ATU-R REPORT

relating to

5G PREPAREDNESS AND RELEVANT USE CASES IN AFRICA

numbered

ATU-R Report 005-0

Acknowledgements

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1. INTRODUCTION

The Digital Transformation Strategy for Africa (2020 – 2030) as established by the Africa Union (2020) sets its overall objective as *"To harness digital technologies and innovation to transform African societies and economies to promote Africa's integration, generate inclusive economic growth, stimulate job creation, break the digital divide, and eradicate poverty for the continent's socio-economic development and ensure Africa's ownership of modern tools of digital management."*

The implementation of 5G technology represents one of the tools African countries can utilise to meet the abovementioned objective. Releasing relevant spectrum bands that are identified for the implementation of international mobile telecommunications (IMT) for the deployment of network technologies is imperative for the achievement of this objective. The African Telecommunications Union (ATU) published the ATU-Recommendation 005-0 in July 2021 providing guidance on the implementation of emerging technologies such as 5G as a strategic contributor to realise digital transformation and attainment of Sustainable Development Goals. The recommendations emanating from this document set actions to be undertaken by ATU Member States for deployment of 5G networks and implementation of new services to connect industries, fostering of new business models and enabling operators to realise cost savings and energy efficiency in rolling out new telecommunications networks and services to meet customer demand.

This report is based on the review of available literature on 5G deployment and responses to the questionnaire on 5G, sent out to all Member States by ATU. The questionnaire sought information, from Member States, on the deployment of 5G, digital strategies adopted by respective Member States at national level; challenges experienced by respective administrations in deploying 5G technology, identification of economic sectors that may derive benefits from the availability of 5G technology and use cases relevant to these sectors as well as challenges encountered by respective countries affecting the adoption of 5G technology.

The report focusses on assessing the readiness of African countries to deploy, operate and use 5G networks. The report further explores challenges impacting the deployment of 5G in Africa and the status of deployment in countries that have already embarked on the process. It also highlights locally relevant use cases for 5G as submitted by Member States in their responses to the questionnaire. In the concluding sections, the report provides recommendations to support decision making for the deployment of 5G networks and use cases.

2. CURRENT STATE OF READINESS FOR 5G DEPLOYMENT IN AFRICA

Rao and Prasad (2018) regard the opportunities provided by 5G technology as more than just a generational step in that it represents a fundamental transformation of the role that mobile technology plays in society. The essential role that mobile technology plays is further underscored taking into account that, at a global level, mobile broadband subscriptions reached 87 per 100 inhabitants in 2022 and an estimated 5.3 billion people had accessed the internet in the same period (ITU, 2022). As the demand for broadband services and continuous connectivity grows, deployment of 5G networks provide an opportunity to create an agile, built-for-purpose network tailored to the different needs of consumers and businesses alike. To fulfil the aforesaid requirement 5G technologies provide several advantages compared to earlier mobile technologies. The advantages include greater speed, ten times lower latency than that for 4G, the ability to connect an increased number of devices and the ability to allow these devices to communicate with each other in real-time exchanging information to drive

different outcomes based on type of databeing routed and analysed as noted byRao and Prasad (2018), GSMA (2019), Vavruška and Očko (2020), Brittain, (2021), Chugh (2022) and many other industry experts.

In the readiness assessment of the African countries in deploying 5G, this report took into account the strategic intent of countries to implement 5G technology as a catalyst for digital transformation, spectrum availability and licences awarded to date, deployment modelsand challenges encountered as countries enter the 5G era.

2.1 Strategic intent of countries to implement 5G

The level of readiness to deploy 5G networks and services within African countries is influenced by multiple factors originating from both internal and external sources with respect to the ICT sector. These factors are considered as variables in determ ining the business case for 5G technology . The factors impact directly on operators and private entities ' readiness to rollout 5G. Whilst stakeholders within the ICT sector can influence internal factors such as spectrum availability ; consumer and enterprise interest in utilising 5G technology, demand and supplyas well as equipment availability, the ICT sector has little or no control over factors external to the sector. Such factors include literacy rates, GDP, economic slowdown due to political instability, civil unrest , war, pandemics and economic sanctions.

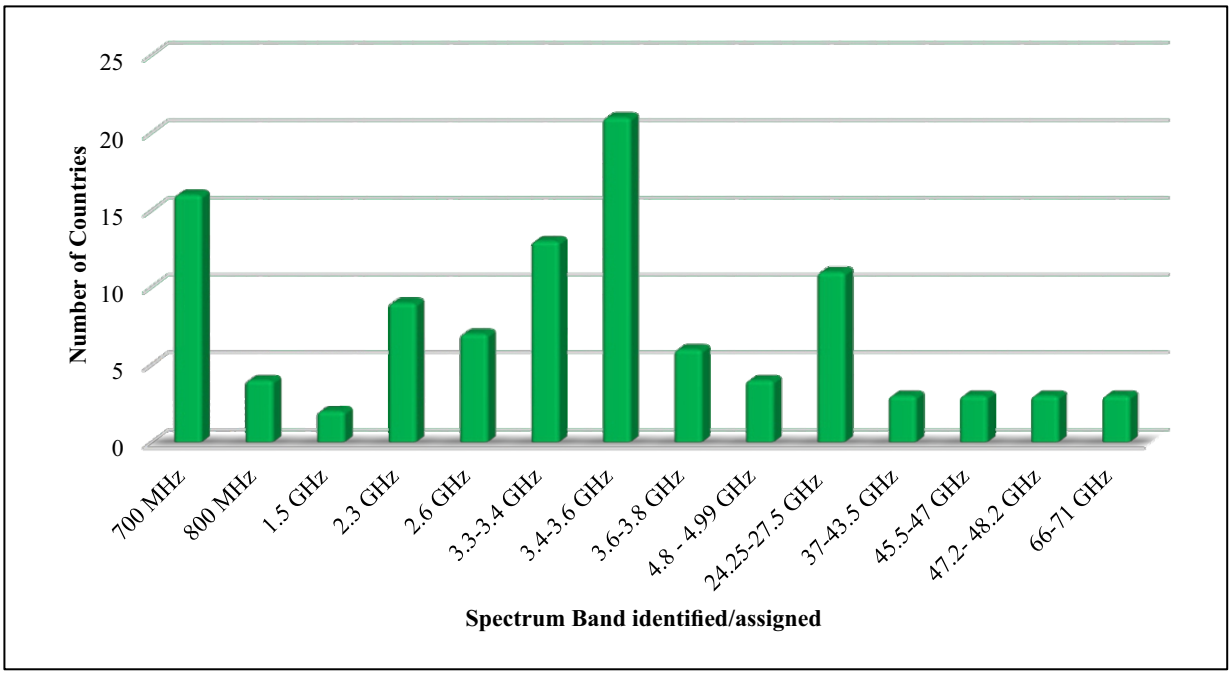
The majority of respondents to the questionnaire (59%) indicated that the deployment of 5G technology is provided for under existing digital transformation policies, digital strategies or national 5G strategies . The remainder of respondents indicated that existing pol icies and strategies do not specifically contain provisions for 5G deployment. In part this can be ascribed to the fact that most countries have adopted aservice and technology neutral approach to broadband service delivery whilst other countries are still in the process of developing enabling policiesand strategies that once finalised will promote the adoption of 5G technology.

2.2 Spectrum availability and licences awarded

A number of the respondents to the questionnaire have indicated that spectrum is licenced on a technology-neutral basis and as such spectrum licences/assignments are not specifically assign ed for 3G, 4G or 5G network deployment – rather for deployment of IMT based mobile broadband technologies. Operators are provided with t he opportunity to re -farm existing spectrum assignments for the deployment of 5G or apply for additional spectrum resources depending on the spectrum regulatory framework adopted within their country of operation.

The 700 MHz and 3500 MHz spectrum bands emerged as the most preferred spectrum bands for 5G network deployment in the low and mid band, whilst the 26 GHz spectrum band is identified as the most preferred spectrum band in the higher bands. This can be attributed to ATU-R Recommendation 005-0, ATU' s assessment of global harmonisation and the economies of scale in relation to network equipment availability, the cost associated with acquiring this equipment and device availability . However, it is notable that a number of countries have identified or issued spectrum licences in 2.3, 2.6 and 3.3GHz spectrum bandsfor 5G deployment. The results in relation to spectrum bands identified or assigned to 5G, as submitted by respondents to ATU questionnaire, are shown in Figure 1 hereunder.

Figure 1: No of Countries that have identified/assigned various Spectrum bands for 5G



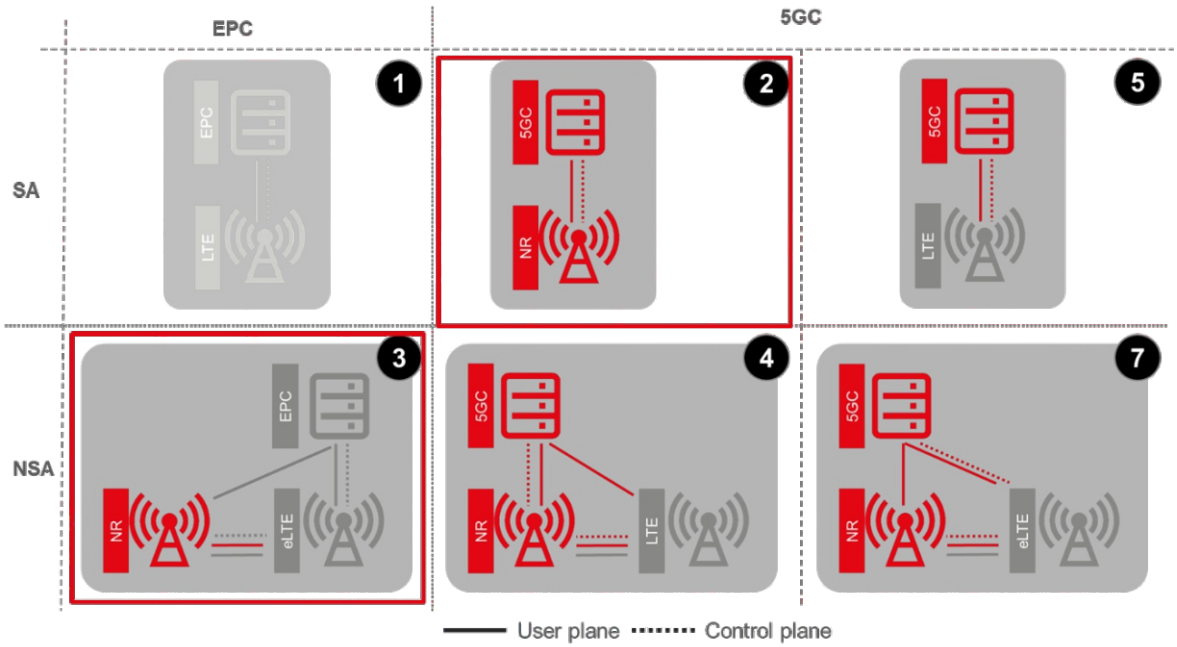
Award of spectrum licences in the above -mentioned spectrum bands range from 2x10 MHz per operator in the low spectrum bands up to 100 MHz per operator in the midbands and 1000 MHz per operator in the high bands. This is in line with the guidelines from ATU Recommendation 005 -0. Issuance of spectrum licences in the mmWave spectrum ba nds is still at a minimum. Due to the large capacity and good coverage of mid -band, countries use mid -band as the first band for nationwide deployment of 5G.

