 2023). LEO satellites have the potential to revolutionise Zimbabwean mobile telecommunications and promote societal progress through improved coverage, increased bandwidth, cost reduction, innovation, and e-governance. E-government has the potential to enhance governance and stimulate economic growth; however, infrastructure and financial constraints remain significant obstacles (Awotwi & Owusu, 2007). LEO

satellites provide data and connectivity for environmental monitoring, resource management, and climate change mitigation, strengthening Zimbabwe's sustainability and resilience. LEO satellites ensure that all individuals, regardless of geographic location or socioeconomic status, can access the digital economy, thereby eliminating injustice and advancing social justice. E-government can bridge the digital gap between government and citizens (Mandari & Koloseni, 2016).

E-government utilises various electronic platforms within the public sector to establish and sustain governmental institutions (Mhlongo & Thomas, 2024). Institutions employ technology and information to enhance relationships among citizens, businesses, and government (Hafel et al., 2022). E-government improves transparency, citizen engagement, and accountability (Silcock, 2001) (Maznorbalia & Awalluddin, 2021). Governments actively adopt e-governance to strengthen social indicators and combat corruption (Batool et al., 2021). E-government utilises information and communication technology to enhance governmental operations and processes, increase transparency and efficiency, provide public access to information, and foster citizen engagement (Batool et al., 2021). E-governance employs information and communication technology to deliver government services, disseminate information, and interact with the public (Batool et al., 2021). E-government leverages technology to create a virtual electronic government, dismantling administrative barriers (Mahlangu & Ruhode, 2020; Safeena & Kammani, 2013; Máchová & Lněnička, 2016; Akman et al., 2005). E-governance enhances governmental processes, facilitates interpersonal connections, and promotes external relationships (Heeks, 2001).

E-government initiatives incorporate information and communication technology into governmental operations to enhance efficiency, transparency, and citizen engagement (STOICA & Ghilic-Micu, 2020) (Shaikh & Khan, 2011). E-government seeks to automate processes, improve service delivery, and combat corruption (Iverson & Barbier, 2021). It necessitates transforming processes, policies, and cultural paradigms (Mirandilla-Santos, 2008). Government agencies in developed nations have implemented progressive web and ICT utilisation measures, enhancing coherence in local internet activities, expanding access and skills, facilitating interactive services for community discourse, and increasing citizen engagement in promoting and managing public services. E-government offers more convenient, customer-oriented, and cost-efficient public services (Karniawati, 2021). It oversees the online dissemination of governmental information to the public, business partners, employees, entities, and other institutions (Sutrisno et al., 2020). LEO satellites can deliver e-government services in rural areas, improving access to information, education, and healthcare, thus fostering social and economic development (Ronyastra et al., 2019; Sharmin & Islam, 2013; Spirakis, 2009; Ndou, 2004).

E-government enhances governance, embodies governmental representation, fulfils governmental responsibilities, and supports businesses and the public (Chen et al., 2023). It improves information dissemination, government services, and citizen engagement in decision-making processes. Citizens can access information, utilise public services, and enhance communication (Arief et al., 2021). By optimising operations, reducing

bureaucracy, and improving accountability, e-government makes governance more transparent, efficient, and effective. It promotes transparency, citizen engagement, and accountability (Atmojo & Nurwulan, 2020). E-government utilises communication and information technology to enhance and streamline governmental services (Alenezi, 2022). Governments communicate with individuals and provide services online through e-government (Deni et al., 2020). LEO satellites facilitate high-speed internet connectivity, enabling businesses to operate efficiently, penetrate new markets, and compete globally, thereby fostering economic growth and job creation.

E-government enhances governance by promoting transparency, accountability, and civic engagement in decision-making (Teodora, 2008). It improves governance alongside public and business services (Ya-guang et al., 2023). E-governance allows citizens to engage directly with the government through digital platforms, minimising distance and hassle while providing 24/7 access to services (Muda et al., 2020). E-government can enhance governmental administration and indirectly involve citizens in decision-making (Maznorbalia & Awalluddin, 2021). It oversees the online dissemination of government information to the public, business partners, employees, corporations, and other entities. E-government boosts information accessibility, citizen engagement, and governmental accountability in Zimbabwe, facilitating the achievement of sustainable development objectives (Arief et al., 2021; Riany, 2021). Telemedicine and remote monitoring with LEO satellites increase access to healthcare in rural areas. Precision agriculture utilising LEO satellites enables farmers to optimise yields, reduce input costs, and mitigate environmental impacts, thus enhancing food security and promoting sustainable agriculture.

