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The Role of Satellite Technology in Socio-Economic Development: Africa's Perspective

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Abstract: The overarching objective of countries across Africa is development. Consequently, various development plans have been implemented. The universal appreciation that technology is a driver of sustainable development has led to the adoption of satellite technology in developed countries. However, several African countries are lagging behind. Therefore, using Albert Hirschman's unbalanced growth theory and Schumpeter's innovation theory, this paper seeks to investigate the contribution of satellite technology towards development and proffer measures to facilitate Afits adoption across Africa. The study utilised Key Informant Interview in gathering data from nine experts. Based on the research findings, this study recommends that African governments prioritise investment in satellite technology in order to enjoy its multiplier effect on other sectors. It further recommends collaboration with the private sector to drive the diffusion of satellite technology towards achieving sustained development.

Keywords: Africa, Development Technology, Innovation, Satellite Technology

Introduction

Development has become the overarching objective of African countries. However, Africa still lags behind in development. Subsequently, scholars have identified determinants of development within the continent. These include increased export, increased government spending, foreign direct investment and human capital development (Kadafi et al., 2023). In addition, one major determinant is technology. Technology is pivotal to development. This is because it fosters innovation, which would facilitate increased productivity, economic growth and improved living conditions (Bishop et al., 2022). There are different types of technology, one of which is satellite technology.

Satellite Technology involves deploying satellite-based solutions. It encompasses space exploration and the use of satellites for communication, navigation, astronomy, and remote sensing, for the socio-economic benefits of man (Reda et al., 2023; Siddique, 2024). Various countries are leveraging on satellite technology to address societal problems and foster development. However, it has not been optimised in Africa (Wood, 2008). This has led to a technology gulf between developed and developing countries (Nikoloski, 2016). These satellites are used for several applications, which include real-time disaster monitoring, agriculture, health, education, internet connectivity, broadcasting, security, and asset tracking. Subsequently, data received from the satellites provide input for informed decision-making by policy makers towards achieving development (Reda et al., 2023; Siddique, 2024).

Consequently, the low adoption of satellite technology in Africa has deprived Africans of its optimal derivable benefits. This provides the background for this study, which aims to underscore the importance of satellite technology in the achievement of development within Africa. This study will seek to answer the following:

1. What is the contribution of satellite technology to development?
2. What factors impede a wider adoption of satellite technology in Africa?

3. How can the adoption of satellite technology be encouraged within Africa?

This study will guide the formulation of policies geared towards increased adoption of satellite technology for the achievement of development in Africa.

Methodology

To investigate the impact of satellite technology in the attainment of development in Africa, this paper adopted Key Informant Interviews (KII), as its source of primary, qualitative data. Therefore, nine experts were specifically selected based on their extensive knowledge and experience in satellite technology-based projects in Africa. These experts encompass a pioneer driver of satellite technology in Nigeria (KII001), top management of public and private-owned Nigerian satellite technology companies and associations (KII002 & KII003), experts from outside Africa (KII004 & KII005), Head of an African satellite association (KII006), Head of a Nigerian space institute (KII007), Know-How Technology Transfer Trainees for Nigeria's satellite (KII008) and a satellite-based innovator (KII009). The assigned codes would guarantee anonymity, while capturing the nuances of the participants.

Semi-structured interviews were conducted through face-to-face, email and telephone. These would engender relevant additional information to enrich the study (Hicks et al., 2021). The consent of the participants was obtained prior to the interview. To ensure thoroughness and data trustworthiness, iterative reviews of transcribed data were conducted. Thematic Analysis was done to identify related and variant underlying themes around the research questions. Direct quotes were used for emphasis. The findings from the analysis formed the premise for the ensuing conclusion and recommendation.

Conceptual Clarification

<u>Development</u>

The concept of development was previously defined within the scope of economic growth. However, this definition evolved as poverty level increased due to inequality in the distribution of gains of economic growth. This resulted in the incorporation of social welfare. Hence, development encompasses economic growth and improvement in the standard of living of people as indicated by poverty reduction, equal distribution of opportunities, education, health, and food security (Litwiński, 2017).

