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Challenges Affecting the Deployment and Utilisation of Space-Based Internet in Some African Communities

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Annotation: This study examines the major challenges affecting the deployment and utilisation of space-based internet in expanding connectivity to underserved and remote communities in Africa. A review research method was adopted to analyse existing studies on the development, adoption, and performance of space-based internet services. The review focuses on the high costs of satellite terminals and subscriptions, limited electricity availability, low digital literacy, regulatory and policy challenges, atmospheric and weather effects, limited network capacity, inadequate ground infrastructure, and shortages of technical skills and maintenance capacity. These factors are particularly important in developing regions where terrestrial broadband infrastructure remains inadequate and access to reliable internet services is still uneven. The findings indicate that although space-based internet can improve connectivity in areas poorly served by terrestrial networks, these challenges can limit its affordability, reliability, scalability, and accessibility. The review further shows that overcoming these barriers requires coordinated efforts among governments, satellite operators, telecommunications providers, and local communities. The study concludes that addressing these challenges through supportive policies, improved infrastructure, affordable technologies, reliable electricity, digital literacy, and technical capacity building is essential for the sustainable expansion of space-based internet services and its contribution to reducing the digital divide.

Keywords: Space-based internet; Digital divide; Satellite connectivity; Internet accessibility; Deployment challenges.



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1. Introduction

Space-based internet has emerged as an important communication technology for extending broadband connectivity to rural, remote, and underserved communities where terrestrial infrastructure remains limited. Recent advances in LEO satellite constellations have improved the potential for high-speed, low-latency connectivity, although their deployment introduces technical, economic, environmental, and regulatory considerations [1]; [2]. In Africa, satellite connectivity is increasingly being considered as a complementary solution to existing terrestrial networks and as a means of reducing persistent disparities in internet access [3]; [4]. Studies of communication systems in Nigeria have also demonstrated the

importance of atmospheric conditions in determining signal performance, providing a relevant basis for understanding environmental influences on satellite and wireless communication [5]. Empirical measurements of Starlink performance further show that satellite internet performance can vary geographically, with factors such as latency, throughput, packet loss, and network conditions influencing the quality of service [6]; [7]. Consequently, examining the challenges affecting the deployment and utilisation of space-based internet is necessary to identify the barriers that may limit its affordability, reliability, scalability, and contribution to bridging the digital divide.

2. Methodology

This study adopted explanatory and review research methods to examine the challenges affecting the deployment and utilisation of space-based internet. The explanatory approach was used to explain how and why factors such as cost, electricity availability, digital literacy, regulation, weather conditions, network capacity, ground infrastructure, and technical skills influence the effective use of satellite internet. Explanatory research is appropriate because it focuses on understanding the reasons and relationships underlying an observed phenomenon. The review research method was used to identify, examine, compare, and synthesise findings from existing scholarly studies on satellite connectivity, LEO satellite networks, digital inclusion, and related infrastructure. Literature reviews provide a structured means of synthesising existing knowledge and identifying patterns, gaps, and areas of agreement or disagreement across previous studies. Recent research works published mainly between 2024 and 2026 were prioritised, with relevant peer-reviewed journal articles, conference papers, and credible research publications selected based on their relevance to the eight identified challenges. The reviewed evidence was analysed thematically, with studies grouped according to the identified challenges and their effects on affordability, accessibility, reliability, scalability, and sustainability. The findings from the reviewed studies were then interpreted using the explanatory approach to establish how the identified challenges can influence the deployment and utilisation of space-based internet, particularly in underserved and developing communities.

3. Results and Discussions

The following are some challenges affecting the deployment and utilisation of space-based internet.

3.1. High Cost of Satellite Terminals and Subscriptions

This refers to the high initial cost of satellite equipment and the recurring subscription fees required to access and maintain space-based internet services. The high cost of satellite terminals and subscription services is a major challenge to the deployment of space-based internet, especially in developing and remote communities. Satellite internet requires specialised equipment such as terminals, antennas, routers, and installation components, which may be expensive for low-income users. In addition, recurring subscription fees can make continuous access difficult for households, schools, healthcare centres, and small businesses. These costs can reduce adoption even where satellite coverage is technically available. Subsidies, flexible payment options, affordable service plans, and community-based access centres can help reduce the affordability barrier. Therefore, lowering equipment and subscription costs is essential for making space-based internet accessible and supporting digital inclusion.

