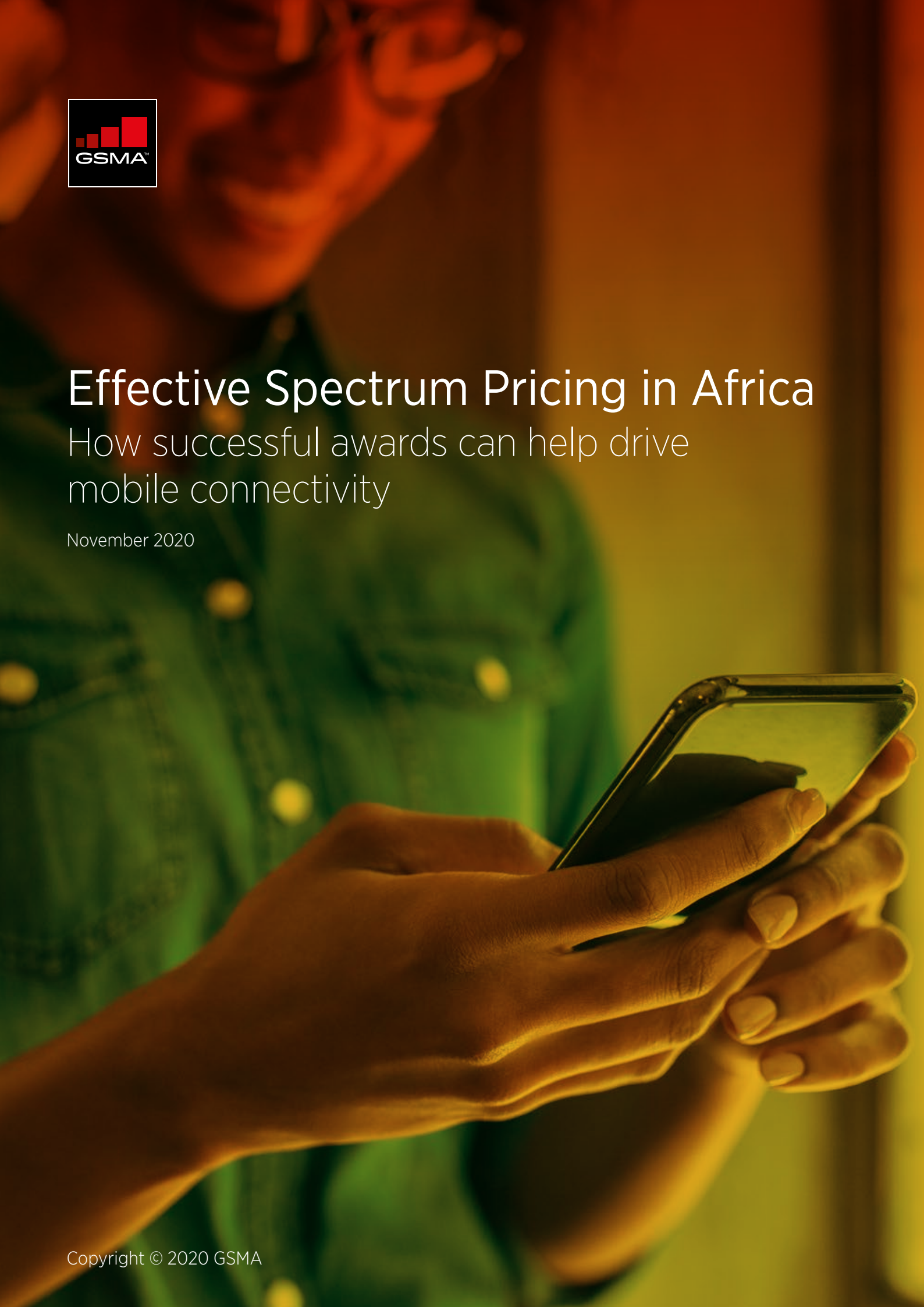


Effective Spectrum Pricing in Africa

How successful awards can help drive mobile connectivity

November 2020

The GSMA represents the interests of mobile operators worldwide, uniting more than 750 operators with nearly 400 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces the industry-leading MWC events held annually in Barcelona, Los Angeles and Shanghai, as well as the Mobile 360 Series of regional conferences.

For more information, please visit the GSMA corporate website at **www.gsma.com.**

Follow the GSMA on Twitter: **@GSMA** and **@GSMAPolicy**

GSMA Intelligence is the definitive source of global mobile operator data, analysis and forecasts, and publisher of authoritative industry reports and research. Our data covers every operator group, network and MVNO in every country worldwide – from Afghanistan to Zimbabwe. It is the most accurate and complete set of industry metrics available, comprising tens of millions of individual data points, updated daily.

GSMA Intelligence is relied on by leading operators, vendors, regulators, financial institutions and third-party industry players, to support strategic decision-making and long-term investment planning. The data is used as an industry reference point and is frequently cited by the media and by the industry itself.

Our team of analysts and experts produce regular thought-leading research reports across a range of industry topics.

www.gsmaintelligence.com

info@gsmaintelligence.com

Authors
Xavier Pedros – Senior Economist
Kalvin Bahia – Principal Economist
Pau Castells – Head of Economic Analysis
Dennisa Nichiforov-Chuang – Lead Analyst, Mobile Spectrum

Published November 2020

Contents

1. Executive summary

Spectrum is the foundation for mobile services. Having sufficient spectrum allows mobile networks to reach more consumers and offer a better quality of service, as recognised by governments that have assigned additional temporary spectrum during the Covid-19 pandemic. The policies adopted by governments are crucial for continued innovation, as they directly impact spectrum costs, affecting mobile operators' ability to cater for greater investment. When done right, spectrum policies can have a positive impact on the quality, capacity and coverage of services offered by mobile operators to consumers, as well as the wider industry.

Despite continued progress with the expansion of mobile service and mobile internet connectivity, 50 per cent of Africans (680 million people) did not use mobile and almost 75 per cent (950 million people) did not access mobile internet services in 2019. Mobile technology provides the primary means of accessing the internet in Africa and is therefore a key platform for economic development, better healthcare and education, and poverty reduction – benefits that the Covid-19 pandemic has only served to make more apparent.

This report, unprecedented in scope and depth, tracks spectrum assignments across nearly 50 African countries and benchmarks them to a set of 80 countries around the world, for the period 2010–2019. Through analysing this unique data, we highlight the following findings:

- **Governments in Africa have assigned approximately half the amount of mobile spectrum compared with the global average.** This gap in spectrum assignments has emerged and expanded over the last decade, making it difficult for African operators to offer fast mobile broadband speeds. African governments have also on average licensed 3G and 4G spectrum around three years later than other regions.
- **African countries account for a large proportion of the highest spectrum prices globally.** Adjusting spectrum prices by income, Africa accounts for about half of all the extremely high spectrum prices worldwide. Even if we exclude extreme outliers, spectrum prices in Africa remain high. Median prices in Africa are four times higher than in the developed world and twice as high as the global median.
- **Licensing more spectrum earlier and at affordable prices can pay dividends for African consumers.** Higher amounts of spectrum and lower spectrum prices are strongly linked to higher population coverage, download speeds and adoption. Countries that have assigned spectrum earlier have also achieved higher coverage levels.

These findings have clear policy implications that can help progress the digital agenda in Africa. Governments should release more spectrum, in a timely manner, to expand coverage, improve speeds and encourage adoption. This is particularly necessary in the context of growing consumer demand for data services and new technologies. Furthermore, policies should avoid artificially increasing spectrum fees. This can happen as a result of high auction reserve prices or governments creating artificial spectrum scarcity – either by limiting spectrum supply or through unclear/uncertain spectrum licencing.

2. The importance of spectrum policy in Africa

Spectrum policy plays a crucial role in enabling the adoption of mobile services and facilitating better networks and services for consumers

To offer mobile services, mobile operators need to be assigned spectrum licences, or the rights to use radio frequencies. The policies governments adopt to license spectrum impact mobile operators, consumers and the benefits that mobile technology can bring to society and the economy.

Effective spectum policy is particularly important in Africa as mobile technology provides the primary means of internet access. In 2019, mobile accounted for 98 per cent of broadband connections in Africa.[1] Mobile technology therefore provides a platform from which to drive economic development, create better healthcare and education, and reduce poverty. At the end of 2019, the economic benefits generated from mobile technology in Africa accounted for 6.2 per cent of the continent's GDP. The rollout of mobile technology has driven a fifth of income per capita growth over the last 20 years.[2] Recent research has also shown that mobile technology has reduced poverty in the region.[3]

Central to an enabling policy environment is the need for timely access to the right amount and type of spectrum. The amount of spectrum available to operators is a key input that determines the cost of deploying networks and improving network speeds. When operators have early access to more spectrum, they can reach more consumers and offer better services with the same physical infrastructure. Empirical research shows that operators with more spectrum can provide greater coverage and faster data speeds, to the benefit of consumers.[4]

1 Source: ITU

2 These are in fact the highest impacts observed across all regions. See Mobile technology and economic growth, GSMA, 2020.

3 The poverty reduction effects of mobile broadband in Africa: Evidence from Nigeria, GSMA and World Bank, 2020

4 The impact of spectrum prices on consumers, GSMA, 2019

The policies adopted by governments can impact the spectrum fees operators pay to access spectrum, which can in turn affect the development of the market. For example, when spectrum is auctioned, governments can increase fees by setting excessive minimum prices (i.e. reserves), artificially limiting spectrum supply or creating uncertainty around the future availability of spectrum.

High spectrum fees increase the average costs for mobile operators, reducing long-term returns and the incentive to invest in expanding and upgrading mobile networks. Excessive prices can also result in spectrum going unsold. This negatively impacts consumers through lower coverage levels and slower network speeds, which can in turn also limit mobile service adoption.

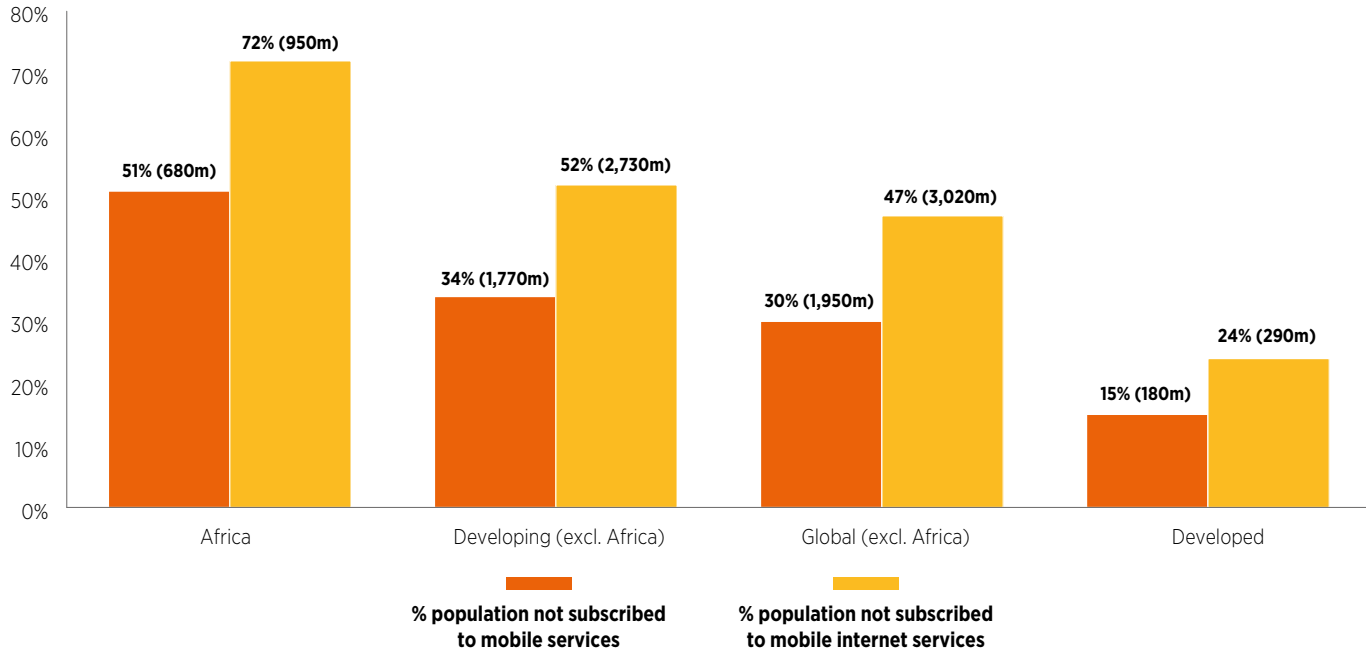
Some 950 million people in Africa remain unconnected; closing this gap is key to fostering social and economic development

Spectrum policies that facilitate greater investment and adoption of mobile technology are particularly important in Africa. Despite continued progress expanding mobile and mobile internet connectivity, by the end of 2019, 50 per cent of the continent's population were not connected to mobile services. This represents around 680 million people. Notably, almost 75 per cent of the population do not access mobile internet services, representing around 950 million people. Recent research shows that connecting all of Africa to mobile internet by 2030 would add 5.5 per cent to projected economic growth in the region over the next decade.[5]

FIGURE 1

Source: GSMA Intelligence

Percentage of population not connected to mobile services and mobile internet services