Technology

Technology is a combination of two Greek words, “techne”, which means “craft or skill”; and “logos”, which means “science” (Nikoloski, 2016). It connotes utilising skills for the purpose of creation or discovery. Therefore, technology refers to something created or discovered through the application of science to serve a specific purpose for the benefit of the society (Carroll, 2017).

Satellites

This study is centred on artificial satellites. Artificial satellites can be defined as electronic devices that are launched into space from the earth, using a space vehicle. Examples include remote sensing satellites, weather satellites, navigation satellites and communication satellites. Satellites can be classified as femto-satellites (less than 100g), pico-satellites (between 0.1 to 1kg), nano-satellites (between 1kg to 10kg), microsatellites (between 10kg to 100kg), mini-satellites (between 100kg to 500kg) and large satellites (above 500kg) (Reda et al., 2023).

Satellite Technology

This is a form of technology in which data is transmitted from satellites to be used for various applications. These applications include broadcasting, remote sensing, and communication (Siddique, 2024).

Theoretical Exposition

Albert Hirschman’s Unbalanced Growth Theory

Early development economists propounded theories on development either from the perspective of the balanced growth or unbalanced growth theory. The advocates of the balanced growth theory postulated that in order for developing countries to achieve development, there must be planned simultaneous investment in most or all sectors of the economy (Jiang et al., 2020; Khan et al., 2020).

On the other hand, economists including, Albert Hirschman, argued against the practicality of the balanced growth theory. They therefore advocated for the unbalanced growth model. This stipulates that development would be achieved by investing in specific prioritised sectors of the economy, thereby intentionally causing an unbalance in the economy. Subsequently, this would stimulate development in other sectors (Kucera et al., 2018). Developing countries have limited capital that would be insufficient for simultaneous investments among various economic sectors. Therefore, it is practical that priority sectors be identified for investment decisions.

Hirschman posited that sectors within the economy with strong linkages be prioritised for investment (Jiang et al, 2020). Investing in such sectors would therefore impact other sectors, leading to overall development in the long run. This theory will be adopted to demonstrate how investment in satellite technology, as a prioritised sector, would stimulate development in other sectors for overall development.

<u>Schumpeter's Innovation Theory</u>

Theories of Entrepreneurship are broadly classified into classical and modern theories. The classical theories described entrepreneurs as managers. However, Joseph Schumpeter, a leading advocate of the modern theories of entrepreneurship, described entrepreneurs as innovators (Upadhyay et al., 2018). Schumpeter highlights the importance of innovation and entrepreneurship in fostering development. He posited that innovation is "creative destruction" and is a catalyst for development. This is because innovation would destroy the existing economic structure while continually creating a new one. This progression of structural changes would therefore engender development. This is opposed to a static and monotonous economy, which leads to an unchanging economy (Śledzik, 2013; Ziemnowicz, 2020).

Subsequently, the entrepreneur would utilise innovation to provide opportunities that would stimulate investment and growth. Innovation encompasses new ideas, products, processes and technology. New and improved technology would therefore continuously replace archaic ones (Śledzik, 2013; Upadhyay et al., 2018; Ziemnowicz, 2020). Innovation has different stages (Figure 1.1). First is invention, in which new technology is discovered. Second is innovation, in which the discovered technology is applied. Third is diffusion in which the innovation is adopted and spreads. The diffusion phase constitutes the most significant phase because it engenders economic growth and development (Kaya, 2015; Śledzik, 2013).

Figure 1.1

Phases of Innovation

Author's Conceptual Model (2025)

Due to the aptness of the above description to this study, Schumpeter's theory will be adopted.

Therefore, the above theories will be blended to showcase a synergy between the government and entrepreneurs towards a viable satellite technology programme in Africa for sustainable development.

Satellite Technology and Socio-Economic Development

Technology is central to development (Steenhuis et al., 2012). Therefore, its adoption places countries at an advantage over those with low technology. According to Niloloski (2016), it encompasses the discovery of an invention, the application of the invention, and its diffusion. This supports Schumpeter's stages of innovation. Technology varies in forms. It includes information technology, biotechnology, robotics technology, and satellite technology (Aunger, 2010). Satellite Technology involves deploying satellite-based ubiquitous solutions. There are different satellites, according to their functions. They include earth observation satellites, meteorological satellites, navigation satellites and communication satellites (Reda et al, 2023; Siddique, 2024).

