The benefits of releasing spectrum for mobile broadband in Sub-Saharan Africa

A report for
the GSMA

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Phillipa Marks
David Lewin
Sarongrat Wongsaroj
Yi Shen Chan

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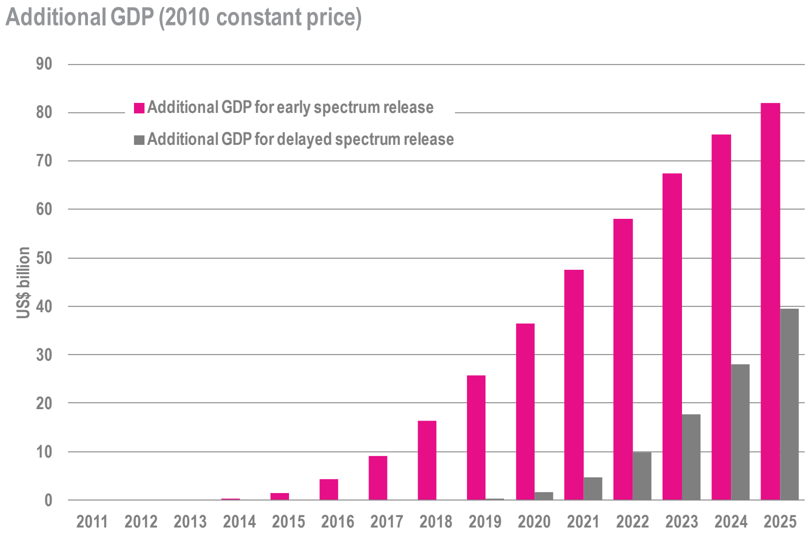
Executive Summary

Mobile broadband has the potential to strengthen economic growth and social development in sub Saharan Africa (sSA). But demand will be limited by the current supply of spectrum for mobile use. The governments of sub Saharan Africa could, by releasing digital dividend and 2.6 GHz spectrum by 2015:

- Increase overall annual GDP by $82 billion by 2025 (see Figure 1) and annual government tax revenues by $18 billion
- Increase GDP per capita by 2.7 percentage points by 2020 and 5.2 percentage points by 2025 (at constant 2010 prices)
- Add up to 27 million additional jobs by 2025, compared with a total of 300 million jobs today.

Figure 1: Forecast impact of spectrum release on GDP in sub-Saharan Africa



Source: Plum Consulting

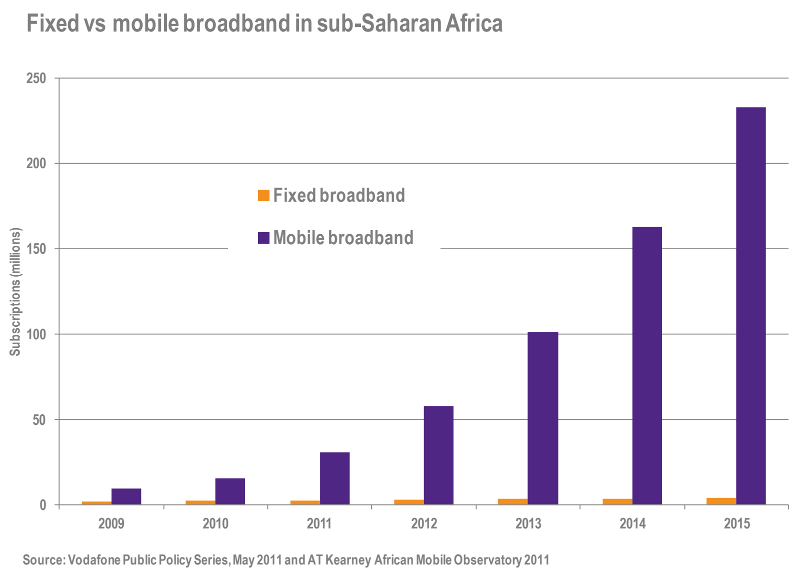
The impact of spectrum release on levels of poverty in sSA could also be substantial. We estimate that:

- There are 410 million people in sub Saharan Africa currently living at or below PPP$1.25 per day per person
- In the absence of spectrum release, forecast GDP growth should lift 86 million of these people above this poverty line between 2015 and 2025
- Spectrum release increases this number by a further 40 million.

Take-up of the broadband Internet is vital for economic and social development in sSA. Mobile voice and SMS services have already made a major contribution over the past decade. In parallel we have seen use of the broadband Internet boost GDP in high-income countries. Recognizing the opportunity to realise these benefits on a global basis, the UN Broadband Commission for Digital Development has set out a global broadband challenge – "*to ensure that...40% of households in developing countries are using broadband Internet by 2015*" [1].

In sub-Saharan Africa (sSA) broadband Internet means mobile broadband. The build out of fixed networks, the principal vehicle for broadband Internet usage in high-income countries, is very limited across most countries of sSA. In contrast mobile networks now reach up to 90% of Africans and offer a much lower cost way of delivering broadband Internet. This is reflected in forecasts for fixed and mobile broadband in the region[2] (see Figure 2).

Figure 2: Forecast fixed and mobile broadband subscriptions in sub-Saharan Africa

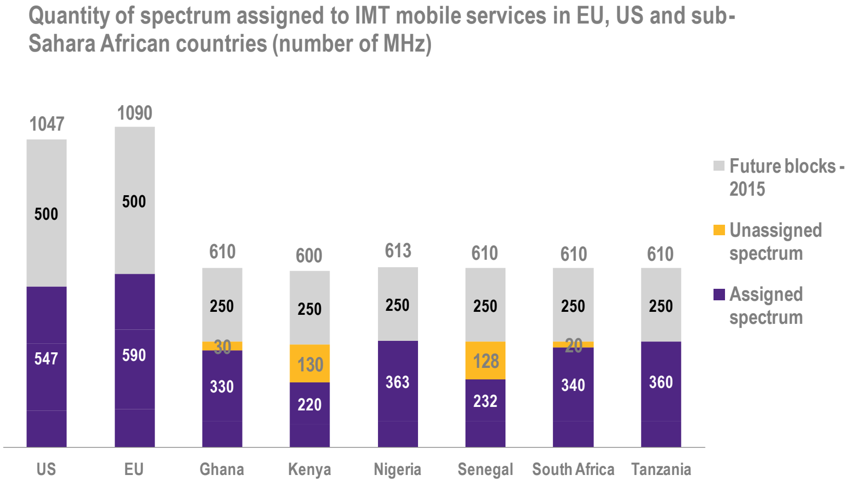


A lot more harmonised spectrum is required if mobile broadband in sSA is to provide sufficient capacity to users at affordable prices. Currently mobile operators in a typical sSA country have access to around 360 MHz of spectrum between them for mobile services (see Figure 3). In contrast, operators in many high-income countries have access to 550 MHz of suitable spectrum. There are plans to release up to 500 MHz more spectrum in high-income countries to support future growth in mobile data traffic.

[1] http://www.broadbandcommission.org/Documents/Broadband_Challenge.pdf, 25 October 2011

[2] The mobile broadband forecasts include W-CDMA as well as HSPA and LTE connections

Figure 3: Amount of spectrum assigned to IMT mobile services – current and possible future allocations



Source: Plum Consulting, regulators, operators

Governments in sSA should give priority to releasing spectrum for mobile broadband. Moreover it is important to release spectrum which is globally ***harmonised*** for mobile broadband use. By 2015 network equipment and end-user devices which use harmonised spectrum for mobile broadband will be in full-scale global production. This minimises the costs of supply and maximises affordability across the population.

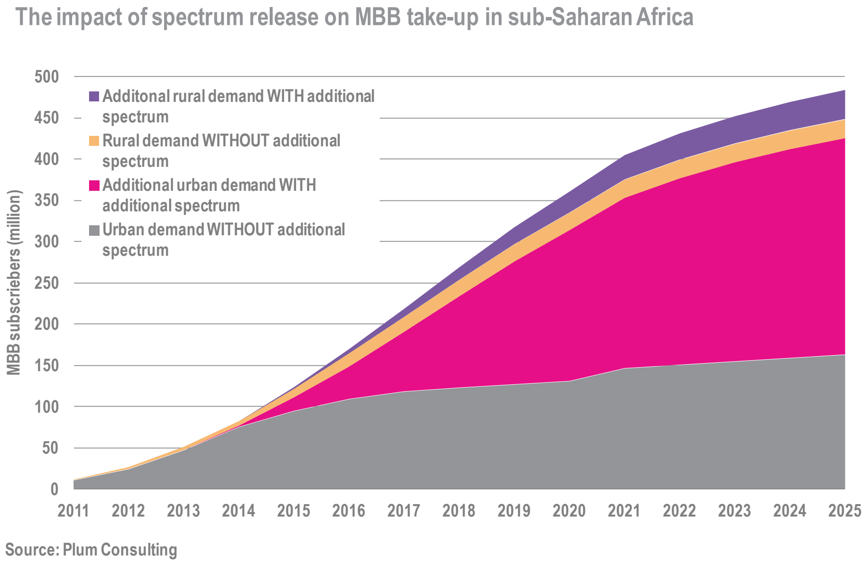
Of particular importance are two frequency bands that are being released for mobile broadband elsewhere in the world – the digital dividend band at 700/800 MHz and the 2.6 GHz band. These bands are complementary and so should be made available together. The digital dividend band is attractive because it offers good in-building coverage in urban areas and low cost coverage in rural areas (where 40-80% of the population live in sSA). The 2.6 GHz band offers much needed capacity in rapidly growing urban areas.

Action is required now to release the required spectrum - which is currently used for other purposes. In particular the digital dividend spectrum is used for analogue TV broadcasting. Most countries in sSA have plans to move from analogue to digital broadcasting by 2015 at the latest. In addition to allowing for the repurposing of spectrum for mobile broadband, digital switchover will enable an order of magnitude increase in the number of terrestrial TV channels. The timely switchover from analogue to digital TV, so as to release the digital dividend spectrum, is imperative for an affordable and speedy take-up of broadband Internet in sSA. In some countries the 2.6 GHz band is also used by other services and these will need to be migrated. Without release of the necessary spectrum, mobile broadband will offer only limited capacity and coverage at high prices.

The economic and social benefits of early release of the digital dividend and the 2.6 GHz band are substantial. Examples of these benefits include more productive farming (e.g. through online access to key information), a stimulus to the development of local e-commerce businesses, enhancing delivery of teaching and training materials to rural schools and reducing the cost of health care delivery by 10-20%. Communication with distant family members will be enhanced – for example through video communication – and it will be easier to keep in contact through online social networks.

Early spectrum release will enable mobile operators to upgrade their existing networks for mobile broadband at relatively modest cost. This should mean affordable prices and strong demand, as forecast in the figure below. This shows that additional spectrum will support over 250m additional mobile broadband users by 2025. The stimulus to broadband take up then leads to substantial economic and social benefits and to a corresponding increase in government tax revenues, as described above.

Figure 4: Forecast impact of digital dividend and 2.6 GHz band on mobile broadband take-up



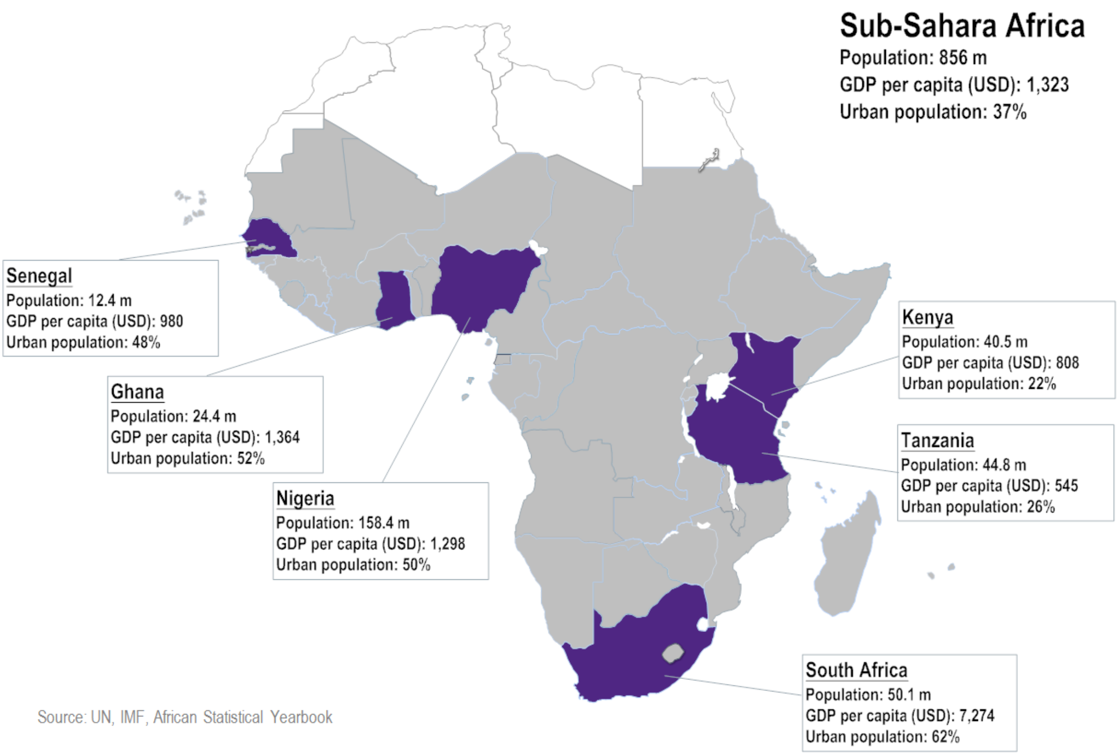
1 Introduction

1.1 The scope of the study

The GSMA asked Plum to carry out an independent study to assess the economic benefits of releasing additional spectrum for mobile broadband in sub-Saharan Africa. This report presents our findings.

The study focuses on six case study countries - Ghana, Kenya, Nigeria, Senegal, South Africa and Tanzania. These countries account for around 40% of the population in sub-Saharan Africa and provide a diversity of situations in terms of incomes and level of urbanisation (see Figure 1-1).

Figure 1-1: The six study countries (2010 data)



1.2 The structure of the report

We have structured the report as follows:

- Over the past 10 years use of the broadband Internet has significantly boosted GDP in high-income countries. There is now an opportunity for a similar boost to GDP in sSA. In ***Section 2*** we consider, in a qualitative way, how this might happen.
- Take-up of the broadband Internet in sSA is limited at the moment. But our analysis indicates that several of the barriers to take-up should diminish significantly over the next few years. In

Section 3 we consider these effects and conclude that the supply of broadband access will remain an important barrier to overcome.

- The supply of broadband access will come from mobile rather than fixed networks in sSA. Whether these networks have sufficient capacity to meet demand for broadband Internet use will depend on how quickly additional spectrum is released for mobile broadband. ***Section 4*** expands on these arguments.
- If harmonised spectrum is released, especially at 700/800 MHz and 2.6 GHz, then the economic and social benefits could be substantial. ***Section 5*** sets out our estimates of these benefits for sSA and specifies the analysis and assumptions which underpin them.

There are then a number of appendices:

- Appendices A to D specify our approach to estimating the economic impact of spectrum release
- Appendices E to J provide estimates of the impact of spectrum release in each of the six individual study countries.

2 How broadband Internet use might stimulate economic development in sSA

2.1 Introduction

There is now a general recognition that use of broadband Internet has the potential to stimulate economic and social development in low-income countries. For example The UN's Broadband Commission for Digital Development has set out a global broadband challenge[3] which calls on world leaders "*to ensure that at least half the developing world's population and 40% of households in developing countries are using broadband Internet by 2015. Consumers in all countries should have access to affordable broadband Internet services, including in developing countries*". The prominence given to these objectives reflects the Commission's view that "*broadband infrastructure and services contribute to economic growth and job creation*" and should therefore be a policy priority.