Numerous nations are implementing e-government, benefiting citizens, governments, and stakeholders (Arief et al., 2021). Automation and reduced administrative burdens improve the resource efficiency and cost-effectiveness of e-governance initiatives for governments. E-government increases openness and integrity to enhance citizens' welfare and reduce corruption and misconduct (Jou et al., 2024). E-governance systems improve citizen services, encourage citizen engagement in decision-making, and enhance government transparency and accountability (Batool et al., 2021). E-governance integrates policies and public services to promote sustainable, inclusive economic growth, social development, and environmental conservation (Castro & Lopes, 2021). E-government boosts communication and collaboration among government entities, corporations, and individuals, thereby enhancing coordination and decision-making. E-government strengthens openness and evidence-based governance by providing access to government data and information for individuals and researchers. Rural schools and educational institutions can bridge the digital divide and improve education with reliable and cost-effective internet connectivity provided by LEO satellites.

LEO satellites will facilitate cloud services for enterprises and individuals, enhancing productivity and innovation (Arief et al., 2021). In Zimbabwe, lacking internet connectivity and digital infrastructure, LEO satellites can help bridge the digital divide and promote socioeconomic development. These satellites can improve communication and networking,

revolutionising agriculture, healthcare, education, and disaster management. LEO satellites can potentially transform the mobile telecommunications sector in Southern Africa, particularly in Zimbabwe, by providing cost-effective, high-speed internet to underserved regions, thereby fostering economic development and enhancing access to education, healthcare, and other essential services. LEO satellites enable intelligent solutions and data-driven decision-making by offering widespread connectivity for IoT applications in agriculture, transportation, and environmental monitoring. Many developing nations modernise e-government to provide seamless services (Ali et al., 2018). E-government aims to improve services for citizens and businesses (Jou et al., 2024). The primary goal of e-government is to boost efficiency, transparency, and citizen accessibility. E-government platforms and services encourage engagement among citizens, businesses, and stakeholders (Al-Ansi et al., 2024). E-government promotes governmental transparency, reduces corruption, fosters citizen participation, and improves public service delivery. LEO satellites facilitate communication and coordination for early warning systems and disaster response networks during natural disasters, thereby saving lives and minimising damage. Low Earth Orbit (LEO) satellites support sustainable development through remote sensing and earth observation by providing data for environmental monitoring, urban planning, and resource management (Musakwa & Niekerk, 2014).

LEO satellites provide economical and scalable high-speed internet connectivity to both urban and rural regions (Raessens & Hera, 2021). The ITU-R P.618 model overestimates attenuation and system design based on temperate climatic data (Ogutu, 2023). LEO satellites can enhance connectivity in sub-Saharan Africa, where unplanned rural settlements hinder the deployment of broadband infrastructure (Ogutu, 2023). They assist developing nations in bridging the digital divide and advancing socioeconomic development, particularly in areas with inadequate terrestrial infrastructure. Mobile telecommunications in remote and underserved regions benefit from LEO satellites due to their reduced latency, increased bandwidth, and broader coverage compared to geostationary satellites. LEO satellites offer a cost-effective alternative to terrestrial infrastructure, improve mobile network coverage, and facilitate e-learning and telemedicine in isolated areas, thereby helping to bridge the digital divide.

Meticulous component selection and optimised maintenance enhance the efficiency and cost-effectiveness of LEO satellites (Plastras et al., 2024). Telecommunications infrastructure surpasses geostationary platforms in efficiency due to reduced signal latency and lower power demands (Pontani, 2007). LEO satellites promote research and development in space technology, fostering innovation and generating highly skilled employment in the telecommunications and aerospace sectors. Their deployment requires supportive regulatory frameworks and policies encouraging equitable competition, protecting consumers, and ensuring responsible spectrum management to create a sustainable and inclusive telecommunications ecosystem. LEO satellites can assist entrepreneurs in developing innovative apps and services, thereby bolstering economic growth and the potential of the digital economy. LEO satellites will connect sensors and devices to establish smart cities, improving urban planning, traffic management, and public safety. They can facilitate the achievement of sustainable development goals and alleviate social challenges

by enhancing education, healthcare, information access, and economic growth. Current literature provides insights into the potential of LEO satellites; however, further research is necessary to examine legislative frameworks, spectrum management, and affordability to ensure fair access and optimise social benefits in Southern Africa. The application framework must improve its utilisation of scientific research and extensive satellite data for societal benefit.