The identification of 3.6 – 3.8 GHz and 6 GHz (6425-7125 MHz) spectrum bands to IMT at WRC-23 will further contribute to mid-band spectrum availability going forward.

2.3 Deployment models

As noted by ITU (2023) 5G is designed to be a sustainable and scalable technology. It is therefore foreseeable that 5G networks deployment models will evolveover time from the initial non-standalone deployment model to standalone deployment as well as adoption of hybrid deployment models encompassing both standalone and non -standalone networks to meet industry needs. Figure 2 shows 5G network deployment models.

Figure 2: 5G Network Deployment Models

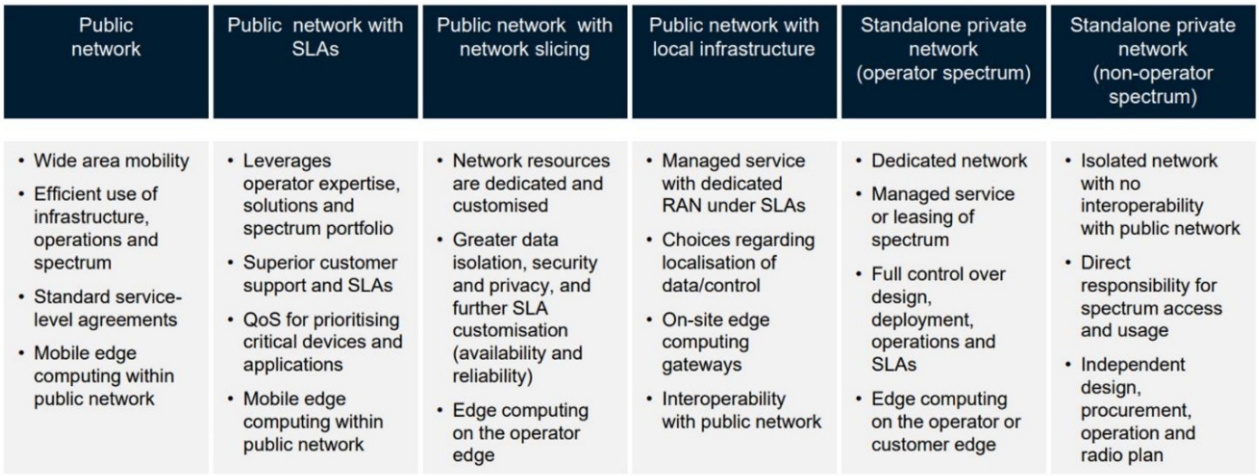


Overall and as deduced from responses to the questionnaire, most spectrum was assigned to national public operators. The majority of responses further indicated that 5G network deployment to date is based on a non -standalone (NSA) model utilising the existing core network supplemented by a 5G radio access network to enhance broadband service delivery. The deployment of 5G standalone (SA) networks is limited and was reported by only four respondents.

This is aligned to the notion put forward byGSMA (2019) that initial rollout out of 5G networkswould be based on non-standalone deployment allowing operators to capitalise for a longer period from the existing investments made in their 4G core networks whilst simultaneously being able to supplement the performance of the aforesaid networks by implementing 5G radio access network equipment to be utilised as a capacity overlay for offering enhanced mobile broadband (eMBB) services. Adopting a non-standalone 5G network deployment model require network operators t o invest in network equipment to support 5G spectrum bands and antenna systems for MIMO. Although this deployment model is suitable for 5G deployment by public networks focussing on macro coverage, implementing standalone 5G networks supports the use of the technology by the enterprise market to meet requirements of industry specific use case. As said by Chugh (2022), *"every private network comes with different requirements on the network. A one-size-fits-all packet data network will not be capable to cope with future data volumes and application requirements."*

2.3.1. Private Networks

Wall (2023) differentiates between th ree 5G network types namely, public, private and hybrid networks. Public 5G networks provides voice and internet connectivity offering high-speed broadband services to both consumers and businesses on a large scale. These networks are owned, constructed , and maintained by tel ecommunications licensees as prescribed by the legislative and regulatory framework within the country of operation. On the other hand , private 5G networks are owned and purposely built to meet 5G use case requirements for specific industry sectors. Enterprises falling within this category construct and maintain the network for their own use providing customized and secure internal connectivity to improve operational efficiency . Different approaches exist as to how the needs of private networks are met, as illustrated in the figure below.



The advantages and disadvantages of the two network types are summarised in **Table 1** below.

Table 1: 5G network types

Network type	Advantages	Disadvantages
Public network	• High-speed connectivity based on eMBB 5G service offerings • Wider coverage area (usually nationwide). • Operators can leverage existing network infrastructure. • Provide access to all provided they are within the network coverage foot print.	• Users are dependent on network operators to ensure their data is secure. • Operators may collect user data for marketing or other purposes. • Cost of service packages is fixed for different market segments
Private network	• Networks owners can optimise network to meet specific requirements for applications • Enhanced security compared to public networks, allowing for	• Organisations need to invest in their own infrastructure deployment, maintenance, and equipment upgrade may be costly. • Where spectrum is reserved specifically for private networks

	restricted access and advanced security measures • Provide for lower latency, which is critical for real-time applications	alone, it raises the risk of inefficient utilisation of scarce national spectrum resources. • Network is limited to a specific location or area. • Network cost will vary based on organisation's unique technical requirements • Risk of unreliable vendors • The organisations may not have the expertise to deploy and effectively manage the network

Source: Wall (2023)

An operator's choice of which deployment model to follow in harnessing the envisaged market opportunities offered by 5G technology depends on its analysis of appropriate use cases for 5G services, potential return on investment and its ability to overcome any challenges within its operational environment.

Challenges experienced by African countries associated with deployment of 5G networks and services are discussed under section 2.5 of this report whilst section 3 focusses on the envisaged socio-economic impact that 5G technology may realise going forward.

2.4 Status of implementation

Respondents to the questionnaire indicated that the deployment of 5G networks are increasing year-on-year since 2020 with most countries reporting the adoption of 5G technology by more than one operator in their respective countries. However, the status of deployment varies from country-to-country with operators either in the process of planning or testing their 5G networks whilst some operators already launched commercial services.

GSMA (2023) reported that globally 297 5G networks commenced commercial services by September 2023, of which 27 networks were launched within 16 African countries namely; Botswana, Ethiopia, The Gambia, Kenya, Nigeria, Madagascar, Mauritius, Mozambique, Réunion, Seychelles, South Africa, Tanzania, Togo, Uganda, Zambia and Zimbabwe. It is anticipated that 5G networks will be deployed in more countries in the near future.

According to GSA, 619 operators in 184 countries and territories have been investing in 5G networks in the form of tests, pilots, licence acquisitions, planned and actual deployments on a worldwide basis by the end of October 2024. Of those, 343 operators in 126 countries and territories had launched or soft-launched at least one 3GPP-ompliant 5G service. **Figure 3.1** on the next page shows recent developments on 5G Worldwide.

Figure 3.1: Map of Operator investments in 5G (End October 2024)

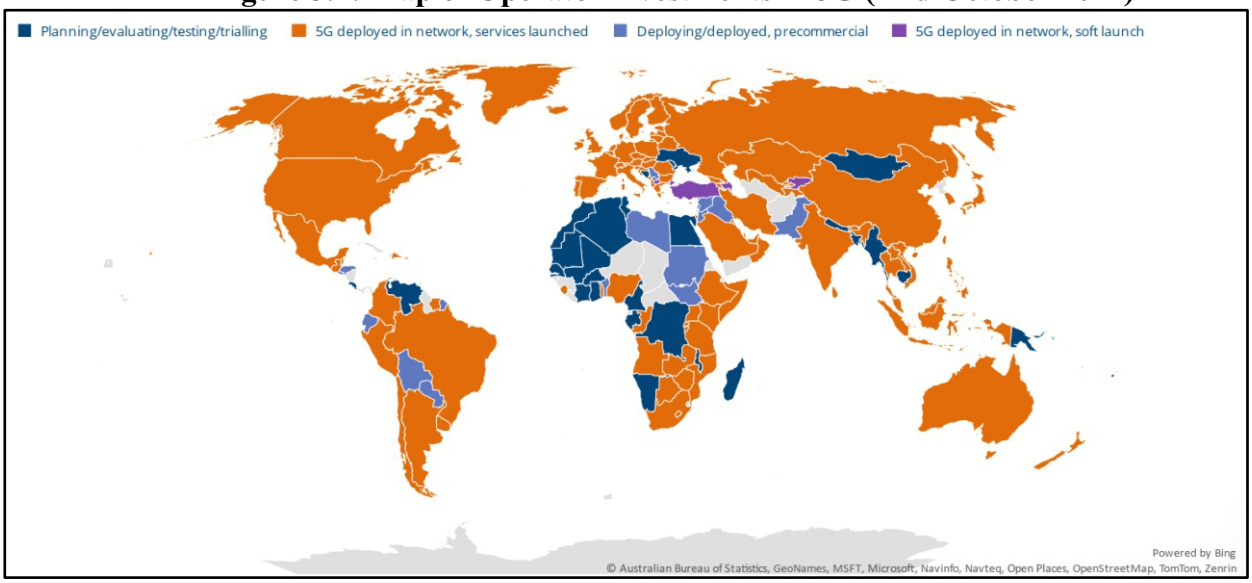
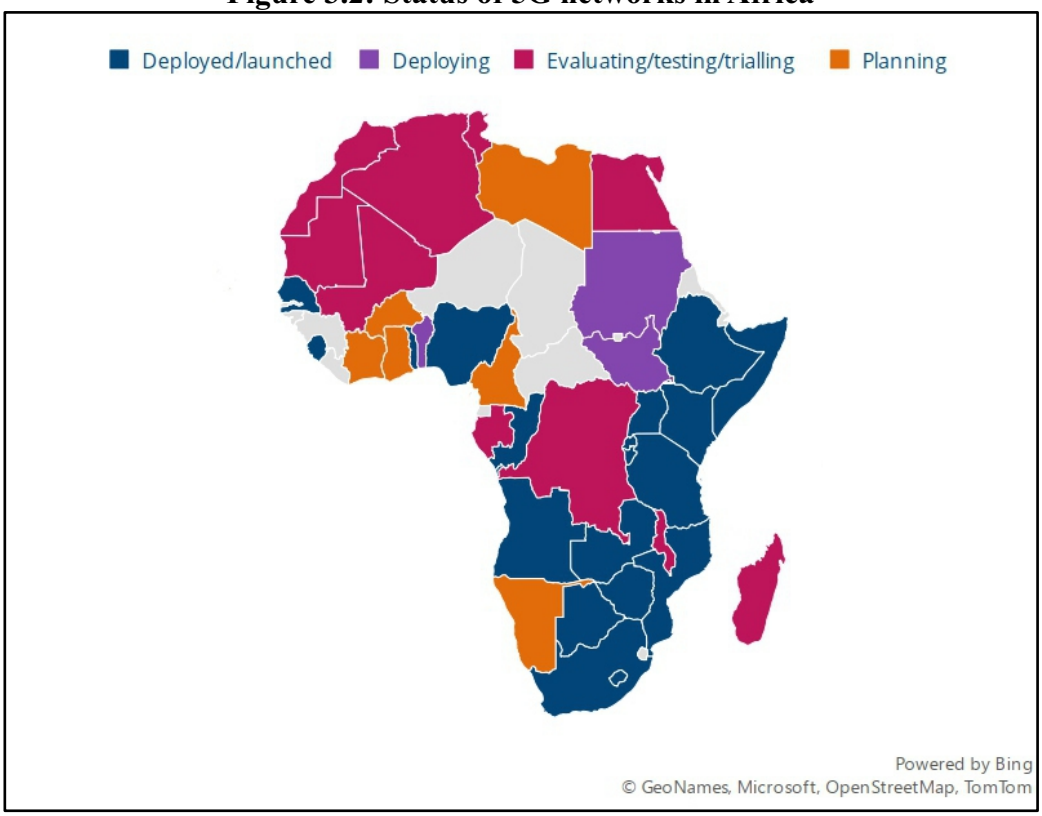


Figure 3.2 below shows the status of 5G networks in Africa.According to the latest GSA data (Region Spotlight – Africa, October 2024) , it has seen 79 operators in 41 countries or just over 12% of the global total investing in 5G mobile or fixed wireless access services.