In this section we describe some of the ways in which the broadband Internet can stimulate economic and social development in sub-Saharan Africa, beyond the already considerable benefits that mobile voice and SMS services have already provided in the region[4]. We consider:

- General impacts on businesses
- Specific impacts on agriculture, education and research, and healthcare
- Impacts on the delivery of government services
- Impact at the level of individuals and households.

We conclude that:

- Rising take-up of access to the broadband Internet over the next 10-15 years will have impacts across the whole economy, as use of broadband pervades all business and government activities and becomes an important platform for social interaction and entertainment
- Examples of these benefits include more productive farming (e.g. through online access to key information), a stimulus to the development of local e-commerce businesses, to enhanced delivery of teaching and training materials to rural schools and to reducing the cost of health care delivery by 10 to 20%
- Communication with distant family members will be enhanced – for example through video communication – and it will be easier to keep in contact through online social networks.

[3] http://www.broadbandcommission.org/Documents/Broadband_Challenge.pdf, 25 October 2011

[4] A recent study (*African Mobile Observatory: driving economic and social development through mobile services,* AT Kearney for GSMA, 2011) estimates that the mobile industry in Africa contributed US$56 billion to the economy and more than 5 million jobs.in 2010.

2.2 Business impacts

2.2.1 General impacts

The availability of broadband Internet can enhance and expand the opportunities and capabilities for businesses. The benefits of broadband to the business environment have been extensively discussed and documented[5]. These include:

- **Improved firm productivity** – more efficient business processes; better supply chain management; lower costs of accessing suppliers/wholesale markets
- **Greater access to and use of information** – reduced search costs; improved interaction and coordination among market agents
- **Extended geographic reach of markets** – facilitates e-commerce; enables access to wider customer base and new ways of delivering products and services
- **Lower barriers to entry –** reduced financial and reputational barriers to trade online (especially for SMEs), access to web tools and applications makes it easier for businesses to develop a web presence
- **Innovation** – new business models; eliminating need for intermediaries in some cases
- **Employment** – better search and matching in labour market; job creation in IT-related sectors; greater flexibility as result of tele-working.

2.2.2 Small and medium enterprises (SMEs) and e-commerce

The arrival of broadband Internet could potentially transform the SME sector and trigger the growth of the nascent Internet economy in sub-Sahara Africa in a similar way to that witnessed over the past decade in countries with high broadband penetration and Internet use. For instance:

- The Internet contributed an estimated £100 billion (7.2 percent of GDP) to the UK economy in 2009[6]
- As shown in Figure 2-1 increasing broadband penetration in US and Korea over the past decade has been accompanied by the rapid growth of e-commerce.

In Ghana developers have come up with applications designed to reflect local needs and boost the prospects of other small businesses. ShopAfrica53[7] is a web-mall which advertises goods and services by small businesses and entrepreneurs ranging from artists to hi-fi equipment distributors. The website also handles logistics like collection and delivery of goods, and takes payment on behalf of the vendors[8].

[5] For example, see OECD Work Party on the Information Economy (2011). The economic impact of internet technologies; ITU-UNESCO (2011). Broadband: a platform for progress. A report by the Broadband Commission for Digital Development.

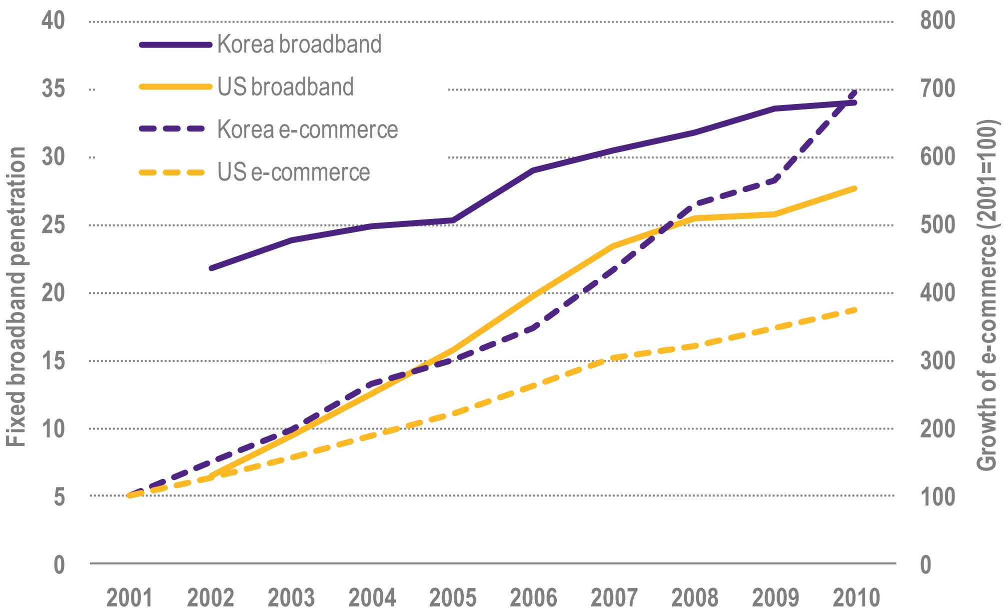
[6] Boston Consulting Group (2010). The Connected Kingdom: how the internet is transforming the UK economy.

[7] http://www.shopafrica53.com/main/Home.aspx

[8] AllAfrica.com, Tech revolution gathers pace, 16 June 2011 http://allafrica.com/stories/201106170973.html

Various factors have been cited for the slow development of SMEs in sub-Saharan Africa including the lack of money, skills and knowledge, technological infrastructure (e.g. telecommunications, electricity supply) and "critical mass"[9]. However a number of recent developments suggest that such obstacles are gradually being overcome.

Figure 2-1: Broadband penetration and e-commerce growth in Korea and US



Source: OECD

The cornerstone of e-commerce is the ability to make purchases over the Internet. While many in sub-Saharan Africa do not have a bank account, the success of the M-Pesa[10] and recent introduction of online transaction services such as Kenya's PesaPal[11] should help overcome the lack of financial services and pave the way for growth of e-commerce.

For small businesses, broadband Internet can improve productivity by allowing them to process large volumes of transactions in a more efficient and cost-effective manner, and extend traditional geographic market boundaries so as to reach regional and even global markets. Access to broadband Internet can also stimulate home-based entrepreneurship and offer opportunities for women to gain financial independence by starting online businesses.

[9] Ifinedo, P (2009). The Internet and SMEs in sub-Saharan African countries: an analysis in Nigeria. Encyclopaedia of Information Science and Technology (2nd ed.)

[10] M-Pesa is a mobile money service launched in Kenya in 2007 which enables cash transfer by text message. As of 2011 it has more than 14 million customers and is now used for salaries, bills and donations. The service is also available in South Africa and Tanzania.

[11] PesaPal is a payment platform that enables users to buy and sell on the Internet using mobile money and credit cards.

2.2.3 Agriculture

Agriculture accounts for 34% of the GDP of sub-Sahara Africa and employs 64% of the labour force[12]. The majority of the rural population in these countries depend on subsistence farming and face significant challenges. First, crop yields are highly variable. This can severely strain farmers' ability to feed themselves and their families. Secondly, physical isolation and poor transport infrastructure make it difficult to access services and markets. This is often compounded by the lack of access to communication resources and information about markets and prices of crops.

The adoption of broadband Internet can help meet these challenges and improve quality of rural life[13]. Table 2-1 summarises the potential benefits to the agriculture industry in sub-Sahara Africa.

Table 2-1: Potential benefits of broadband Internet in agriculture

Key applications	Potential benefits of broadband Internet
Education and awareness	Access to information on good cultivation practices, improved crop varieties, pest and disease management.
Commodity prices and market information	Access to market prices and preferences, which affects planting decisions, not just post-harvest sales
Data collection	Applications using mobile devices to collect and/or access agriculture data
Pest and disease outbreak warning and tracking	Send and receive data on disease incidence and outbreaks
Weather information	Access to real-time weather data and forecasts (e.g. satellite imagery), facilitate better planning and use of scarce resources (e.g. water)
Collaboration	Better information sharing and collective action among producers through cooperatives, producer organisations
Complementary services	Access to financial services

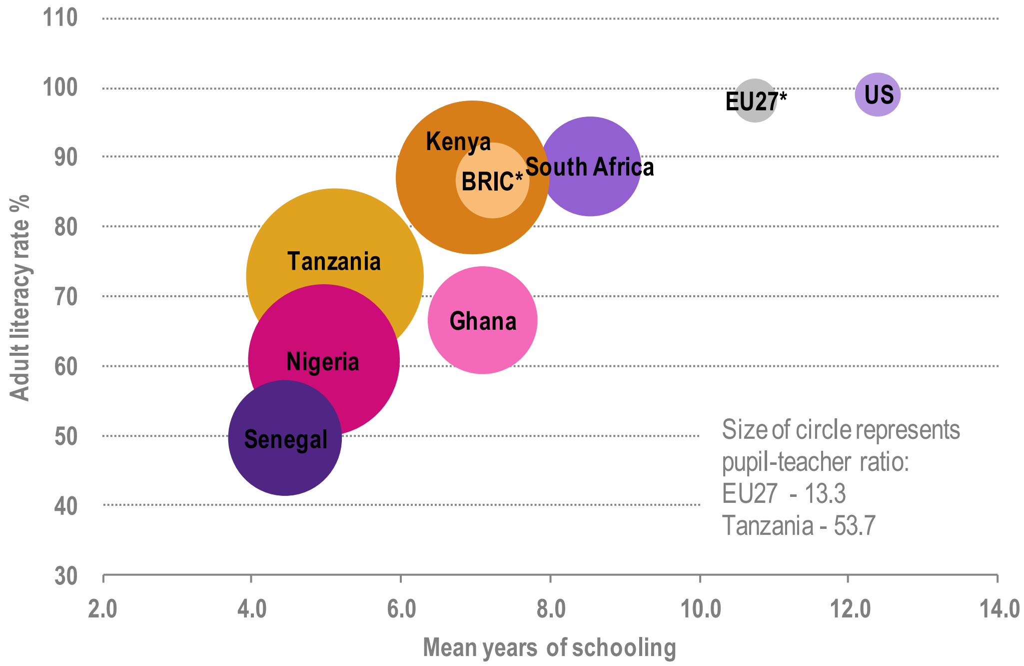
2.3 Education and research

Education is another area in which broadband Internet can bring major socio-economic benefits. This is particularly pertinent in sub-Sahara Africa where many countries have low adult literacy rates and schooling resources are often inadequate in rural areas (see Figure 2-2).

[12] World Bank. 2008. World Development Report 2008: Agriculture for Development. Washington, DC: World Bank.

[13] Hellstrom, J. 2010. The innovative use of mobile applications in East Africa. Sida Review, 2010:12

Figure 2-2: Comparison of education statistics



Note: * unweighted

Source: Plum analysis of data in UN Human Development Report 2011

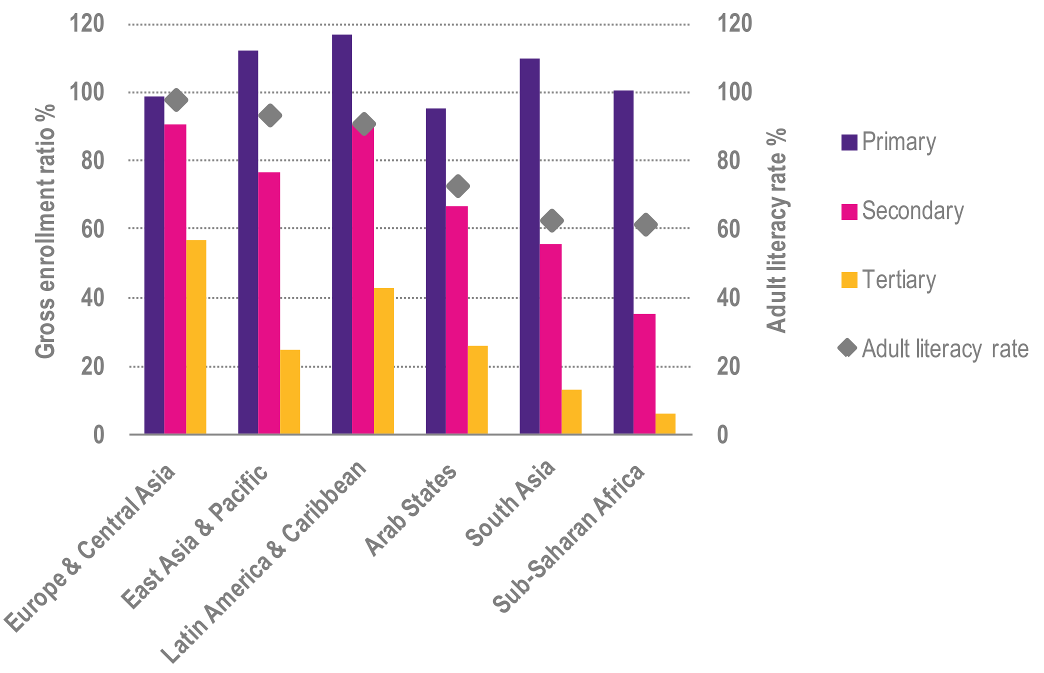
There are two main educational benefits which broadband access can help deliver. First, the Internet can improve education by enhancing remote communication and the delivery of teaching or training materials[14]. This could help ease perennial problems of the lack of teachers, facilities and resources and enable students in rural areas to access online learning materials via mobile phones or laptops outside the classroom.

Second, broadband Internet can improve the quality of education by expanding the range of synchronous and asynchronous learning opportunities through online services and applications. These include email, discussion boards, live webcasts, podcasts, wikis, blogs, customisable course management platforms such as Blackboard, WebCT, Moodle and Sakai.

Around the world many universities have made their classes available online to the public for free. Having Internet access means tertiary education should become more accessible and affordable and help sub-Sahara African countries close the gap with the rest of the world in the provision of tertiary education. This gap is shown graphically in Figure 2-3.

[14] OECD (2011).The economic impact of Internet technologies.

Figure 2-3: Enrolment and literacy rate



Source: Plum analysis of data in UN Human Development Report 2011

Apart from general education the Internet can also enhance academic and scientific research. For example the Internet can improve communication, and exchange of expertise, between researchers and research centres, as well as facilitate "virtual laboratories" and large-scale collaborative projects involving specialist researchers and ordinary citizens (e.g. NASA's SETI@home project).