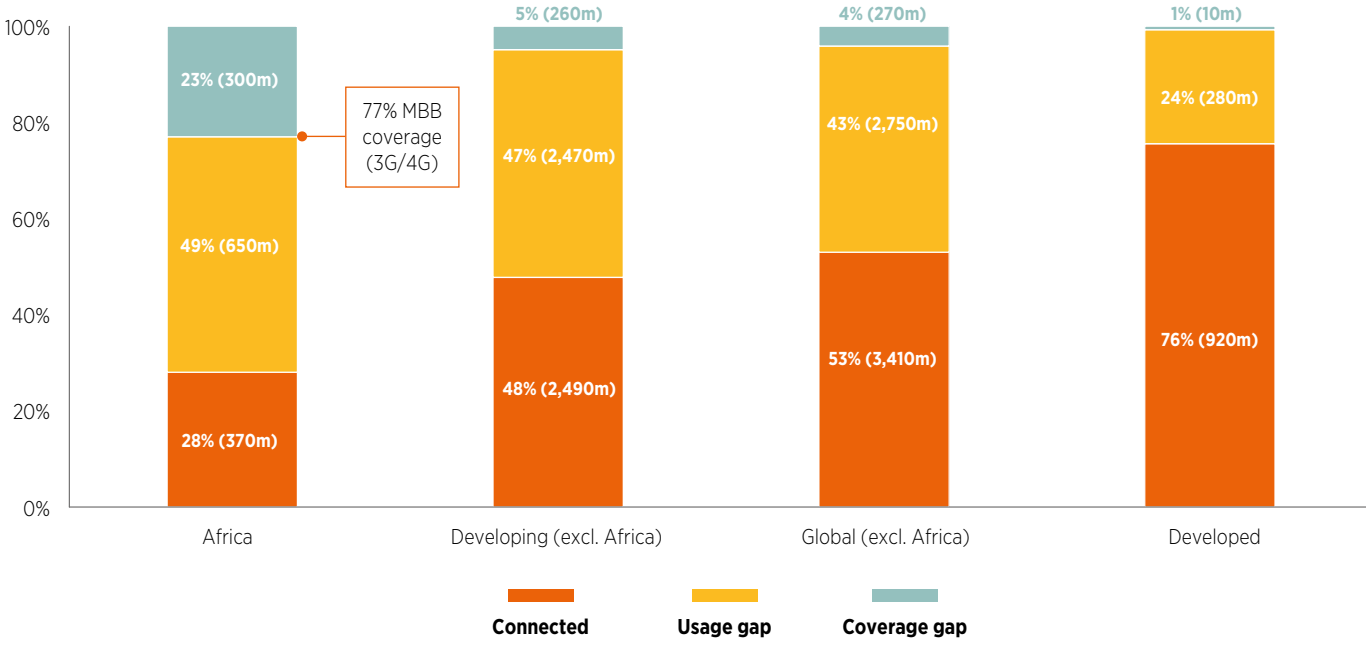
5 Mobile technology and economic growth: Lessons to accelerate economic growth and recovery, GSMA, 2020

Coverage is one of the main barriers deterring broader mobile and mobile broadband adoption in Africa.[6] At the end of 2019, mobile broadband population coverage (3G/4G networks) was around 78 per cent. This means 22 per cent of the population is not covered by mobile broadband networks – we refer to this as the 'coverage gap'. Figure 2 shows that this gap is several times higher than anywhere else in the world. For the remaining individuals that are unconnected, 52 per cent of the continent's population are covered but are not currently using mobile internet – we refer to this as the 'usage gap'. This demand-side gap is typically explained by issues such as the affordability of mobile services/ devices and a lack literacy and digital skills.

FIGURE 2

Source: GSMA Intelligence

Mobile broadband coverage and usage gaps in Africa and the rest of the world[7]
Base: total population



6 See analysis of barriers to connectivity in The State of Mobile Internet Connectivity Report 2019, GSMA, 2019

7 Connected: refers to the number of unique people who have used internet services on a mobile device. Mobile internet services are defined as any activity that consumes mobile data.

3. Spectrum licences in Africa, 2010–2019

Governments decide when and how much spectrum is made available for mobile services. Their policies are central to expanding coverage and offering high quality services, for two reasons:

- More spectrum means that operators do not have to deploy as many sites to achieve a given level of coverage, thereby reducing deployment costs. More spectrum also means operators' networks can host more traffic, or more capacity, with their infrastructure. Spectrum at frequencies below 1 GHz (coverage spectrum) is generally better suited to expanding coverage in areas with low population density and deep inside buildings. Spectrum in frequencies above 1 GHz (capacity spectrum) is generally used to achieve greater data traffic capacity and faster speeds.
- While having sufficient spectrum is crucial, making it available in a timely manner (when there is demand for it) is also important. To deploy and upgrade mobile networks, operators need to deploy a network of physical sites, towers and masts. This is often a complex process that requires time. For this reason, the sooner mobile operators have access to spectrum, the sooner they can start developing infrastructure, including via sharing, to expand coverage, improve network speeds and drive consumer adoption.

This chapter reviews the amount of spectrum holdings licensed for mobile services during the period 2010–2019. We review spectrum holdings and timings in 49 countries in Africa, and compare these to another set of 80 markets across the rest of the world.[8]

8 See Appendix A1.1 for the list of African markets that have been considered, along with the countries used in the developing, developed and global benchmarks shown in this chapter. The 49 African countries and 80 global markets refer to countries included for the 2019 statistics, with the time series analysis consisting of a subset of countries where data is available.

3.1 Africa has licensed less spectrum than the rest of the world

Governments in Africa have on average assigned approximately half the amount of spectrum compared to the global average

By the end of 2019, African governments had licensed an average of around 80 MHz of spectrum per operator and 250 MHz per country. The global average was almost double this amount, with 150 MHz assigned per operator and 480 MHz per country. Relative to other developing countries, African countries have assigned less spectrum: 30 MHz less per operator and 100 MHz less per country.[9]

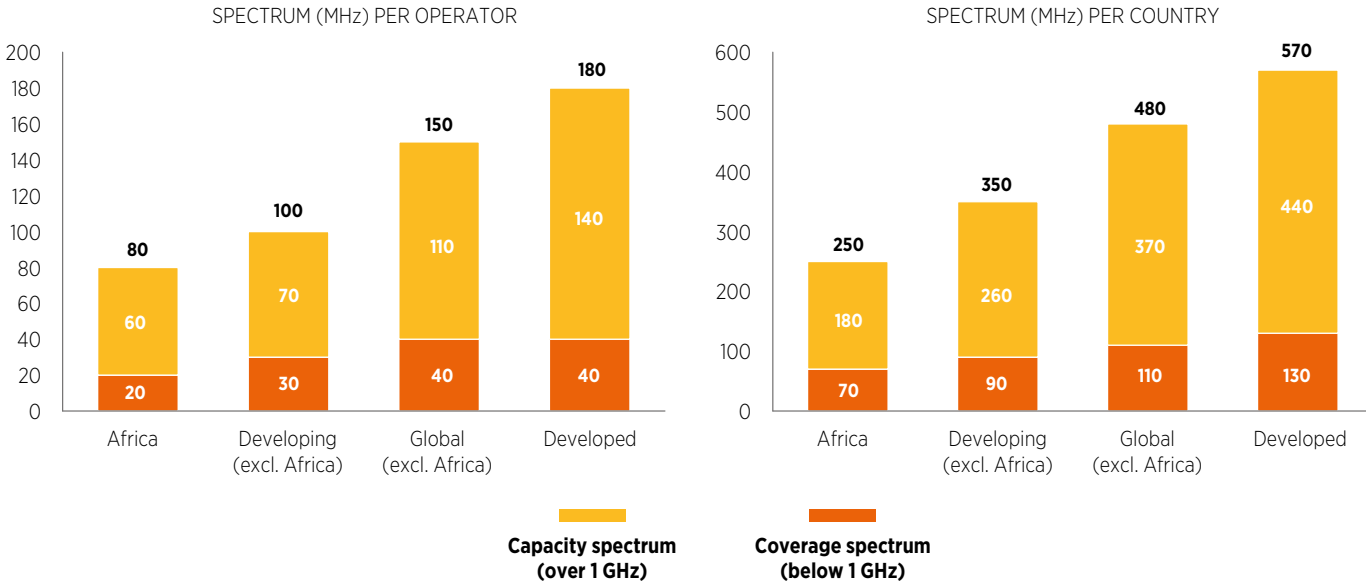
This means African governments have licensed 70–80 per cent of the spectrum assigned in other developing economies.

Figure 3 shows that Africa lags behind in both coverage and capacity spectrum. For both, the amount assigned equates to around half the global average.

FIGURE 3

Source: GSMA Intelligence

Average spectrum assignments, 2019



Spectrum assignments below 3.7 GHz and excluding 5G-specific licences.

Spectrum holdings vary across sub-regions of Africa, but all are below the average amount licensed in other developing countries and globally. Spectrum per operator is the lowest in Central Africa, while total spectrum per country is lowest in Southern and Central Africa (see Figure 4).

9 Throughout this report, country classifications for developed markets are based on the World Bank's "High income" category. The rest of the countries are regarded as developing.

FIGURE 4

Source: GSMA Intelligence

Average spectrum per operator and per country, 2019[10]

Spectrum assignments below 3.7 GHz and excluding 5G-specific licences.

10 See Figure 21 in the Appendix for the countries included in each sub-region

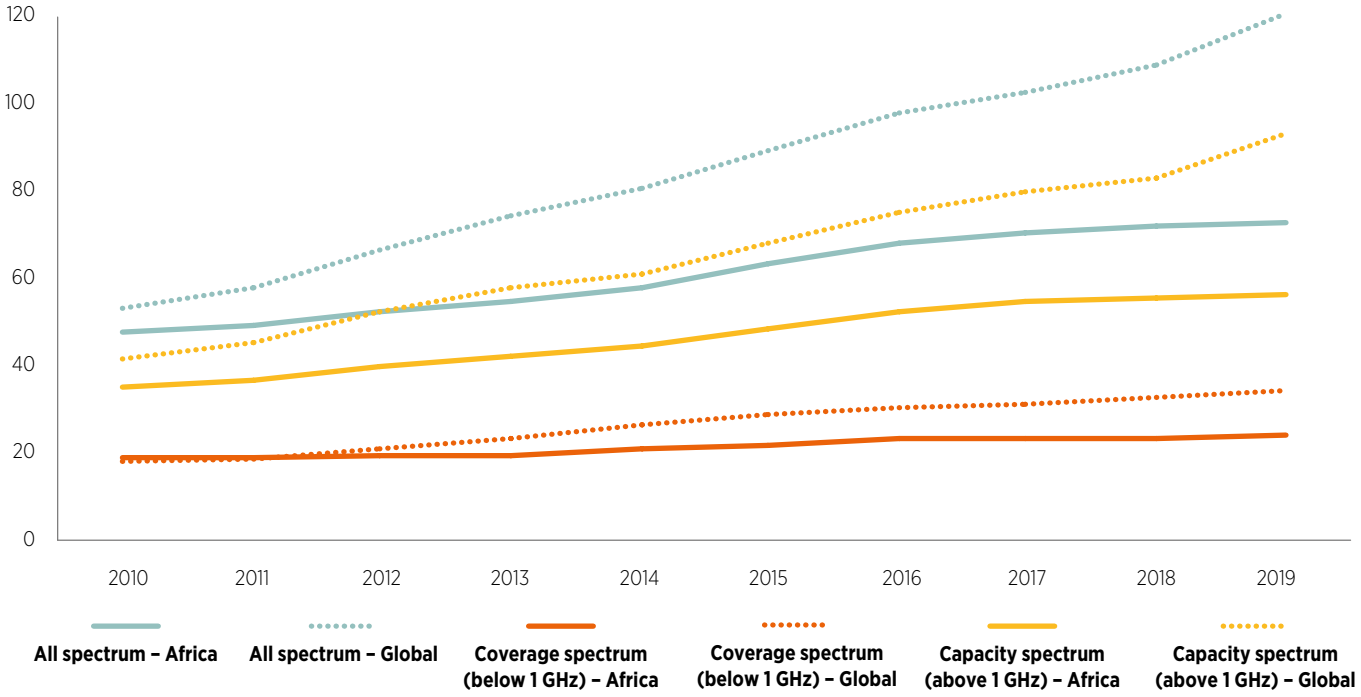
The notable gap in spectrum assignments versus the rest of the world has emerged and expanded over the last decade

In 2010, African governments assigned spectrum in line with the other benchmarks evaluated (see Figure 5). Over the last 10 years, however, African governments have awarded less additional spectrum for mobile services compared to the rest of the world.

FIGURE 5

Source: GSMA Intelligence

Average spectrum (MHz) per operator in Africa and a sample of countries globally



Spectrum assignments below 3.7 GHz and excluding 5G-specific licences.

3.2 Governments in Africa assigned spectrum later than elsewhere

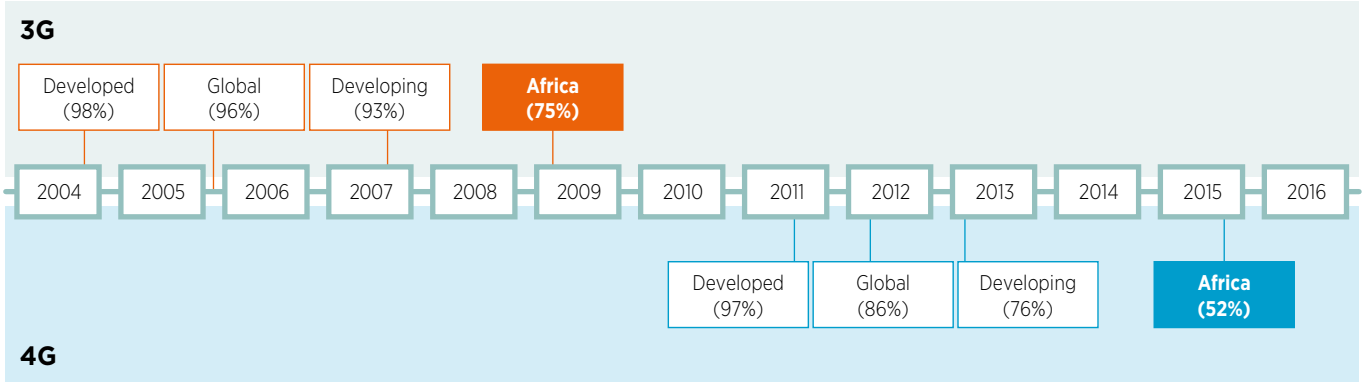
The first assignments of 3G and 4G spectrum took place, on average, three years later in Africa compared to the rest of the world

Our analysis shows that not only have countries in Africa licensed less spectrum than in other parts of the world since 2010, but that governments have also licensed spectrum significantly later. The first assignment in Africa for 3G technology was approximately two years later than other developing countries, and four years after developed markets (see Figure 6). Furthermore, the lag in spectrum assignments by African governments persisted with 4G. Overall, our analysis shows that the first 3G and 4G assignments in Africa on average came three years later.