Satellite Technology has significant socio-economic impact. This is because it can be applied in various sectors including agriculture, medicine, and environment (Okon, 2018). Some of these various satellites, their applications, and impact on development are examined below.

The first is earth observation satellites. These satellites use remote sensing to transmit data to the earth. The data is used for natural resource exploration, agriculture, monitoring of climatic changes and weather forecasting (Siddique, 2024). Earth-observation satellites further enable monitoring of the earth, in real-time, for urban planning, disaster management and environmental monitoring. Satellites are used to capture images. These images provide support for development policy decision-making (Juma et al., 2017; Siddique, 2024). For example, satellite images could be used to determine the best sites for dam construction, monitor land use and urban growth. This will support decision-making on urban and infrastructural planning. Furthermore, the images can be used to investigate climate patterns and weather monitoring. This would facilitate the development of systems to provide early warning for natural disasters, thereby saving lives. In addition, satellites provide images of disaster areas, which would facilitate effective planning of disaster emergency rescue (Juma et al., 2017; Okon, 2018; Siddique, 2024). Juma et al. (2017) illustrated the impact of satellite data on the health sector by noting that satellite images were used to provide early warning for malaria outbreak. Consequently, about 500,000 cases of malaria were averted in 28 countries.

The second is navigation satellites. These enable global navigation systems, which facilitates precision positioning. For example, it facilitates precision agriculture by providing data used to assess crop status, improve crop quality, and increase crop productivity. This would ensure steady food supply and profit. Satellites also facilitate global tracking of assets and wildlife tracking, as anti-robbery measures (Atayero et al., 2011; Siddique, 2024). In addition, they facilitate the management of air, rail and ship traffic. (Chrzan et al., 2024; Siddique, 2024). Additionally, global positioning system (GPS) chips have been introduced into smartphones for location tracking (Okon, 2018).

The third is communication satellites. These are used to deploy Internet solutions to remote areas. They also facilitate data, voice and video communication. This is important in enabling emergency communication during occurrences of disaster and unrest. Furthermore, they provide the platform for the delivery of tele-education services. This facilitates distance learning, ensuring that people in rural areas have access to qualitative educational resources (Bakare et al., 2016; Okon, 2018). Also, they enable tele-medicine in order to facilitate access to specialised medical care (Atayero et al., 2011; Okon, 2018; Siddique, 2024). Patients in the rural areas can be connected via video to specialists in teaching hospitals for diagnosis and prescription. This would ensure that in emergency situations, the right diagnosis is given in order to determine the right treatment and prescription, ultimately saving lives (Atayero et al., 2011). Furthermore, communication satellites are used for broadcasting content such as religious, news, entertainment, cultural, and educational programmes on high-definition television and radio, to different people across different regions. This enables dissemination of information on a large-scale for enlightenment. (Atayero et al., 2011; Siddique, 2024). Communication satellites also facilitate trade and e-commerce (Siddique, 2024).

The above shows that the satellite technology sector has strong linkages with other sectors. Therefore, according to Hirschman's unbalanced growth theory, prioritising investment in satellite technology will create an initial unbalanced growth. Subsequently, due to its strong linkages, other sectors would be impacted, resulting in overall development. Satellite Technology therefore provides a platform to solve challenges, ensure productivity in various sectors of the economy and improve the standard of living, thereby fostering development (Siddique, 2024; Okon, 2018).

Factors Impeding Wider Adoption of Satellite Technology in Africa

Technology and innovation drive development. According to Schumpeter's innovation theory, it causes "creative destruction", in which the economic structure is improved continuously through the diffusion of new technology and inventions. Therefore, development would be stimulated, not just by the presence of technology, but by its adoption and diffusion (Bishop et al., 2022; Kala, 2023). This aligns with Schumpeter's phases of innovation. Consequently, various countries have embraced satellite technology.

Despite the significant contribution of satellite technology to development, less than half of African countries own satellites (Spacehubs Africa, 2024). Subsequently, the low adoption of satellite technology has resulted in a significant margin between developing and developed countries (Nikoloski, 2016). Several factors have been attributed to this.