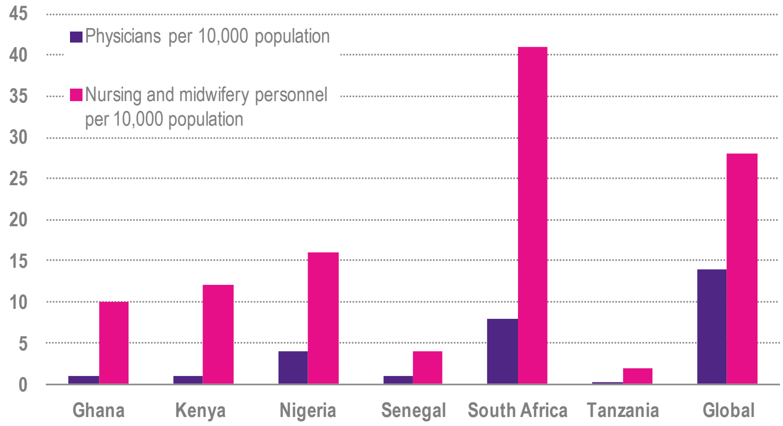
Table 2-2: Potential benefits of the broadband Internet for education and research

Key applications	Potential benefits of broadband Internet
Telepresence and e-education	Creates a virtual experience over a converged network, delivering real time face-to-face interactions, using advanced visual, audio, and collaboration technologies
Interactivity and personalisation	Brings lessons beyond school-based structures enabling teachers to provide individual coaching based on specific needs of individual students
E-learning and open source platforms	Use of open source e-learning platforms reduces costs of providing education and training
Crowdsourcing and information resources	Online reference databases which pool user-generated information to create collective knowledge resources e.g. Wikipedia, online dictionary, encyclopaedia, translation services
Academic research and e-science	Digitisation and storage of research materials (e.g. JStore, ScienceDirect, Google scholar) ; citizen participation and collaboration in science projects

2.4 Healthcare

Healthcare like education is a long-standing problem in sub-Sahara Africa. People in the region have a life expectancy at birth of just 54.4 years and there is a child mortality rate of 129 per 1,000 live births according to the 2011 UN Human Development Report 2011. The global average for life expectancy is 69.8 years and for child mortality is 58 per 1,000 live births. There is also a severe shortage of healthcare providers, especially physicians, in sSA as illustrated in Figure 2-4.

Figure 2-4: Healthcare providers in sub-Sahara



Source: World Health Organisation

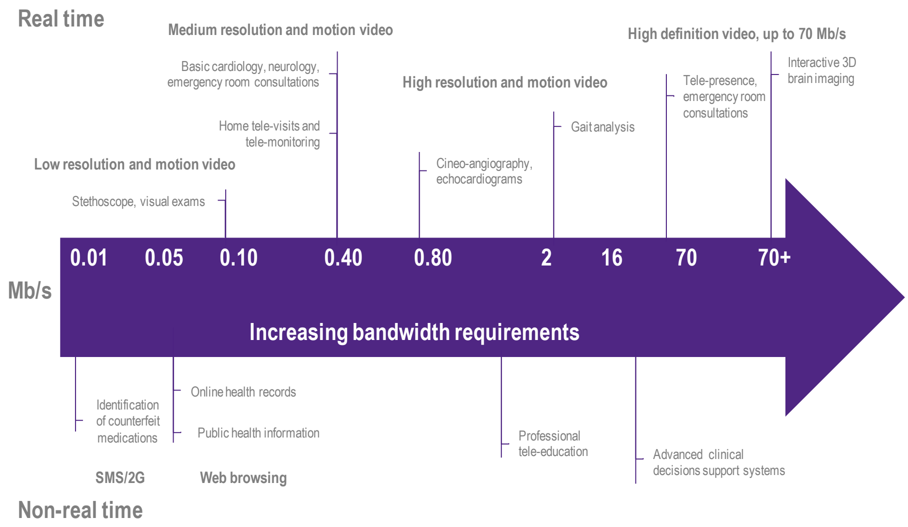
While broadband alone cannot substitute for doctors, nurses and health care workers, the benefits of Internet applications in healthcare are potentially large. Appropriate mobile solutions can improve the quality of life for patients, increase efficiency of healthcare delivery models, and reduce costs for healthcare providers.

It has been estimated that the use of telemedicine delivered by broadband could achieve cost savings of between 10% and 20%[15]. This would be particularly important for sub-Saharan Africa where a combination of high population growth and short life expectancies, will see a projected 52 percent increase in health spending from 2005 to 2025.[16]

[15] Boston Consulting Group (2011) cited in ITU-UNESCO (2011) Broadband: a platform for progress

[16] World Bank (2006). Health Financing revisited: a practitioner's guide

Figure 2-5: Medical uses of broadband



Source: ITU-UNESCO

In Africa mobile health initiatives involving the use of SMS have been used to help increase awareness of diseases such as HIV/AIDS and to encourage testing, and the use of systems for verifying the authenticity of pharmaceuticals to combat the fake-drug business[17]. The arrival of broadband could further bolster the development of e-health services and expand their scope into areas such as visual tele-monitoring and emergency room consultations, as shown in Figure 2-5. A summary of the benefits is given in Table 2-3.

Table 2-3: Potential benefits of the broadband Internet for healthcare

Key applications	Potential benefits of broadband
Education and awareness	Websites and social networking to support public health and behavioural change campaigns. Also helps in information sharing among health workers.
Data collection and health record access	Mobile applications to collect and/or access real-time patient data and records
Monitoring/medication compliance	Maintain care giver appointments or ensure medication regime adherence via one-way or two-way communications
Disease/epidemic outbreak tracking	Send and receive data on disease incidence, provide warnings during outbreaks and public health emergencies
Health/administrative systems	Accessible cloud-based drug inventory management, up-to-minute stock checking, verification of drugs to help combat counterfeit drugs
Analysis, diagnosis and consultation	Phone as point-of-care device. Mobile phone-based diagnosis, or microscope pictures sent to distant reference centres for tele-diagnosis

[17] E.g. HP's mPedigree mobile service in Ghana and Nigeria.

2.5 Government activities

Just as for businesses, governments in sSA can use the broadband Internet in a number of beneficial ways to:

- Raise the productivity and efficiency of government departments. For example government departments might reduce basic paper filing, which incurs significant costs in terms of staff, transportation and resources, especially in rural areas.
- Widen the availability and improve the quality of government services. The development of e-government services, such as online systems for tax filing and public procurement, can give both citizens and businesses convenient, round-the-clock access to required government services using a broadband connection. Such e-government processes can help reduce processing times and improve national competitiveness.
- Strengthen governance processes. The Internet provides new channels and possibilities to promote governance by facilitating citizen to citizen, citizen to government and government to citizen interactions. Increased interaction with the government and easy access to documentation can also raise transparency and promote democratisation.

Potential e-government applications include government news/information updates; law enforcement/safety; elections; disaster and crisis management; data collection and monitoring and employment services[18].

2.6 Individuals and households

For individuals and households broadband Internet can improve consumer welfare and help deliver development outcomes in a variety of ways. These impacts are summarised in Table 2-4 below. They should translate into a significant improvement in individual and household well-being.

Table 2-4: Benefits to individuals and households

Development impacts	Potential benefits of broadband Internet
Social	Enable easy and speedy communication with family members, friends, business associates, employees and employers Social networking and formation of communities of interest
Economic	New distribution channels for existing products and services (e.g. e-commerce, digital music, video or software) More efficient search mechanisms for locating information and better availability of assessment of consumer goods which could lead to lower prices New ways of addressing consumers' needs on line, often at very minimal cost (e.g. e-mail, mobile marketing) Expanded sources of income, means of employment (e.g. tele-working) Improved productivity through reduction of travel time and cost
Knowledge	Better education, learning opportunities Greater knowledge access, accumulation and dissemination

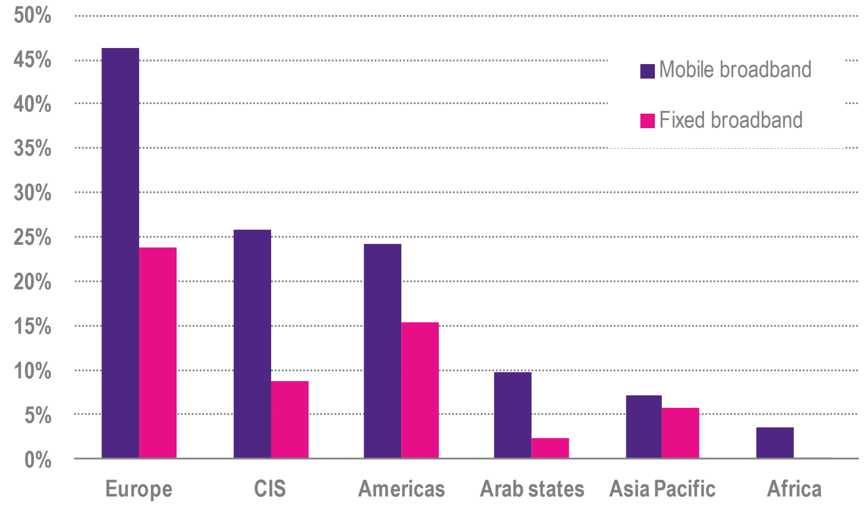
[18] Hellstrom (2010)

3 The barriers to broadband Internet take-up

3.1 Current barriers

Current take-up of the broadband Internet in Africa, and particularly in sSA is low, as Figure 3-1 illustrates.

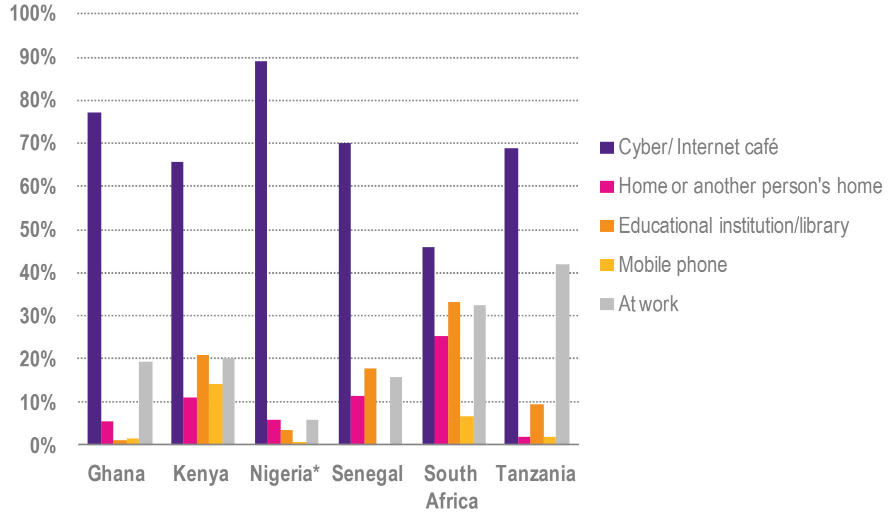
Figure 3-1: Broadband penetration by region (2010 estimate)



Source: ITU World Telecommunication/ICT Indicators database

At the moment most Internet users in sSA access the Internet using narrowband access via Internet cafes. Figure 3-2 illustrates.

Figure 3-2: Points of access for those who use the Internet



Source: Research ICT Africa

At the same time surveys suggest that there are three main reasons, as set out in Table 3-1, why the vast majority of the population do not use Internet:

- They do not have access to a computer
- They do not know how to use a computer
- They do not have access to the Internet.

Table 3-1: Reasons for not using the Internet (among non-users)[19]

Country	I do not have access to a computer	I do not know how to use computers	I do not want to use the Internet	I have no one to send email to	I do not have access to any Internet facilities	I cannot afford to use the Internet
Ghana	49.9%	70.8%	6.3%	25.0%	25.9%	7.8%
Kenya	35.0%	40.9%	24.7%	27.9%	37.8%	2.2%
Nigeria*	47.0%	48.4%	3.1%	15.5%	30.2%	1.6%
Senegal	30.3%	54.1%	7.0%	11.7%	18.2%	7.6%
South Africa	53.1%	25.4%	8.0%	10.0%	38.1%	12.9%
Tanzania	64.6%	71.5%	5.6%	18.9%	19.3%	15.4%

Surveys in high-income countries also suggest that there are five main barriers to use of the broadband Internet:

- Lack of availability of broadband services
- The relatively high price of broadband services and devices.
- An inability to pay for e-transactions.
- Low levels of literacy and also digital literacy
- Perceptions of the irrelevance of Internet-based services and applications

3.2 Removing these barriers

There is a good chance that market developments will lead to a substantial reduction in some of these barriers, especially if the broadband Internet is delivered using mobile rather than fixed broadband;

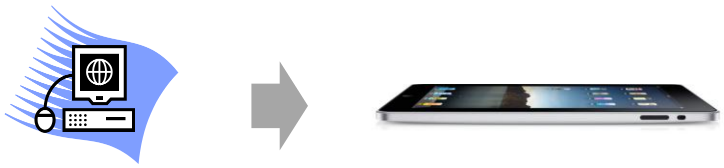
- Mobile broadband devices, such as smartphones and tablets, offer an easier way of using the broadband Internet than traditional PCs. Figure 3-3 illustrates. This means that, while full digital literacy is still required for an effective workforce to use PCs, the level of literacy required for basic use of the broadband Internet is much reduced

[19] Schmidt, JP and Stork, C (2008). E-Skills. *RIA Policy Paper*, Vol.1 Paper 3.

- Mobile broadband devices facilitate shared use of Internet services and applications in a way which fixed broadband PCs do not. Such sharing is effective in spreading an appreciation of the value of using the Internet. It is, in effect, a form of viral marketing, which should stimulate broadband Internet take-up
- Mobile operators in low-income countries have successfully developed payment services which can be adapted to enable e-transactions, and so enhance the value of broadband Internet use.
- If analysts forecasts are right, mobile broadband devices will be more available and more affordable in sSA than laptops and desktops using fixed broadband

This still leaves the availability of broadband services as a barrier. We consider this problem in the next section.

Figure 3-3: Market developments are lowering requirements for basic digital literacy



PCs - Important for ICT at work but:

- Complex
- Keyboard and browser-based
- Vulnerable
- Fixed broadband can be challenging to set up

Smart phones and tablets - more limited functionality but:

- Simple (complexity concealed)
- Touch screen and Apps based
- More secure
- (Mobile) communications included

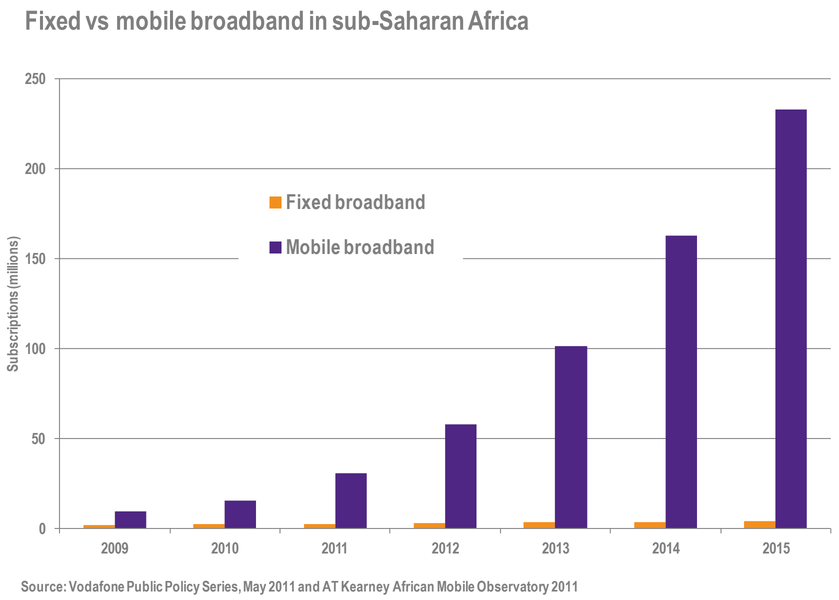
4 The need for additional spectrum for mobile broadband

4.1 Fixed versus mobile broadband

The future availability of the broadband Internet in sSA will depend on access to mobile rather than fixed broadband networks.

Use of fixed broadband in sSA is likely to be rare. Existing investment in the fixed network is low and the reach of the fixed network is limited. This severely constrained the opportunity to upgrade fixed networks for broadband in a cost-effective way. In contrast mobile networks already reached 90% of the population in many sSA countries and it is relatively simple matter to upgrade them for broadband use. This difference is reflected in the forecasts for fixed and mobile broadband take-up in sSA. Figure 4-1 illustrates.