FIGURE 6

Source: GSMA Intelligence

Average time of first spectrum licence, 3G and 4G
(2019 % population coverage)

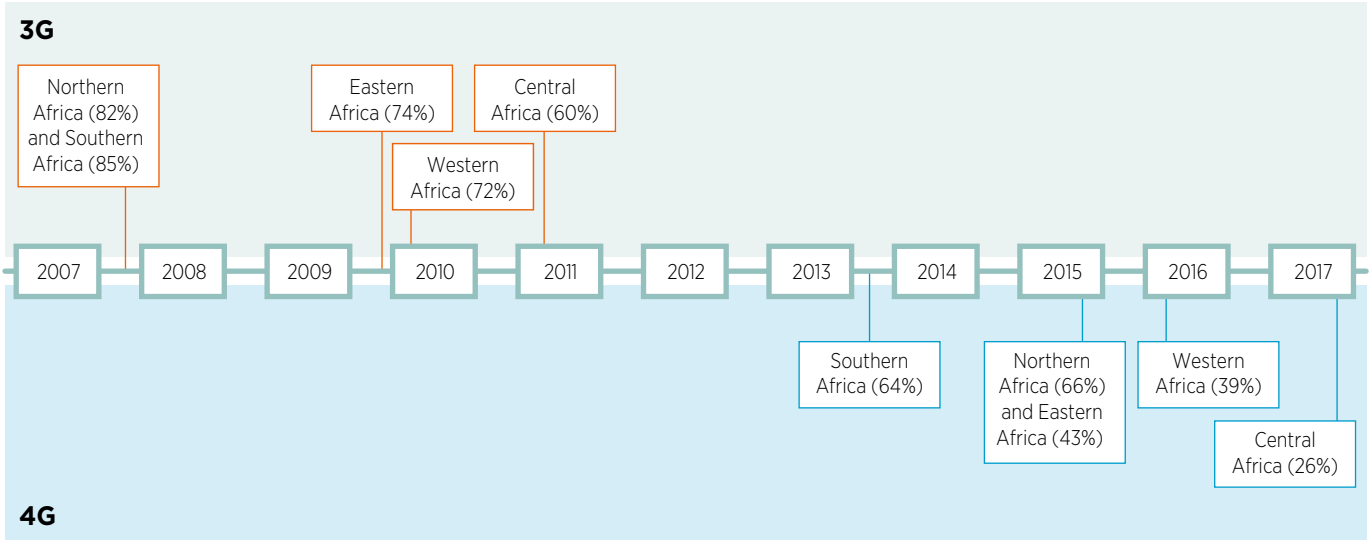


Within the continent, Northern and Southern Africa released 3G and 4G assignments earlier than other African sub-regions and today enjoy higher levels of coverage (see Figure 7). Meanwhile, Central and Western Africa were the last to release 3G and 4G spectrum. These sub-regions had the lowest 3G and 4G population coverage levels at the end of 2019.

FIGURE 7

Source: GSMA Intelligence

Average time of first spectrum licence, 3G and 4G, by sub-region
(2019 % population coverage)



For the purposes of calculating regional averages of first time of 3G and 4G assignments, it is assumed that countries that have not yet launched 3G or 4G mobile services launched networks in 2020. This understates the lag of Africa when compared to regions where all countries have launched networks.

4. Spectrum prices in Africa, 2010–2019

To gain access to spectrum, mobile operators usually pay an upfront fee, through either an auction or an administrative award.

To compare the upfront spectrum fees faced by mobile operators across countries, for each spectrum licence, we adjusted the prices paid by the total amount of spectrum that operators were awarded and the length of the licence. We refer to this as the 'unit cost' of spectrum.[11] We then use two metrics to make comparisons meaningful across countries and regions:

- The **unit price of spectrum per population.**[12] Unit costs have been divided by the population of each country, as an indication of the market size that operators can address. These prices, in dollar terms, are calculated by equalising the purchasing power of different currencies, eliminating differences in price levels between countries.[13]
- The **unit price of spectrum per income.**[14] While the unit price of spectrum per population is informative, it is necessary to account for the fact that incomes per capita vary extensively in Africa and the rest of the world. The unit price of spectrum per income measures the value of spectrum (as an input or access cost), in relation to the value of the market where operators are investing (an output or their addressable market). This metric therefore provides a better approximation of the relative cost of spectrum.[15]

11 We define a single unit as the price paid for 1 MHz of spectrum per year. Regarding duration, if one considers spectrum as a production input, the licence length effectively represents the useful life of the asset. An operator would therefore pay more for a licence that lasts 20 years compared to one that last five years.

12 The price per MHz per year per population.

13 We use international dollars, purchasing power parity adjusted.

14 The price per MHz per year per GDP.

15 As a robustness check for the analysis of unit price of spectrum per income, we also evaluate the unit prices of spectrum per revenue. This is an alternative measure for the value over which operators recoup their investments, which captures the existing value of the market in the short term (while income is a broader measure for the profitability of the market in the longer term). For simplicity, only the results for spectrum per income are presented in this section, as the results for spectrum per revenue were similar and largely consistent.

4.1 Spectrum prices are influenced by government policy

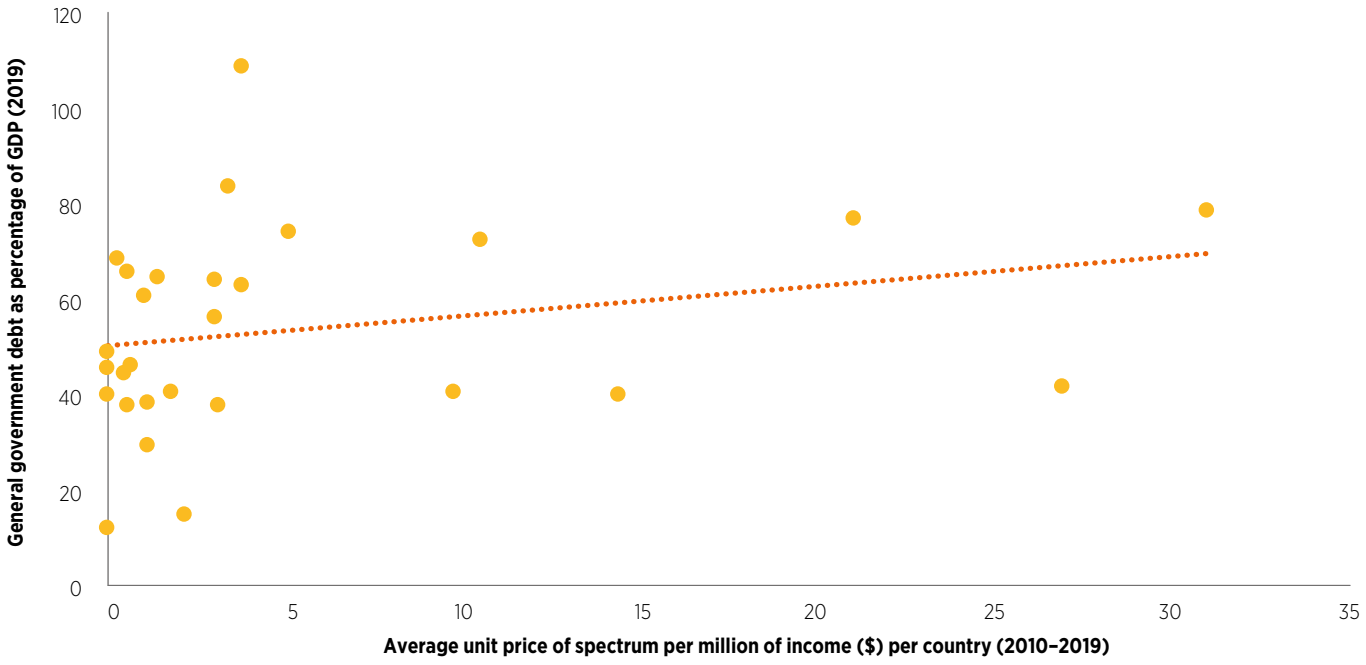
The primary goal of charging for spectrum is to assign a scarce and valuable resource to those who will use it most efficiently to deliver the maximum benefit to society. A well-designed auction by a government will assign spectrum at a market-determined price, to the operators that value it most, thus incentivising them to use it efficiently through investment in widespread, high-quality mobile networks.[16]

However, as governments can obtain substantial revenue from spectrum, some of them prioritise maximising spectrum revenue over the efficient allocation of spectrum (and the improved mobile services and associated benefits for the economy and society). Those African countries where the public sector is highly indebted tend to have higher spectrum prices (see Figure 8). Given that spectrum prices are unlikely to determine government debt, the more plausible interpretation is that African governments experiencing financial challenges are influencing spectrum fees, in order to maximise public sector revenues. This is also consistent with findings in other developing countries.[17]

FIGURE 8

Source: GSMA Intelligence and World Bank

More indebted countries license spectrum at higher prices



The price metric considers average spectrum prices in coverage and capacity bands on a per-country basis over the period 2010–2019. It includes countries in Africa where there is at least one assignment with price information available in both coverage and capacity bands, and where there is debt data available.

16 "A welfare analysis of spectrum allocation policies" in RAND Journal of Economics, Hazlett & Muñoz, 2009

17 Spectrum pricing in developing countries: Evidence to support better and more affordable mobile services, GSMA, 2018

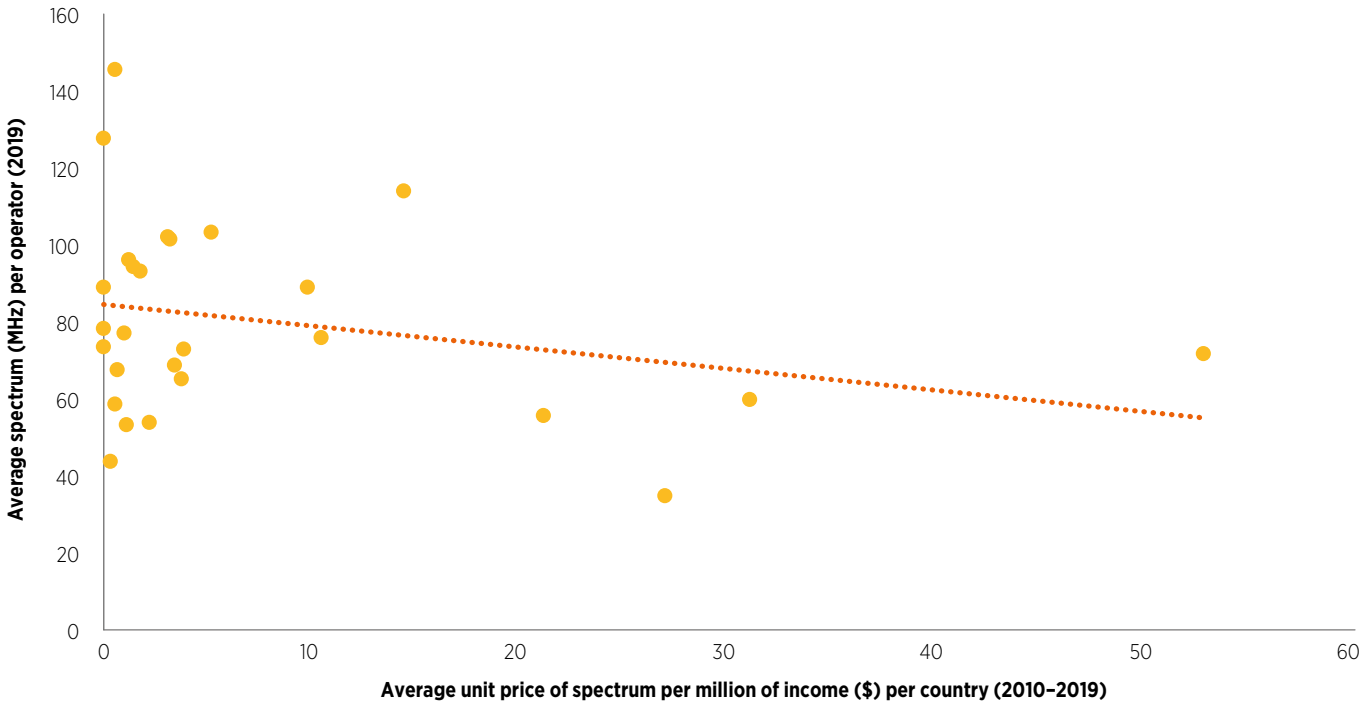
There are a number of ways in which government policies can, inadvertently or not, influence spectrum fees:

- Setting excessive reserve prices (i.e. the minimum price at which the government is prepared to license the spectrum).[18]
- Driving high spectrum prices through poor auction design – for example, limiting the possibility of price discovery, poorly planned lot sizes, or inflexible bidding rules and payment terms.[19]
- Inflating prices when assigning – for example, by directly setting upfront or high annual fees.
- Increasing auction prices by artificially creating scarcity and uncertainty. Governments can do this by restricting the supply of spectrum. As we have seen, less spectrum is available in Africa compared with the global average and other developing markets. Indeed, the data shows that the lower the amount of spectrum held per operator, the higher the unit prices of spectrum paid (see Figure 9). They can also create uncertainty regarding future awards by not committing to a spectrum roadmap or through a delayed or unclear licence renewal process. This introduces risks and uncertainties for operators, which can lead them to overbid for available spectrum.

FIGURE 9

Source: GSMA Intelligence

African countries where governments have licensed less spectrum have a higher average unit price of spectrum per income



The price metric considers average spectrum prices in coverage and capacity bands on a per-country basis over the period 2010–2019. It includes countries in Africa where there is at least one assignment with price information available in both coverage and capacity bands.

18 High reserve prices discourage participation. At best, they artificially increase the final price paid, which risks reduced network investment and higher consumer prices. At worst, they leave vital, in-demand spectrum unsold.