Gur and Kulesza [8] examined equitable access to satellite broadband in developing countries and argued that meaningful connectivity requires access conditions that are affordable and equitable, particularly for populations that remain underserved by conventional broadband infrastructure. Similarly, McMahon [9], through an empirical study of LEO satellite services in two remote Indigenous communities in Northern Canada, found that although Starlink provided better connectivity and cost-effectiveness than some existing satellite services, affordability remained a concern because of high initial costs and dependence on proprietary user terminals. These findings demonstrate that satellite coverage alone does not guarantee effective access when potential users cannot afford the required equipment and recurring service charges. The financial burden can be particularly serious for low-income households, schools, healthcare facilities, and small businesses in rural communities. Consequently, reducing terminal prices, providing flexible subscription arrangements, and introducing targeted subsidies or community-access models can improve adoption. Addressing affordability is therefore essential for ensuring that space-based internet contributes meaningfully to digital inclusion and the reduction of the digital divide.

3.2. Limited Electricity Availability

This refers to inadequate or unreliable electricity supply needed to power satellite terminals, routers, and other equipment required for internet connectivity. Limited electricity availability is another major challenge affecting the effective utilisation of space-based internet in rural and remote communities. Although satellite connectivity reduces dependence on terrestrial infrastructure, satellite terminals, routers, and user devices still require a reliable power supply. Communities with poor or unreliable electricity may experience frequent service interruptions or may be unable to operate satellite equipment consistently. Dependence on generators can further increase operating costs because of fuel consumption and maintenance requirements. Solar power systems with battery storage can provide a practical alternative for off-grid and underserved communities. Improving reliable electricity access is therefore important for ensuring continuous and sustainable utilisation of space-based internet.

According to Okello [10], access to affordable and sufficient electricity is one of the factors impeding the diffusion and adoption of low-cost satellite internet in rural Kenya. Similarly, Falowo and Falowo identify erratic power supply as a challenge to LEO satellite internet penetration in Sub-Saharan Africa, noting that consistent electricity is required for the continuous operation of LEO satellite receivers and other devices. These findings demonstrate that although satellite technology can overcome geographical limitations associated with terrestrial networks, it does not eliminate the need for reliable electricity at the user end. In communities with unstable or unavailable electricity, satellite terminals and associated networking equipment may not operate continuously, thereby affecting the reliability of internet access. Falowo and Falowo further propose solar-powered batteries as a possible means of powering satellite kits in rural and remote locations. Therefore, integrating space-based internet deployment with reliable renewable-energy solutions, particularly solar power and battery storage, can improve service continuity and support sustainable connectivity in electricity-deficient communities.

3.3. Low Digital Literacy

Low Digital Literacy deals with the limited knowledge and skills required by users to operate digital devices and effectively access and utilise space-based internet services. Low digital literacy is a significant challenge affecting the utilisation of space-based internet, particularly among people in rural and underserved communities. Access to satellite connectivity alone does not guarantee effective use if users lack the skills required to operate digital devices and online platforms. Some users may experience difficulties with setting up equipment, connecting devices, navigating websites, and using online services effectively. This can limit the benefits of space-based internet for education, healthcare, employment, communication, and digital financial services. Digital literacy programmes, community training, and user-friendly technologies can help improve users' ability to benefit from satellite connectivity. Therefore, strengthening digital skills is essential for ensuring that space-based internet produces meaningful and sustainable benefits.

The reviewed literature indicates that low digital literacy can significantly limit the effective utilisation of space-based internet in rural and underserved communities. Okello [11] reports that rural and marginalised communities in Kenya generally have lower levels of digital literacy and technology adoption than urban populations, and identifies digital-literacy programmes as important for improving digital engagement. Similarly, Guo and Ogbodo [12], in their comparative study of rural communities in China and Nigeria, found persistent differences in digital access and literacy between rural and urban populations, with inadequate infrastructure and limited digital skills contributing to the continuing digital divide in Nigeria. These findings are relevant to space-based internet because providing satellite connectivity does not automatically ensure that users can make productive use of the available service. Individuals with limited digital skills may experience difficulties operating connected devices, navigating online platforms, accessing information, and using digital services for education, healthcare, employment, and business activities. Consequently, low digital literacy can reduce the social and economic benefits expected from satellite connectivity even where reliable internet access has been established. Community-based training, practical digital-skills programmes, and continuous user support can therefore improve the effective utilisation of space-based internet. Digital literacy should consequently be incorporated into satellite connectivity programmes as an essential component of achieving meaningful and sustainable digital inclusion.

3.4. Regulatory and Policy Challenges

This is defined as the difficulties arising from licensing requirements, spectrum regulations, government policies, and other legal frameworks governing satellite internet deployment and operation. Regulatory

and policy challenges can affect the deployment and utilisation of space-based internet across different countries and regions. Satellite internet services may require appropriate licensing, spectrum allocation, landing rights, and compliance with national telecommunications regulations. Complex or unclear regulatory procedures can delay deployment and increase the cost of providing services to underserved communities. Differences in national policies may also create difficulties for satellite operators seeking to provide services across multiple countries. Governments can address these challenges by developing clear, transparent, and supportive regulatory frameworks for satellite connectivity. Effective policies can encourage investment, promote competition, and facilitate the expansion of space-based internet to areas where terrestrial infrastructure is limited.