First is lack of funds (Okon, 2018; Wood, 2008). This is compounded by the high cost of satellite technology (Kala, 2023). According to Statista (2024), the total global expenditure on space programme in 2023 was about $117 billion, of which the United States expended about $73.2 billion, while China expended above $14 billion. On the other hand, Nigeria's capital budget for its space programme in 2023 was about $11.8m (Budget Office of the Federation, 2023; CBN, 2023). Therefore, the United States accounted for about 63% of the global expenditure, China, about 12%, while Nigeria accounted for less than 1%.
It is significant to note that most African countries are characterised by low GDP. As seen above, the United States' expenditure on its space programme in 2023 was $73.2 billion. This exceeds the current GDP of 43 African countries; that is, about 80% of African countries. Examples are Benin (GDP $21.32billion); Burundi ($4.29 billion);

Chad ($18.67 billion); Republic of Congo ($15.04 billion); Gabon ($20.9 billion); Guinea ($25.47); Guinea Bissau ($2.19billion); Liberia ($4.76 billion); Sierra Leone ($7.41 billion); and Togo ($9.77 billion) (IMF, 2024). Therefore, given the high cost of satellite technology amidst conflicting needs, including food insecurity, poor housing, and inadequate health services coupled with limited funds, spending on satellite technology becomes unattractive (Kala, 2023). Investment in satellite technology is thus considered wasteful (Juma et al, 2017).

The second factor is lack of required expertise (Okon, 2018; Wood, 2008). Satellite technology is advanced technology and requires advanced skills (Kala, 2023; Kala, 2023; Siddique, 2024). However, there is shortage of required expertise in Africa. This includes shortage of engineers and scientists skilled in the satellites' various subsystems, telemetry, tracking and control of the satellite. (Onuh et al., 2019). This has resulted in a skills gap between Africa and developed countries (Hakizimana, 2021).

The third factor is low awareness about satellite technology (Okon, 2018; Wood, 2008). This would undermine its import in achieving development, resulting in poor adoption (Kganyago et al., 2019). Furthermore rigid cultural practices or established processes could prevent the adoption of satellite technology (Kala, 2023). Thus, most African countries in implementing development plans do not prioritise satellite technology or invest in it, due to poor appreciation of its value.

Fostering Wider Adoption of Satellite Technology in Africa.

Satellite technology is capital intensive. However, the huge derivable benefits cannot be overlooked. Therefore, African countries should recognise its significance in driving development. Given the associated costs, the huge investments needed for space researches are usually undertaken by the Government (Ozuyar et al., 2017). Government's involvement is therefore crucial (Holz, 2011). In support, Juma et al. (2017) advocates for the government's budgetary allocation and subsequent investment in satellite technology. Ugwunna et al. (2024) also advocates for a sizeable allocation of the budget to it, rather than to recurrent expenditure. This supports Albert Hirschman's unbalanced growth theory, which links development to investment in specific prioritised sectors of the economy.

Furthermore, recent innovations have resulted in the development of small satellites. These provide a more cost effective solution to African countries. In addition, countries can collaborate to launch a satellite, or exchange satellite data, thereby sharing cost. The Regional African Satellite Communication Organisation (RASCOM) and the African Resource Management (ARM) best illustrate this (Froehlich, 2019; Juma et al., 2017). Although owning a satellite would provide additional sources of revenue from sale of satellite images and other forms of service delivery, African countries can equally purchase data from satellite owners rather than owning satellites. This would afford the opportunity to utilise satellite technology to foster development, without the cost of launching a satellite (Juma et al, 2017).

Also, there is need to build indigenous capacity within the continent. This would foster innovation and ensure effective diffusion and sustainability of satellite technology. This can be achieved through technology transfer. This encompasses transferring knowledge and skills for designing, manufacturing and controlling satellites and also interpreting satellite data. It can occur between countries or between private satellite companies and other countries (Nikoloski, 2016; Onuh et al., 2019). For example, for the launch of Nigeria's earth observation satellite, NigeriaSat-1, 15 Nigerian engineers and scientists were trained under a Know-How Technology Transfer (KHTT) Scheme. Likewise, 54 indigenous engineers and scientists were trained as part of the launch of Nigeria's communication satellite, NigComSat-1. Consequently, the ground control system for the communication satellite, located in Abuja, Nigeria, is managed by the trainees and others whom they also trained (Onuh et al., 2019). Furthermore, 100 engineers were trained during the building and launch of South Africa's micro-satellite, Sunsat-1 (Juma et al., 2017).