19 See a detailed discussion of auction formats and characteristics that may lead to increased prices in Spectrum pricing: GSMA Public Policy Position, GSMA, 2017

Recent research has found that high spectrum prices can have a causal effect in reducing the coverage and quality of mobile services in both developing and developed markets.[20] This is because spectrum fees raise the average cost of mobile services, reducing long-term returns on investment and weakening incentives to expand and upgrade mobile networks, negatively affecting coverage and network speeds for consumers.[21] Excessively high prices can also lead to unsold spectrum because operators' valuation of spectrum is below the reserve prices set by the government or regulator. In some African countries, such as Ghana, Senegal and Mozambique, digital dividend spectrum[22] has gone unsold in spectrum auctions due to excessively high reserve prices.

Furthermore, while spectrum fees typically comprise upfront fees, they can include additional costs such as annual fees. Although these should be set to cover the costs of regulators managing spectrum, annual fees are often above and beyond these. For example, regulators in Kenya and Gabon charge relatively high annual fees – and Gabon's fees have doubled since 2018. Moreover, spectrum licences may have obligations attached, such as minimum coverage levels, which have additional cost implications for operators.[23]

This chapter evaluates spectrum assignments from 2010 to 2019, in Africa and the rest of the world. In total, we analyse the prices of 96 assignments for Africa, and 428 assignments across the rest of the world, covering 28 and 82 countries, respectively.[24] Due to data availability and because upfront fees are often the largest component of spectrum costs, we focus on upfront spectrum fees across countries.

20 The impact of spectrum prices on consumers, GSMA, 2019

21 In particular, investment will negatively be impacted by spectrum fees through a variety of channels, including spectrum policy itself affecting operators' forward-looking costs and revenue, and the commercial strategies that they can adopt; or due to the intrinsic difficulties in predicting future costs and revenue in the mobile market, subject to constant innovation. See a more detailed discussion of the arguments in The impact of spectrum prices on consumers, GSMA, 2019

22 Digital dividend bands refer to spectrum in 700 and/or 800 MHz bands that becomes available once analogue television services are delivered digitally. This spectrum has propagation characteristics that make it suitable for achieving wider network coverage, which can help to connect the unconnected.

23 For example, network quality and coverage obligations.

24 See Appendix A1.3 for a description of the prices under analysis and the coverage of countries.

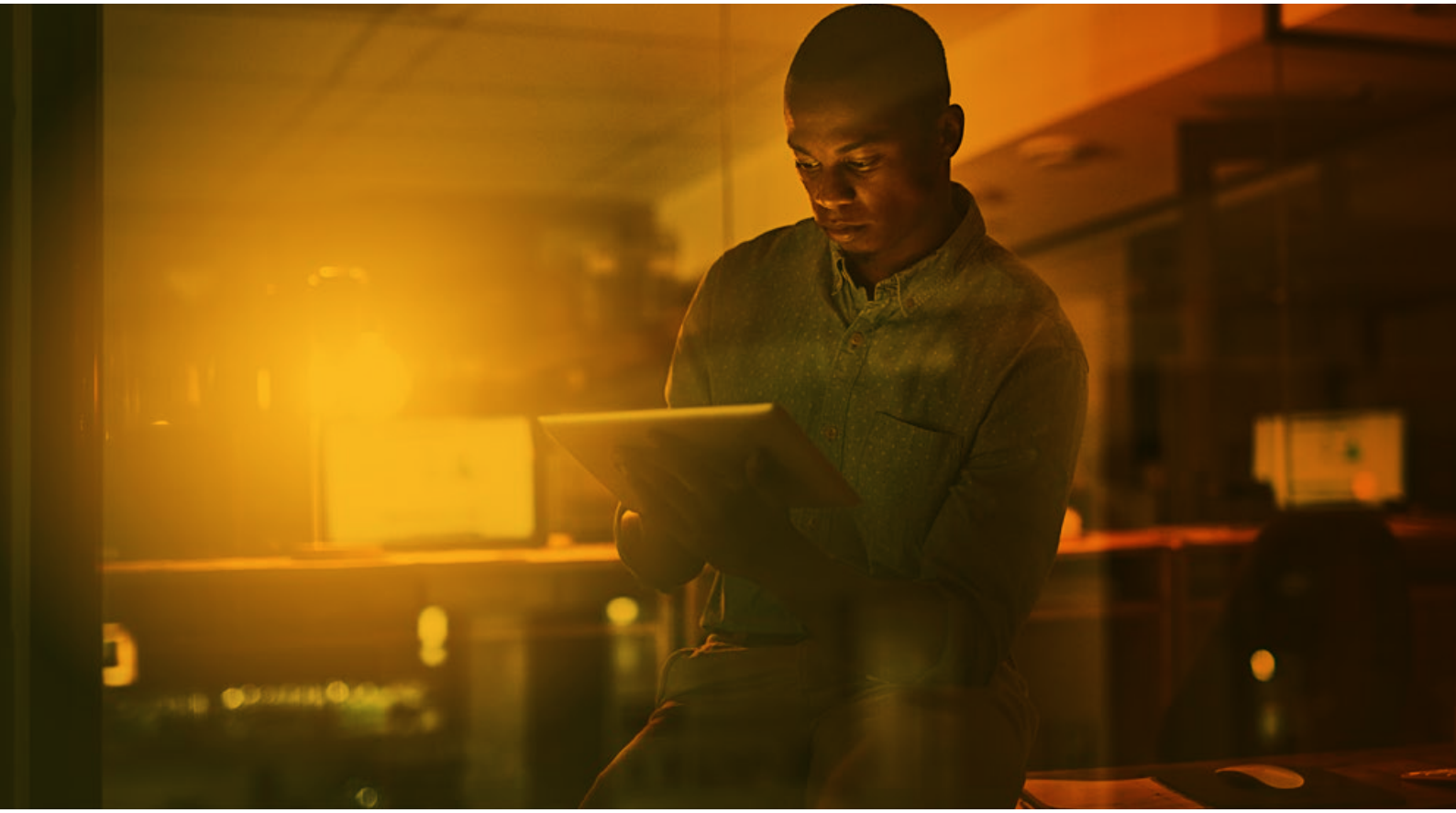
4.2 Spectrum prices in Africa are significantly higher than the rest of the world once income is taken into account

Taking income into account, the median spectrum price in Africa is four times higher than in the developed world and twice the global median

Figures 10 and 11 show median unit prices per population and per income, respectively, for the period 2010–2019.[25]

The unit price of spectrum per population is lower in Africa, compared to the benchmarks evaluated (Figure 10). This is not particularly surprising given the differences in incomes between Africa and the rest of the world – or the value of the markets in which mobile operators recoup their investments in spectrum. For example, Africa's average income per capita is $2,500 – less than half the average income per capita in other developing countries.

Accounting for the important differences in income across countries, the median price of African spectrum assignments over the 2010–2019 period was more than four times the median in developed markets; it was also twice the global median, and similar to other developing countries (see Figure 11). By band, it is notable that the price per unit of coverage spectrum was particularly high in Africa compared to the rest of the world, and a third higher relative to other developing countries. This may exacerbate the challenge of overcoming the coverage gap in the region.



25 The median represents the price in the "middle" if we were to sort a list of prices of every assignment. This is a suitable indicator because it allows for the comparison across regions to be less sensitive to very high spectrum prices, which some countries may have.

FIGURE 10

Source: GSMA Intelligence and World Bank

Median unit price of spectrum from 2010 to 2019, per population ($ PPP)

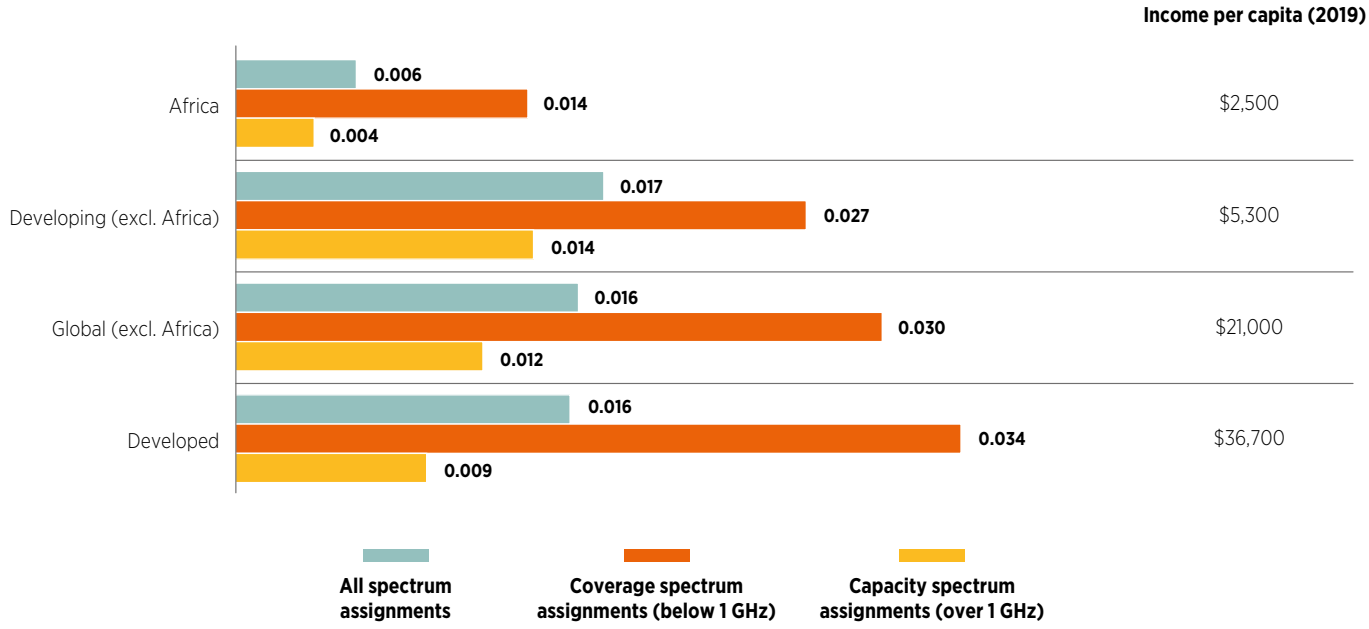
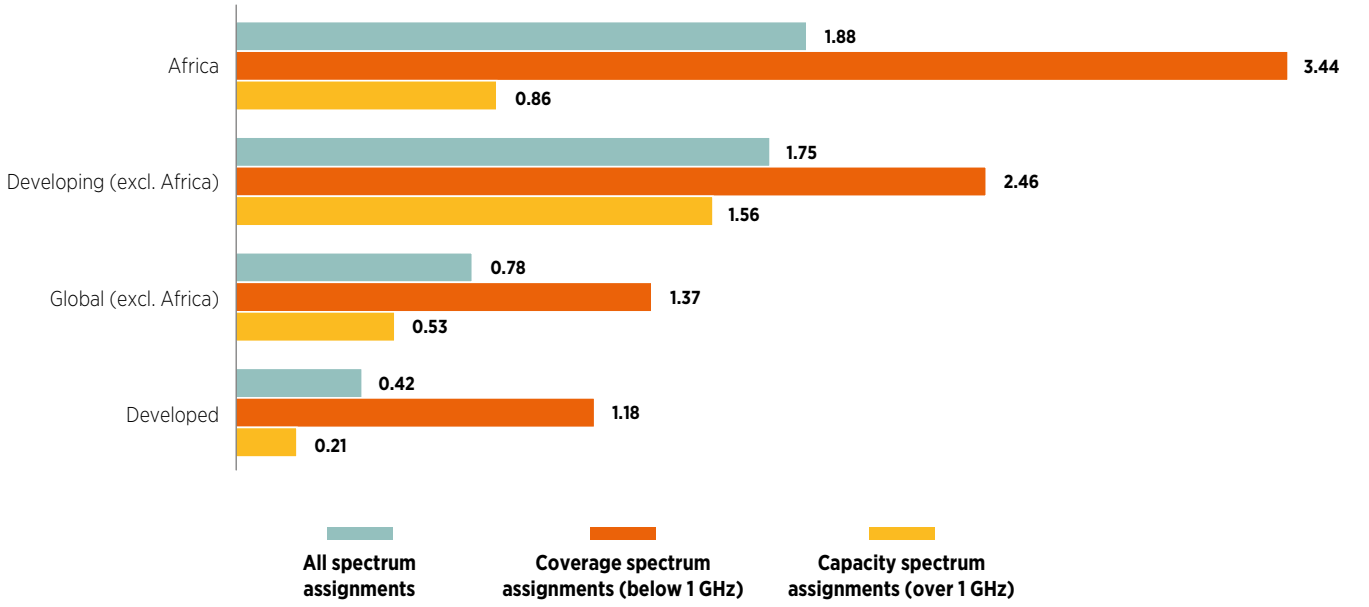


FIGURE 11

Source: GSMA Intelligence

Median unit price of spectrum from 2010 to 2019, per million of income ($)



The median is calculated among prices for all assignments available, from 2010 to 2019. In each year, each country may record multiple price observations due to assignments to different frequency bands.