Figure 4-1: Forecast fixed and mobile broadband subscriptions in sub-Saharan Africa 2009-2015



4.2 Demand for mobile broadband

Demand for mobile broadband is forecast to grow very strongly in sSA over the next decade as highlighted in Figure 4-1. There is a danger that the mobile networks will not have sufficient capacity to meet demand and that the economic development from use of the broadband Internet, described in qualitative terms in Section 2, will not be realised.

The extent to which this happens will depend on the speed with which the governments of sub-Saharan African countries release additional harmonised spectrum for mobile broadband services. Release of such spectrum should:

- Enable higher-speed broadband for end-users
- Lower the unit costs of providing mobile broadband
- Enable operators to offer better in-building coverage in urban areas
- Enable operators to upgrade their existing radio access networks in rural areas in a cost-effective way, so as to deliver broadband there and enable rural economic development.

The capacity available to provide mobile broadband services depends on the amount of spectrum assigned to the operator and the number of base stations in its network. Once the existing spectrum capacity is fully used operators must, in the absence of suitable additional spectrum, start to add more base stations to the network to deal with congestion caused by growth in data services. This is expensive – typically costing five or six times more than adding additional spectrum to existing base stations[20]. Providing additional spectrum is the obvious way to keep costs and prices down.

4.3 The need for more spectrum

4.3.1 The current allocations will become congested

Mobile operators in the six case study countries can use spectrum in a range of bands to supply voice, SMS and data services. As a general rule the frequency bands at 900 MHz, 1800 MHz and 2100 MHz have been assigned to operators in sSA[21]. Most of the available frequencies have now been assigned. These provide capacity for continued growth in voice and SMS services.

Most data use in sub-Saharan Africa is currently on Edge networks [22], but mobile broadband services using EVDO, WCDMA and HSPA technologies have also been launched in the 850 MHz, 900 MHz and 2100 MHz bands. However, we expect that this capacity will become fully used in urban areas over the next five years as the number of users with significant broadband requirements grows[23]. This growth is a natural consequence of economic growth, increasing urbanisation and declining costs of broadband devices and services.

4.3.2 Government recognition of the need for more spectrum

Governments in high-income countries recognise the need for more spectrum to meet mobile broadband demand at affordable prices. In the EU and US they have already made available around 550 MHz of spectrum to mobile operators, compared with 360 MHz in sSA. They plan to nearly double this allocation over the next few years. Figure 4-2 illustrates the differences between the EU and US and sSA in terms of spectrum allocation for mobile use.

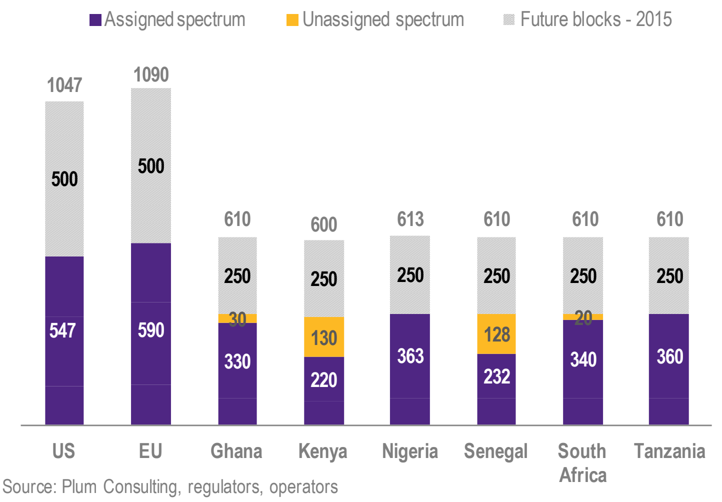
[20] See http://www.plumconsulting.co.uk/pdfs/Plum_June2011_Benefits_of_1.4GHz_spectrum_for_multimedia_services.pdf

[21] Although in some countries (e.g. Nigeria) there is also some use of North American bands at 850 MHz and 1900 MHz

[22] Coyle and Williams overview in *Making Broadband Accessible to All*, The Policy Paper Series, May 2011, Vodafone, http://www.vodafone.com/content/dam/vodafone/about/public_policy/policy_papers/public_policy_series_12.pdf

[23] This is confirmed by the modelling described in Section 5

Figure 4-2: Current mobile spectrum and possible future allocations



Source: Plum Consulting, regulators, operators

In practice demand for additional spectrum in sSA is likely to be even greater than in high-income countries, where mobile broadband supplements fixed broadband and most broadband traffic uses the fixed network. In sSA there is little opportunity to use fixed broadband and virtually all the traffic will use the mobile networks.

4.4 The need for digital dividend and 2.6 GHz spectrum

It is important that any additional spectrum released in sSA is at globally harmonised frequencies, for which network equipment and end-user devices are manufactured on a global scale. Only in this way are the unit costs and prices for mobile broadband minimised.[24]

Two of the main bands which meet this requirement are:

- The digital dividend spectrum at 700 or 800 MHz, which offers 60 MHz or more of additional spectrum
- The 2.6 GHz band, which offers 190 MHz of additional spectrum.

The digital dividend and the 2.6 GHz bands are both internationally harmonised and will support mobile broadband services using LTE technology. The digital dividend spectrum is at relatively low frequencies, below 1 GHz, and so is particularly good for providing low cost coverage in rural areas and indoor coverage in urban areas. The 2.6 GHz band offers much more spectrum than the digital dividend spectrum and so is well suited to providing capacity in densely populated urban areas where lack of capacity is a key issue. The complementary characteristics of the two bands mean that many governments have released them together or in a similar timeframe.

[24] http://www.gsmworld.com/documents/Impact_of_spectrum_harmonisation_on_DD_handset_costs.pdf

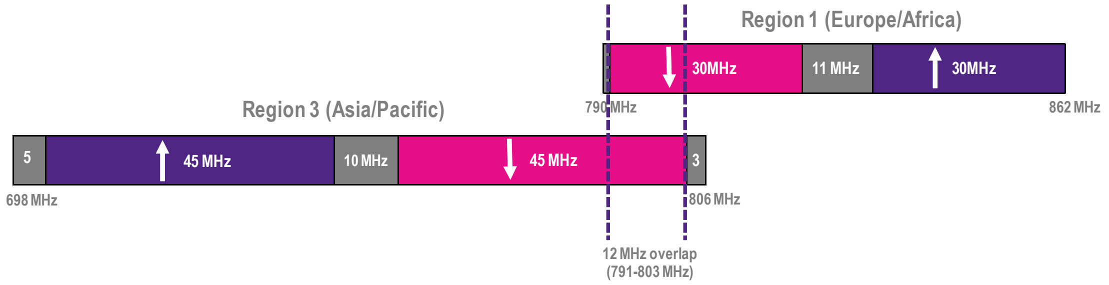
4.5 Releasing the digital dividend spectrum

4.5.1 The digital dividend options

There are two possible scenarios for release of the digital dividend spectrum in sSA as illustrated in Figure 4-3:

- To adopt the CEPT band plan (790-862 MHz) for Europe which would release 2x30 MHz
- To adopt the APT band plan (698-806 MHz) which would release 2x45 MHz.

Figure 4-3: Digital dividend band plans



Source: GSMA

As part of ITU Region 1, the obvious option for sSA countries is to adopt the CEPT plan. Harmonisation with Europe would create economies of scale and benefit consumers through lower costs, interoperability and facilitate cross-border coordination. However, the APT plan for ITU Region 3 would allow more spectrum to be released and would allow the continued operation of mobile services at 850 MHz.

So far of the six study countries, Ghana and South Africa[25] have indicated a preference for the CEPT plan. So too has the Southern African Development Community[26]. For simplicity in our analysis we assume that the CEPT plan is adopted.

4.5.2 Releasing the digital dividend spectrum

Whichever digital dividend option is adopted, existing users of the band will need to be migrated to other frequencies. In the study countries digital dividend spectrum is used mainly[27] for analogue TV

[25] National Communications Authority (2011). Selection and award procedure for digital terrestrial pay television network licenses: invitation for comment. http://www.nca.org.gh/downloads/dtt/Public_Consultation_on_DTT_Licences_Oct_2011.pdf Republic of South Africa Government Gazette (2009). South Africa Final Terrestrial Broadcasting Frequency Plan 2008 http://www.icasa.org.za/Portals/0/Regulations/Regulations/Broadcasting%20Spectrum%20Planning/Final%20Terrestrial%20Broadcast%20Frequency%20Plan%2032728.pdf

[26] South Africa and Tanzania are SADC members. SADC Roadmap for Digital Broadcasting Migration, November 2010 www.crasa.org/download.php?doc=doc_pub_eng66.pdf

[27] Mobile broadcasting services (DVB-H) have also been deployed in the band[27] (e.g. in the main metropolitan areas in Ghana, Kenya, Nigeria and South Africa)[27] and several countries (e.g. Kenya, Nigeria, South Africa) have allocated some of the frequencies mobile services, specifically in the frequency range 824-849/869-894MHz.

broadcasting. However, all countries have plans to introduce digital terrestrial TV (digital terrestrial TV) and to shut down analogue TV services so as to release the "digital dividend". These plans are set out in Table 4-1. So far none of the countries has achieved nationwide deployment of digital terrestrial TV but many of the national plans envisage a two to three year switchover process from analogue to digital transmission.

Table 4-1: Broadcast TV landscape and digital migration targets for the 6 study countries

Country	Ghana	Kenya	Nigeria	Senegal	South Africa	Tanzania
Total households (thousands), 2009	5,432	8,605	31,636	1,446	12,422	8,537
TV households, 2009	47%	41%	41%	48%	72%	10%
TV weekly reach	68%	58%	80%	Not known	90%	41%
Analogue terrestrial channels (national)	2 (1)	1	1 (3)	At least 3 (4)	6 (5)	4
Analogue terrestrial channels (regional)	18 (1)	18 (2)	est. 150 (3)		2 (6)	21
Proposed analogue TV switch off date	Dec-14	2012	Jun-12	Not known	Dec-13	Dec-13

Notes: (1) Assumption of 1 channel per company licensed, includes another 10 licensed services which are not yet on air; excludes 2 analogue terrestrial pay TV licences (DSTV, Crystal TV) which have expired. (2) Based on station ID, KBC regional stations not included. (3) One national network, NTA, which has about 100 stations; 37 state-owned stations; 14 private stations. (4) Public broadcaster RTS has 2 nationwide TV channels (RTS1 and RTS2); private channel 2sTV. (5) Includes pay terrestrial channel M-Net. (6) Regional channels SABC 4 and SABC 5 planned but not yet launched.
Sources: ITU, AudienceScapes, Nielsen, mediareach OMD, Open Society Foundations

4.5.3 Digital switchover – more TV plus spectrum for mobile broadband

Digital switchover offers a potential win-win outcome – more capacity for additional TV channels plus more spectrum for mobile broadband.

The greater spectrum efficiency of digital terrestrial TV means television pictures can be transmitted in a fraction of the bandwidth required by an equivalent analogue TV signal. The capacity depends on the technology used. But, with majority of the six study countries proposing to adopt the latest DVB-T2 and MPEG4 standards, there is likely to be plenty of capacity for broadcasting services post-switchover. While one 8 MHz frequency channel can carry only ***one*** analogue TV service, the same spectrum bandwidth can accommodate a multiplex of digital services with up to ***22*** standard definition digital TV services plus digital radio and text-based services using the latest transmission and compression standards (see Table 4-2).

Table 4-2: Number of TV programme of channels per digital terrestrial TV multiplex by technology

Channel type	TV standard	MPEG-2	MPEG-4
Standard definition	DVB-T	8	16
	DVB-T2	11	22
High definition	DVB-T	1	2
	DVB-T2	2	4

Source: Aegis, Plum

For a typical region in each of the six study countries there are on average of four to six analogue channels, while the main cities usually have around 10 TV channels. This suggests that only two or three digital terrestrial TV multiplexes will be required.

In European countries which have completed digital switchover there are typically between three and six digital terrestrial TV multiplexes in each country. These offer a variety of TV channels (free-to-air, pay, public service, commercial), in both standard and high definition formats. Europe has a much more crowded spectrum planning environment than in sSA, largely because of higher population densities. We would therefore expect that, in principle, countries in sSA would have sufficient spectrum available to engineer at least the number of multiplexes found in Europe.

On the basis of this analysis we conclude that the digital terrestrial TV platform could accommodate many times the existing number of TV channels in sSA (assuming they are financially viable), without using the digital dividend spectrum.

4.5.4 The need to minimise the cost of digital switchover

While digital switchover will benefit sub-Saharan Africa in terms of additional broadcasting services and wider provision of mobile broadband, there is a cost to achieving this migration comprising:

- Equipment costs for individual households. These will include the purchase of digital set-top boxes (which currently cost about US$50 to 100) and possibly also new rooftop aerials (US$15).
- The costs to broadcasters/the broadcast transmission provider of upgrading terrestrial transmitter sites or building new ones.
- The higher than normal operational costs during a “Dual illumination” transmission period in which both analogue and digital services are in operation.
- The production costs of content/programmes for additional digital channels.

Importantly the low average GDP per capita in sub-Saharan Africa (of US$1,300 per year or US$110 per month) means many households will have problems in paying for the necessary equipment. For example, in Nigeria it is estimated that more than two-thirds of the population may be unable to afford digital TV without some form of subsidy or incentives[28].

[28] APC-Balancing Act (2011). Digital broadcast migration in West Africa: Nigeria research report.

To help meet the costs involved in digital migration, some governments in sub-Saharan Africa have set up mechanisms to fund investments and to promote universal access to ICT services[29]. These funds, together with spectrum licence fees, could be used to help ease digital switchover. In addition countries like Ghana are planning to set up manufacturing plants to produce their own digital set-top boxes to help reduce the costs of digital switchover.[30]

[29] For example in South Africa, the Universal Service and Access Fund (USAF) established by the Electronic Communications Act mandates contributions from all broadcast and telecommunications licensees (0.2% of annual turnover) with the aim of promoting universal access and universal service in underserved areas of South Africa.

[30] APC-Balancing Act (2011). Digital broadcast migration in West Africa: Ghana research report.

5 The economic benefits from additional spectrum release

5.1 Approach

The qualitative analysis of Sections 2 to 4 suggests that the economic benefits from releasing 140 MHz of spectrum at 2.6 GHz and 60 MHz of digital dividend spectrum at 800 MHz in sSA could be substantial. In this section of the report we assess the scale of these benefits relative to a base case in which:

- Digital switchover happens by 2015 (2014 in South Africa);
- Up to 2015 mobile broadband is provided using 2.1 GHz spectrum and in some cases a small amount of 900 MHz spectrum. Other bands are assumed to be used for voice services and narrowband data services;
- Any unreleased harmonised spectrum at 900/1800/2100MHz (and in some cases 850 MHz) is released over the period if there are plans in place to release it. Otherwise this spectrum is excluded when we calculate network capacities.
- Network deployment continues to be undertaken throughout the entire modelling period as traffic grows, and the number of base stations roughly increases by 50% to 60% on average between 2010 to 2025.