Also, the active participation of the private sector is important for increased adoption and sustainability. The space ecosystem encompasses government, service providers, manufacturers, launch insurers and financiers (Okon, 2018). Innovation is significant in fostering advancement in satellite technology and entrepreneurs are in the forefront of the innovation. Collaborative efforts, in the form of public-private partnership, are therefore vital (Olivari et al., 2021). While the government is needed for the initial intensive investment, as postulated by Hirschman's unbalanced growth theory, entrepreneurs and start-ups play a strong role in driving innovation for the application and adoption of satellite technology and its spin-offs, as posited by Schumpeter's innovation theory. Further advancement would then engender subsequent innovations and investment opportunities, fostering growth in other sectors (Echegu et al., 2024; Holz, 2011; Olivari et al., 2021).

As a prelude for development, Hirschman underscored government's investment in a prioritised sector that has strong linkages with other sectors. Satellite technology provides a viable example. However, the impact of an investment in satellite technology would be accelerated through innovation, driven by entrepreneurs. Additionally, implementation of appropriate policies is necessary to drive increased adoption of satellite technology in Africa. This enables technology management. Therefore, it is not just the technology, but its management, in the form of suitable policies, that would engender development. Policies could include the creation of government institutions for effective promotion of satellite technology (Juma et al., 2017; Nikoloski, 2016; Steenhuis et al., 2012). For example South Africa's national space policy Act birth the South Africa's National Space Agency (SANSA). Subsequently, SANSA played a major responsive role during flood incidence in South Africa and Mozambique in 2013. This underscores the importance of suitable policy formulation and implementation (Juma et al, 2017). Likewise, Nigeria's national policy on Information Communication and Technology (ICT) is geared towards increased investment, innovation and entrepreneurship in order to foster increased adoption both in the rural and urban areas, thereby bridging the digital divide (Echegu, et al 2024).

Furthermore, policies should also be implemented to promote satellite technology education and public awareness of the benefits of satellite technology in order to foster buy-in. This would facilitate its wider adoption and diffusion, thereby accelerating development (Echegu, et al., 2024; Juma et al., 2017). Therefore, the government would undertake the initial capital investment in satellite technology. Subsequently, the entrepreneurs would drive the invention and innovation phases, while the government through appropriate policies, in conjunction with the entrepreneurs, drive its diffusion.

Discussion of Findings

The respondents avidly elaborated on the relevance of satellite technology in development. As ***KII003*** succinctly posited:

"Satellite technology is a catalyst to socio-economic development"

The above assertion was a congruent theme, exemplified by participants through impact analysis on various economic sectors including communications, education, agriculture, finance, aviation, mineral resources and urban planning. This aligns with Siddique (2024) and Okon (2018)'s affirmation on the impact of satellite technology, visible through its application in various sectors. It depicts a strong linkage between satellite technology sector and the other sectors. The experts placed emphasis on its criticality, especially in remote areas characterised by limited infrastructure. For instance, satellite technology, given that it is ubiquitous, has fostered increased mobile connectivity and financial inclusion. **KII005** illustrated this using Kenya's digital payment system, M-Pesa, which facilitated financial services in the rural areas.

In addition, ***KII009*** identified the Precision Agriculture Programme of Nigeria's National Space Research and Development Agency (NASRDA), in monitoring farmlands and providing early warnings on droughts. Furthermore, ***KII006*** highlighted its usefulness in animal husbandry for geo-fencing and geo-location. As noted by Atayero et al. (2011), this can be used as anti-robbery measures. ***KII007*** and ***KII009*** also underscored its import in combating insecurity using surveillance images from Nigeria's NigeriaSat and for providing secure, efficient communication among operational teams using Nigeria's NigComSat-1R. ***KII007*** posited the efficacy of addressing insecurity from higher echelon, through satellite technology. He submitted that:

"Insecurity is fought through Space".