LOE Regulation

To encourage innovation and competition, LEO satellite services in Zimbabwe should be governed through licensing, spectrum allocation, and data protection. The success of mobile telecommunications in Zimbabwe depends on the collaboration between the government, regulators, mobile network operators, and satellite service providers to foster investment, innovation, and sustainable growth. The government can promote infrastructure sharing and public-private partnerships to lower deployment costs and improve network coverage, thereby accelerating mobile telephony adoption. Regulatory policies should encourage competition and innovation to provide cost-effective, high-quality telecommunications services (Pau, 2011).

Regulations govern the telecommunications sector and impact the integration of advanced technologies such as LEO satellites (Asongu et al., 2021). Mobile telephony can enhance financial inclusion by providing mobile banking, payment services, and microfinance in remote areas with limited banking infrastructure. It is essential to analyse telecommunications regulations to identify opportunities and challenges in achieving desired outcomes (Pau, 2011). The regulatory framework must balance innovation, consumer protection, fair competition, and the prevention of anti-competitive practices.

The telecommunications infrastructure of Zimbabwe could benefit from integrating LEO satellites, especially during natural disasters or infrastructure failures. Strategic regulation is essential for enabling innovative service provision, particularly in underserved areas, and for fostering competitive markets that support new entrants, which is crucial for developing the information infrastructure (Gillwald, 2005). Zimbabwean mobile network operators must adapt to LEO satellite services strategically to stay competitive and capitalise on new opportunities. The government should promote digital literacy and provide training to empower individuals to utilise mobile telecommunications services and participate in the digital economy (Hemeson, 2006).

Mobile communication has enabled previously marginalised individuals to access cellular services in developing economies. Significant efforts are needed to enhance mobile services and strengthen competition within the cellular sector, especially in rural developing countries (Meddour et al., 2011). The transformation of the African mobile telecommunications sector and recent mergers and acquisitions may spur economic growth by reallocating networks to financially sound and efficient operators (Curwen & Whalley, 2011). Mobile technology facilitates agricultural marketing (Katengeza et al., 2011).

Low-income individuals continue to face challenges in acquiring mobile cellular services. Mobile telecommunications infrastructure can improve education and healthcare in remote and disadvantaged areas. Expanding mobile telecommunications infrastructure and services can create network deployment, maintenance, and customer support jobs. Mobile communication enables Africans to verify doctor availability before undertaking extensive travel for medical treatment (Kalil, 2009). The quality of infrastructure and user expenses are significant factors (Alper & Miktus, 2019). Despite government initiatives to offer complimentary e-services, enhance network coverage, and improve ICT infrastructure, rural regions continue to face challenges stemming from inequality and poverty (Blom & Uwizeyimana 2020).

LEO satellite communication may assist Zimbabwean mobile network operators in enhancing coverage, improving service quality, and offering novel services to consumers and businesses (Nunavath et al., 2020). Mobile technologies and information accessibility can enhance inhabitants' well-being and stimulate emerging nations' economies. ICTs drive economic activity by minimising waste and improving communication among producers, dealers, and customers, increasing demand for mobile-based services and creating job opportunities (Bhusal, 2022). The government should promote competition among mobile network operators and satellite service providers to prevent monopolies and ensure fair pricing. Additionally, it should encourage public-private partnerships to invest in telecommunications infrastructure and enhance digital inclusivity, thus bridging the urban-rural digital divide (Zimba et al., 2021). Telecentres can help close the information divide by providing public access to ICT services, especially in remote areas (Meng et al., 2013). The government should fund digital literacy initiatives to teach individuals about mobile telephone usage and engagement in the digital economy.

Enhancing mobile telecommunications infrastructure and services can generate jobs in network deployment, maintenance, and customer support. Overall, mobile telecommunications improve Zimbabwe's social welfare and promote inclusive and sustainable economic development.

6.0 Research Methodology

This study utilised a qualitative research methodology, through a case study approach focussing on Zimbabwe to thoroughly examine the influence of LEO satellites on the mobile telecommunications sector and social advancement in Southern Africa.