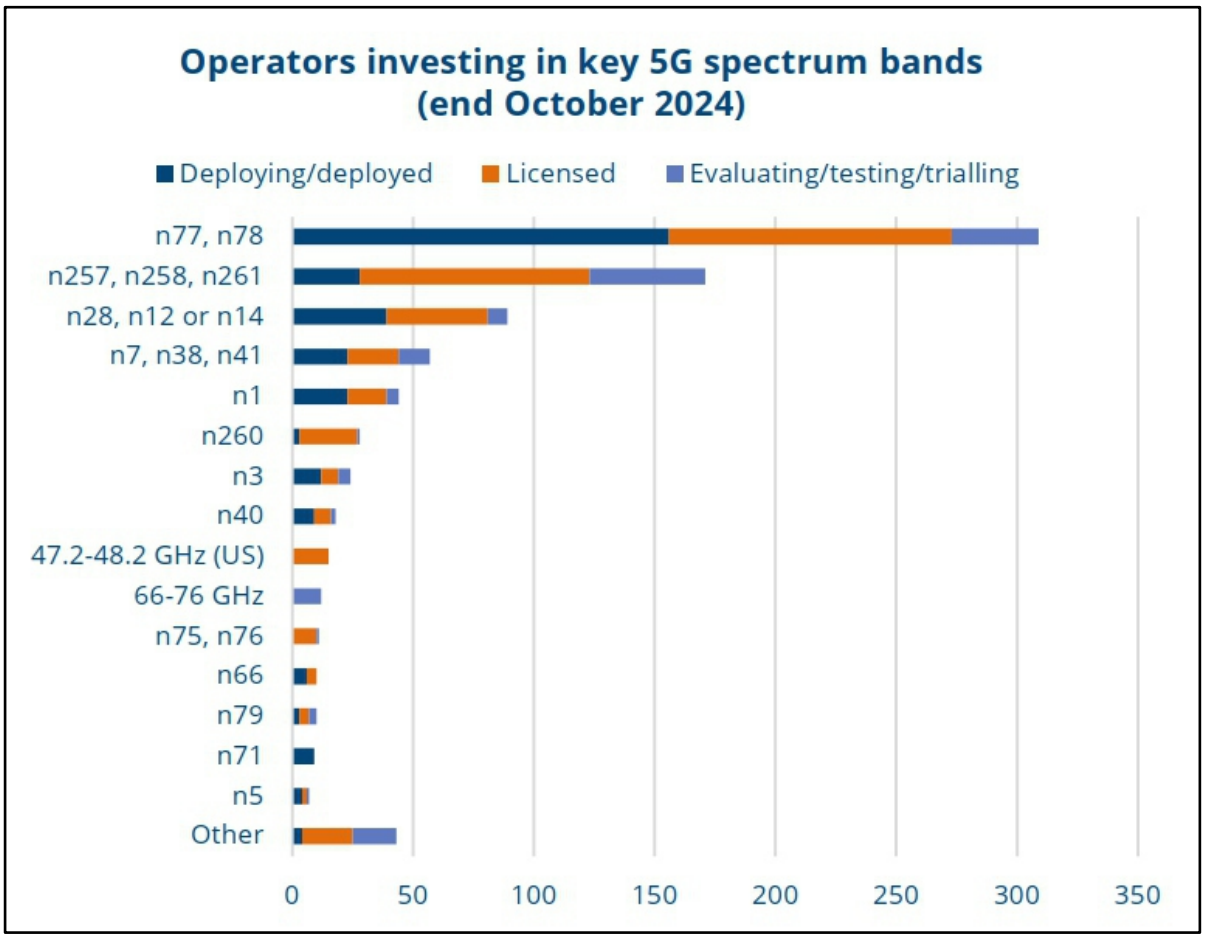
The number of launched networks shows that 5G is still to gain a strong foothold in Africa. As of the end of September 2024, only 35 operators in 21 countries or 10% of the global figure had launched 5G networks.

Figure 3.2: Status of 5G networks in Africa



In addition, the spectrum bands most supported in deploying or deployed 5G networks according to the GSA 5G Market Snapshot published in October 2024 are C-band (n77, n78), 700 MHz (e.g.n28), 26/28 GHz (n257, n258, n261), 2.1 GHz (e.g. n1) and 2.5 GHz (e.g. n7) is shown in **Figure 4** below

Figure 4 - Operators investing in key 5G spectrum bands (end October 2024)



2.5 2G/3G network sunset[1]

The trend that is likely to be seen in the near future in leading and emerging 5G markets/ countries in the African region is the sunsetting of 2G and 3G networks to accelerate 5G service and network upgrade, which is beneficial to national ICT infrastructure construction and digital economy development.

As regards spectrum, sunsetting 2G and 3G networks could play a key role in addressing the growing demand for data and spectrum in Africa because it allows operators to re-farm their existing spectrum, a scarce resource, and to combine it with other bands to enhance the growth of 4G and 5G services. This will provide faster data speeds, lower latency, enhanced connectivity , spectrum efficiency and

[1] The terms "2G sunset" and "3G sunset" refer to the process of phasing out or shutting down 2G and 3G wireless networks by mobile network operators.

network performance improvement, which is based on the particular sunsetting plan, step and condition of each country.

Devices will also play a key role in t he consideration to sunset 2G and 3G networks : In countries where 2G and 3G sunsetting is to be considered, it is necessary to consider introducing mechanisms that will encourage the availability of 4G and 5G devices (e.g., consideration can be given to putting in place a framework which discourages availability of 2G-only and 3G -only devices 1 -3 years in advance of sunsetting decisions being implemented), as well as ensuring that spectrum licensing frameworks are technology neutral. Therefore, the introduction of 5G-enabled devices could be expanded to promote 5G services and usage, and further development of the digital economy.

Regulation is important where 2G and 3G sunset is planned . Therefore, Regulators need to develop enabling policy and regulatory frameworks to pave way for the sunset plan based on the needs of particular country and its mobile industry development.

The Republic of South Africa is planning to sunset the 2G and 3G mobile networks. Its policy on 2G/3G network su nset is contained in a document " ***Next-Generation Radio Frequency Spectrum Policy for Economic Development*** "[2] released in 2024 through a statement by the Minister of Communications and Digital Technologies.

2.6 Challenges

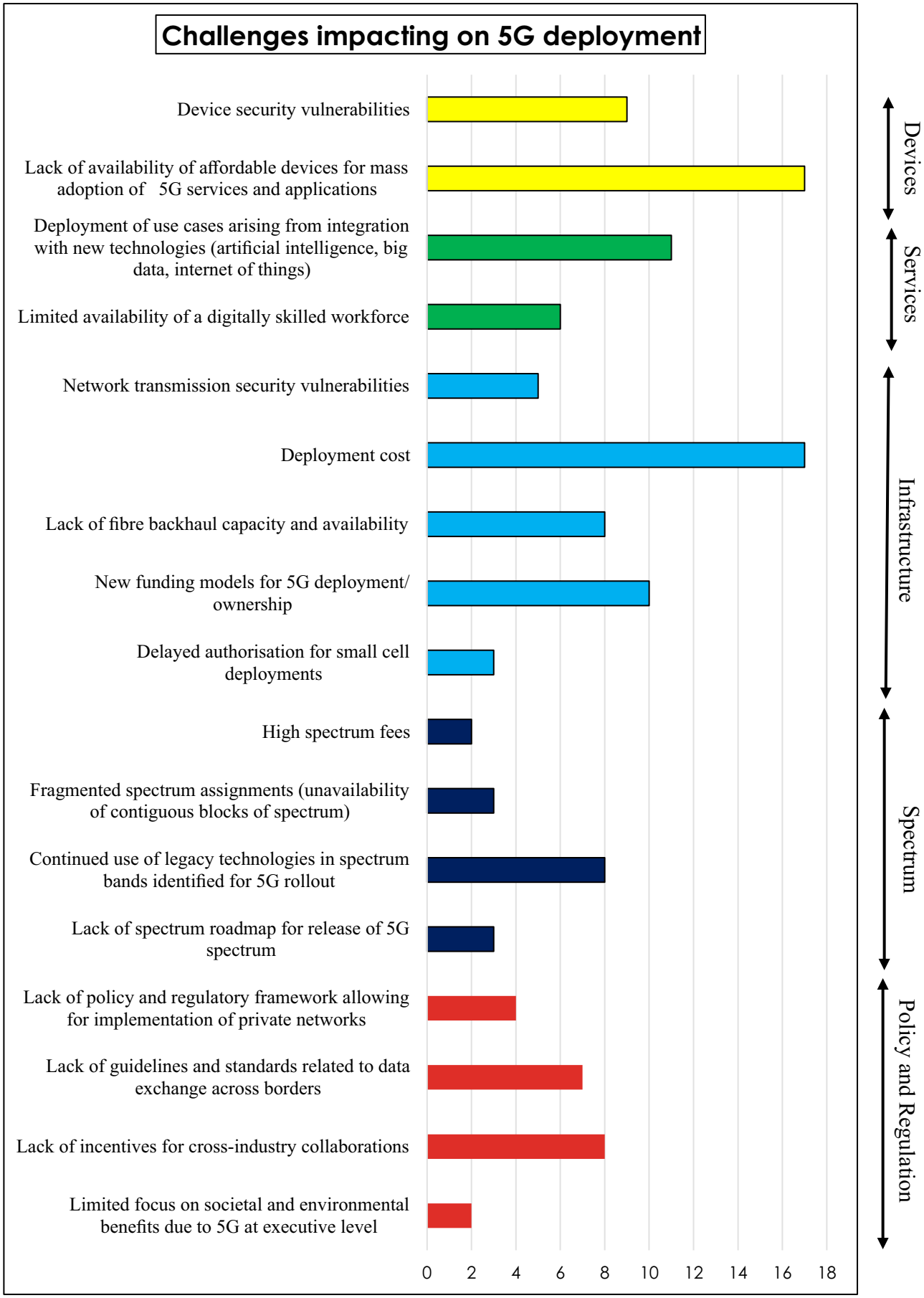
The deployment of mobile networks and services, including 5G technology, in Africa does not come without challenges given the diverse socio-economic status and goals of African countries. To gain an understanding of challenges encountered by African countries respondents to the questionnaire were requested to highlight challenges experience d in deploying 5G networks and services as far as it pertains to the areas of policy and regulation, spectrum, infrastructure, services and devices. The responses as received are depicted in **Figure 5**.