In summary our model estimates the stimulus to mobile broadband take-up that arises from the release of the 800 MHz and 2.6 GHz spectrum. We then estimate the impact on GDP growth of the additional broadband use made possible by the spectrum release. The main steps for each case study country are as follows:

- Estimate the mobile broadband traffic capacity of the networks with and without spectrum release in urban and rural areas through to 2030
- Estimate the number of effective mobile broadband subscribers which can be supported, both with and without spectrum release in urban and rural areas. An effective mobile subscriber is one who undertakes substantial use of broadband and so generates economic activity. We assume that such a user generate 0.5 GB per month of downlink data in 2010, rising to 3.5 GB per month in 2020 and subsequent years
- Make projections through to 2030 for ***urban*** mobile broadband demand, both with and without spectrum release. We use commercial forecasts of subscribers to EVDO, EVDO+, HSPA, HSPA+ and LTE based services, with extrapolation where necessary. We assume that 40% of these subscribers are effective mobile broadband users. The projections are subject to affordability constraints[31] and to the network capacity constraints calculated in the previous step
- Make projections through to 2030 for ***rural*** mobile broadband demand, both with and without spectrum release. We assume that demand starts from zero in 2015, is constrained by affordability[32], and is subject to network capacity constraints

[31] We assume that urban penetration does not exceed 70%.

[32] We assume that there is at most one subscription per household in rural areas served by mobile broadband.

- Estimate the increase in mobile broadband penetration made possible by spectrum release through to 2030
- Estimate the impact of these additional effective mobile broadband users on GDP growth. Based on the findings of the economic studies set out in Appendix B, we assume that a 10% increase in mobile broadband penetration generates a 0.5% boost to GDP growth which persists for five years
- Estimate the additional government tax revenues generated as a result of this additional GDP.

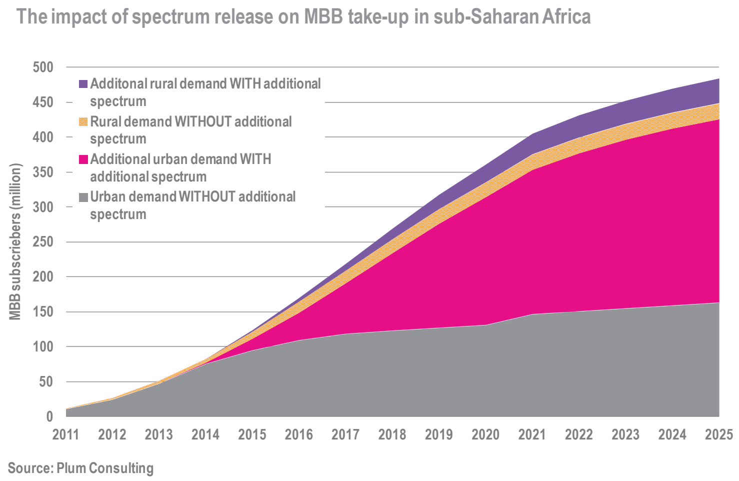
Appendices A to D provide more details.

We then sum the individual results for the six study countries and scale for sSA as a whole. We gross up mobile broadband demand pro rata to population and we gross up economic benefits and tax revenues pro rata to GDP.

5.2 Impact of spectrum release on mobile broadband take-up

We estimate that the additional spectrum released would support up to 300 million additional mobile broadband subscribers[33] by 2025, giving a total of around 480 million (see Figure 5-1). Without the additional spectrum we estimate that take-up would be limited, by network capacity constraints, to around 180m users, assuming reasonable service quality is provided.

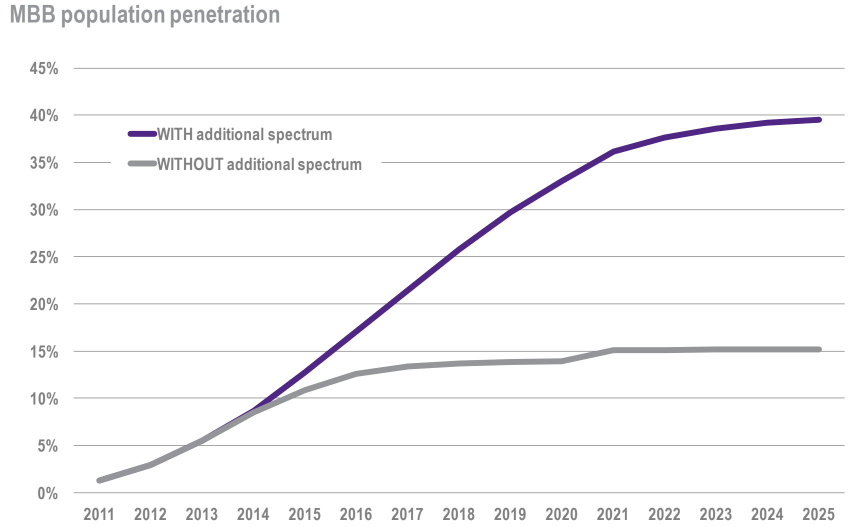
Figure 5-1: The impact of spectrum release on MBB take-up in sSA, 2011-2025



Spectrum release would allow mobile broadband penetration to rise to nearly 40% by 2025 as shown in Figure 5-2. Without the additional spectrum penetration would reach only 15%.

[33] We define an effective mobile broadband user as 40% of all existing and forecast EVDO, EVDO+, HSPA, HSPA+ and LTE subscriptions. This is the number of users who are assumed to make significant use of data services i.e. use 0.5 MB is 2015 rising to 3.5 MB/month in 2025

Figure 5-2: Effective mobile broadband penetration with and without spectrum release



Source: Plum Consulting

5.3 Economic impacts

While strong growth in GDP is forecast for many countries in sub-Saharan Africa over the next five years[34], our model suggest that release of the digital dividend and 2.6 GHz spectrum would provide a further stimulus to economic growth. Specifically spectrum release in 2015 would mean:

- Overall GDP is increased by an additional $82 billion per year by 2025 while government tax revenues increase by $18 billion per year. See Figure 5-3 and Figure 5-4.
- GDP per capita, at constant 2010 prices, increases by an additional 2.7% by 2020 and 5.2% by 2025

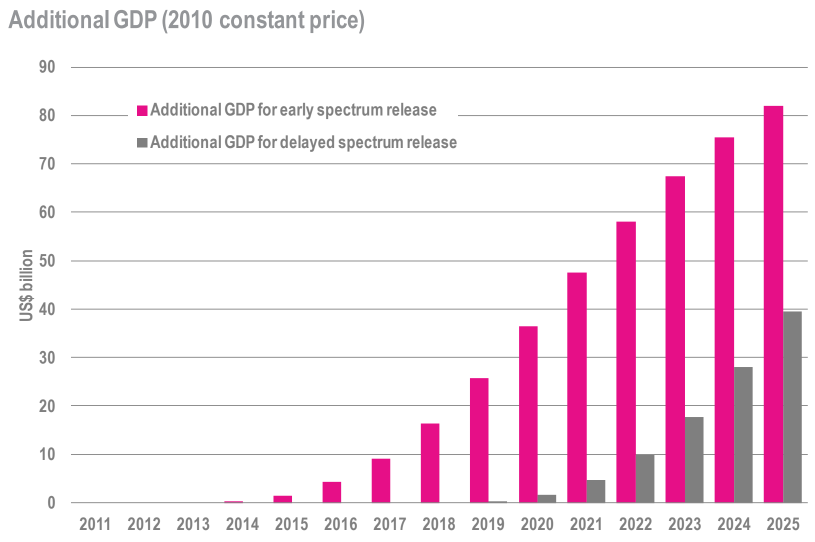
Delaying spectrum release to 2020 could significantly reduce these benefits. With spectrum release in 2015 the net present value of additional GDP over the 10 year period 2015 to 2025 is $230 billion, while the corresponding NPV for tax revenues is $50 billion[35]. A five-year delay would reduce these benefits to $50 billion and $10 billion respectively[36].

[34] IMF World Economic Outlook Database (September 2011 edition) http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/index.aspx

[35] These calculations assume a 5 percent discount rate.

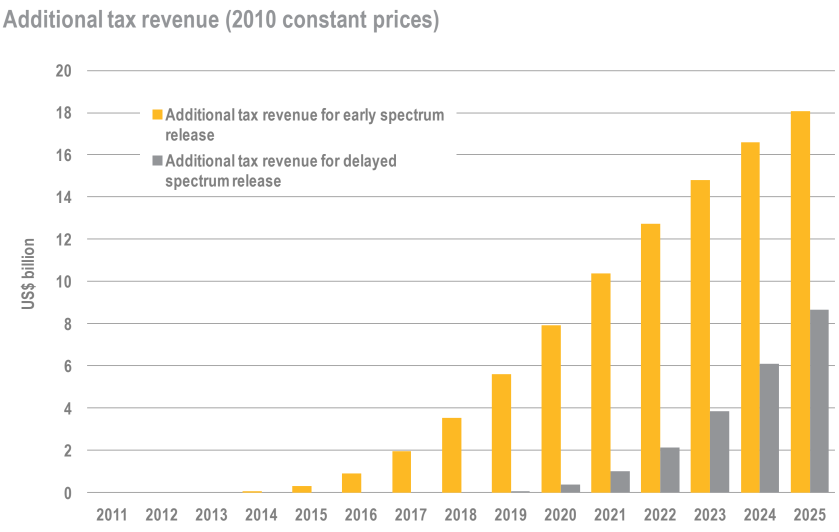
[36] If a fifteen year period (2015-2030) is used for the NPV calculations the values are $430 billion GDP increase and $95 billion for tax. With a five year delay these fall to $200 billion and $45 billion respectively.

Figure 5-3: Additional GDP with 2015 and 2020 spectrum release dates in sSA, 2011 - 2025



Source: Plum Consulting

Figure 5-4: Additional tax revenue with 2015 and 2020 spectrum release dates in sSA, 2011 - 2025



Source: Plum Consulting

5.4 Impacts on jobs and numbers in poverty

Broadband is a general purpose technology which has the potential to bring significant benefits across the whole economy, and so we expect the release of spectrum for mobile broadband to have a positive impact on employment across agriculture, industry and services sectors. To estimate this impact on employment in sub-Saharan Africa, we take the ratio of jobs per $000 GDP in 2009[37] and multiply this by the additional GDP generated by the release of spectrum. In effect we assume that all GDP growth results in more jobs and not in higher wages. Spectrum release generates $82bn pa in additional GDP in 2025. This leads to an estimated for increase in employment of ***up to*** 27 million jobs by 2025.

The impact of spectrum release on levels of poverty in sub-Saharan Africa could also be substantial. We estimate that[38]:

- There are 410 million people in sub Saharan Africa currently living at or below PPP$1.25 per day per person[39]
- In the absence of spectrum release, forecast GDP growth[40] could lift 86 million of these people above this poverty line between 2015 and 2025
- Spectrum release increases this number by a further 40 million, assuming that additional GDP provides the same proportionate increase in per capita GDP across the population.

Appendix D provides more details.

[37] The International Labour Office reports there were a total of 300m jobs in sub-Saharan Africa in 2009 (ILO Global Employment Trends 2011). GDP in 2009 is estimated at $950bn (IMF World Economic Outlook Database, Sep 2011).

[38] Details of the calculation are given in Appendix D

[39] Plum analysis of data in UN Human Development Report 2011, http://hdr.undp.org/en/reports/global/hdr2011/

[40] Based on Plum analysis

Appendix A: Modelling approach

Figure A-1 shows the structure of the model used to estimate the economic benefits of spectrum release. We discuss each step below.

Figure A-1: Structure of the economic model

A.1 Step 1: estimate the busy hour downlink capacity required by a mobile broadband user

Very few mobile broadband users in sub-Saharan Africa will have access to fixed mobile broadband. We therefore need to look at estimates of broadband traffic per subscriber for fixed, as well as mobile, broadband when considering what traffic a mobile broadband user in sub-Saharan African might generate. In particular we note that:

- A Plum study for Vodafone [41] estimates that socially necessary use of broadband would comprise at a minimum usage that enables a subscriber to at least carry out 10 hours of web browsing, send or receives 200 e-mails (10 with attachments), spend 10 hours on instant messaging, and download 30 minutes of MP3 music every month. This amounts to a monthly traffic volume of 0.25 GB[42] per user. As an upper bound for our traffic assumptions we use 1 GB per user as this is the traffic level reported for 44% of broadband-consuming households in the US in 2008[43] and for 24% of broadband users in Ireland in 2007[44].

[41] *Are telecommunications services affordable?* Plum for Vodafone, November 2010

[42] [42] http://shop.orange.co.uk/shop/mobile-broadband;jsessionid=mHLlMkQD0m0vMhKN9KBnybCLz06vvJ41ljhjJv6TkLzvh0nlsVnJ!-458086414

[43] *Priced and unpriced on-line markets*, Ben Adelman, Journal of Economic Perspectives, Summer 2009, Volume 23 Number 3

[44] Response to ComReg con Doc 08/41, eircom, August 2008

- ABI forecasts mobile broadband use of 1.8 GB per month in 2015 and 6.8 GB per month in 2020[45] in high-income countries.
- Based on Cisco 2011's mobile data traffic projection for Asia Pacific[46], Plum estimates that average mobile broadband data traffic per subscription in developing Asia Pacific region will rise from 1.21 GB per month in 2012 to 1.60 GB per month in 2015.

Based on these studies we assume that an effective mobile broadband user in sub-Saharan Africa generates:

- 0.5 GB per month of data 2010 rising in equal annual increments to
- 3.5 GB per month of data in 2020 and from then on.

Other relevant common assumptions used in making our estimates in all country-level models are set out in Table A-1, Table A-2 and Table A-3.

Table A-1: Common network assumptions

Parameter	Value used	Source
% traffic in busy hour	10%	Plum study for Ericsson and Qualcomm[47]
% traffic in downlink	70%	Plum study for Ericsson and Qualcomm
% utilisation of capacity for reasonable quality of service for end user	60%	Plum study for Ericsson and Qualcomm
Sectors per BTS	3	
Spectrum efficiency (bps/Hz) 2010 - 2012 2012 - 2021 2021 and after	 0.35 0.35 – 1.25 1.25	Plum study for Ericsson and Qualcomm
Year on year change in spectrum efficiency between 2012 and 2021 (bps/Hz)	0.05	Plum's estimate

Table A-2: Common 'effective' mobile broadband forecast assumptions

Parameter	Value used	Source
'Effective' MBB subscriber usage (GB/ month) 2010 - 2020 2020 and after	 0.5 3.5	Plum's estimate
Year on year change in 'effective' MBB subscriber usage between 2010 and 2020 (GB/month)	0.3	Plum's estimate
% of Informa's HSPA subscriptions assumed to be effective MBB subscribers	40%	Plum's estimate

45 *Economic benefits of 1.4 GHz spectrum for multimedia services,* Plum for Qualcomm and Ericsson, June 2011

46 *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010–2015,* Cisco, February 2011

47 http://www.plumconsulting.co.uk/pdfs/Plum_June2011_Benefits_of_1.4GHz_spectrum_for_multimedia_services.pdf

Table A-3: Common subscriber forecast assumptions (Gompertz parameters)

Parameter	Value used	Source
First-year[48] additional URBAN subscribers as a % of 2030 additional urban subscribers	5%	Plum's estimate
First-year additional RURAL subscribers as a % of 2030 additional rural subscribers	5%	Plum's estimate
Number of years to maximum subscriber growth from date of spectrum release	3	Plum's estimate

A.2 Step 2: estimate the downlink capacity of existing urban base stations

We assume that capacity constraints occur in the downlink in mobile networks. The current downlink capacity of urban base stations is a function of:

- The spectrum available for the downlink
- The number of urban base stations
- The number of sectors per base station
- Spectrum efficiency over time
- The utilisation of base station capacity which is possible

The first four parameters are relatively straightforward to estimate and project forward. See Table A-1 for our estimates. For the utilisation of base station capacity, we assume that the average level in all countries is uniform at 80%

A.3 Step 3: estimate the maximum number of urban and rural subscribers given existing spectrum

Step 3 is simple. We divide the effective urban and rural capacity of Step 2 by the capacity required per effective subscriber of Step 1. In this way we estimate maximum number of effective mobile broadband subscribers, given current levels of allocated spectrum.