Africa drives the largest proportion of spectrum price outliers globally: about half of all extremely high spectrum prices observed globally are from African awards

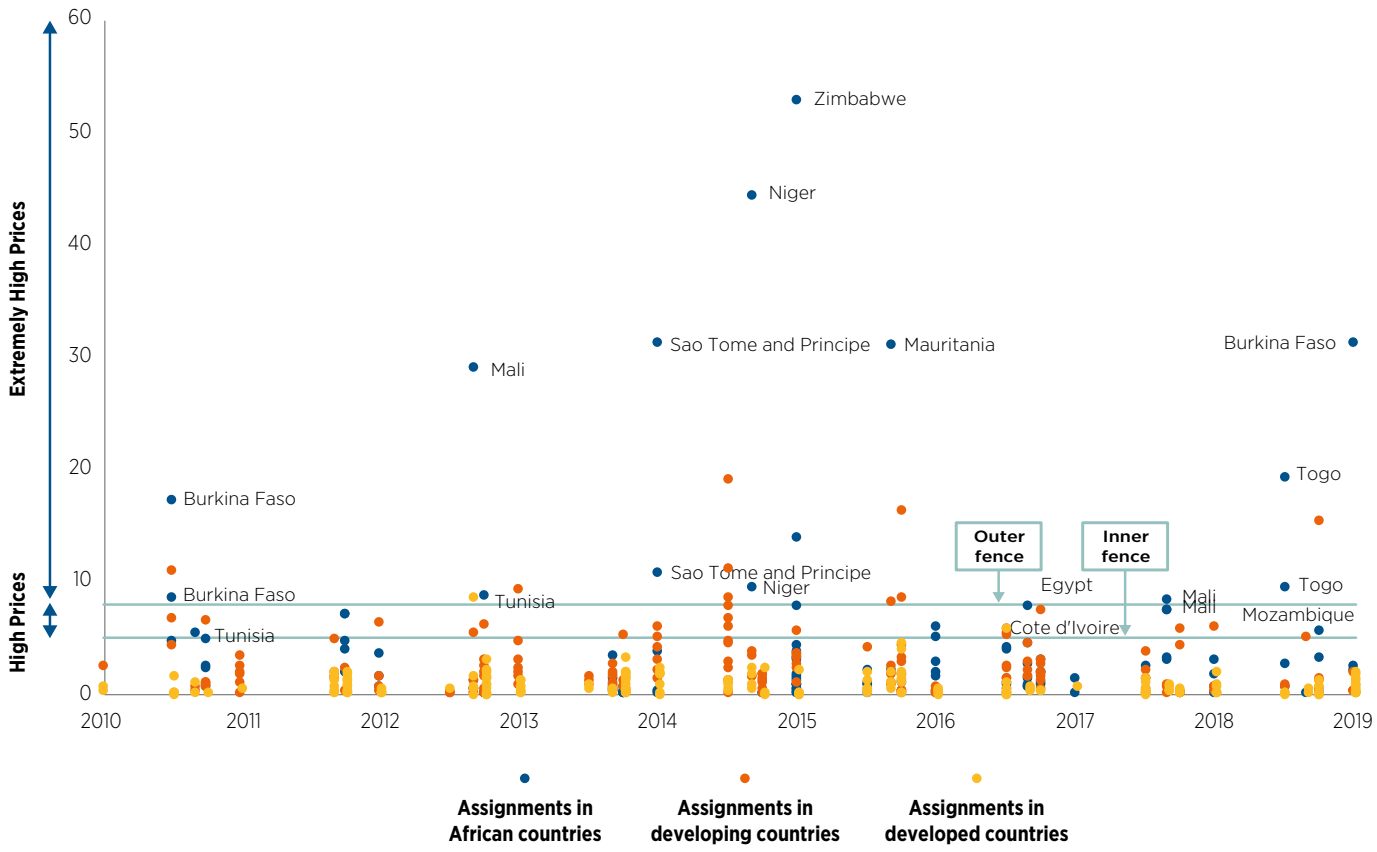
While the median price analysis provides a useful comparison between Africa and other benchmarks, there are many assignments that had especially high prices, suggesting that high price awards were more likely in Africa than the rest of the world. To evaluate to what extent African spectrum prices are especially high, outlier prices are identified above an inner fence, where we consider prices as 'high'. Above the outer fence, we consider prices as 'extremely high' relative to other assignments.

Adjusting for income, African spectrum assignments account for about half of all the extremely high spectrum prices.[26] Most of the high or extremely high prices per income are concentrated in Western and Northern Africa (16 of the 20 high or extremely high prices). In Figure 12, the countries with high or extremely high prices in Africa include Mali (4 assignments), Burkina Faso (3) and Niger, Tunisia, Togo and Sao Tome and Principe (2 each).

FIGURE 12

Source: GSMA Intelligence

Unit price of spectrum per million of income ($), for each individual spectrum assignment, 2010–2019



*The IQR is a statistical measure of data dispersion. The global outer fence frontier is calculated as 3rd quartile + 3*IQR. The global inner fence is calculated as 3rd quartile + 1.5*IQR. Each dot in the chart represents an individual spectrum assignment. Each country may have multiple dots at the same point in time due to assignments in different frequency bands.*

26 Adjusting by revenue, we also find that a significant portion of high or extremely high prices belong to African countries.

The average amount of spectrum assigned for mobile services globally (480 MHz) would cost annually more than 4 per cent of market revenue in 10 African countries

So far, we have evaluated prices for one unit of spectrum. However, what would be the total upfront fees associated with acquiring a fixed amount of spectrum across countries? In our dataset, by the end of 2019, the average amount of spectrum assigned per country globally was 480 MHz – 370 MHz in bands over 1 GHz, and 110 MHz in frequencies below.

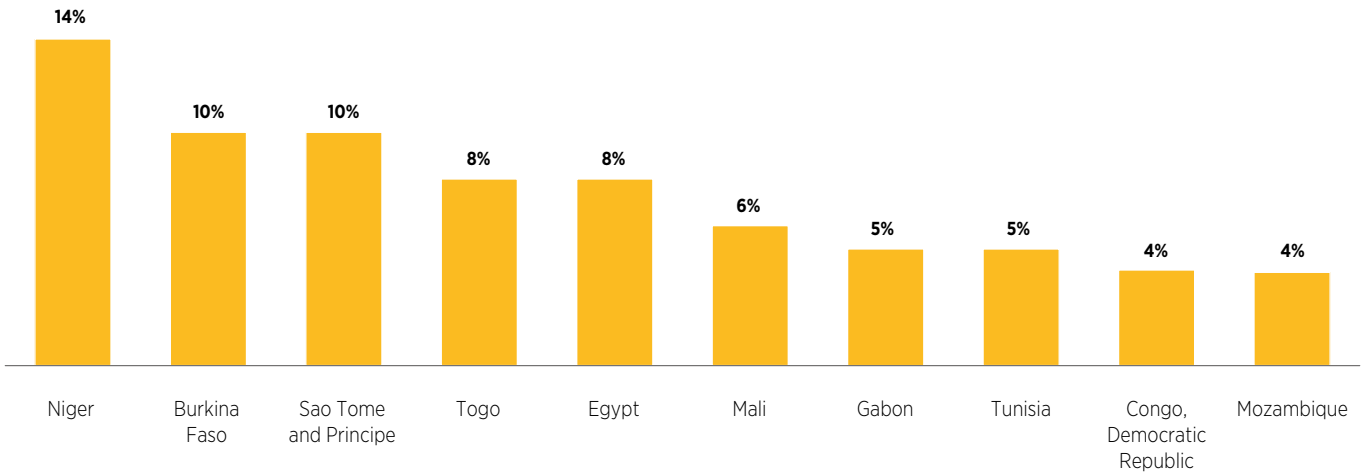
Based on the unit prices paid in each country (for low and high bands, during 2010–2019), we estimate that acquiring 480 MHz of spectrum would cost more than 4 per cent of market revenues in 10 countries.

Figure 13 shows the results by country. Niger has the highest price of spectrum and some of the lowest levels of mobile broadband coverage, network speeds and mobile adoption on the continent.

FIGURE 13

Source: GSMA Intelligence

Annual cost of 480 MHz of spectrum, as a percentage of market revenue, in top 10 most unaffordable markets



Considers average price of spectrum in low and high bands, per country, available over the period 2010–2019.

5. Impacts on consumers and the mobile market

Previous chapters show that governments in Africa awarded approximately half the amount of spectrum compared to the global average, and 70–80 per cent of the spectrum assigned in other developing countries – and that awards typically occurred three years later than the global average. Furthermore, the spectrum pricing analysis shows that the unit price per income in Africa is four times the price in the developed world, twice the global median, and similar to other developing countries. In fact, the African continent accounts for half of all high or extremely high spectrum prices observed worldwide from 2010 to 2019.

With African governments assigning less spectrum at a later date, and at higher prices, here we evaluate the impacts these policy choices have on consumers. Section 5.1 looks at how the amounts and timings of spectrum assignments relate to coverage, speeds and overall mobile adoption. Section 5.2 analyses how spectrum prices relate to the coverage, speeds and adoption for consumers.

5.1 Timely assignments of significant amounts of spectrum are strongly linked to greater population coverage, download speeds and adoption

In Africa, governments that licensed more spectrum facilitated wider mobile broadband coverage

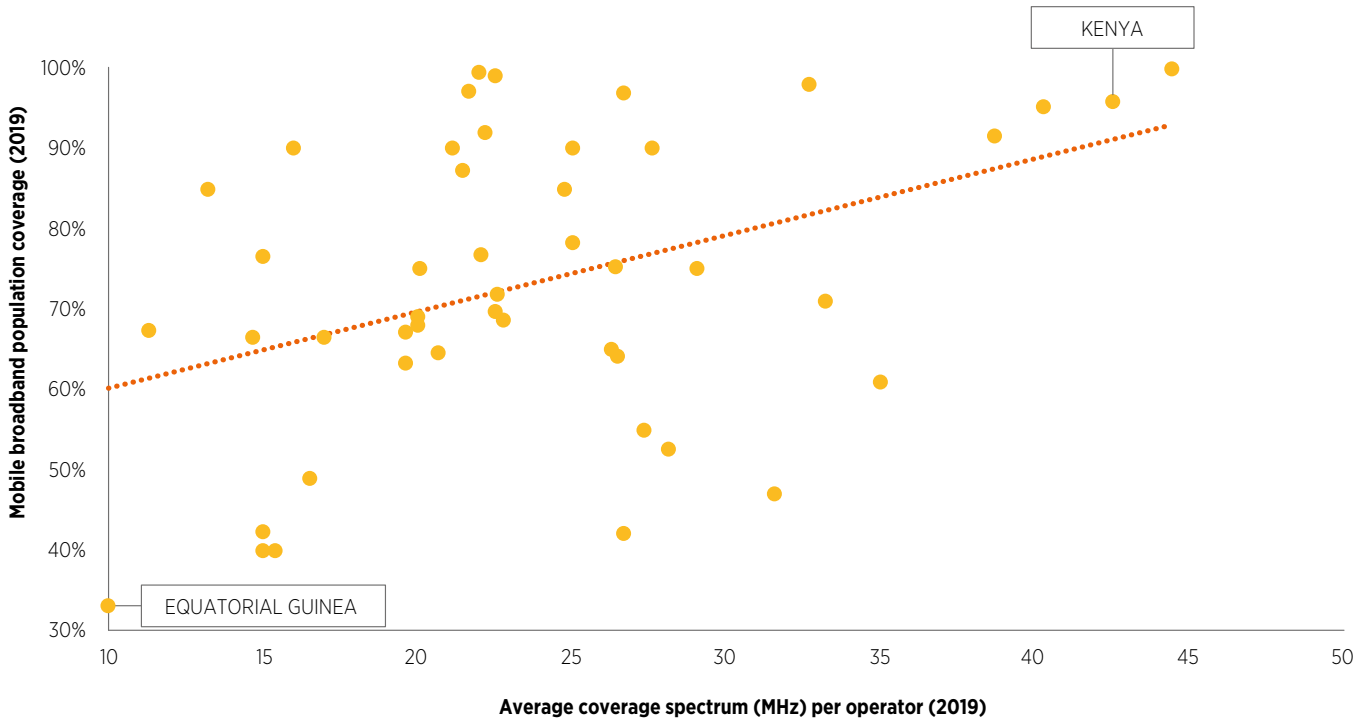
Access to spectrum holdings (especially in the coverage bands) means operators are able to achieve higher coverage levels and lower network rollout costs, particularly in rural areas.

African countries whose governments assigned more spectrum in the coverage bands tend to have higher levels of mobile broadband coverage (see Figure 14). For example, Kenya has assigned one of the highest amounts of coverage spectrum per operator in Africa, and its mobile broadband has reached close to 90 per cent population coverage. Meanwhile, Equatorial Guinea has the lowest amount of coverage spectrum and relatively low mobile broadband coverage.

FIGURE 14

Source: GSMA Intelligence

The greater amount of coverage spectrum assigned, the higher broadband coverage across African countries



Spectrum per operator includes assignments below 3.7 GHz and excludes 5G-specific licences.

A direct link exists between greater amounts of spectrum assigned and faster network speeds

Larger amounts of spectrum assigned allow operators to build more capacity into their networks with the same level of infrastructure investment. This allows users of mobile services to experience improved quality of service, including faster upload and download speeds.

Figure 15 shows that African countries where governments licensed more capacity spectrum (above 1 GHz) per operator also have higher average download speeds.

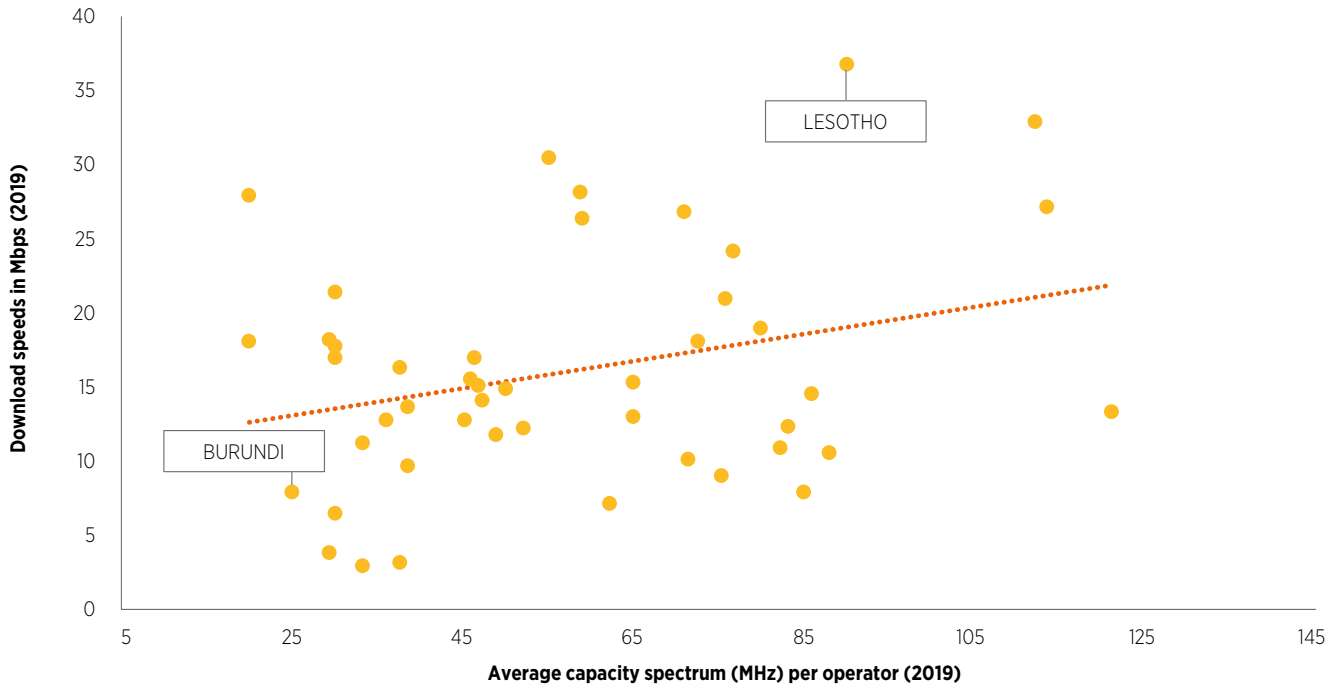
Burundi has one of the lowest assignments of capacity spectrum per operator and is among the countries with slower networks.