From the responses provided it can be concluded that deployment cost associated with the implementation of 5G technology; the lack of availability of affordable devices to ensure mass adoption of 5G services and deployment of 5G use cases arisi ng from integration with new technologies such as artificial intelligence, big data and IoT are viewed as the biggest challenges to overcome in order to ensure successful deployment of 5G in the countries. The aforesaid challenges are closely followed by adopting new funding models for 5G deployment, continued use of legacy technologies in spectrum bands identified for 5G, lack of fibre backhaul capacity and availability, device security vulnerabilities, lack of incentives for cross industry collaboration and lack of standards or guidelines related to governing of cross border data exchanges. Some of the challenges mentioned in this report are interlinked and can not therefore be effectively resolved independently from each other. Addressing these challenges will requirea collective effort between governments, regulators and industry players across different economic sectors.

This report analyses the top three challenges and also how these challenges are interlinked with some of the other challenges highlighted by the respondents that impacts on the deployment of 5G technology within their countries.

[2] https://www.gov.za/sites/default/files/gcis_document/202407/50725proc166.pdf

Figure 5: Challenges impacting on 5G deployment



2.6.1 Deployment cost of 5G technology

The socio-economic value of 5G technology differs from previous generations of mobile and fixed telecommunications technologies in that it provides for communications solutions over and above the provisioning of broadband telecommunications services thus exceeding the limits of traditional telecommunications market models. Traditionally, telecommunications operators focussed on providing network coverage and offering standardised products based on voice, SMS and data bundles to different market segments. Foreseeably, entities deploying 5G technology will harness the user-centric functionality and features offered by 5G to create both vertical and horizontal end-to-end solutions meeting business-to-business and business-to-customer requirements utilising 5G infrastructure as the underlying network to support vertical products previouslyto some extent offered by the IT sector. The telecommunications and information technology will continue to converge with little to no differentiation between the two sectors going forward.

A further point of consideration will be that the target market for 5G products and services may already have access to exiting broadband services and support networks through alternative technologies. Customer acquisition is thus more likely to focus on service quality and tailor-made solutions to meet business and consumer needs.

It is therefore necessary that market modelling to determine a sustainable business case for 5G deployment includes the identification of key variables impacting on deployment of 5G use cases and an accurate assessment thereof to determine the socio-economic value to be derived from the aforementioned use cases to ensure viability and long-term sustainability to achieve return on investment. ITU (2023) identifies elements such as the existing regulatory and legislative frameworks for granting of service and spectrum licences, behavioural characteristics of the existing market and taxation regimes to be considered in addition to business variables in developing the business case for 5G. To some extent the business demand for 5G services, capital investment required for 5G infrastructure deployment, operational expenditure and funding mechanisms are impacted by the fact that 5G differs from earlier mobile telecommunic ations technology standards. Lehr (2021) highlights four of these key differentiators namely-

(i) That 5G deployment is nolonger the sole domain of mobile operators, in that the inherent capabilities of 5G technology lends it to be deployed by private or stan dalone deployments separate from mobile operator owned networks;
(ii) That the scope of technological improvements made enables 5G to improve performance of existing application and create new opportunities for smart, mission-critical and IoT applications;
(iii) That 5G offers the capability to address the diverse needs of the aforesaid applications by making use of network slicing to provide differential service quality to meet specific application or use case requirements; and
(iv) That the ultra-reliable low latency functionality of 5G allows for the realisation of edge computing solutions by pushing computation and storage resource closer to the edge of the network.

The above-mentioned characteristics of 5G combined with its *enhanced mobile broadband* functionality presents governments and industry with an extensive toolbox of potential applications rather than the one-size-fits-all market model for telecommunications networks and services prevailing to date. Inherent thereto lies the challenge in calculating and overcoming 5G deployment cost which in turn is closely linked to adoption of new funding, ownership and business models based on service demand, potential revenue generations, capital investment and operational expenditure.

Determining market demand for envisaged products and services relies in part on availability of statistical income data, socio-economic conditions of market segments to be targeted and the predisposition of these segments to spend on communications products. In developing the business case for 5G it is foreseen that mobile network operators' future growth will be closely linked to vertical applications targeting healthcare, energy and mining, trade, finance and agriculture and other economic sectors in addition to providing broadband services. The growing emphasis on data protection and information security may play a further role on customer acquisition. On the other hand, smaller entities may harness 5G technology to deploy standalone networks for niche market segments or choose to deploy and maintain their own private 5G networks to have more control over the security and operational efficiency of their businesses thereby creating a new level of competition in the communications market to be factored into market demand forecasting models. ITU(2023) highlighted intentions surveys, service feature evaluations, choice models, trial markets, and analysis of challenges and solutions leading to successful deployment of 5G in other countries as tools that can be utilised to determine market demand. The outcome of the market demand modelling exercise will play a fundamental role in determining other variables used to calculate the deployment cost of 5G such as potential revenue generations, operational expenditure and capital investment.

(i) Revenue generation

To date mobile product offerings have been based on voice and mobile broadband with improvements in data speed and latency following implementation of each generation of mobile technology from 2G to 4G. If it is assumed that enhanced mobile broadband services will follow the same principles for introduction of 5G products, mobile operators can estimate potential revenue by calculating the average revenue per user (ARPU) and multiplying it with the estimated demand for products to be offered. Whilst this approach may be applicable for public telecommunications operators offering off-the-shelf products it may not necessarily apply to those entities that wish to harness the new features and customer-centric design capability of 5G technology to introduce customised vertical products into the market aimed at serving specific 5G use cases.

Revenue estimation in line with the latter product portfolio will not only be based on usage charges for delivery of broadband services. Depending on the customer's willingness to pay for enhance service quality, security and reliability as well as service providers offering specialised applications and machine to machine communication services additional revenue may be derived by providing customised solutions to meet customer requirements. The final

revenue estimation needs to include products and services to be offered for all target market segments.

(ii) Operational expenditure

In determining operational expenditure, it can be expected that the envisaged costs will follow a curve in line with the expected demand for products and services. ITU (2023) offers three possible approaches that can be followed to forecast operational expenditure in preparation of the business case for 5G deployment namely using cost models, benchmarks or past costs for similar projects. Operators will base their decision as to what method to follow on data availability within or external to their organisations.

Depending on the approach to be followed operational expenditure estimates will include the following elements-

- Expenses incurred in the production and delivery of the service such as general and administrative expenses, financial expenses and cost of sales;
- Cost of capital;
- Spectrum fees;
- Operation and maintenance costs, which costs will be linked to capital investments to be made in network infrastructure; and
- Costs paid to other service provider e.g. transmission or tower rental.

(iii) Capital investment

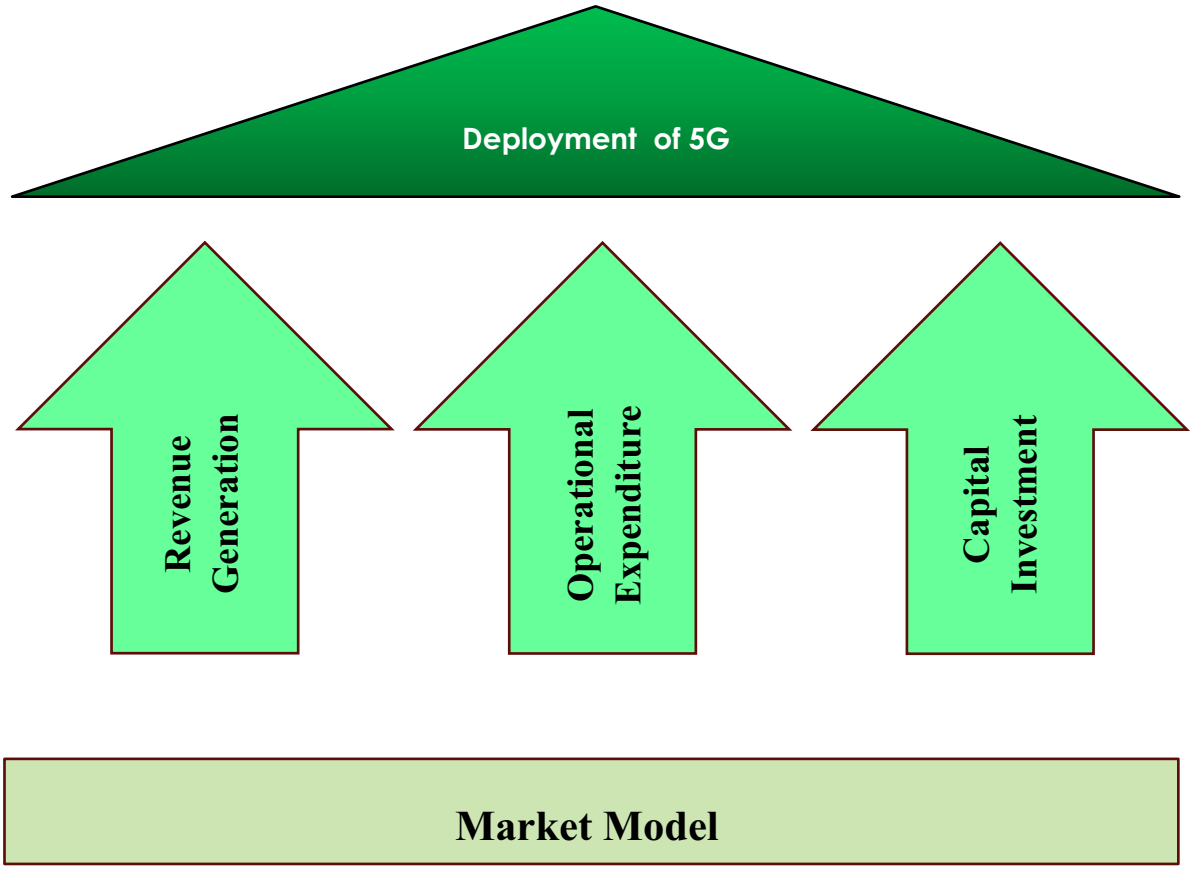
Implementation of 5G involves more than just planning and re-architecting of the radio access network. Estimation of capital costed linked to 5G deployment should include all cost related to supporting systems infrastructure, the core network and the radio access network to be utilised for provisioning of 5G services and products.