In the area of emergency response, ***KII005*** cited how satellite phones and Internet facilitated rescue operations in Mozambique during Cyclone Idai in 2019. ***KII003*** noted how through satellite, information on ebola virus disease, safety measures and hygiene management were broadcast to sensitise Nigerians, even at the grassroot, as a preventive measure. This bears semblance to Juma et al. (2017)'s illustration of the aversion of 500,00 malaria cases in 28 countries through the dissemination of early warning information using satellite data. The economic relevance of satellite technology as a source of revenue, through fund generation and conservation and job creation, was also underlined. The experts therefore had a unanimous view on the socio-economic significance of satellite technology.

It is important to note that while ***KII004***, ***KII006*** and ***KII007*** observed the probability of the achievement of socio-economic development exclusive of satellite technology, they however cautioned that satellite technology provides a faster and more effective route. ***KII007*** captures this below:

"It can be achieved, but at a very slow

pace and it won't match current trend. With satellite technology, it's better, enhanced and faster".

KII008 surmises the enhancing capability of satellite technology thus:

"Satellite technology does not necessarily create socio-economic development. It only enhances it".

The experts also aligned on the factors impeding the adoption of satellite technology in Africa. The foremost reoccurring theme is high cost of satellite technology coupled with insufficient funds among competing needs. This resonates Kala (2023) and Okon's (2018) submission. This is also compounded by the investment gestation period. According to ***KII006***:

"We need to know that the GDP of countries differ. Cost of launching is high (about $250m) and it may be 8 – 10 years before you can see your returns".

Another unambiguous theme is the lack of awareness. This factor was also underlined by Okon (2018) and (Wood 2008). Accordingly, ***KII004*** observed that:

"Satellite is invisible to most people, even though it touches their lives heavily".

Other factors identified include Africa's limited infrastructure, lack of political will reflected by lack of clear space policies, lack of skills and capability, and harsh economic conditions amid competing priorities. Some of these identified factors were also highlighted by scholars (Kalu, 2023; Onuh et al., 2019; Siddique, 2024;).

However, a variant perspective was presented, which borders on the market positioning and intricacies of developed countries. According to ***KII007:***

"The western world came in first, so competition is stiff. They can have 2-3 redundant satellites over Africa as backup whereas an African country would struggle to have 1, thereby no redundancy. It is therefore difficult to compete with the western world in terms of price, redundancy, heritage and infrastructure".

KII004 also opined:

"The developed countries would rather prefer that African countries pay them for satellite services, rather than launching and owning their own satellites".

This was supported by ***KII001,*** who noted that:

"Most developed countries are not ready to transfer the technology".

Furthermore, ***KII005*** introduced a cultural perspective by identifying resistance to adoption of new technologies, which negatively impacts its integration into key sectors, such as agriculture. This aligns with Kala's (2023) submission that cultural practices or established practices could hinder the adoption of satellite technology.

Notwithstanding the above, participants identified measures for fostering satellite technology adoption in Africa. Given the huge initial capital outlay, they advocated for prioritised investment by the government because of its enormous effect on other sectors, aligning with Hirschman's unbalanced growth theory (Jiang et al., 2020). Also, ***KII006*** noted the need for government intervention, due to its socio-economic impact. He stated that:

"Government funding is very important because the benefits would accrue to citizens".

While ***KII006*** had noted the gestation period of investment in satellite technology as a probable deterrent, ***KII002*** opined that such investment should be incorporated into a long-term plan. He states:

"Government can't focus on everything due to limited resources otherwise some areas would be underfunded. Instead government should focus on a few ones with high multiplier effects. For example, government should invest in satellite technology because of its multiplier effect. You may not see it immediately, but it will be part of a long-term plan".

Also, participants advised that countries could seek grants for satellite launches.

KII009 highlighted African Development Bank (ADB) and AU funding. ***KII008*** encapsulated the combination of government funding with external funds thus:

"The Government would give a seed fund. African countries should also take advantage of funds available in Exim banks and African Development Bank. They have funds available for ICT".