A.4 Step 4: make projections of effective mobile broadband subscribers to 2025 with existing spectrum

We then project forward spectrum-constrained mobile broadband demand in urban and rural areas to 2025 - 10 years beyond the assumed spectrum release date of 2015. The projected demand in Year T is given by the ***minimum*** of:

[48] In the year of the release of additional spectrum.

- The unconstrained demand projections for mobile broadband in Year T, as estimated from Wireless Intelligence or other commercial sources. In line with our definition of an effective mobile broadband user, unconstrained demand is taken to be 40% of all forecast HSPA subscriptions generated by Informa. This is to account for multiple subscriptions in Informa's forecast as well as the fact that not all HSPA subscriptions will be effective mobile broadband subscribers as we previously defined due to their level of usage.
- The affordability-constrained demand in Year T. It is assumed that a maximum of 70% of the urban population can afford the service and that there can only be as many subscribers as there are households due to low per-capita income.
- The spectrum constrained urban and rural capacity in Year T from Step 3

A.5 Step 5: project additional urban demand following release of additional spectrum

The release of an additional 250 MHz of spectrum (the digital dividend plus the 2.6 GHz band) increases urban network capacity by up to 350%. There are two possible constraints on urban demand – affordability and spectrum.

The binding constraint may be affordability. Given this we project the additional demand assuming an affordability constraint using an S-shaped Gompertz curve which uses assumptions on:

- The number of additional subscribers in 2015[49] – the year in which additional spectrum is released;
- Additional demand grows in the long-term to 70% of the population less the constrained demand in urban areas given existing spectrum;
- The maximum growth along the S-shaped Gompertz curve occurs three years on from 2015.

For the spectrum-constrained demand scenario, we project, in a similar way, the additional subscriber demand which is possible given the new spectrum limits following the release of additional spectrum.

Finally we use the lower of these two projections as the incremental demand in urban areas.

A.6 Step 6: project additional mobile broadband demand in rural areas

In countries, where operators have no realistic expectations of using some of their 900 MHz allocation for 3G, we assume that release of the 800 MHz spectrum will make it commercially attractive for at least one of the mobile operators to upgrade its 2G rural network to offer mobile broadband. Where operators are expected to be able to use or have started using a part of their 0.9 GHz spectrum to offer 3G service, the new 800 MHz spectrum will be used to expand this 3G network. Here again, there are two possible constraints on urban demand – affordability and spectrum.

Affordability could constrain demand. We therefore project demand using a Gompertz curve in which:

[49] Plum estimates that this is equal to 10% of 2015 spectrum constrained demand.

- Each household[50] (but not each person) in the rural areas currently served by a 2G network becomes a mobile broadband subscriber in the long-term
- There are an estimated number of additional rural mobile broadband subscribers in 2015[51] – the year in which the spectrum is released
- The maximum growth along the Gompertz curve occurs four years on from 2015.

Similarly, for the spectrum-constrained demand scenario, we project, the additional subscriber demand which is possible under the new spectrum limits following the release of additional spectrum.

We, then, use the lower of these two projections as the incremental demand in rural areas.

A.7 Step 7: calculate the impact of new spectrum release on total demand

Total additional demand is calculated from the urban and rural demand curves derived in Step 5 and Step 6 described above.

A.8 Step 8: estimate the impact of additional mobile broadband use on GDP growth to 2025

Over the past few years a number of econometric studies have measured the relationship between increases in the penetration of broadband and GDP growth. These are summarised in Appendix B. Based on this review we assume that a 10% increase in mobile broadband penetration generates a 0.5 percentage points increase in GDP growth rate over a number of years.

The studies measure the impact of ***fixed*** broadband rather than ***mobile*** broadband on economic growth. But we believe it is reasonable to apply this relationship to economic growth in sub-Saharan Africa using ***mobile*** broadband penetration given that:

- Mobile broadband will be the only form of broadband available to almost all potential users in sub Saharan Africa
- Studies on the impact of mobile narrowband (voice plus SMS) indicate that a 10% increase in penetration generates a 0.6 percentage points boost to GDP growth rate[52].

We assume that the boost to GDP last for five years. This is consistent with mobile broadband boosting productivity by 10%[53] for 25% organisations in the economy.

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[50] This is due to low per-capita income in rural areas.

[51] Plum assumes that this is 10% of 2015 spectrum constrained demand.

[52] See for example *Mobile phones and economic development in Africa*, J Acker and I Mbiti, Working paper 211, Center for Global Development, June 2010;

[53] A number of studies report productivity boost from use of broadband of this magnitude. See for example *The Need for Speed: Impacts of Internet Connectivity on Firm Productivity,* Arthur Grimes, Cleo Ren and Philip Stevens. October 2009.

A.9 Step 9: estimate the impact of spectrum release on government tax revenues

This impact is calculated based on the GDP forecasts and the ratio of taxes to GDP. This tax-to-GDP ratio has been conservatively estimated based on historical data from the African Statistical Yearbook 2011[54].

[54] http://www.afdb.org/en/documents/publications/african-statistical-yearbook/

Appendix B: Impact of broadband on GDP

B.1 Overview

There is a growing number of economic studies which have estimated the relationship between fixed broadband penetration and GDP growth or productivity growth that we have used as the basis for the assumed impact[55]. Almost all of these studies are for high income countries and some rely on data for the period from the mid-1990s and 2000s when broadband speeds were much lower than they are today. We do not consider this to be a problem as it is likely to mean our estimates are on the low side i.e. conservative. Another reason why they will be conservative is that the capabilities and applications offered by access to the Internet which will be better in 2015 in sSA than say 10 years ago.

The following table summarises some of the study results – particularly those that are more recent (see also Appendix B for a short description of the studies). As can be seen, values range from 0.025-1.2 percentage points impact on GDP growth rates. Kenny and Kenny (2010) have criticised some of the higher estimates, partly because the underlying studies include time periods in which there was no broadband service. We have there used an estimate towards the low end of 0.5%.

Table B-1: Estimates of impact of change in broadband penetration on GDP growth

Authors	Impact of 10 percentage point change in broadband take up on GDP growth rate
Czernich et al (2009)	0.9 to 1.5 percentage points
Grimes et al (2009)	1.0 percentage point
Katz et al (2010)	0.025 percentage points (for high speed broadband)
Koutroumpis (2009)	0.25 percentage points
McKinsey (2009)	0.5 percentage points
Micus (2008)	0.7 percentage points
OECD (2011)	1.09 percentage points
Qiang et al. (2009)	1.2-1.4 percentage points (higher end of range is for low/middle income countries)

One factor none of the studies addresses explicitly is the time period over which the effect persists – in some cases the analysis suggests they persist indefinitely while in most studies this issue is not directly addressed. We have assumed a 5 year impact.

B.2 Macro-level studies of GDP impacts

Authors	Summary

[55] We are not aware of any such studies for mobile broadband. One reason for this is the relatively short time period over which such services have been available and used. Even studies of fixed broadband effects are hampered by lack of a long time series and so tend to use cross sectional data as well as time series.

Corrado, May 2010 "Communications capital, Metcalfe's law and US productivity growth, The Conference Board, New York	Uses a growth accounting framework to examine the role of communication network externalities in US productivity performance and to measure the link between ICT services and ICT capital assets. Finds that over the period 2000-2007, communication network effects could have contributed 0.47 percentage points to aggregate US non-farm business sector productivity. This is about 30% of multi-factor productivity growth over the period.
R.Katz, S.Vaterlaus, P. Zenhäusern & S.Suter (2010), The Impact of Broadband on Jobs and the German Economy, Intereconomics: Review of European Economic Policy. Vol. 45, Issue 1, p. 2 (Jan. 2010)	Use input-output analysis to assess the impact on jobs and GDP in Germany of investment in high speed broadband – 50 Mbps (75% households by 2014) and 100 Mbps (50% households by 2020). Impact of 10% increase in high speed broadband penetration on GDP is 0.025%.
OECD, May 2011. The Economic Impact of Internet Technologies, Working Party on the Information Economy, DSTI/ICCP/IE(2011)/REV1	Reviews studies undertaken by others and undertakes own estimates of the correlations between broadband penetration and GDP growth and IPV4 Internet addresses per capita and GDP growth. The former impact is twice the latter. Argues IPV4 Internet addresses per capita is potentially a better measure of Internet development.
Nina Czernich, Oliver Falck, Tobias Kretschmer, Ludger Woessmann. December 2009. Broadband Infrastructure and Economic Growth. CESIFO working paper no. 2861[56]	Based on annual data for a panel of OECD countries and using an instrumental-variable approach, one study finds that the introduction and diffusion of broadband had an important impact on growth in GDP per capita. After a country has introduced broadband, GDP per capita is 2.7 to 3.9 percent higher on average than before its introduction, controlling for country and year fixed effects. In terms of subsequent diffusion, an increase in the broadband penetration rate by 10 percentage points raises annual growth in per-capita GDP by 0.9 to 1.5 percentage points.
Lehr, Osorio, Gillett and Sirbu. September 2005. "Measuring broadband's economic impact." Paper presented to the 33rd Annual Telecommunications Policy Research Conference[57]	A US study examined geographic areas according to their broadband availability and/or use of broadband to determine whether there were observable deviations from secular trends in a number of economic indicators between 1998 and 2002. The study concluded that broadband access does enhance economic growth and performance, with communities in which broadband became available experiencing more rapid growth in employment, the number of businesses overall and the number of businesses in IT-intensive sectors. Lehr et al also observed an increase in market rates for rental housing (a proxy for property values) in areas with broadband availability
Jed Kolko. January 2010. "Does Broadband Boost Local Economic Development? Public Policy Institute of California.[58]	Another US study of geographic data finds a positive relationship between broadband expansion and economic growth. This relationship is stronger in industries that rely more on information technology and in areas with lower population densities. However, the study finds that although the evidence leans in the direction of a causal relationship, the data and methods do not definitively indicate that broadband caused this economic growth. It also finds that the economic benefits to residents in an area appear to be limited. Broadband expansion is also associated with population growth and that both the average wage and the employment rate—the share of working-age adults that is employed—are unaffected by broadband expansion.
Pantelis Koutroumpis. October 2009. "The Economic Impact	A study of the impact of broadband penetration on economic growth in EU countries in the period of 2004-2006 finds that significant causal positive

[56] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1516232&http://scholar.google.co.uk/scholar?hl=en&q=economic+impact+of+high+speed+broadband&btnG=Search&as_sdt=0%2C5&as_ylo=&as_vis=0

[57] http://repository.cmu.edu/tepper/457/

[58] http://www.ppic.org/content/pubs/report/R_110JKR.pdf

of Broadband on Growth: A simultaneous approach." Telecommunications Policy Volume 33, Issue 9, Pages 471-459	link especially when a critical mass of infrastructure is present. The study estimates the critical mass for household broadband as 20% of households, as this provides broadband access for close to 50% of the population.
Micus. 2008 "The Impact of Broadband on Growth and Productivity".60	A study for the EU found that process improvement, increased specialization in knowledge-intensive activities and broadband-based development of innovative markets resulted in a growth of the European Gross Value Added (GVA) of € 82.4 bn per year (+0.71%) in 2006. The impact of broadband on national economies depends on the level of broadband development: in the most advanced European countries, broadband-related GVA growth reaches 0.89%, whereas in the countries with less-developed broadband, this growth is limited to 0.47%.
Christine Zhen-Wei Qiang and Carlo M Rossotto. 2009. "Economic impact of broadband". Information and Communications for Development.61	A World Bank study summarising the economic literature on economic growth and productivity and develops an econometric model to test the impact of broadband on GDP. The econometric study finds that increasing broadband penetration by 10% increases per capita GDP growth by 1.21% in high income countries and 1.38% in low and middle income countries.
Boston Consulting Group. October 2010. The Connected Kingdom – How the Internet is transforming the UK economy.	Study estimates that Internet contributed £100b or 7.2% of GDP in the UK economy in 2009 and forecast contribution to grow to 10% by 2015. The study also claimed that benefits additional to GDP include consumer benefits of £63b and commercial activities not in GDP of £363b.
Robert and Charles Kenny. November 2010. Superfast; Is it really worth a subsidy?	Study review many of the studies claiming significant economic benefits of broadband and finds that these studies have significant flaws that result in overstatement of the benefits. For example, Qiang World Bank study covers period back to 1980 well before broadband was available and produces implausible estimate of impact on growth.
Hal Singer and Jeffrey West. March 2010. "Economic effects of broadband infrastructure deployment and tax incentives for broadband deployment"62	A US study for FTTH council on economic benefits of (1) universal access to current generation broadband capability at 3 Mbps downstream and 768 Kbps upstream; and (2) 80% of homes passed with competitive next generation broadband capability at 50 Mbps downstream and 20 Mbps upstream delivered at peak periods. They estimate the economic impact of the proposed investment in current generation between 2011-15 as $38b in output and an increase in annual employment of 40,000. The impact of the next generation investment is $198.4b and the increase in annual employment is 250,000.

[59] http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VCC-4WYCT8V-1&_user=10&_coverDate=10%2F31%2F2009&_rdoc=1&_fmt=high&_orig=gateway&_origin=gateway&_sort=d&_docanchor=&view=c&_searchStrId

[60] http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/broadband_impact_2008.pdf

[61] http://siteresources.worldbank.org/EXTIC4D/Resources/IC4D_Broadband_35_50.pdf

[62] http://www.ftthcouncil.org/node/858

Appendix C: Country modelling assumptions

C.1 Ghana

C.1.1 Country-specific network and market assumptions

Parameter	Value used	Source
Year of spectrum release	2015	Plum's estimate
Year of introduction of MBB over 900MHz	2011	Plum's estimate
BTS in urban areas 2010 2025	 2800 4200	Operators and Plum's estimate
BTS in rural areas 2010 2025	 2200 2860	Operators and Plum's estimate
Urban population network coverage 2010 2025	 100% 100%	Plum's estimate
Rural population network coverage 2010 2025	 55% 68%	ITU and Plum's estimate
2100MHz spectrum available for downlink	60MHz	Regulator
800MHz spectrum available for downlink	30MHz	Regulator and Plum's estimate
2600MHz spectrum available for downlink	103.5MHz	Plum's estimate (including TDD mode)
900MHz spectrum available for MBB	15MHz	Plum's estimate
Network capacity utilisation	80%	Plum's estimate based on work for Qualcomm

C.1.2 Country-specific demographic and GDP assumptions

Parameter	Value used	Source
Number of people per HH	4.3	Plum's estimate based on historical statistics from Ghanaian government
Urbanisation level 2010 2025	 52% 63%	African Statistical Yearbook 2011 and Plum's estimate
Boost to GDP growth rate per 10% additional BB penetration	0.5% pa for five years	Plum's estimate based on econometric studies
Duration of sustained GDP growth uplift	5 years	Plum's estimate
Assumed base year on year GDP growth from 2017[63]	3%	Plum's estimate
Assumed tax contribution to total annual GDP	14%	IMF, African Statistical Yearbook 2011 and Plum's estimate

C.2 Kenya

C.2.1 Country-specific network and market assumptions

Parameter	Value used	Source
Year of spectrum release	2015	Plum's estimate
Year of introduction of MBB over 900MHz	2015	Plum's estimate
BTS in urban areas 2010 2025	 2600 3900	Operators and Plum's estimate
BTS in rural areas 2010 2025	 2000 4000	Operators and Plum's estimate
Urban population network coverage 2010 2025	 100% 100%	Plum's estimate
Rural population network coverage 2010 2025	 82% 89%	ITU and Plum's estimate
2100MHz spectrum available for downlink	40MHz	Regulator

[63] Base year on year GDP growth rates between 2010 and 2016 are derived from IMF's GDP forecast.