The estimation of capital costs will be directly linked to the deployment model chosen and market strategy chosen by the operator. GSMA (2019) and Lehr (2021) identify the following elements to be considered in determining capital cost for 5G

- Number of new micro and macro sites required in radio access network;
- Possible upgrade of the 4G access network to support both LTE-UTRAN and NR;
- MIMO antennae selection and implementation taking account of performance and implementation requirements;
- Upgrading of the 4G core network if a non-standalone network model is implemented;
- Upgrades to billing and customer care systems to support new services and product offerings;
- Expansion of backhaul network capacity; and
- Devices, notably fixed wireless access CPEs.

Figure 6 below provides a holistic view of all elements contributing to determining the business case for 5G deployment.

Figure 6: The business case for 5G deployment



Analysing earlier deployments of 5G in countries that have already deployed networks and offers commercial 5G services aid in identifying best practices and how these operators' overcome challenges in deploying 5G networks. Although all the components discussed in this section forms an integral part in determining the overall cost of 5G deployment, the extent to which each element is required and the associated cost will be determined by the operator's strategy and deployment model.

2.6.2 Availability and affordability of devices

Availability of devices is a key element in creating a conducive ecosystem for 5G adoption after network deployment.

The Global Suppliers Association (GSA) in its October 2024 report on 5G Device global Ecosystem, indicated that the number of announcedmodels 5G models' devices reached a totalof 3,125 5G models devices. Of these, at least 2,730 are understood to be commercially available, representing ~ 87.4% of all announced 5G models devices. The aforementioned devices are not limited to mobile handsets but also includes hot spots, fixed wireless access CPEs, laptops, modules, industrial routers and tablets.

This is an annual increase of 45% from 1,884 in the number of commercial 5G devices as can be seen in **Figure 7** below.

Figure 7: Announced and commercially available models of 5G devices (end October 2024)

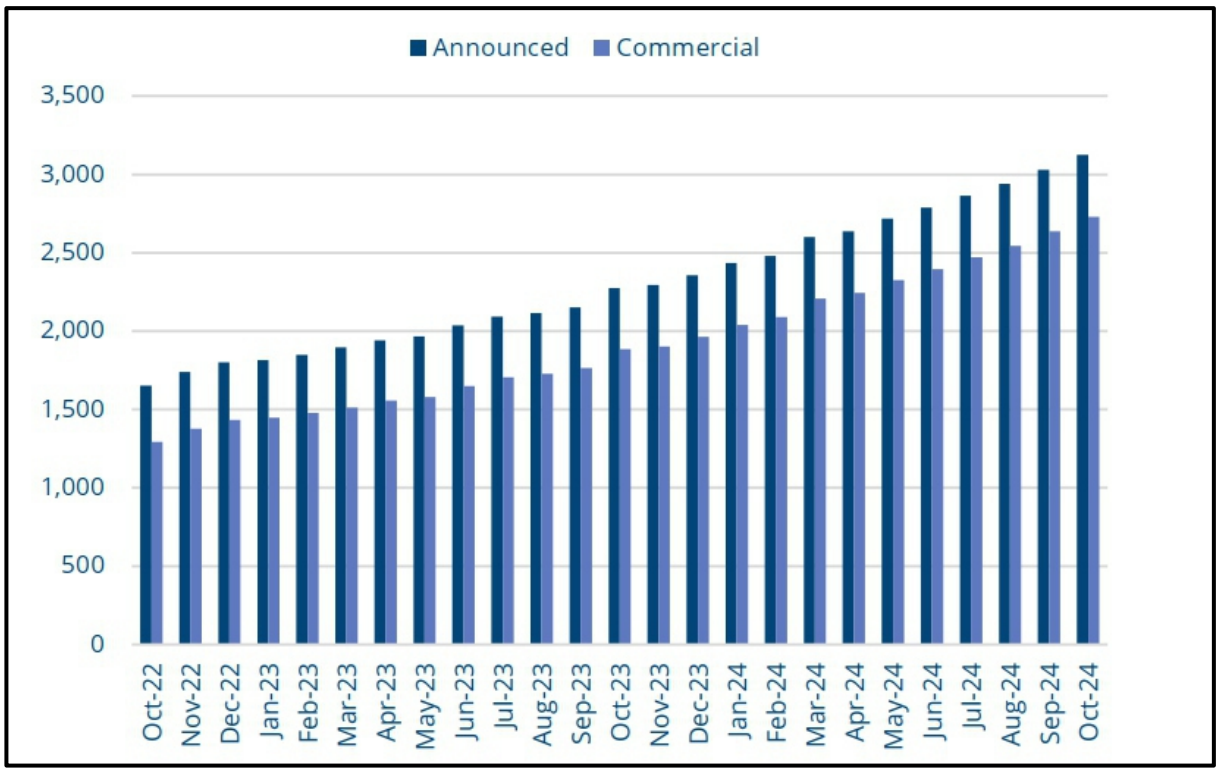
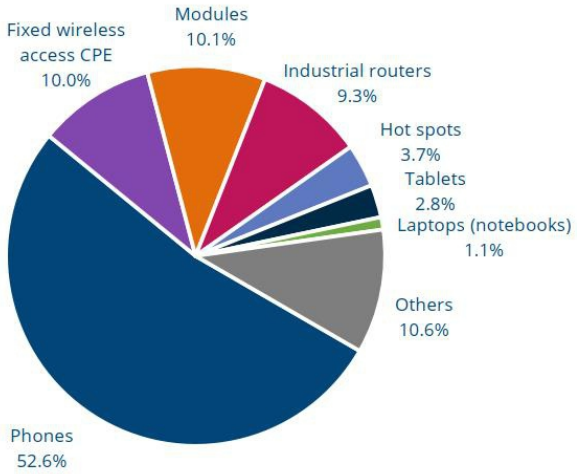


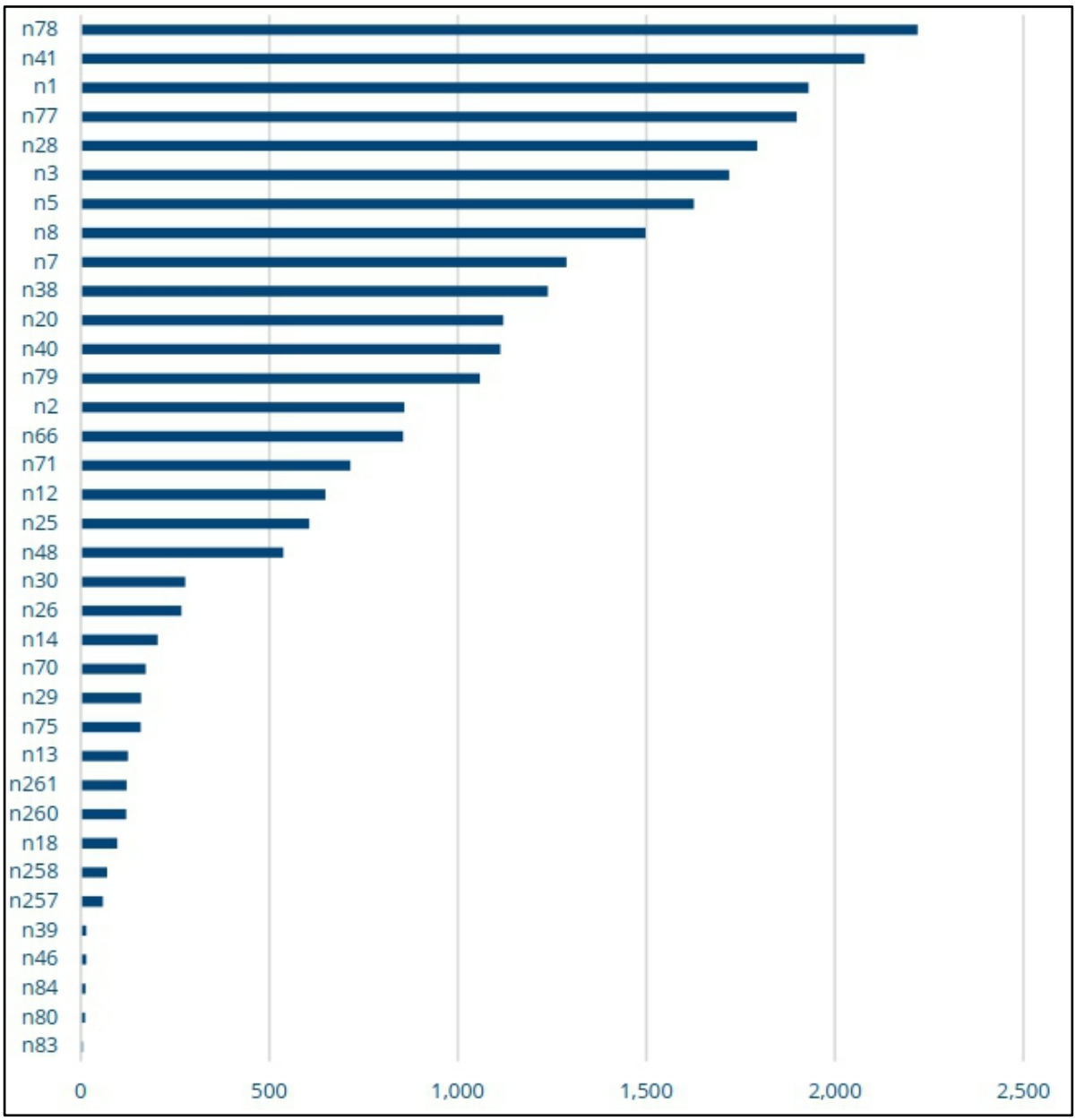
Figure 8, represented by a pie chart below shows the announced 5G device models by form factor. Phones, Modules and Fixed wireless access CPE continue to be the most prevalent 5G devices representing 52.6 %, 10.1%, and 10% respectively. By the end of October 2024, GSA has identified 1,643 announced 5G phones, up more than 84% from 891 at the start of 2023.

Figure 8 - Announced 5G device models by type (end October 2024)



Further, Figure 9 below shows announced 5G device models supporting key 5G spectrum bands (GSA report on 5G Market Snapshot November 2024).

Figure 9: Announced 5G device models supporting key 5Gspectrum bands (end October 2024)



From the graph in **Figure 9** above, the bands known to be the most supported by all announced 5G devices are band n78, n41 and n1. The number of models' devices with support for band n78 (3,300 – 3,800 MHz) has now reached 2,300 and the number of models devices for band n77 (3300 – 4200 MHz) is not far behind with 1,976 announced models' devices. The number of announced models' devices for bands n79 (4.4 – 5.0 GHz) and n71 (DL: 617 - 652 MHz / UL: 663 - 698 MHz) are 1,081 devices; and 731 devices respectively.