Lesotho, on the other hand, has one of the highest amounts of capacity spectrum per operator and one of the fastest networks. While this analysis excludes 5G, the early 5G assignments in the 3.5 GHz band in this country are a sign appropriate spectrum policy continues into the 5G era.

FIGURE 15

Source: GSMA Intelligence analysis, based on Speedtest Intelligence® data provided by Ookla®

The greater the amount of capacity spectrum, the faster the download speeds, across Africa



Spectrum per operator includes assignments below 3.7 GHz and excludes 5G-specific licences.

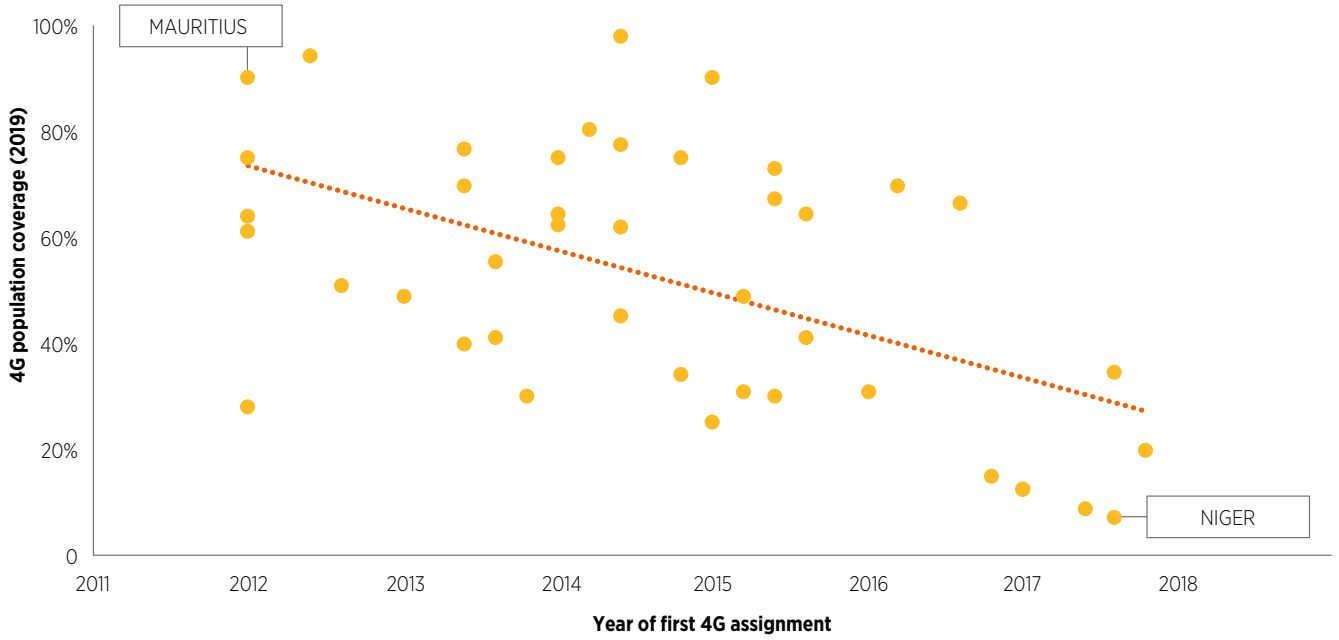
Timely assignment of spectrum by governments allows mobile operators to expand coverage more rapidly

Across countries in Africa, the earlier spectrum is licensed, the greater the population coverage achieved by mobile operators (see Figure 16). As discussed above, this is linked to the time and complexities involved in the deployment of network infrastructure. As an example, Mauritius was among the first countries to license 4G spectrum and today has one of highest 4G population coverage levels (close to 90 per cent). Meanwhile, in countries that have released 4G spectrum recently, such as Niger, 4G coverage is below 20 per cent.

FIGURE 16

Source: GSMA Intelligence

The earlier 4G spectrum is licensed, the higher the 4G coverage



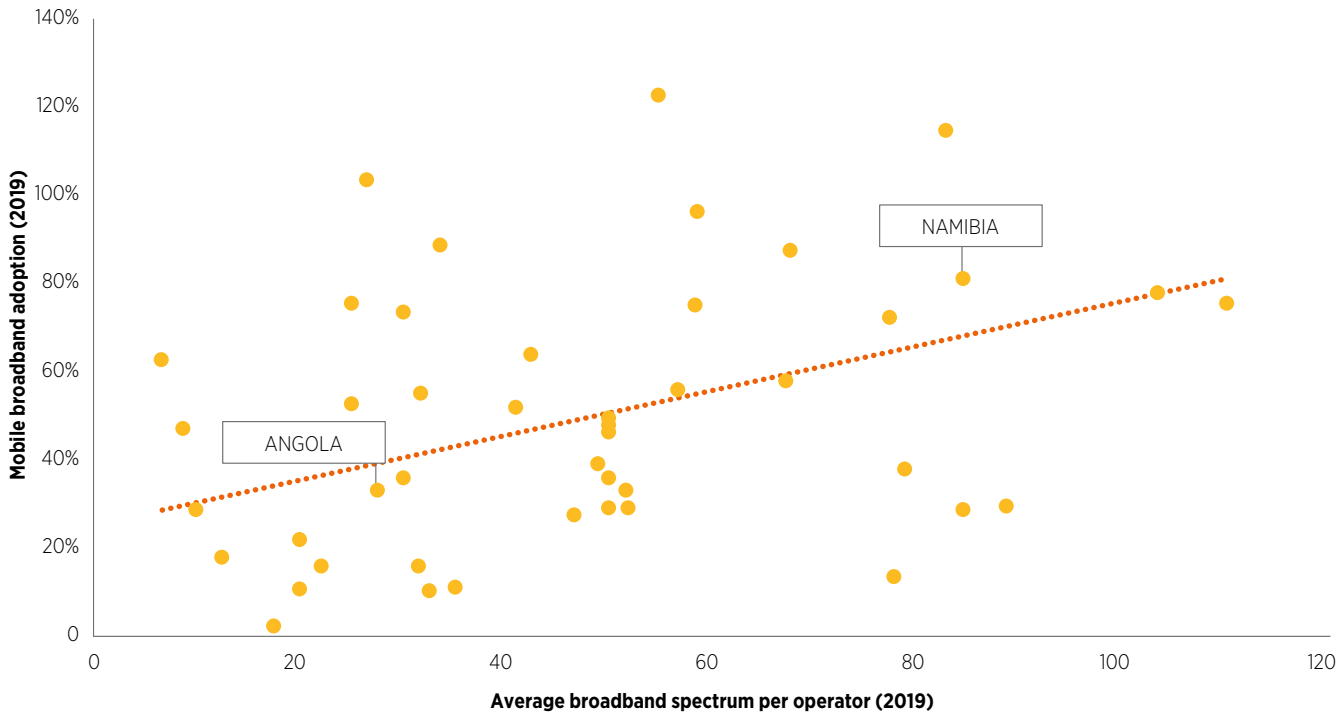
African countries where governments have licensed more mobile broadband spectrum have greater mobile broadband adoption

Licensing more spectrum is also linked to greater consumer adoption of mobile broadband (use of 3G and 4G). Figure 17 shows that countries with more spectrum assigned have higher rates of mobile broadband adoption and are therefore better placed to drive the economy-wide benefits of mobile and digital technologies. Countries with higher amounts of overall broadband spectrum, such as Namibia, have also achieved higher adoption relative to markets with lower overall broadband spectrum, such as Angola, which tend to have lower adoption.

FIGURE 17

Source: GSMA Intelligence

African countries where governments have licensed a larger amount of broadband spectrum have greater mobile broadband adoption



Mobile broadband adoption includes 3G and 4G connections. Spectrum per operator includes assignments below 3.7 GHz and excludes 5G-specific licences.

5.2 High spectrum prices are strongly linked to reduced coverage, download speeds and mobile broadband adoption

Countries with lower spectrum prices have achieved wider population coverage and faster speeds

Higher spectrum prices can impact a mobile operator's return on investment, therefore weakening incentives to invest. Excessive spectrum prices may lead to unsold spectrum (i.e. unused capacity). This can lead to less investment in infrastructure or less spectrum for mobile services, with consumers negatively impacted by lower coverage and network quality.

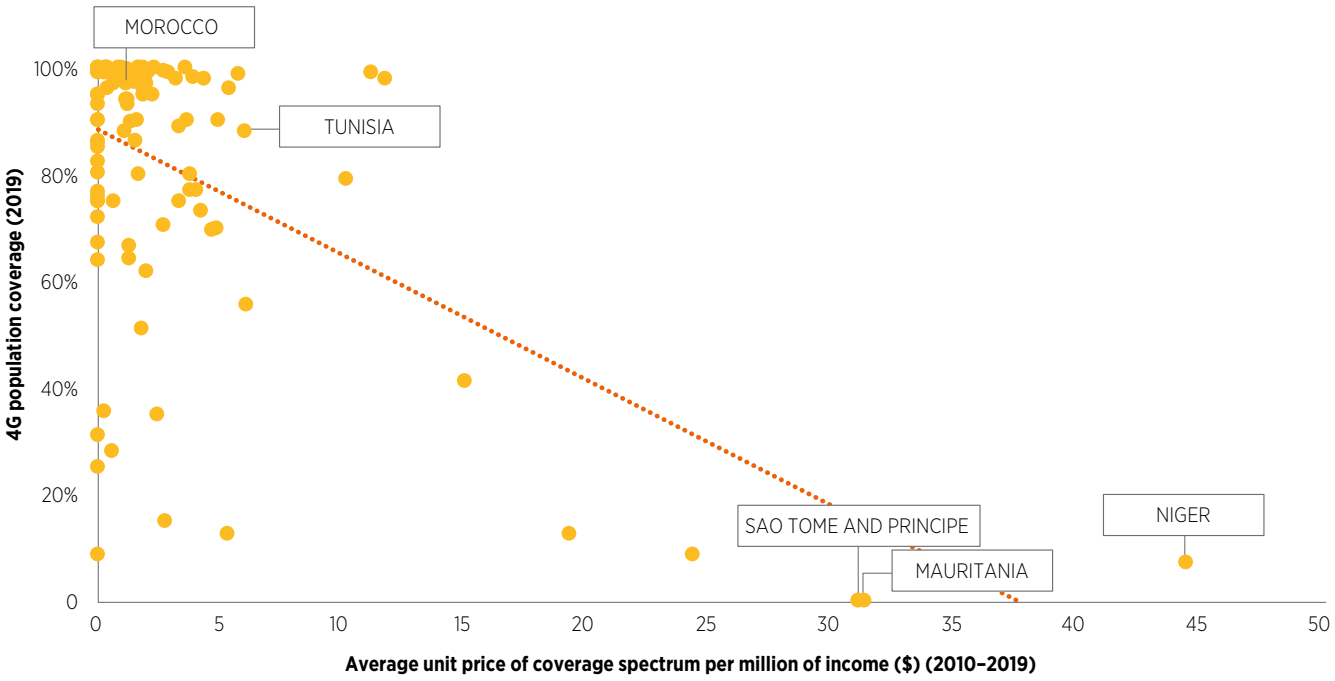
Earlier in this report, we show that Africa has a substantial 'coverage gap' (Chapter 2) and particularly high spectrum prices for coverage spectrum (Chapter 4). Figure 18 shows how coverage and coverage spectrum prices vary across countries in Africa and the rest of the world. The analysis shows that coverage is lower in countries where spectrum prices are higher, suggesting that the higher spectrum prices may be playing a role in driving lower coverage. Further, Figure 19 shows that high spectrum prices not only relate to lower coverage but also slower network speeds.

Across countries in Africa, we find that Morocco and Tunisia have lower spectrum prices for coverage spectrum and relatively higher coverage, and have among the fastest networks on the continent. Meanwhile, Mauritania, Niger and Sao Tome and Principe have some of the highest spectrum prices, and as a result have lower coverage levels and slower download speeds.