Parameter	Value used	Source
800MHz spectrum available for downlink	30MHz	Regulator and Plum's estimate
2600MHz spectrum available for downlink	103.5MHz	Plum's estimate (including TDD mode)
900MHz spectrum available for MBB	20MHz	Plum's estimate
Network capacity utilisation	80%	Plum's estimate based on work for Qualcomm

C.2.2 Country-specific demographic and GDP assumptions

Parameter	Value used	Source
Number of people per HH	4.4	Plum's estimate based on historical numbers from Kenyan bureau of statistics
Urbanisation level 2010 2025	 21% 27%	African Statistical Yearbook 2011 and Plum's estimate
Boost to GDP growth rate per 10% additional BB penetration	0.5% pa for five years	Plum's estimate based on econometric studies
Duration of sustained GDP growth uplift	5 years	Plum's estimate
Assumed base year on year GDP growth from 2017[64]	5%	Plum's estimate
Assumed tax contribution to total annual GDP	21%	IMF, African Statistical Yearbook 2011 and Plum's estimate

C.3 Nigeria

C.3.1 Country-specific network and market assumptions

Parameter	Value used	Source
Year of spectrum release	2015	Plum's estimate
Year of introduction of MBB over 900MHz	N/A	Plum's estimate

[64] Base year on year GDP growth rates between 2010 and 2016 are derived from IMF's GDP forecast.

Parameter	Value used	Source
BTS in urban areas 2010 2025	 10500 21000	Operators and Plum's estimate
BTS in rural areas 2010 2025	 4500 9000	Operators and Plum's estimate
Urban population network coverage 2010 2025	 100% 100%	Plum's estimate
Rural population network coverage 2010 2025	 80% 87%	ITU and Plum's estimate
2100MHz spectrum available for downlink	40MHz	Regulator
800MHz spectrum available for downlink	30MHz	Regulator and Plum's estimate
2600MHz spectrum available for downlink	103.5MHz	Plum's estimate (including TDD mode)
900MHz spectrum available for MBB	None	Plum's estimate
Network capacity utilisation	80%	Plum's estimate based on work for Qualcomm

C.3.2 Country-specific demographic and GDP assumptions

Parameter	Value used	Source
Number of people per HH	5	Plum's estimate based on historical statistics from Nigerian government
Urbanisation level 2010 2025	 50% 60%	African Statistical Yearbook 2011 and Plum's estimate
Boost to GDP growth rate per 10% additional BB penetration	0.5% pa for five years	Plum's estimate based on econometric studies

Parameter	Value used	Source
Duration of sustained GDP growth uplift	5 years	Plum's estimate
Assumed base year on year GDP growth from 2017[65]	5%	Plum's estimate
Assumed tax contribution to total annual GDP	25%	IMF, African Statistical Yearbook 2011 and Plum's estimate

C.4 Senegal

C.4.1 Country-specific network and market assumptions

Parameter	Value used	Source
Year of spectrum release	2015	Plum's estimate
Year of introduction of MBB over 900MHz	N/A	Plum's estimate
BTS in urban areas 2010 2025	 2400 3120	Operators and Plum's estimate
BTS in rural areas 2010 2025	 600 780	Operators and Plum's estimate
Urban population network coverage 2010 2025	 100% 100%	Plum's estimate
Rural population network coverage 2010 2025	 77% 74%	ITU and Plum's estimate
2100MHz spectrum available for downlink	30MHz	Regulator
800MHz spectrum available for downlink	30MHz	Regulator and Plum's estimate
2600MHz spectrum available for downlink	103.5MHz	Plum's estimate (including TDD mode)
900MHz spectrum available for MBB	None	Plum's estimate

[65] Base year on year GDP growth rates between 2010 and 2016 are derived from IMF's GDP forecast.

Parameter	Value used	Source
Network capacity utilisation	80%	Plum's estimate based on work for Qualcomm

C.4.2 Country-specific demographic and GDP assumptions

Parameter	Value used	Source
Number of people per HH	8.4	Plum's estimate based on statistics from ITU and African Statistical Yearbook 2011
Urbanisation level 2010 2025	 48% 58%	African Statistical Yearbook 2011 and Plum's estimate
Boost to GDP growth rate per 10% additional BB penetration	0.5 pp	Plum's estimate based on econometric studies
Duration of sustained GDP growth uplift	5 years	Plum's estimate
Assumed base year on year GDP growth from 2017[66]	3%	Plum's estimate
Assumed tax contribution to total annual GDP	19%	IMF, African Statistical Yearbook 2011 and Plum's estimate

C.5 South Africa

C.5.1 Country-specific network and market assumptions

Parameter	Value used	Source
Year of spectrum release	2014	Plum's estimate
Year of introduction of MBB over 900MHz	2011	Plum's estimate
BTS in urban areas 2010 2025	 8000 12000	Operators and Plum's estimate
BTS in rural areas 2010 2025	 13000 14950	Operators and Plum's estimate
Urban population network coverage 2010 2025	 100% 100%	Plum's estimate

[66] Base year on year GDP growth rates between 2010 and 2016 are derived from IMF's GDP forecast.

Parameter	Value used	Source
Rural population network coverage 2010 2025	 99% 100%	ITU and Plum's estimate
2100MHz spectrum available for downlink	60MHz	Regulator
800MHz spectrum available for downlink	30MHz	Regulator and Plum's estimate
2600MHz spectrum available for downlink	103.5MHz	Plum's estimate (including TDD mode)
900MHz spectrum available for MBB	20MHz	Plum's estimate
Network capacity utilisation	80%	Plum's estimate based on work for Qualcomm

C.5.2 Country-specific demographic and GDP assumptions

Parameter	Value used	Source
Number of people per HH	4	Plum's estimate based on statistics from ITU and African Statistical Yearbook 2011
Urbanisation level 2010 2025	 62% 75%	African Statistical Yearbook 2011 and Plum's estimate
Boost to GDP growth rate per 10% additional BB penetration	0.5% pa for five years	Plum's estimate based on econometric studies
Duration of sustained GDP growth uplift	5 years	Plum's estimate
Assumed base year on year GDP growth from 2017[67]	1%	Plum's estimate
Assumed tax contribution to total annual GDP	21%	IMF, African Statistical Yearbook 2011 and Plum's estimate

[67] Base year on year GDP growth rates between 2010 and 2016 are derived from IMF's GDP forecast.

C.6 Tanzania

C.6.1 Country-specific network and market assumptions

Parameter	Value used	Source
Year of spectrum release	2015	Plum's estimate
Year of introduction of MBB over 900MHz	2015	Plum's estimate
BTS in urban areas 2010 2025	 2200 3300	Operators and Plum's estimate
BTS in rural areas 2010 2025	 2300 4600	Operators and Plum's estimate
Urban population network coverage 2010 2025	 100% 100%	Plum's estimate
Rural population network coverage 2010 2025	 86% 93%	ITU and Plum's estimate
2100MHz spectrum available for downlink	60MHz	Regulator
800MHz spectrum available for downlink	30MHz	Regulator and Plum's estimate
2600MHz spectrum available for downlink	103.5MHz	Plum's estimate (including TDD mode)
900MHz spectrum available for MBB	20MHz	Plum's estimate
Network capacity utilisation	80%	Plum's estimate based on work for Qualcomm

C.6.2 Country-specific demographic and GDP assumptions

Parameter	Value used	Source
Number of people per HH	4.8	Plum's estimate based on historical statistics from Tanzanian government

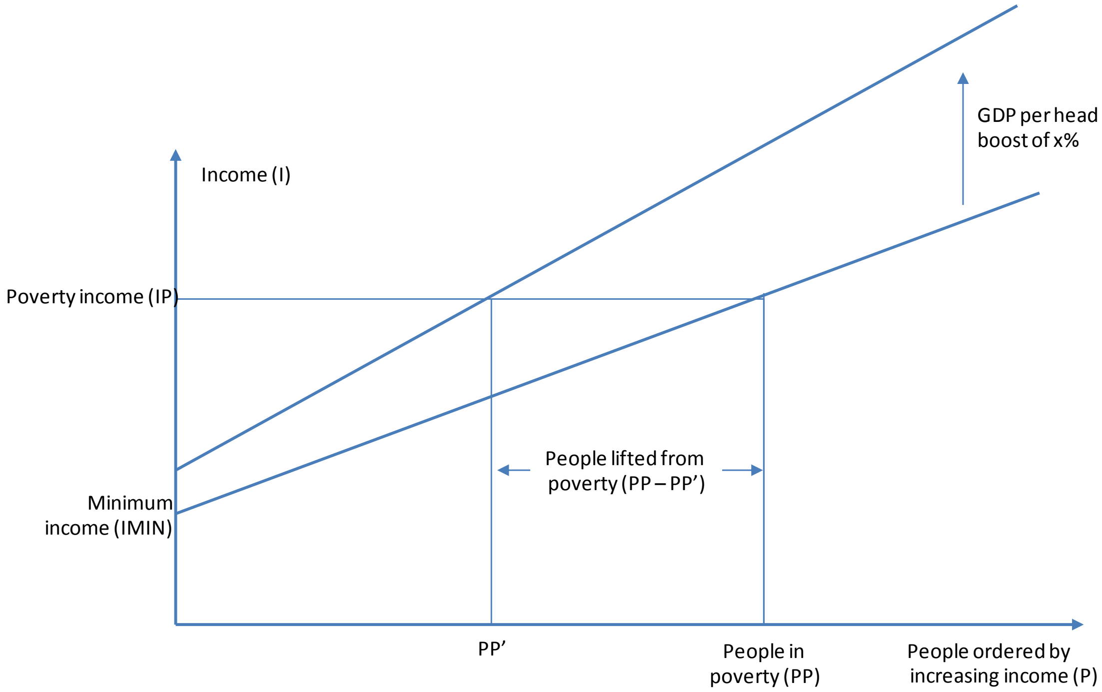
Parameter	Value used	Source
Urbanisation level 2010 2025	 26% 32%	African Statistical Yearbook 2011 and Plum's estimate
Boost to GDP growth rate per 10% additional BB penetration	0.5% pa for five years	Plum's estimate based on econometric studies
Duration of sustained GDP growth uplift	5 years	Plum's estimate
Assumed base year on year GDP growth from 2017[68]	5%	Plum's estimate
Assumed tax contribution to total annual GDP	13%	IMF, African Statistical Yearbook 2011 and Plum's estimate

[68] Base year on year GDP growth rates between 2010 and 2016 are derived from IMF's GDP forecast.

Appendix D: Estimating change in numbers of people in poverty

D.1 Theory

We assume that incomes in SSA at the lower end rise in a linear fashion as shown in the graph below. Boosting GDP per head by x% reduces the number in poverty from PP to PP'.



Income I is given by:

I = IMIN + aP where a = [IP – IMIN]/PP

With an x% GDP boost and assuming a neutral impact by income distribution:

I = (1 + x)*[IMIN + aP]

Then PP' is given by

(1 + x)* [IMIN + aPP'] = IP and

PP' = [PP/(IP-IMIN)*[IP/(1+x) – IMIN] **Equation 1**

The slope of the Income line I is determined by the poverty gap (PG). This is defined as:

[Poverty income - Average income of those in poverty]/Poverty income

Assuming a linear function for I:

PG = (IP – IMIN)*PP/2/[IP*PP] = 0.5[1 – IMIN/IP]

So IMIN = [1 - 2*PG]*IP **Equation 2**

D.2 Quantification

There are 860 million people in SSA of whom 48% live on an income per person of less than \$PPP1.25 per day i.e. 413 million people live below the poverty line. This is the UN's international poverty line.

Between 2015 and 2025 we expect GDP per head to grow by 9.3%[69] without the spectrum release and 14.8% with spectrum release.

The poverty gap is estimated at 21% for SSA[70].

So IMIN = \$PPP1.25*0.58 = \$PPP0.72

We can then estimate PP' as follows

Without spectrum release

PP' = [413/(1.25-0.72)][1.25/1.093 – 0.72] = 327 million

With spectrum release

PP' = [413/(1.25-0.72)][1.25/1.148 – 0.72] = 287 million

So spectrum release leads to an additional 40 million people being lifted out of poverty. Note this estimate is conservative because the population of SSA is forecast to grow by 50%[71] over the next 15 years.

[69] Based on Plum analysis

[70] Poverty gap for SSA (developing only) in 2005. Source: World Bank data http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2

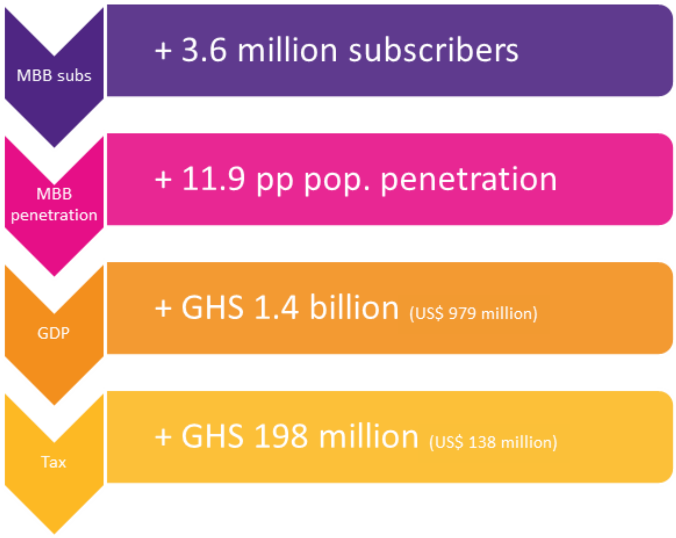
[71] United Nations, World Population Prospects, the 2010 Revision http://esa.un.org/unpd/wpp/index.htm

Appendix E: Ghana

E.1 Summary of results

Figure E-1 provides a summary of the key benefits in 2020 of releasing additional spectrum in 2015. The derivation of these values and market background are given below.

Figure E-1: Summary of benefits in 2020 in Ghana of spectrum release in 2015



Source: Plum Consulting

E.2 Background

Ghana's economy is widely projected to grow strongly in the foreseeable future. Hyperinflation that had plagued the country in recent years has now largely disappeared. Inflation in the second half of 2011 has fluctuated between 8% and 9% per annum, down from the 5-year high value of 20.7%[72] that the country recorded in June 2009. This prompted Ghana's central bank to lower its benchmark interest rate twice in 2011[73]. In conjunction with the 2010 opening of the new Jubilee oil field[74], this is expected to further stimulate investment and drive GDP growth.

Data from the IMF[75] shows that GDP at current prices grew strongly in 2009 and 2010 - 21.2% in 2009 and 26.3% in 2010. In 2011, this growth is forecast to remain above 25%, and GDP will reach GHS 57.9 billion (US$ 35.4 billion). Data from the IMF[76] suggests that GDP per capita (at 2010 constant

[72] http://www.businessweek.com/news/2011-11-09/ghana-inflation-rate-gains-to-8-6-as-weaker-cedi-boosts-price.html

[73] http://www.bloomberg.com/news/2011-10-18/ghana-may-keep-benchmark-interest-rate-at-12-5-after-cedi-drops.html

[74] http://www.ft.com/cms/s/0/2a785790-0877-11e0-80d9-00144feabdc0.html#axzz1eRqoxhwM

[75] http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/weorept.aspx?sy=2009&ey=2016&scsm=1&ssd=1&sort=country&ds=.&br=1&pr1.x=35&pr1.y=10&c=694%2C722%2C199%2C738%2C652%2C664&s=NGDP&grp=0&a=#download

[76] http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/index.aspx

prices[77]) will grow from GHS 1,951 (US$ 1,364) in 2010 to GHS 2,507 (US$ 1,753), which represents an increase of 28% over the 5-year period.