GSMA (2022) made the following statement-

"As with previous mobile generations, the consumer market will be an important growth driver for 5G. Beyond that, enterprise services and solutions will fuel 5G's incremental revenue potential, leveraging the technology's unique capabilities to enable the digital transformation of industries. For both segments, innovative use cases and applications, as well as device availability and affordability, will be crucial to drive uptake"

It is therefore not surprising that respondents to the questionnaire identified the lack of availability of affordable devices as the greatest challenge to mass adoption of 5G. As was the case with the deployment of 4G technology, the initial devices entering the market were aimed at the high spending market segments. With the development of more affordable chipsets over time and increased adoption of the technology, the average r etail price of 4G capable devices decreased. GSMA (2022) reported that the price of entry -level 4G devices as a percentage of GDP per capita decreased from 38.7% in 2016 to 24.6% in 2021. It can be anticipated that the pricing of 5G devices will follow a similar curve over time directly linked to 5G deployment and subsequently increasingly demand for 5G devices in various forms.

Devices generally presents the biggest cost factor for consumers to adopt a new technology, especially if these costs have to be incurred upfront. Although 5G-ready handsets can be acquired for as low as USD 150 from vendors, l arge segments of the population in African countries are not able to afford smartphones at current pricing levels. It will therefore be necessary to consider intervention at governmental, regulatory and operator level to improve affordability of devices and foster a conducive environment for the continued growth of 4G and adoption of 5G in thei r respective countries. Such interventions may include-

(i) Financing scheme to offset the impact of upfront device costs when purchasing a smartphone;
(ii) Lowering taxes levied on importation of smart devices;
(iii) Operator-OEM partnerships e.g. Safaricom's launch of a 4G smartphone package in partnership with Google;
(iv) In-country manufacturing of smartphones e.g. partnership between Safaricom and Jamii Telecom with TeleOne Technology to assemble smartphones in Kenya.
(v) Consider promotion of dongles and cloud phones as a way to lower the cost barrier (a dongle is a network card that connects to the mobile network and plugs to the USB port of a computer or tablet, to provide internet access to the device. A cloud phone is a low - configuration feature ph one that integrates the cloud app functions to enable low -end users to access the Internet).

Additionally, harmonization can help to drive down the cost of network equipment. For example, harmonization of spectrum ranges for use by IMT to deploy 5G services in various jurisdictions serves to expand the market for network equipment with consistent technical specifications, generating cost savings for manufacturers based on economies of scale, which can then be passed to consumers and operators purchasing the equipment at a national level.

2.6.3 Integration of 5G with other new technologies

Enhanced mobile broadband, ultra-reliable low latency communication, massive machine type communications and improved security identified as function driversin the adoption of 5G technology provides the basis for implementation of vertical use cases serving enterprises and public entities within specific economic sectors. Combining 5G technology with other emerging technologies such as IoT, artificial intelligence, augmented and virtual reality, cloud computing provides for delivery of use cases that are dependent on the capability to provide high speed reliable connectivity , to connect multiple devices and to process and analyse large amounts of data to meet specific industry requirements. Several factors such asavailability of sufficient spectrum resources, legal and regulatory requirements, coverage reach, security, avail ability and reliability, data sovereignty, ease of use and liability, responsibility and ownership play a role in implementation of vertical use cases combining 5G and complementary technologies to meet business requirements in service delivery.

The difficulty in overcoming this challenge lies in the fact that it cannot be resolved by following one single approach as user requirements are specific to industry needs. Respondents to the questionnaire identified several complimentary technologies to 5G that can be utilised to meet the aforesaid requirements as discussed in section 3.3 of this report.

3. RELEVANT USE CASES

The benefits to be derived from 5G technology networks extend well beyond broadband access and are unique to the national development agenda of African countries meaning that it may not be the same for every African country, economic sector or business within that country Consideration should therefore be given to the notion that applications and services supported by 5G technologies a re not limited to only the ICT sector but spans across multiple economic sectors including agriculture, finance, education, health, mining and trade amongst others. The full potential benefit to be derived from 5G technologies therefore depends on the identification of areas or industries where deployment of 5G together with the use of other complementing technologies can make a meaningful, measurable and sustainable impact on socio-economic development.

Deployment of 5G networks, applications and services has the capability to add both economic and social value through contributing to social welfare in bridging the digital divide and supporting industrial advances by enhancing operational efficiency and effectiveness of industries across various economic sectors.

In 2020, the World Economic Forum estimated the value to be derived from meaningful connectivity delivered by 5G technology to be approximately USD 3.6 trillion in economic returns and creation of 22.3 million jobs within the 5G value chainglobally. To derive increased benefits from the deployment of 5G technology, it is necessary to assess how the improvement in broadband speed, service quality and reliability can be utilised in various economic sectors to increase operational efficiency a nd provide new services and applications to consumers.

3.1 Economic sectors to benefit from 5G technology deployment

The respondents to the questionnaire were requested to indicate which sectors in their opinion will benefit from 5G deployment . African member states that responded to the questionnaire did not identify one specific economic sector that will benefit more than all other economic sectors from the deployment of 5G technology. Analysis of the responses highlighted that the aforementioned technology will be beneficial to the agriculture, education, entertainment, ICT, government and public service, finance, health, logistics and transport, manufacturi ng and construction, mines and energy, public safety and disaster relief and tourism economic sectors.

The extent to which the aforesaid sectors will differ from country-to-country in that the benefits to be derived from 5G implementation will be dependent on the 5G use cases (applications) deployed in each sector.

The continued adoption of 5G technology to support digital transformation at all economic levels will not be only aimed at meeting national development goal but will also stem from new market requirements for enhanced broadband connectivity as the basis for implementation of vertical 5G use cases to meet specific industry needs. Addressing these market requirements will require-

(i) The implementation of policies and regulations to create an enabling environment that will allow for cost-effective rollout of 5G networks, including small cell deployment and increased backhaul capacity;
(ii) The timely release of sufficient spectrum resources at a cost that support s digital connectivity goals by providing affordable 5G service with enhanced security and higher quality of service; and
(iii) Review of regulatory frameworks at the national and local level to facilitate new site acquisitions and fibre rollout, avoid ing network monopolies to encourage competition and investment into additional digital infrastructure and adoption of renewable energy resources by operators

The above actions will, to a large extent, support the rollout of large scale 5G networks by public operators and meet market requirements for government driven use cases in the education, health, energy, trade and logistics, agriculture and public service sectors.

In addition to consumer applications , the utilisation of 5G technology by private enterprises to implement highly specialised use case s is an important scenario to realize the full benefits of 5G . It will require further refinement of governmental policies and regulatory frameworks in collaboration with the private sector to ensure support for rollout and operation of private networks, enhanced security, data privacy, control of mission critical information and processes, low er latency and higher reliability for improved operational efficiency and productivity.It must be noted that itis not necessary for enterprises to build their own private networks. In practice, the majority of enterprises do not have the ability to deploy and operate 5G private network s independently. Therefore, 5G services can be provided to enterprises through operator's networks, and specific QoS requirement can be metwith the help of network slicing. Setting aside designated spectrum for use by private networks has been demonstrated as an effective mechanism for incentivising private network adoption and deployments.

African countries should create a conducive policy, legislative and regulatory environment for 5G deployment. Further, it has be en noted that market demand for specific technological solution determines the use cases that are relevant, evaluated and implemented in each country.

As a starting point, the potential economic and social value to be added by harnessing the capabilities of 5G can be assessed through consideration of key industry trends, identification of sample use cases and the transformative impact that implementation of these uses case will have in the attainment of sustainable development goals as illustrated in **Table 2** below.

Table 2: Impact analysis of 5G use cases

Industry Sector	Key Industry Trends	Sample Use Cases	SDG impacted	Transformation enabled
Manufacturing	• Hypercompetition with no sustainable competitive advantages • Increasingly volatility from business cycles and product life cycles • Smart factory advances due to development in IoT and automation • The need to securely connect systems on a common infrastructure • Increasing consumer demand for customised and personalised products • Demand for products that are more complex to build and deliver	• Smart factory floor • Human-to-robot collaboration • Predictive maintenance • Digital twins • Augmented reality • Virtual reality • Digital performance management • Asset tracking and management	SDG 7 SDG 8 SDG 9 SDG 12 SDG 13	• Advanced predictive maintenance can lead to enhanced equipment availability and throughput • Remote maintenance can lead to lower operational costs • Digital performance management and digital standard operational operating procedures result in enhanced operational efficiency • Factories of the future have smart automated manufacturing
Healthcare	• Increasing consumer attention on well-being • Increasing cost to meet socio-demographic changes	• Remote patient monitoring • Internet of medical skills/remote surgery • Image transfer	SDG 3 SDG 4 SDG 5 SDG 8 SDG 9	• m-Health and the wider introduction of telemedicine result in increased accessibility of to quality healthcare

	• Increasing demand on quality, patient safety and data storage • Changing consumer behaviour, freedom of choice and alternative service providers	• AR/VR enabled health care • Disease management • Wearables • Drone-enabled medical service delivery • Health records management		• Preventative healthcare measures lead to decrease in long term healthcare costs • Automated health management systems
Financial Services	• Disruption from fintech (technology used to support online financial services) due to online payments, e-wallets, etc. • Challenging customer relations with online/mobile transactions and customised financial solutions • Structural changes: state involvement, protectionism and fiscal measures	• Mobile banking: centre of all banking transactions • Wearables for payment • Virtual personalised financial advisory • Digital deposits, payments and peer-to-peer lending • Mobile as a digital wallet • Remote teller	SDG 4 SDG 5 SDG 8 SDG 9 SDG 13	• Shorter settlement cycles in capital markets lead to enhanced economic activity • Virtual personalised services and all-in-one mobile wallets enhance the customer experience
Energy	• Electrification and renewable energy generation • New decentralised business models • Structural shifts with increasing retiring assets • Political and societal push for sustainable energy systems • Production and transmission assets often located in remote locations	• Smart grid • Drone monitoring capabilities • Smart energy management • Hazard and maintenance sensing • Electric vehicles • Residential smart meters • Smart street lighting	SDG 7 SDG 8 SDG 9 SDG 13	• Smaller plants dependent on renewable energy and smart grids enhance reliability and availability • Demand-side integration with suppliers unlocks commercial opportunities for suppliers • The digitalisation of energy networks leads to faster decision making,

	• Need for improved customer engagement			minimising potential losses • Remote hazard and maintenance sensing can improve safety for workers and increase efficiency through predictable maintenance cycles
Entertainment and Media	• Consumers of content acting as content creators • Increasingly interactive and immersive forms of entertainment • A new sensory dimension to entertainment • Expansion of digital content through new platforms and markets • Ecosystem complexity	• Immersive media applications (ultra-high-definition AR and VR) • Live in-stadium experiences • 3D holographic suites • 3D holographic displays • Gaming (AR and cloud gaming) • Home entertainment subscriptions for car • In-venue media	SDG 3 SDG 4 SDG 5 SDG 8	• Content fuelled interactions igniting emotional connections lead to increased customer expenditure • The consumer as content co-creator results in increased consumer engagement • Gamification is induced in other industries • Immersive media and other digital content provide opportunities for the local creative economy, and can help drive economic growth indirectly though mechanisms such as tourism promotion
Agriculture	• Precision Agriculture • Sustainable Agriculture • Digital Agriculture • Automation and Robotics	• Real-time Crop Monitoring • Autonomous Farm Equipment • Livestock Monitoring • Supply Chain Optimization	SDG 2 SDG 3 SDG 5 SDG 6 SDG 12 SDG 13	• Increased agricultural productivity and efficiency. • Improved crop yields and quality. • Optimized resource utilization (water,