As reported by Pedram and Georgiades [13] who examined regulatory frameworks governing LEO satellite markets, existing frameworks face difficulties in balancing national security, competition, licensing, and the expansion of satellite services to underserved communities. In the same way, Bonsall [14] examined the impact of Starlink on connectivity initiatives in Africa and highlighted how spectrum regulation, national telecommunications policies, and regulatory interests can influence the rollout of LEO satellite networks across African countries, including Nigeria and South Africa. These findings indicate that satellite operators cannot simply provide services in a country based on technical satellite coverage because national authorisation and telecommunications requirements must also be satisfied. Licensing procedures, spectrum allocation, landing rights, local ownership requirements, and concerns relating to data sovereignty can delay or restrict service deployment. This challenge can be particularly significant in developing countries where regulatory frameworks may not have been designed for rapidly expanding LEO satellite constellations. Therefore, governments need clear, transparent, and adaptable regulatory frameworks that protect national interests while facilitating responsible satellite connectivity.

3.5. Atmospheric and Weather Effects

This refers to the degradation or interruption of satellite communication signals caused by rainfall, thunderstorms, clouds, and other atmospheric conditions. Atmospheric and weather conditions can affect the reliability and performance of space-based internet services, particularly satellite communication links operating at higher frequencies. Heavy rainfall, thunderstorms, clouds, and atmospheric disturbances can weaken or interrupt signals between satellites and ground terminals. This effect, commonly associated with rain attenuation, can become more noticeable during periods of intense rainfall. In regions with frequent tropical storms and heavy seasonal rainfall, weather-related signal degradation may reduce service quality and availability. Improved link design, adaptive technologies, adequate signal margins, and appropriate frequency selection can help reduce these effects. Therefore, understanding and managing local atmospheric conditions is important for maintaining reliable space-based internet connectivity.

As observed by Sodunke [15] who investigated rainfall characteristics and their effects on Earth–satellite communication in Southwestern Nigeria, variations in rainfall can produce significant rain attenuation, with implications for satellite link performance, throughput, and latency. Also, Ukommi [16] examined three years of rainfall and rain-induced attenuation data across the South-South region of Nigeria and reported that rain fade can degrade signal quality, increase path loss, and reduce satellite communication coverage, particularly at frequencies above 10 GHz. These findings are particularly relevant to space-based internet services operating in tropical regions where intense and frequent rainfall occurs. Atmospheric effects such as rain attenuation can weaken the signal travelling between the satellite and ground terminal and may consequently reduce connection quality during severe weather conditions. The effect can become more pronounced as operating frequency increases, making appropriate link planning and weather modelling important for reliable service delivery. Therefore, satellite internet providers need to consider local rainfall patterns, frequency characteristics, link margins, and appropriate mitigation techniques when deploying services. In addition, addressing weather-related signal degradation is essential for improving the reliability and continuity of space-based internet, especially in tropical regions such as Nigeria.

3.6. Limited Network Capacity

This deals with the restricted bandwidth and network resources available to support increasing numbers of users and growing internet traffic. Limited network capacity can affect the ability of space-based internet systems to provide consistent and efficient connectivity as the number of users increases. Satellite networks have finite bandwidth and other technical resources that must be shared among

connected users within a coverage area. During periods of high demand, increased traffic can result in congestion, reduced speeds, higher latency, and lower quality of service. This problem can become more significant when satellite internet is introduced into communities with limited alternative connectivity options. Increasing satellite capacity, improving spectrum utilisation, deploying additional satellites, and using efficient traffic-management technologies can help address congestion. Therefore, adequate network capacity is essential for supporting the scalability and long-term utilisation of space-based internet services.

Hu in their study found that LEO satellite systems have constrained resources and experience uneven traffic distribution, which can result in low resource utilisation and increased blocking when the number of users becomes high. Their study demonstrates that efficient allocation of channels and transmission power is necessary to accommodate varying traffic demands and maintain acceptable quality of service. Similarly, Yao explained that the expected growth in LEO satellite deployment and the increasing number of users can place substantial pressure on satellite-terrestrial links, resulting in congestion and degraded network performance. Their review of LEO intersatellite communications highlights resource allocation and network management as important requirements for supporting the increasing demand for satellite connectivity. These findings show that satellite internet does not provide unlimited bandwidth or network resources, and increasing numbers of users can place pressure on available capacity. Traffic concentration in particular geographical areas can further produce congestion and unequal service quality. Consequently, efficient resource allocation, traffic management, beam management, and capacity expansion are necessary to accommodate increasing demand.