FIGURE 18

Source: GSMA Intelligence

The higher the average unit price of coverage spectrum per income, the lower the 4G coverage across African countries

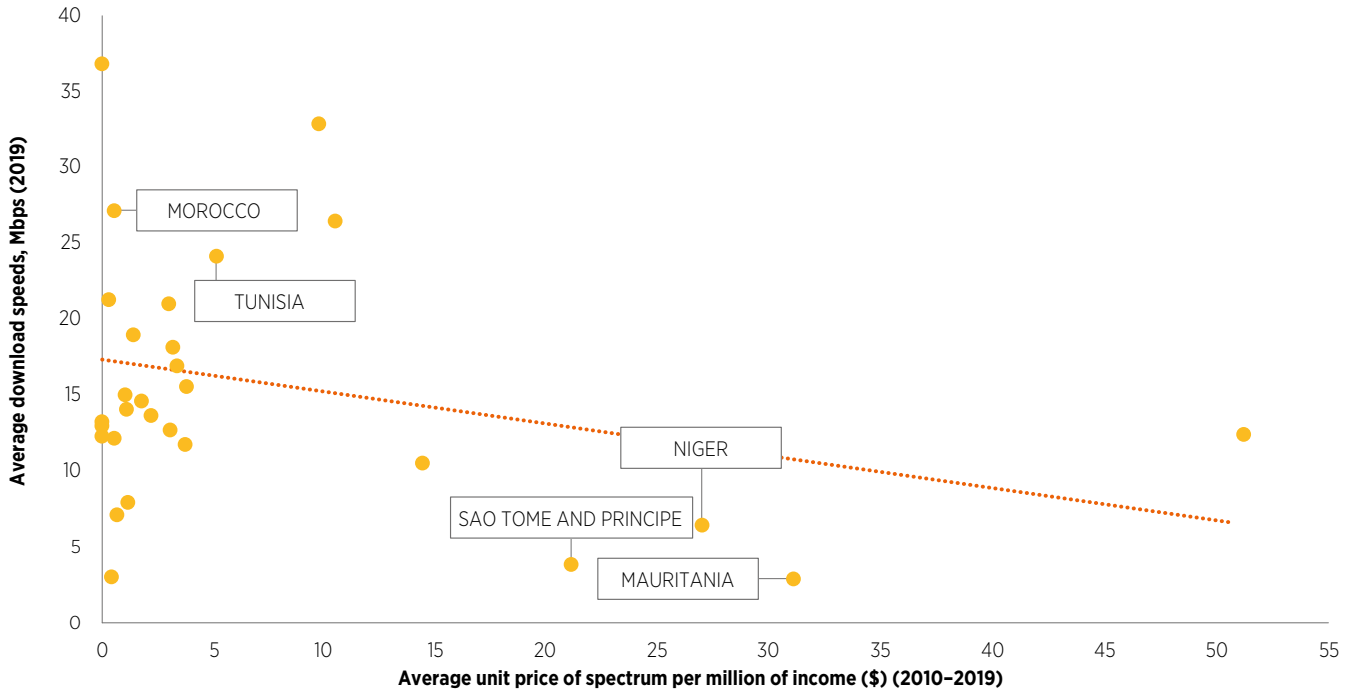


The price metric considers average prices of coverage and capacity spectrum, per country, available over the period 2010–2019.

FIGURE 19

Source: GSMA Intelligence analysis, based on Speedtest Intelligence® data provided by Ookla®

The lower the unit price of spectrum per income, the faster the download speeds



The price metric considers average prices of coverage and capacity spectrum, per country, available over the period 2010–2019.

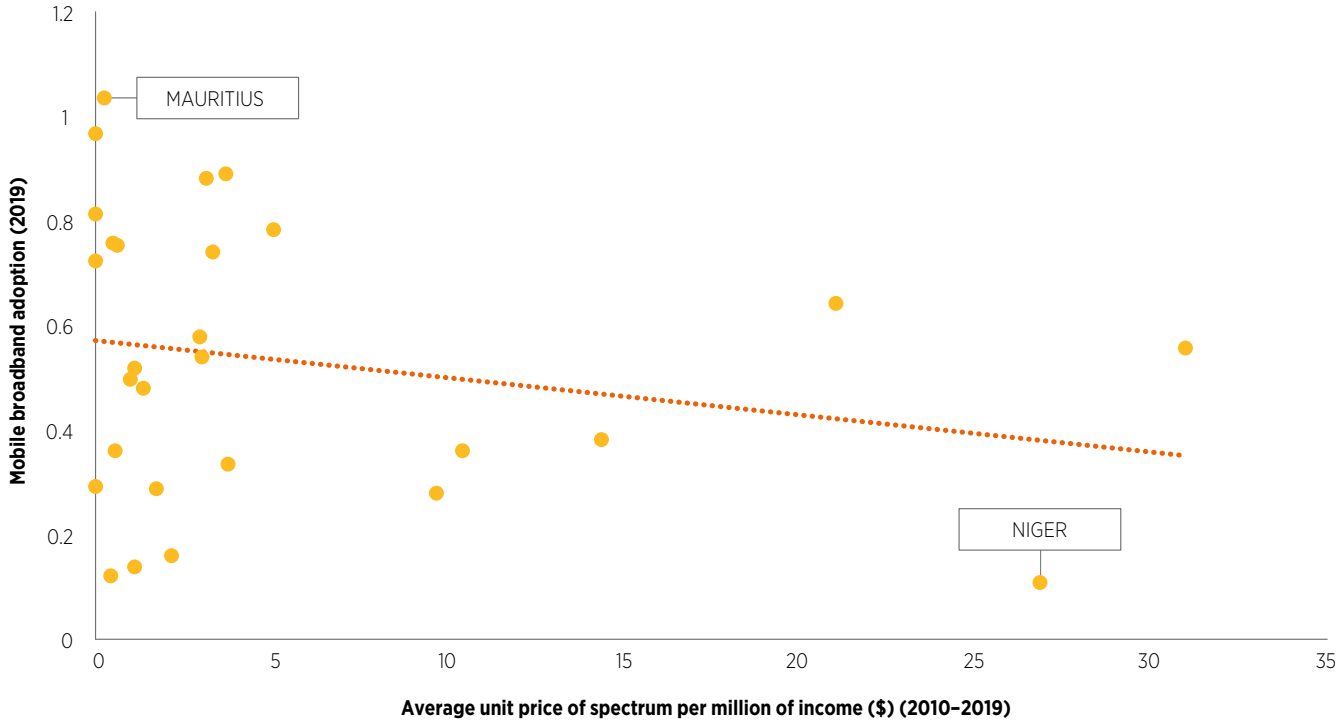
Markets with lower spectrum prices have higher levels of mobile broadband adoption

Countries with lower spectrum prices do not only tend to have mobile networks with more coverage and faster speeds; they also tend to have greater mobile broadband adoption (see Figure 20).

FIGURE 20

Source: GSMA Intelligence

The lower the unit price of spectrum per income, the greater the mobile broadband adoption



Mobile broadband adoption includes 3G and 4G connections. The price metric considers average prices of coverage and capacity spectrum, per country, available over the period 2010–2019.

6. Conclusions and policy recommendations

This study shows that governments in Africa have licensed approximately half the amount of spectrum compared to the global average. They have also done so later and at less affordable prices. This has had negative consequences for consumers, in terms of lower mobile broadband coverage, speeds and user adoption. These findings have clear policy implications that can help inform the digital agenda in Africa.

African governments should release more spectrum, to expand coverage, improve network quality and encourage mobile adoption

More spectrum is required to help Africa maximise the socioeconomic benefits from high-quality digital connectivity. Assigning sufficient spectrum is particularly necessary in the context of growing consumer demand for mobile data services and new technologies. Some countries in the region, such as Nigeria, have fully assigned spectrum in most bands available for mobile services, therefore encouraging development of mobile services.[27] Governments in other countries, such as South Africa, still have much spectrum to be assigned.

Spectrum is required in bands both for coverage and capacity. Governments should assign spectrum that is left over for use in the 900, 1800 and 2100 MHz bands, and further assign spectrum that facilitates 4G coverage expansion, including digital dividend spectrum (700 and 800 MHz bands), as well as capacity spectrum (2300 and 2600 MHz bands). Authorities should also plan to allocate mmWave spectrum, which will be required for 5G.

To realise the full potential of mobile services, authorities should license spectrum in a timely manner, provide certainty and allow for technological neutrality

To facilitate faster and wider mobile network deployment, regulators should aim to license spectrum as soon as operators have a business case to use it. This ensures the amount of available mobile spectrum keeps pace with demand and that network investment is optimised, leading to higher quality services. A good example in the region is Mauritius, which was among the first to assign 4G, and today has achieved one of the highest 4G coverage rates on the continent.

Governments can also facilitate the expansion and improvement of networks by providing operators with certainty over assignments. Providing long licence durations and guaranteeing renewals are two important aspects. Moreover, authorities should give operators the flexibility to manage spectrum, with technology-neutral licences, so they can optimise the use of each band, in the context of the totality of their spectrum holdings. Many countries have issued technology-neutral licences, including Gabon, Lesotho, Morocco, Namibia, Nigeria, South Africa, Tanzania, Tunisia and Uganda.

27 In Nigeria, the 800, 900, 1800, 2100 and 2300 MHz bands are fully assigned to mobile services. This is also the case for the 700 MHz bands, albeit with some spectrum allocated to the military.

Expensive spectrum is detrimental for consumers; governments should ensure policies support affordable spectrum pricing

Governments should ensure spectrum policy supports affordable spectrum pricing, prioritising improved mobile broadband services over short-term government revenue maximisation. Allowing the market to set the price, through an auction, is an efficient way to assign spectrum. However, for auctions to result in an efficient outcome, they need to be well-designed with clear rules and guidelines. Policymakers should consider the following:

- Set modest reserve prices and annual fees. High reserve prices discourage participation. At best, they artificially increase the final price paid, which risks reduced network investment; at worst, they leave vital, in-demand spectrum unsold. In Africa, there are several examples of spectrum being unsold due to high reserve prices, including Ghana (2016: 800 MHz band), Senegal (2016: 700, 800 and 1800 MHz bands), Mozambique (2013: 800 MHz band).
- Avoid creating artificial scarcity, through insufficient spectrum supply or unclear licencing plans. When insufficient spectrum is available to meet demand, or when the timing of future awards is uncertain, operators can be forced to pay excessively. A long-term spectrum roadmap provides the clarity and certainty needed for investment.
- Avoid auction formats that inflate spectrum prices and ensure appropriate spectrum lots. Auction formats should not limit price discovery; otherwise, operators are forced to bid blindly and risk overpaying or not obtaining spectrum. The size of spectrum lots should be carefully planned too, to ensure operators do not risk failing to win enough spectrum to support their customers. Spectrum bidding rules and payments terms should also be flexible.

Appendix 1. Spectrum data

A1.1 Spectrum holdings

a) General approach

Spectrum data was obtained from GSMA Intelligence's Spectrum Navigator. The analysis focused on licences of spectrum for mobile services,[28] other than 5G, and in bands below 3.7 GHz,[29] assigned to mobile operators and for national coverage.[30] For each spectrum assignment available, the analysis considered:

- amount of MHz assigned[31]
- assignment date
- duration of the licence
- frequency band of the licence.

For each country for the period 2010–2019, we estimated the total amount of MHz by considering the licences that were active at each point in time, taking into account the MHz assigned, the date of assignment and licence duration. To do so, the analysis included spectrum holdings from licences starting before 2010, where the licence was active for the relevant years of analysis: 2010–2019 (in some countries, this included spectrum licences starting in the 1990s).

Results shown in this report focus on a set of countries where there was enough information on spectrum assignments, following a screening process. We included countries where spectrum assignments were available for at least 70 per cent of the bands where mobile operators have launched mobile services[32], sourced from GSMA Intelligence. Carrying out this analysis for spectrum assignments and bands with launched networks by 2019 led to the sample of countries used for the 2019 statistics. To establish the sample of countries for the time series trends, we separately considered the spectrum assignments and bands with networks launched by 2013, and restricted the sample to countries where we had completion of bands over 70 per cent, for 2013 and 2019.

To estimate total country spectrum holdings, in cases where the percentage of bands with spectrum assignments information was between 70 per cent and 100 per cent, the results from the holdings calculations were escalated proportionally. With the total amounts of spectrum holdings per country, we then calculated spectrum per operator, considering the number of operators active in the country.[33]

28 We exclude FWA and WiMax licences.

29 This excludes mmWave spectrum and 5G spectrum in high bands. Pricing for this type of spectrum, primarily allocated in developed countries, has been at significantly lower fees. Excluding this allows for a less biased comparison between Africa, developing and developed countries.

30 We exclude licences for regional coverage.

31 We consider the total MHz of the assignment. For example, for a 2x15 MHz assignment, we consider a total of 30 MHz.

32 This 70 per cent completion rate is weighted by the market shares of the operators within a given market.

33 Mobile operators with more than 3 per cent of mobile connections market share.

b) Spectrum holdings by technology

We classified spectrum licences by 2G, 3G or 4G technology based on two sources:

- Where it was specified and available, we considered the mobile technology established in licence conditions. Where an assignment was specified as technology-neutral, we considered spectrum assignments in that band as belonging to 2G, 3G and 4G at the same time (without splitting the MHz amount). Similarly, if the licence conditions established the possibility of the use of two technologies, we counted spectrum holdings as belonging to these two.
- Where licence conditions did not specify a technology, we considered the technologies used by the relevant operator, in the frequency band of the licence, in the relevant year of the time series. The latter were sourced from GSMA intelligence. Where there are multiple technologies in place, we have counted spectrum assignments in that band as belonging to all technologies.

c) Sample of countries

Overall, the analysis for spectrum holdings includes 49 countries in Africa, for the 2019 holdings estimates, and 43 markets for the time series analysis (see Figure 21). Note that the classifications of Northern, Southern, Central, Western and Eastern Africa have been based on economic regions.[34] Countries not belonging to economic unions have been classified following the equivalent geographic classifications.

FIGURE 21

Source: GSMA Intelligence

Sample of countries for spectrum holdings analysis – Africa

✓ Indicates complete countries, as discussed in Appendix A1.1 section a).

Country	2019	Time series
Central Africa		
Cameroon	✓	✓
Chad	✓	✓
Congo	✓	
DRC	✓	✓
Equatorial Guinea	✓	✓
Sao Tome and Principe	✓	✓
Eastern Africa		
Burundi	✓	
Eritrea	✓	✓
Kenya	✓	✓
Somalia	✓	✓
South Sudan	✓	
Tanzania	✓	✓
Uganda	✓	✓

Country	2019	Time series
Northern Africa		
Algeria	✓	✓
Egypt	✓	✓
Libya	✓	✓
Mauritania	✓	✓
Morocco	✓	✓
Sudan	✓	✓
Tunisia	✓	✓

34 Southern Africa Development Community, Bank of Central African States, Central Bank of West African States and East African Community.

FIGURE 21 (cont.)

Source: GSMA Intelligence

Sample of countries for spectrum holdings analysis – Africa

✓ Indicates complete countries, as discussed in Appendix A1.1 section a).