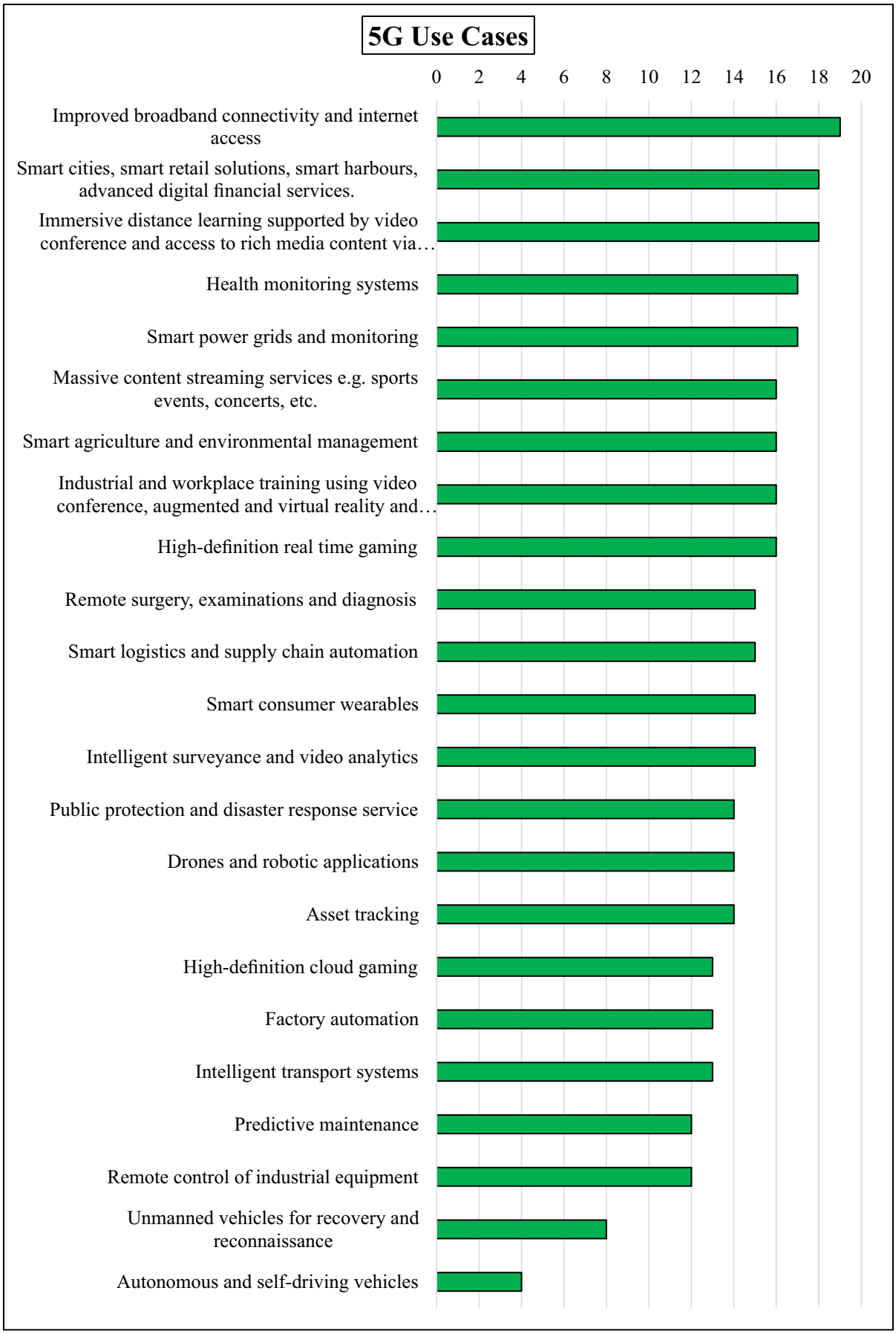
				7fertilizers, pesticides). • Enhanced food safety and traceability. • Reduced environmental impact. • Creation of new business models and job opportunities

Source: World Economic Forum

3.2 Identification of use case relevant to African countries

As of January 2024 , enhanced mobile broadband has emerged as the priority use case in 5G deployment as stated by GSMA (2023). This statement also holds true for African countries with the majority of 5G deployments done by mobile operators based on a non -standalone business model. Notwithstanding, respondents to the questionnaire have indicated a number of use cases other than enhanced mobile broadband to be relevant to Africa as indicated in **Figure 10** on the next page.

Figure 10: Relevant 5G use cases



Given the variance in socio-economic status between African countries, not all of the aforementioned use cases may be of the same relevance in all countries. The following five use cases were ranked highest by respondents to the questionnaire-

(i) Improved broadband connectivity and internet access;
(ii) Smart cities, smart retail solutions, smart harbours, advanced digital financial services;
(iii) Immersive distance learning supported by video conference and access to rich media content via the internet and content platforms;
(iv) Health monitoring systems; and
(v) Smart power grids and monitoring.

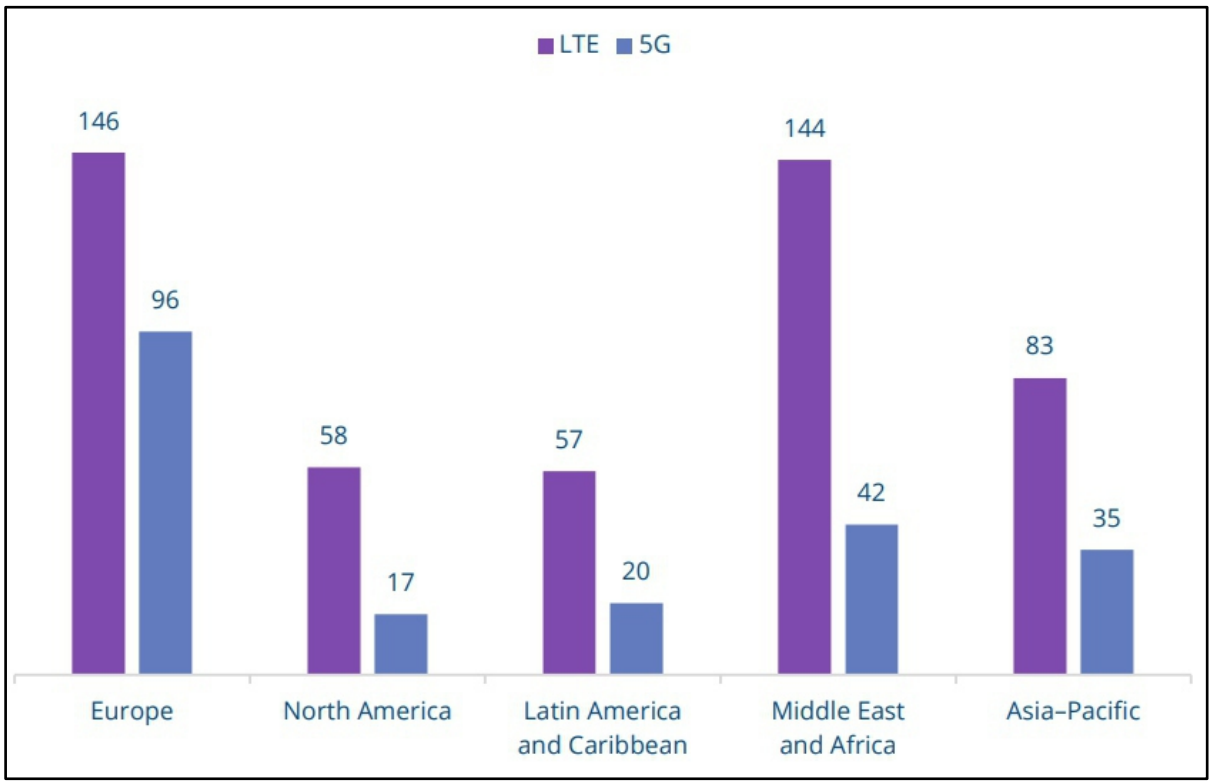
It is notable that these use cases are closely linked to digital transformation policies and strategies and national development plans adopted in these countries aimed at improving the livelihoods of citizens and equipping them with the necessary digital skills to actively participate in future economic activities.

Fixed broadband connectivity and internet access over mobile networks has become the main use case for 5G in Africa (and other regions). Mobile broadband can deliver residential and business broadband services. Mobile operators have used LTE, LTE-Advanced and 5G networks to deliver internet connectivity in locations that are poorly served, or not served at all, by fixed-line broadband technologies based on copper, coaxial cable or fibre.

However, wireless residential and business broadband services are no longer limited to mobile data subscriptions associated with mobile phones, dongles or MiFi or hot-spot devices. Wireless broadband now relies on mobile networks to provide the main broadband connection for a home or business. This takes the form of a fixed wireless access (FWA) service delivered to a mains-powered customer-premises equipment (CPE) device, which in turn provides local connectivity to other devices, typically over Wi-Fi. This has become a mainstream service offer in many African countries. There are several examples across Africa of successful use of 5G technology to provide fixed broadband to homes and business: Rain in South Africa, Safaricom in Kenya, Orange in Botswana, MTN in Nigeria, Vodacom in Tanzania, Airtel in Uganda.

The GSA Fixed Wireless Access Report of November 2024 indicates that of the 343 operators that had announced 5G launches or soft launches worldwide until the end of August 2024, GSA has catalogued 169 that are marketing residential or business 5G FWA broadband services, up more than 300% from 41 in November 2021. It is also reported that there are more operators marketing FWA services in Europe than any other region, particularly in the 27 countries that make up the EU, which has 72 commercially launched 5G FWA networks, closely followed by the Middle East and Africa. Please see **Figure 11** below:

Figure 11: **Count of identified launched FWA services based on LTE or 5G, by region**



Moving beyond broadband internet connectivity, anumber of industry specific use cases, implemented by the private sector or by mobile operators , have also been ranked of high relevance to African countries focussing on specific economic sectors. It is clear that 5G technology has been identified to potentially be a key enabler of sustainabl e industrialisation and innovation. In selecting the most relevant use cases based on individual country needs it is necessary to –

(i) Map 5G connectivity features such as enhanced mobile broadband, ultra -reliable low latency, security, ability to connect a large number of devices to support data-intensive applications and power efficiency to use case requirements;
(ii) Identify complementary technologies to 5G , as applicable, to ensure successful implementation of use cases as per customer needs
(iii) Quantify the socio-economic impact of selected use cases across industry sectors. This can be done following a bottom-up approach;
(iv) Identify and evaluate cross sector collaboration opportunities; and
(v) Determine market demand, cost of deployment, funding required and time period to attain return on investment.

To this end respondents to the questionnaire were requested to identify other technologies that can be used in conjunction with 5G technology to meet specific use case requirements and enhance service delivery. Complimentary technologies to 5G as identified included artificial intelligence, augmented reality, edge computing, cloud computing, blockchain, Internet-of-Things and virtual reality.