The data-gathering method targeted 15 key interview informants, purposively selected from leaders within the telecommunications industry, along with marketing and business development executives, telecommunications regulatory authorities, and government officials, leveraging their expertise and experience. A semi-structured questionnaire was employed to gather the interviewees' perspectives. The data was analysed using NVIVO software to establish themes and ensure validity and reliability. A documentary study was conducted to examine relevant policy papers, regulatory frameworks, industry reports, and scholarly publications. The data analysis incorporated a thematic analysis of interview transcripts and document content, employing inductive and deductive coding methods to

identify principal themes and patterns related to the study questions. Qualitative research approaches are particularly beneficial in politically unstable contexts (Musasa, 2021).

7.0 Results and Discussion

The results indicate that the emergence of Low Earth Orbit Satellite (LEOS) technology presents transformative potential for telecommunications companies in Zimbabwe. Successful implementation relies on overcoming numerous challenges while leveraging potential socio-economic advantages. This discourse organises essential findings into categories that include obstacles and opportunities related to LEOS implementation. Despite considerable challenges concerning regulatory adaptation and infrastructural requirements amid ongoing economic uncertainties, the potential benefits of integrating Low Earth Orbit Satellite technology into Zimbabwe's telecommunications sector are significant if pursued strategically through collaborative stakeholder engagement to enhance accessibility and affordability while fostering sustainable growth pathways. This approach could ultimately bridge existing divides across all involved sectors, benefiting society as a whole over time. The results are presented and discussed through the six thematic pillars that emerged from the NVIVO software, and the results are analysed, specifically the regulatory obstacles, investment infrastructure, economic variables, socio-economic consequences, ecological factors, and collaborative efforts ventures.

Regulatory Obstacles

A significant obstacle to using LOES technology lies in Zimbabwe's regulatory framework. Zimbabwe's legislative system must adapt to foster innovation while protecting data privacy and security. The existing laws may inadequately accommodate the rapid advancements in satellite technology or address future challenges in data protection. This creates uncertainty for telecommunications providers regarding their compliance obligations and operational protocols. To facilitate the effective integration of LOES, regulators must engage stakeholders such as telecommunications companies, civil society organisations, and technical experts in developing flexible regulations that encourage innovation while ensuring user rights are protected. *“The licensing of Starlink was a big scandal; you had a president of the country pronouncing that it now licensed and yet there was no framework for its licensing, and the Ministry of ICT and the regulator worked backwards to accommodate the LEOs player”* – Interviewee 12. This highlights the main challenges in unstable political-economic and legal environments where the President of Zimbabwe announced that a newly formed company, IMC Communications, was registered exclusively to supply the LEOs services. *“Look, this is not well thought out. The Mobile Network Operators are paying a license fee of USD135 million, while the LEOs are given a license for only half a million USD for the same period. Yet, they don’t have the burdens of infrastructure development and compliance taxes that the rest of the players grapple with.”* Interview 6. This denotes the imperative need to set standards in the regulatory environment to allow for players to compete fairly and strengthen the telecommunications ecosystems, which anchor societal development in the attainment of the SDGs and the African Union Agenda 2063 objectives.

Investment in Infrastructure

Implementing LOES requires significant investments in multiple areas: satellite acquisition, ground station development, and enhancements of network operational capabilities. The finding that *"the considerable investment required... demands a dependable power supply and resilient infrastructure"* – Interviewee 2 emphasises the need for fundamental improvements before utilising advanced technologies. In many areas of Zimbabwe, inadequate electricity supply poses a major challenge; therefore, investments should prioritise energy solutions, such as solar power, that can ensure reliable service delivery, particularly in remote locations. This a strategic challenge for the entire telecommunications ecosystem, which if it is to be strengthened to anchor societal development, the government must prioritise stabilising the sector through fiscal support with tax holidays, subsidies to support influx in infrastructure developments *"Starlink is bearing the investment costs in the countries it is entering in Southern Africa. The government, particularly through the African Union and the Southern Africa Development Community (SADC), should ensure that policies are investment-friendly by imposing conditions that foreign technology must invest in local infrastructure development funds."* Interviewee 15

User Engagement and Digital Proficiency

User acceptance is crucial for fully realising the benefits of LOES technology. The assertion that "promoting widespread adoption among users, particularly in regions with limited digital literacy, will be essential" Interviewee 3, highlights an important aspect that is sometimes overlooked during technical implementations. Effective strategies are needed to enhance digital skills through community training programs tailored for diverse groups. Providers can significantly increase usage rates by improving understanding and familiarity with new technology, leading to better economic outcomes.