Country	2019	Time series
Southern Africa		
Angola	✓	✓
Botswana	✓	✓
Comoros	✓	✓
Eswatini	✓	✓
Lesotho	✓	✓
Madagascar	✓	✓
Malawi	✓	
Mauritius	✓	✓
Mozambique	✓	✓
Namibia	✓	✓
Seychelles	✓	✓
South Africa	✓	✓
Zambia	✓	✓
Zimbabwe	✓	✓

Country	2019	Time series
Western Africa		
Benin	✓	✓
Burkina Faso	✓	✓
Cabo Verde	✓	✓
Cote d'Ivoire	✓	✓
Gambia	✓	✓
Ghana	✓	✓
Guinea	✓	✓
Guinea-Bissau	✓	✓
Liberia	✓	✓
Mali	✓	✓
Niger	✓	✓
Nigeria	✓	✓
Senegal	✓	
Sierra Leone	✓	
Togo	✓	✓

The developing (excluding Africa), global (excluding Africa) and developed benchmarks include the countries shown in Figure 22.[35] For the developing (excluding Africa) benchmark we include a set of 35 markets for 2019 holdings estimates, of which 20 are considered for the time series analysis. The group of developed economies includes 44 countries for 2019, of which 38 are considered for the time series.

35 Note: country classifications for developed markets are based on the World Bank's "High income" category. The rest of the countries are regarded as developing.

FIGURE 22

Source: GSMA Intelligence

Sample of countries for spectrum holdings analysis – developing and developed benchmarks

✓ Indicates complete countries, as discussed in Appendix A1.1 section a).

Country	2019	Time series
Developing countries (excl. Africa)		
Afghanistan	✓	✓
Albania	✓	✓
Argentina	✓	
Bangladesh	✓	✓
Belarus	✓	
Bolivia	✓	✓
Bosnia and Herzegovina	✓	✓
Brazil	✓	
Bulgaria	✓	✓
Colombia	✓	
Costa Rica	✓	
Ecuador	✓	
El Salvador	✓	✓
Georgia	✓	
Indonesia	✓	
Iraq	✓	✓
Jordan	✓	✓
Kosovo	✓	
Lebanon	✓	✓
Malaysia	✓	
Mexico	✓	
Moldova	✓	✓
Mongolia	✓	✓
Montenegro	✓	✓
Nepal	✓	
North Macedonia	✓	
Pakistan	✓	✓

Country	2019	Time series
Developed countries		
Antigua and Barbuda	✓	✓
Austria	✓	✓
Bahamas	✓	
Bahrain	✓	✓
Belgium	✓	✓
Chile	✓	
Croatia	✓	✓
Czechia	✓	✓
Denmark	✓	✓
Estonia	✓	✓
France	✓	✓
Germany	✓	✓
Greece	✓	✓
Hong Kong	✓	
Hungary	✓	✓
Iceland	✓	✓
Ireland	✓	✓
Italy	✓	✓
Japan	✓	✓
Korea, South	✓	✓
Latvia	✓	✓
Liechtenstein	✓	
Lithuania	✓	✓
Luxembourg	✓	✓
Malta	✓	✓
Netherlands	✓	✓
New Zealand	✓	✓

FIGURE 22 (cont.)

Source: GSMA Intelligence

Sample of countries for spectrum holdings analysis – developing and developed benchmarks

✓ Indicates complete countries, as discussed in Appendix A1.1 section a).

Country	2019	Time series
Developing countries (excl. Africa)		
Papua New Guinea	✓	✓
Peru	✓	✓
Philippines	✓	✓
Serbia	✓	✓
Syria	✓	✓
Turkey	✓	
Ukraine	✓	✓
Vietnam	✓	✓

Country	2019	Time series
Developed countries		
Oman	✓	✓
Panama	✓	✓
Poland	✓	✓
Portugal	✓	✓
Qatar	✓	✓
Romania	✓	✓
Saudi Arabia	✓	✓
Singapore	✓	✓
Slovakia	✓	✓
Slovenia	✓	✓
Spain	✓	✓
Sweden	✓	✓
Switzerland	✓	✓
Taiwan	✓	
Trinidad and Tobago	✓	✓
United Arab Emirates	✓	✓
United Kingdom	✓	✓
Uruguay	✓	

Note: country classifications for developed markets are based on the World Bank's "High income" category. The rest of the countries are regarded as developing.

A1.2 Spectrum timings

a) General approach

The first dates of 3G or 4G spectrum assignments were sourced from the dates of assignment as per GSMA's Spectrum Navigator. In countries where dates of assignments were not comprehensive, we used the first date when mobile operators started recording mobile connections in 3G and 4G technologies, sourced from GSMA Intelligence. For the purposes of calculating regional averages of the first 3G and 4G spectrum assignments, countries that have not yet launched 3G or 4G mobile services were assumed to have launched networks in 2020.[36] Using this assumption means that we understate the lag of Africa in this analysis.

b) Sample of countries

The analysis considered countries that we regarded as having sufficient spectrum holdings data for 2019, as set out in Appendix A1.1

A1.3 Spectrum pricing

a) General approach

The analysis of spectrum prices focused on one-off prices, during 2008–2020, obtained from the GSMA Intelligence Spectrum Navigator. Assignments with pricing information available covered a sub-sample of the larger set of spectrum assignments used for the spectrum holdings data (described in Appendix A1.1). For each spectrum licence, we considered the one-off price of spectrum, MHz assigned, duration, frequency band and date.

The analysis considered prices for new spectrum assignments during 2008–2020 (either active or expired as of today), as well as prices paid for licence renewals. The analysis considered licences for mobile services,[37] other than 5G, on bands below 3.7 GHz, assigned to mobile operators and for national coverage.[38]

b) Metrics calculation

Unit price per spectrum

The unit price of spectrum per income is the one-off price as a percentage of income, adjusting for licence duration and the amount of MHz assigned.[39] This metric defines the relative cost of spectrum price considering the incomes of consumers, and hence the potential demand for mobile services. This therefore measures the potential or addressable market for the operator obtaining spectrum.

The unit price metric was calculated per assignment year and frequency band, per country. For example, where multiple operators obtained spectrum in the same assignment year and frequency band, we aggregated the prices paid by operators, and the MHz obtained by all entities.[40] In the case of assignments where operators obtained spectrum in multiple frequency bands, for a given one-off price, the price was split (i.e. with an unbundled price for spectrum in each band) on the basis of the amount of MHz per band and the propagation characteristics of each band.

36 In Africa, 3G has not been yet launched in Eritrea. 4G has not been launched in Equatorial Guinea and Sao Tome and Principe, Eritrea, South Sudan and Mauritania.

37 We exclude FWA and WiMax licences.

38 We exclude licences for regional coverage.

39 The unit price as a percentage of income can be alternatively considered as a percentage of a country's income, or as a share of income per capita (i.e. the unit price per person as a percentage of income per capita is mathematically equivalent to the unit price as a percentage of income).

40 Where operators obtained spectrum with different licence durations, this has been taken into account calculating a weighted average licence duration, based on the MHz obtained by each operator.

Annual cost of 480 MHz of spectrum

The analysis considered countries where there was pricing available for at least one spectrum assignment, in bands for coverage and capacity (for Africa, this is 19 countries). We considered the average unit price of spectrum observed in coverage and capacity bands, and multiplied by the amounts of coverage and capacity spectrum (110 and 370 MHz, respectively). The annual cost was calculated by dividing this by 15 years, which is the average licence duration length across African countries, and is expressed as a proportion of overall country revenue.

c) Sample of countries

Overall, from 2010 to 2019, we analysed prices from 93 spectrum assignments in Africa, covering 27 countries, and 405 assignments from the rest of the world, from 82 markets. For the analysis of where we use average spectrum prices for each country, we restricted this to countries where there was at least one assignment for coverage and capacity spectrum, throughout the period of analysis.

FIGURE 23

Source: GSMA Intelligence

Number of assignments with prices available (2010–2019)

Region	Number of prices			Number of countries	
	Total prices	Coverage spectrum prices	Capacity spectrum prices	At least one price	At least one price for coverage spectrum and one price for capacity spectrum
Central Africa	20	8	12	5	4
Eastern Africa	8	5	3	2	1
Northern Africa	15	5	10	5	3
Southern Africa	17	6	11	7	3
Western Africa	36	16	20	9	8
Africa total	96	40	56	28	19
Benchmarks					
Developing (excl. Africa)	175	58	117	39	28
Developed countries	253	96	157	43	40
Global (excl. Africa)	428	153	274	82	68

FIGURE 24

Source: GSMA Intelligence

Countries with spectrum assignments with prices available (2010–2019) – Africa

Country	At least one price	At least one price for coverage spectrum and one price for capacity spectrum
Central Africa		
Cameroon	✓	✓
CAR	✓	
DRC	✓	✓
Gabon	✓	✓
Sao Tome and Principe	✓	✓
Eastern Africa		
Kenya	✓	✓
Tanzania	✓	
Northern Africa		
Algeria	✓	
Egypt	✓	✓
Mauritania	✓	
Morocco	✓	✓
Tunisia	✓	✓
Southern Africa		
Botswana	✓	
Lesotho	✓	✓
Madagascar	✓	✓
Mauritius	✓	
Mozambique	✓	✓
Namibia	✓	
Zimbabwe	✓	
Western Africa		
Burkina Faso	✓	✓
Cote d'Ivoire	✓	✓
Ghana	✓	
Mali	✓	✓
Niger	✓	✓
Nigeria	✓	✓
Senegal	✓	✓
Sierra Leone	✓	✓
Togo	✓	✓

FIGURE 25

Source: GSMA Intelligence

Countries with spectrum assignments with prices available (2010–2019) – developing and developed benchmarks

Country	At least one price	At least one price for coverage spectrum and one price for capacity spectrum
Developing countries (excl. Africa)		
Asia Pacific		
Bangladesh	✓	✓
Fiji	✓	✓
India	✓	✓
Indonesia	✓	
Malaysia	✓	✓
Mongolia	✓	✓
Myanmar	✓	
Nepal	✓	✓
Pakistan	✓	✓
Sri Lanka	✓	
Thailand	✓	✓
CIS		
Armenia	✓	
Georgia	✓	✓
Kazakhstan	✓	✓
Moldova	✓	✓
Russian Federation	✓	
Ukraine	✓	
Europe		
Albania	✓	✓
Bulgaria	✓	✓
Montenegro	✓	✓
North Macedonia	✓	✓
Serbia	✓	✓

Country	At least one price	At least one price for coverage spectrum and one price for capacity spectrum
Developing countries (excl. Africa)		
Latin America & the Caribbean		
Argentina	✓	✓
Bolivia	✓	✓
Brazil	✓	✓
Colombia	✓	✓
Costa Rica	✓	✓
Dominican Rep.	✓	✓
Ecuador	✓	
Honduras	✓	
Jamaica	✓	✓
Mexico	✓	
Nicaragua	✓	✓
Paraguay	✓	✓
Peru	✓	✓
Middle East		
Afghanistan	✓	
Iraq	✓	
Jordan	✓	✓
Turkey	✓	✓

Country	At least one price	At least one price for coverage spectrum and one price for capacity spectrum
Developed countries		
Asia Pacific		
Australia	✓	✓
Hong Kong	✓	✓
Korea, South	✓	✓
New Zealand	✓	✓
Singapore	✓	✓
Europe		
Austria	✓	✓
Belgium	✓	✓
Croatia	✓	✓
Cyprus	✓	✓
Czechia	✓	✓
Denmark	✓	✓
Estonia	✓	✓
Finland	✓	✓
France	✓	✓
Germany	✓	✓
Greece	✓	✓
Hungary	✓	✓
Iceland	✓	✓
Ireland	✓	✓
Italy	✓	✓
Latvia	✓	✓
Lithuania	✓	✓
Netherlands	✓	✓
Norway	✓	✓
Poland	✓	✓
Portugal	✓	✓
Romania	✓	✓
Slovakia	✓	✓
Slovenia	✓	✓
Spain	✓	✓
Sweden	✓	✓
Switzerland	✓	✓
United Kingdom	✓	✓

Country	At least one price	At least one price for coverage spectrum and one price for capacity spectrum
Developed countries		
Latin America & the Caribbean		
Panama	✓	✓
Uruguay	✓	✓
Middle East		
Bahrain	✓	
Israel	✓	
Kuwait	✓	
Oman	✓	✓
Saudi Arabia	✓	✓
North America		
Bahamas	✓	✓
Canada	✓	✓
USA	✓	✓

Appendix 2. Other data

A2.1 Network coverage

Data on network coverage was sourced from GSMA Intelligence. Coverage measures the proportion of population resident in an area where 3G or 4G networks are available (i.e. coverage by population rather than by geographic area). Data was gathered from operators and regulators. Where coverage is not reported in each quarter, data was estimated by GSMA Intelligence modelling.

A2.2 Network speeds

This study analysed overall average download speeds. Data was sourced from Ookla®, using the Speedtest® consumer-initiated testing platform that allows mobile users to perform a test to measure network performance at any given time.[41] Each time a user runs a test, the platform provides download speed, upload speed and latency. The test also records the consumer's location, the network operator and the technology being used at the time of the test. Each year, Speedtest is used by 500 million unique users globally, and an average of 10 million consumer-initiated performance tests are run per day. Using these test results, Ookla calculates the average network performance across all users, at a given point in time, per operator or country.[42]

A2.3 Macroeconomic data

FIGURE 26

Source: GSMA Intelligence

Macroeconomic data sources

Indicator	Description	Source
Population	Millions of people (2019)	World Bank
GDP	Real GDP (2019)	IMF
Inflation	Percentage change in inflation (several years, depending on the spectrum assignment date)	IMF and World Bank
Exchange rates	Conversion of local currencies to US dollars (several years, depending on the spectrum assignment date)	Oanda
PPP	PPP conversion factor, LCU per international USD (2019)	IMF and World Bank

41 https://www.speedtest.net/apps/mobile

42 For further information on Ookla's methodology for benchmarking network performance, see https://www.speedtest.net/insights/blog/how-ookla-ensures-accurate-reliable-data-2020/


www.gsma.com/spectrum

Floor 2, The Walbrook Building
25 Walbrook, London EC4N 8AF UK
Tel: +44 (0)207 356 0600

spectrum@gsma.com
www.gsma.com