GSMA (2023) estimates that 5G would account for 22% of connections in Africa by 2030. Although the provisioning of enhanced mobile broadband dominates the deployment use cases to date, several African countries have deployed 5G use cases leveraging on the other drivers for deployment of 5G as indicated below:

(i) Safaricom, in partnership with Huawei, established three 5G experience centres in Kenya that offer VR gaming zones;
(ii) Implementation of business-to-business commercial application enabling real-time data transmission thereby improving production efficiency and worker safety e.g. Minetec Smart Mining (South Africa's first 5G connected coal mine) and Hima Cement Plant, Uganda; and
(iii) Nigeria's Baze University signed a memorandum of understanding with Huawei to promote 5G-powered learning and teaching innovations.

At the time of developing this report and based on the status of 5G deployment in Africa, it is clear that the implementation of 5G networks and services are dominated by mobile operators whose product portfolios follow the traditional telecommunications models in offering enhanced mobile broadband. This is not surprising as the main focus of policy and regulatory actions were aimed at providing sufficient spectrum resources and enabling license regimes for telecommunications operators.

The introduction of vertical use cases through collaboration between government, operators and industry players from other economic sectors and deployment of enterprise owned private networks are slow and may require target interventions to gather traction. Government as the policy maker and custodian of citizens personal data will play a pivotal role in the implementation of 5G use cases identified in Figure 5 that will improve delivery of essential services in the health, education, agriculture, energy, government, logistics and transport sector services delivery will remain policy driven and funded by government resources to ensure inclusivity and accessibility of services irrespective of a person's economic circumstances. Notably four of the five top ranked use cases identified in this report falls in this category.

Increased competition and the need to improve operational efficiency will serve as the basis for industry to adopt 5G technology for supply chain and factory automation, improved worker safety, asset tracking and other use cases. Similarly use cases such as smart wearables and high-definition online gaming are based on consumer needs. The implementation of the aforementioned use cases is driven by market demand and influenced by factors such as device availability, affordability, service reliability, need for operational efficiency and improved productivity and security requirements.

As a result, the sustainable deployment of 5G will not only require a review of policies, legislation and the regulatory framework in the ICT sector, but also require review of the same governing instruments in other economic sectors.

4. RECOMMENDATIONS

In order to maintain the momentum gained to date in the deployment of 5G technology to foster an enabling environment for digital transformation in African countries it is recommended that African Member States:

(i) **Formulate** national IMT roadmaps and development plans and define national 5G industry development goals such as population coverage, user experience standard , penetration rate, number of industry applications. As part of these roadmaps and to facilitate investment planning it is proposed to include accompanying target dates of within this decade for 5G initial deployments.

(ii) **Streamline** Licensing and Permitting Processes by converting spectrum and operational licensing frameworks to technology-neutral to accelerate deployment of 5G infrastructure.

(iii) **Review** governmental policies and strategies to drive the adoption of 5G and complementary technologies for delivery of improved essential services in the health, education , energy, logistics and agriculture sectors.

(iv) **Ensure** availability of sufficient spectrum for the deployment of 5G. Demand for mobile data continues to grow rapidly and this place increasing pressure on the mobile networks. Meeting this demand can be assisted with more spectrum. A balance of spectrum is needed in low, medium and high bands (such as 700MHz, 1.5 GHz, 3.5 GHz/ and 26 GHz,) to allow increased capacity in both dense urban areas and rural areas.

5G leading countries have taken measures to encourage 5G network construction at the time of release of spectrum, such as instalment payment and price concessions. Such supportive policies have enabled countries to achi eve rapid expansion of 5G coverage. Furthermore, African administrations should target reasonable spectrum prices.

(v) **Establish** regulatory frameworks that support the implementation of locally relevant 5G use cases to enable the use of digital technologies to enhance operational efficiency across all economic sectors;

(vi) **Create** more awareness amongst enterprises and specialised industries on the socio-economic value to be derived from the implementation of 5G and identified complementary technologies to enhance market demand

(vii) **Support** the continued rollout of networks capable of providing meaningful broadband connectivity to ensure economic inclusivity of all persons living in African Member States;

(viii) **Include** Fixed Wireless Access through 5G networks as an element in the national strategy for fixed broadband connectivity.

(ix) **Remove** obstacles to network deployment. African administrations are encouraged to implement flexible, light -touch regulation that creates an environment for continued mobile sector investment and innovation. For example, they should aim to simplify planning procedures and regulations for site acquisition, co-location and upgrades of base stations. It is also necessary to provide operators with access and rights of way (RoW) to public/government facilities for antenna siting and fibre deployment on reasonable terms and conditions. Policymakers should also offer a reasonable expectation of approval for voluntary network sharing deals while avoiding mandated sharing agreements that may amount to an access obligation.

(x) **Review** legislative and regulatory frameworks to ensure availability of affordable 5G devices. For instance, consider

a. to provide financial support to low -income citizens that purchase an entry -level smartphone;
b. to reduce taxes levied on importation of mobile devices;
c. to encourage operators to cooperate with entry-level mobile phone manufacturers
d. to promote policy and regulatory harmonization that fosters access to available and low-cost 5G devices and equipment

(xi) **Promote** the use of 5G technology to improve service delivery in public institutions e.g. education and health;
(xii) **Identify** opportunities to build a digital skilled workforce to meet market demand;
(xiii) **Harness** the benefits to be derive from 5G technology to progress toward the attainment of sustainable development goals by 2030;
(xiv) **Analyse and develop** definitive solutions t o challenges encountered in the adoption and deployment of 5G technology;
(xv) **Develop** new funding models to support the deployment of 5G networks , as the 5G network deployment would benefit from public funding.
(xvi) **Incentivize** Private Sector Investment in 5G through enabling policies that incentivize private equity and venture capital investments in the industry, particularly for 5G -related startups, digital infrastructure projects, and value -added services. This could involve risk-sharing mechanisms or access to afore-mentioned public funding.
(xvii) **Promote** Green 5G Initiatives by supporting service providers in adopting energy -efficient technologies (such as green 5G base stations) by offering green energy subsidies or carbon tax exemptions for companies reducing their carbon footprint through innovative, sustainable practices in 5G deployments; and
(xviii) **Consider** the use of Universal Service Funds (USFs) to co-finance 5G deployments in hard-to-reach areas where the business case may be weak, thus ensuring that rural and underserved areas also benefit from 5G services while reducing the financial burden on service providers

5. CONCLUSION

The ICT sector plays an increasingly strategic role in Africa 's economic development as countries advance digital transformation across all sectors. Decision-makers within the sector are committed to ensuring that mobile technology goes beyond providing broadband services , focusing on the development of vertical use cases to fully harness the benefits of 5G. Achieving this would require greater collaboration with players and the integration of complementary technologies such as artificial intelligence, cloud computing and edge computing, ensuring customer requirements are met.

While the readiness to deploy 5G varies across African nations, the number of commercially available 5G networks is expected to rise steadily supported by the release of low and mid-band spectrum to telecommunications operators. However, to drive market demand, more awareness is needed amongst enterprises and other economic sectors about the operational efficiencies that 5G can offer . This will require a regulatory review to create an enabling framework for the deployment of standalone 5G networks, particularly for private entities to support specific industry use cases.

Challenges in deploying 5G technology are not confined to the ICT sector alone. Key issues, such as the availability of affordable devices for mass adoption, the need for a digitally skilled workforce, and new funding models to cover deployment costs, will require government intervention and collaboration across sectors. These efforts must also support the local manufacturing of devices to enhance accessibility and reduce costs.

The relevance of 5G use cases will vary across African countries, depending on their national circumstances, market environments and development goals. The deployment of use cases in essential services must be policy driven and aligned with national digital transformation strategies to ensure meaningful socio-economic impact.

The successful implementation of 5G networks and use cases has the potential to significantly contribute to the attainment of Sustainable Development Goals. In this regard, the ICT sector is pivotal to national governments as they seek to foster inclusivity in the socio-economic development of their respective countries. The widespread deployment of 5G, complemented by effective policy, regulatory, and market strategies, will be critical in fostering economic growth and advancing digital transformation across the continent.

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7. LIST OF FIGURES AND TABLES

8. ABREVIATIONS

3G	3rd generation mobile telecommunications technology based on IMT
4G	4th generation mobile telecommunications technology based on IMT
5G	5th generation mobile telecommunications technology based on IMT
AR	Augmented reality
ARPU	Average revenue per user
ATU	African Telecommunications Union
CPE	Customer premise equipment
eMBB	Enhance mobile broadband
GDP	Gross domestic product
GSMA	GSM Association
ICT	Information and Communication Technology
IMT	International mobile telecommunications telecoms standard
IoT	Internet-of-Things
ITU	International Telecommunications Union
LTE-UTRAN	Long term evolution - UMTS Terrestrial Radio Access Network
MIMO	Massive-in-massive-out
MR	Mixed reality
NR	New radio
OEM	Original equipment manufacturer
SDG	Sustainable development goal
VR	Virtual reality
WRC-15	ITU's World Radiocommunication Conference 2015
WRC-19	ITU's World Radiocommunication Conference 2019
WRC-23	ITU's World Radiocommunication Conference 2023

9. ANNEX: SUMMARY OF THE 17 UN SUSTAINABLE DEVELOPMENT GOALS

Number	Goal	Description	Number of Target/Indicator
1	No Poverty	Ending poverty in all its forms everywhere	7 targets and 13 indicators
2	Zero Hunger	Ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture	8 targets and 14 indicators
3	Good Health and Well-Being	Ensuring healthy lives and promoting well-being for all at all ages	13 targets and 28 indicators
4	Quality Education	Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all	10 targets and 12 indicators
5	Gender Equality	Achieving gender equality and empowering all women and girls	9 targets and 14 indicators
6	Clean Water and Sanitation	Ensuring availability and sustainable management of water and sanitation for all	8 targets and 11 indicators
7	Affordable and Clean Energy	Ensuring access to affordable, reliable, sustainable and modern energy for all	5 targets and 6 indicators
8	Decent Work and Economic Growth	Promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	12 targets and 16 indicators
9	Industry, Innovation, and Infrastructure	Building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation	8 targets and 12 indicators
10	Reduced Inequalities	Reducing inequality within and among countries	10 targets and 14 indicators
11	Sustainable Cities and Communities	Making cities and human settlements inclusive, safe, resilient, and sustainable	10 targets and 14 indicators
12	Responsible Consumption and Production	Ensuring sustainable consumption and production patterns	11 targets and 13 indicators
13	Climate Action	Taking urgent action to combat climate change and its impacts	5 targets and 8 indicators
14	Life below Water	Conserving and sustainably using the oceans, seas, and marine resources for sustainable development	10 targets and 10 indicators
15	Life on Land	Protecting, restoring, and promoting sustainable use of terrestrial ecosystems, sustainably managing forests, combatting desertification, and halting and reversing land degradation, and halting biodiversity loss	12 targets and 14 indicators
16	Peace, Justice, and Strong Institutions	Promoting peaceful and inclusive societies for sustainable development, providing access to justice for all, and building effective, accountable and inclusive institutions at all levels	12 targets and 24 indicators
17	Partnerships for the Goals	Strengthening the means of implementation and revitalizing the global partnership for sustainable development	19 targets and 24 indicators

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