Furthermore, in order to optimise costs, there were discussions on collaboration among African countries, based on needs assessment. This could entail launching a joint satellite or multiple satellites on a single launch vehicle as cost optimisation measures. RASCOM illustrates this collaboration (Froehlich, 2019; Juma et al, 2017). Consequently, ***KII004*** noted the need for new models of collaboration within or across African countries. Participants opined that subsequent joint ventures would provide additional funds and help to share the associated risk. Collaboration, particularly with the private sector would engender increased adoption and sustainability; therefore it is important (Olivari et al., 2021). The private sector comprises of entrepreneurs. According to Schumpeter's innovation theory, these entrepreneurs are innovators (Upadhyay et al, 2018). The essence of innovation as a driver to the diffusion of satellite technology was summarised by ***KII009***:

"Innovation plays a crucial role in accelerating the adoption of satellite technology by making it more accessible, cost-effective, and applicable across various industries".

KII004 supported this and underscored the relevance of innovative hubs as problem-solving mechanisms. Furthermore, ***KII006*** agreed on the importance of innovation, using NIGCOMSAT's Accelerator Programme as an example:

"It is to create a platform for innovators with innovative ideas to layer them on satellite technology, which are then taken to the market".

Therefore, innovative ideas are created, applied, adopted and spread through the accelerator programmes. This is in tandem with Schumpeter's phases of innovation and its catalytic effect on development (Kaya, 2015).

Another theme is the need for capacity building through consistent training and retraining. Indigenous capacity building would promote satellite technology diffusion and sustainability (Nikoloski, 2016; Onuh et al., 2019). Participants opined that the KHTT model provides an effective example of how to address the skill gap in Africa. However, an underlying precursor is infrastructure and equipment planning. This would guarantee that KHTT trainees have the requisite technical environment to apply their knowledge and to provide hands-on training for others, thereby ensuring continuity. One major asset that is needed for continuity is the satellite itself. Consequently, ***KII008*** noted that some of the African-owned satellites had reached or were nearing end-of-life, with no replacement satellites. ***KII007*** advocated that negotiations for future launch of every African-owned satellite should include Know-How Technology Transfer.

Another identified measure on capacity building, reiterated by ***KII001, KII005***, ***KII007*** and ***KII009***, is the integration of satellite technology into University curricula. Furthermore, ***KII007*** opined that its introduction into lower schools would foster early career interest.

Another patent theme is the need for increased awareness and sensitisation. ***KII005*** recommended community engagement and implementation of satellite-based pilot projects to showcase its benefits. This was illustrated using *Farmerline* in Ghana, which uses satellite data and SMS to send farming tips. ***KII004, KII007 and KII009*** emphasised the need for orientation and awareness campaign, especially at the grassroots.

In addition, ***KII006*** underscored the need to sensitise countries on spectrum management and frequency licensing so they are aware of benefits accruable to them. He stated:

"According to ITU policy, each nation (whether developed or developing) is entitled to two orbital slots (North/East). Some African countries may not be

aware of this. ITU ensures equitable rights on frequency allocation".

Therefore, participants believe improved awareness of satellite technology and its benefits would engender appropriate policies to drive its adoption. According to them, these policies would create an enabling environment for technology management and adoption. This is important because technology management, in the form of suitable policies, would engender development (Juma et al., 2017).

Conclusion

Satellite Technology is pivotal to development. While developed countries are enjoying its benefits, most African countries are yet to embrace it. This is due to high cost, limited funds, lack of awareness and low technical capabilities. This study supports prioritised investment, by African countries, in satellite technology due to its strong linkage to other sectors, leading to development. It also advocates concerted efforts in awareness creation, partnering with the private sector and international organisations, collaborating with other African countries for cost optimisation, improved infrastructure, capacity building and favourable policy environment, as measures to engender the adoption of satellite technology. Additionally, it underscores the importance of innovation in driving the adoption and spread of satellite technology for the achievement of sustained development.

Recommendation

Based on the findings of this research, the following are recommended:

African governments should prioritise investment in satellite technology because of its strong linkage to other sectors. This would facilitate overall development. Therefore, a specified percentage of the country's budget should be allocated to it. This would be driven by strong political will.

1. African countries should explore additional funding options for satellite technology initiatives. These include grants from ADB and AU funding.
2. African countries should utilise the pair of orbital slots assigned to them by ITU in order not to lose them.

3. There is need for improved sensitisation and awareness about satellite technology, especially at the grassroots, through community engagement and satellite-based projects.

4. There should be deliberate integration of space programmes into schools' curricula.

5. African governments should partner with the private sector for satellite-based innovative solutions to drive its adoption, spread and sustainability.

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