3.7. Inadequate Ground Infrastructure

This refers to the lack of supporting facilities such as gateways, power systems, network centres, and local infrastructure required for effective satellite internet operation. Inadequate ground infrastructure is a major challenge affecting the effective deployment and utilisation of space-based internet services. Although satellite systems can provide connectivity to locations without fibre or cellular networks, they still depend on ground-based facilities such as gateways, network operation centres, power systems, and distribution infrastructure. In remote areas, the absence of suitable sites, reliable power, transportation networks, and supporting telecommunications facilities can complicate deployment and maintenance. Poor ground infrastructure can also increase installation costs and make it difficult to repair or replace damaged equipment. Strengthening supporting infrastructure through investment in suitable facilities, reliable power systems, and local distribution networks can improve service availability. Therefore, adequate ground infrastructure is necessary to complement satellite technology and ensure sustainable connectivity in underserved communities.

According to Abe [17] in their investigation of satellite network infrastructure, it was stated that the placement of gateway stations is an important consideration in LEO satellite networks because gateways provide essential connections between satellites and terrestrial networks. Their study shows that gateway location and routing must be carefully planned to ensure efficient satellite-network operation. Similarly, He [18] explain that the ground segment of a LEO satellite constellation consists of gateway stations and operation and maintenance control centres, which are responsible for connecting satellite networks with terrestrial networks and managing network operations. These findings indicate that space-based internet cannot operate effectively through satellites alone because adequate ground facilities are required to connect satellite systems to users and wider internet networks. In areas where gateways, points of presence, reliable power supplies, fibre connections, and network-management facilities are limited, deployment may become more expensive and service quality may be affected. The absence of strategically located ground infrastructure can also increase latency when user traffic has to be routed through distant gateways. Therefore, expanding gateway stations, points of presence, supporting power systems, and terrestrial backhaul infrastructure is important for improving the performance and geographical reach of space-based internet. Addressing ground-infrastructure gaps is consequently essential for achieving reliable, scalable, and sustainable satellite connectivity in underserved communities.

3.8. Shortage of Technical Skills and Maintenance Capacity

This refers to the insufficient availability of trained personnel and local technical resources needed to install, manage, troubleshoot, and maintain space-based internet systems. The shortage of technical skills and maintenance capacity can limit the successful deployment and long-term operation of space-based internet systems. Satellite networks require skilled personnel to install terminals, configure equipment,

monitor network performance, diagnose faults, and carry out repairs. Many remote communities may have limited access to trained technicians, resulting in dependence on specialists from distant urban areas. This can increase maintenance costs and prolong service interruptions when technical problems occur. Capacity-building programmes, local technical training, and partnerships between service providers and educational institutions can help develop the required expertise. Building local maintenance capacity is therefore essential for improving the reliability, sustainability, and long-term utilisation of space-based internet services.

Ma [19], carried out a practical work, thus, based on the practical experiences deploying Starlink-supported networks in remote Northern British Columbia, identified the difficult operating environments and limited infrastructural support in remote locations as important challenges requiring technical solutions and local operational capacity. Confirming this, Lagunas, explain that the increasing complexity of LEO satellite constellations creates technical and operational challenges that require appropriate expertise for network management, integration, and reliable operation. These findings indicate that deploying satellite terminals alone is insufficient to guarantee sustainable connectivity, since equipment must be properly installed, configured, monitored, maintained, and repaired. In remote communities, the shortage of personnel with satellite-network expertise can increase dependence on external technicians and prolong service interruptions when faults occur. This can also increase maintenance costs because technical specialists may need to travel long distances to reach remote installations. Therefore, local technical training, certification programmes, remote technical support, and partnerships with satellite operators can strengthen maintenance capacity. Developing local expertise is consequently essential for improving the reliability, sustainability, and long-term utilisation of space-based internet services.

4. Conclusion

This study examined the major challenges affecting the deployment and utilisation of space-based internet using explanatory and review research methods. The review established that although LEO satellite systems have considerable potential to extend reliable connectivity to remote and underserved communities, their effectiveness can be constrained by several interrelated factors. These include the high cost of terminals and subscriptions, limited electricity availability, low digital literacy, regulatory and policy barriers, atmospheric and weather effects, limited network capacity, inadequate ground infrastructure, and shortages of technical skills and maintenance capacity. Recent literature similarly indicates that satellite connectivity should be viewed as a complementary component of the wider connectivity ecosystem rather than a complete replacement for terrestrial infrastructure. The study therefore concludes that addressing these challenges requires coordinated efforts involving governments, satellite operators, telecommunications providers, regulators, and local communities. Measures such as affordable service models, reliable renewable-energy systems, digital-literacy programmes, supportive regulations, improved ground infrastructure, network-capacity expansion, and local technical training can enhance the sustainability and accessibility of space-based internet. Ultimately, overcoming these barriers is essential for ensuring that the growth of satellite connectivity translates into meaningful digital inclusion and contributes effectively to reducing the digital divide.

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