Economic Variables

Economic instability poses a significant challenge for telecommunications companies in Zimbabwe in implementing LOES systems. The observation that *"sustaining low prices despite locally increasing foreign exchange costs..."* Interviewee 9 illustrates how external financial factors complicate the pricing structures necessary for competitive services. Providers must tackle these challenges by exploring alternative financing arrangements or partnerships that could mitigate currency fluctuations risks while maintaining consumer affordability. Network dependability and efficiency are also critical considerations. This presents a substantial challenge, as local players are not allowed to charge in USD, yet they import broadband from seaports. This situation creates an unfair advantage for foreign-owned LOES, which charges in foreign currency.

The stability of a network is closely tied to consumer satisfaction, which is a crucial factor in the competitive landscape of global telecommunications markets. The claim that *"high-speed networks are linked to productivity"* Interview 5, suggests that disruptions from unreliable connections can lead to financial losses for businesses due to decreased efficiency or damaged reputations stemming from poor service experiences. Therefore,

investing in resilient infrastructure capable of handling large bandwidths and effective traffic management strategies is vital as user demand grows after adoption.

Socio-Economic Consequences

The implementation of LOES has significant consequences beyond simple connectivity improvements; it catalyses extensive socio-economic development projects throughout communities in Zimbabwe. Improved access to education creates a flourishing environment for digital entrepreneurship. Enhanced internet access enables educational resources like online learning platforms, empowering students regardless of geographic limitations while allowing entrepreneurs from marginalised backgrounds to access previously unavailable market information, all contributing to reducing socio-economic disparities.

Ecological Factors

Although sometimes overlooked in debates over satellite deployments, environmental sustainability must be acknowledged in light of increasing global awareness of climate change effects: “Sustainability practices should be integrated into the deployment…” Interview 14, Incorporating sustainable practices, such as employing renewable energy at ground stations and implementing responsible waste disposal, will promote long-term economic and environmental viability.

Collaborative Ventures

Ultimately, forming partnerships is crucial for addressing specific identified challenges: *“Limited access to partnerships with LEO service providers constrains collaborative potential.”* Interview 1, Collaborating with established international entities that possess expertise in navigating complex regulatory environments or have developed best practice frameworks can provide local operators with essential insights into efficient implementation processes while sharing costs related to infrastructure development initiatives.

8.0 Recommendations

To efficiently deploy Low Earth Orbit Satellite (LEOS) technology and optimise its advantages for telecommunications in Zimbabwe, diverse stakeholders, including governmental regulators, telecoms providers, civil society organisations, and community leaders, must engage in strategic collaboration. The subsequent proposals are designed to tackle identified issues while capitalising on opportunities:

Government and Regulatory Authorities

Enhance Regulatory Frameworks: Revise current legislation to integrate LOES technologies by formulating explicit standards that foster innovation while safeguarding data privacy and security.

Optimise Licensing Procedures: Simplify licensing processes for LEO service providers such as Starlink to accelerate market entrance and enhance competition in the telecommunications industry.

Encourage Infrastructure Development: Implement tax incentives or subsidies to promote investments in satellite infrastructure and ground station development.

Telecommunications Entities

Invest in Community Engagement: Develop outreach programs to educate potential users about the benefits of LOES technology, emphasising digital literacy activities tailored to local conditions.

Enhance Network Reliability: Prioritise investment in robust network infrastructure capable of maintaining high-speed connectivity with minimal interruptions; consider implementing advanced traffic control technologies.

Investigate Novel Financing Frameworks: Explore collaborations with financial institutions or overseas investors to obtain money essential for extensive deployments while maintaining affordability.

Global Collaborators and Stakeholders

Offer Technical Support: Provide proficiency in traversing intricate regulatory landscapes or formulating best practice frameworks derived from successful worldwide deployments.

Participate in Knowledge Dissemination Initiatives: Organise knowledge exchange programs enabling experts from nations with established LOES systems to share views on effective techniques for addressing common issues encountered during implementation phases.

The academia & educational institutions

Conduct Research Studies: Launch research projects assessing the socio-economic impacts of LOES implementation among diverse populations in Zimbabwe; findings should guide policy development and strategic planning efforts.

Develop specialised training curricula focused on telecommunications engineering, satellite communications, and digital entrepreneurship, aligned with the sector's evolving demands driven by emerging technologies.

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