Table E-1: Basic economic data for Ghana, 2010 and 2015

Metric	Value (2010)	Value (2015)
Population	24.4 million	27.5 million
Urbanisation level	52%	55%
GDP per capita	US$ 1,364 (GHS 1,951)	US$[78] 1,753 (GHS 2,507[79])

Source: IMF, UN, Plum's estimate

As GDP and income rise, the proportion of the population that will be in the position to afford mobile service is also expected to grow. In addition, service costs have been progressively declining since 2004[80].

As is the case in the rest of the region, demand for data and Internet service has been growing in Ghana. Operators have also been keen to align their strategies with this trend. MTN reported that data usage increased sharply as it introduced new data bundles, since the service launch of its mobile broadband (MBB) service[81]. Millicom also began offering its own affordable data package, SmartBrowse, which cost GHS 0.3 for 5 MB of data in 2010.

There has also been a rise in the international bandwidth capacity in Ghana. The submarine cable system, Main One, which offers an additional bandwidth capacity of 1.92 Terabits per second between West Africa and Portugal, landed in Ghana in May 2010[82]. In addition, the West African Cable System (WACS) is expected to become operational in early 2012 and will provide further bandwidth expansion in Ghana[83]. Staggered service commencement over new cables is expected to steadily increase competition in the market and gradually erode the cost of international bandwidth in Ghana, making the cost of providing broadband service lower for domestic service providers including MBB operators.

Wireless Intelligence forecasts that the number of mobile subscriptions will grow from 17 million in 2010 to 30 million in 2015. These equate to a mobile population penetration of 69% in 2010 and 107% in 2015.

[77] Adjusted using GDP deflator from the IMF's World Economic Outlook database, September 2011 revision

[78] Exchange rate used by the IMF for conversion of 2010 values in World Economic Outlook, September 2011 is used.

[79] 2015 GDP per capita is stated at 2010 constant prices.

[80] http://www.researchictafrica.net/publications/Policy_Paper_Series_Towards_Evidence-based_ICT_Policy_and_Regulation_-_Volume_2/Vol%202%20Paper%208%20-%20Ghana%20ICT%20Sector%20Performance%20Review%202010.pdf

[81] http://www.mtn-investor.com/mtn_ar2010/ofr_ghana.php

[82] http://www.africafc.org/news/item.php?uid=24dd5cc8-6335-11df-9

[83] http://www.reuters.com/article/2011/05/13/ghana-cable-internet-idUSLDE74C23G20110513

Table E-2: Mobile market indicators in Ghana, 2010 and 2015

Metric	Value (2010)	Value (2015)
Mobile subscriptions	17 million	30 million
Mobile population penetration	69%	107%
Monthly mobile ARPU	US$ 5.8	N/A

Source: Wireless Intelligence

Of the total forecast subscription base of 30 million in 2015, we estimate that around 8 million will be subscriptions with a device capable of accessing MBB service. Altogether, we expect that there will be 3.3 million potential effective MBB subscribers amongst these subscriptions.

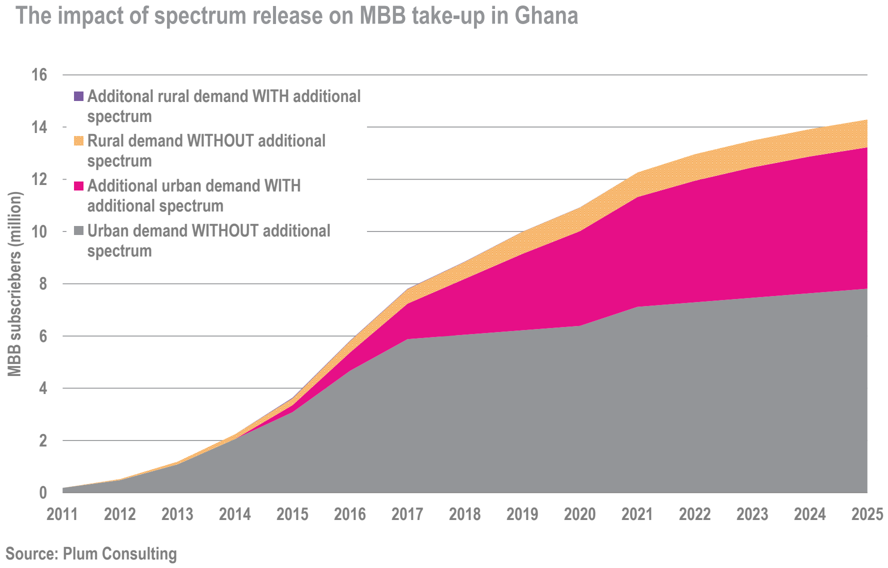
E.3 Impact of spectrum release on MBB take-up

The proposed release of the extra spectrum in 2015 will have the effect of nearly tripling network capacity for MBB subscribers by 2020, from the level without additional spectrum. This translates to a capacity increase of 13 million, taking the total to 21 million subscribers. Capacity in rural areas will rise from 1 million to 3 million[84]. This will make it possible for operators to offer service to potential effective MBB subscribers, who, in the scenario without additional spectrum, cannot be accommodated due to capacity constraints.

We forecast the total number of effective MBB subscribers in urban and rural areas will be 11 million by 2020, assuming spectrum is released, and only 7 million if it is not released shown in Figure E-2. All of the increase in subscriber volume will come from urban areas because there is sufficient capacity in existing allocations to cater for rural demand. Demand in rural areas is also expected to be low. This is largely due to the relatively high level of urbanisation in the country.

[84] Due to its inferior propagation characteristics, we assume that it's uneconomical for operators to deploy MBB over 2.6GHz in rural areas, so that only the 0.8GHz will be used. This gives only 30MHz of additional downlink bandwidth in rural areas. In urban areas, on the other hand, both the 2.6GHz and 0.8GHz will be used for deploying MBB, resulting in a total of 133.5MHz of additional downlink bandwidths.

Figure E-2: The impact of spectrum release on MBB take-up in Ghana, 2011 - 2025



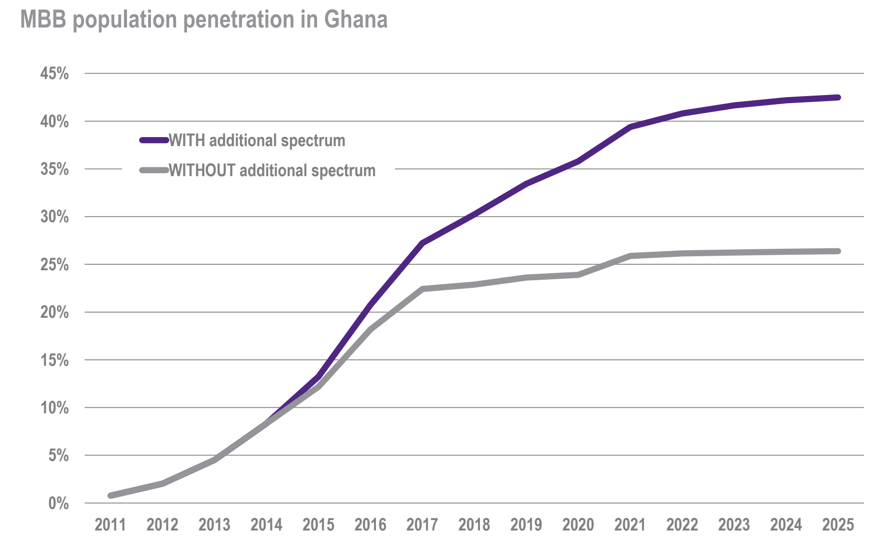
Source: Plum Consulting

We estimate, based on historical trends, that by 2025 around 63% of the population will have been urbanised. In addition, we assume that income inequality[85] will persist so that each rural household will only be able to afford one MBB subscription. This means that the total size of the addressable market for effective MBB subscribers will only be between 13% and 15% of the rural population, and demand from such a small volume of subscribers can be accommodated in part of the existing 900 MHz spectrum.

Figure E-3 shows a comparison of the levels of MBB penetration that can be expected under the scenario with additional spectrum and under the scenario without additional spectrum. The difference in population penetration grows from 12 percentage points in 2020 to 16 percentage points in 2025.

[85] The lowest quintile had an mean annual household income of just a half of the mean annual household income for greater Accra in 2006: http://www.statsghana.gov.gh/docfiles/glss5_report.pdf

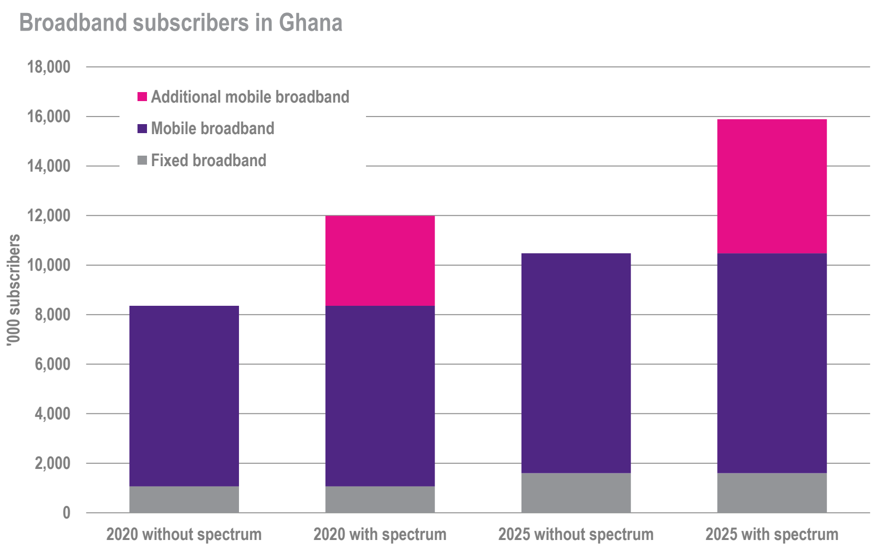
Figure E-3: Comparison of mobile broadband penetration levels in Ghana, 2011 - 2025



Source: Plum Consulting

The impact of the spectrum release on the total forecast number of broadband subscribers – fixed[86] and mobile - whose traffic demand can be met is shown in Figure E-4.

Figure E-4: Comparison of broadband subscriber numbers in Ghana, 2020 & 2025



Source: Plum Consulting

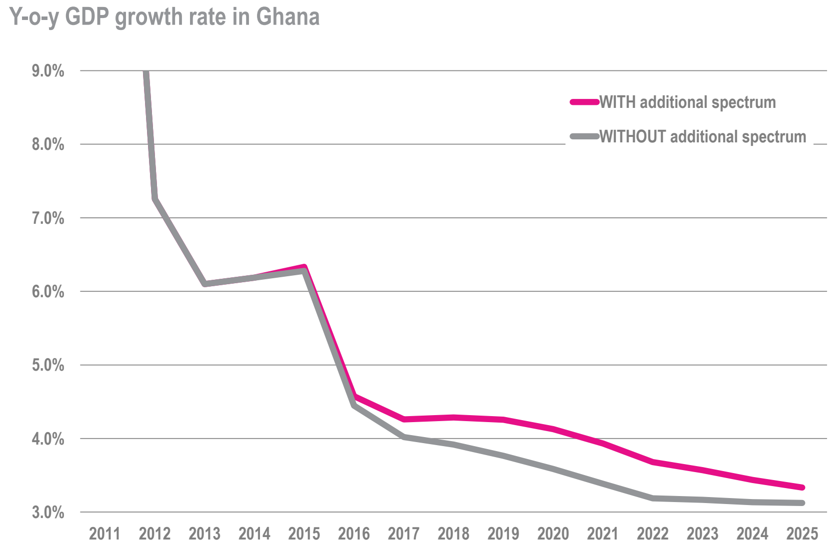
The increase in mobile broadband penetration that follows the increase in the number of effective MBB subscribers will have a positive impact on the annual growth rate of GDP and hence governmental tax revenues.

[86] We assume that fixed broadband subscribers will growth linearly between 2010 and 2025 and that, by 2025, the number will be 10 times the number in 2010, which is taken from Informa.

E.4 Economic benefits

The year on year increase in MBB penetration rate will be much higher in the 5-year period immediately after the assumed date of release, if additional spectrum is assigned to mobile operators in 2015. MBB penetration will rise by 4.6 percentage points per year on average between 2015 and 2020. On the other hand, if no extra spectrum is issued, the average year on year increase in MBB penetration will only be 2.6 percentage points. As a result, with the additional spectrum, a significant uplift on GDP growth can realised as illustrated in Figure E-5.

Figure E-5: Comparison of GDP growth rates in Ghana, 2011 -2025



Source: Plum Consulting

Compared to the scenario without additional spectrum, year on year growth rate of GDP[87] in 2020 will be 0.5 percentage points higher. This is equivalent an increment of GHS 1.4 billion (US$ 979 million) in absolute terms. Even in 2025, when much of the early effect on GDP growth of MBB penetration has been discarded[88], a 0.2-percentage-point increase in year on year GDP growth rate will remain. Figure E-6 shows GDP increments in local currency for the period 2011 to 2025.

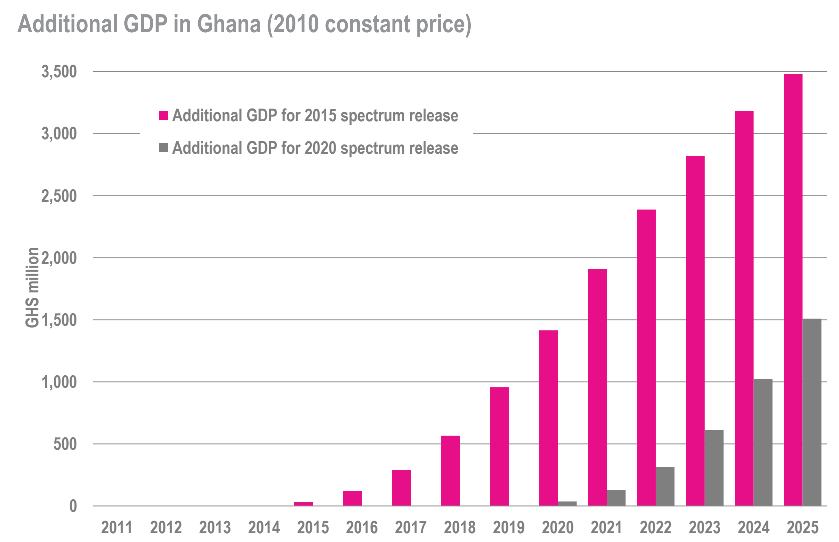
This additional GDP will lead to more employment. 9.8 million people are currently in employment[89]. We estimate that 930,000 more jobs might be created, if we assume that all GDP growth results in more jobs and not in higher wages.

[87] Contribution from mining and quarrying sector is excluded from this GDP, since the impact of increased MBB penetration on industries in this category is small.

[88] We assume that the positive GDP impact of a rise in MBB penetration only lasts 5 years.

[89] Plum analysis based on 2009 World Bank data. http://data.worldbank.org/indicator/SL.EMP.TOTL.SP.ZS/countries

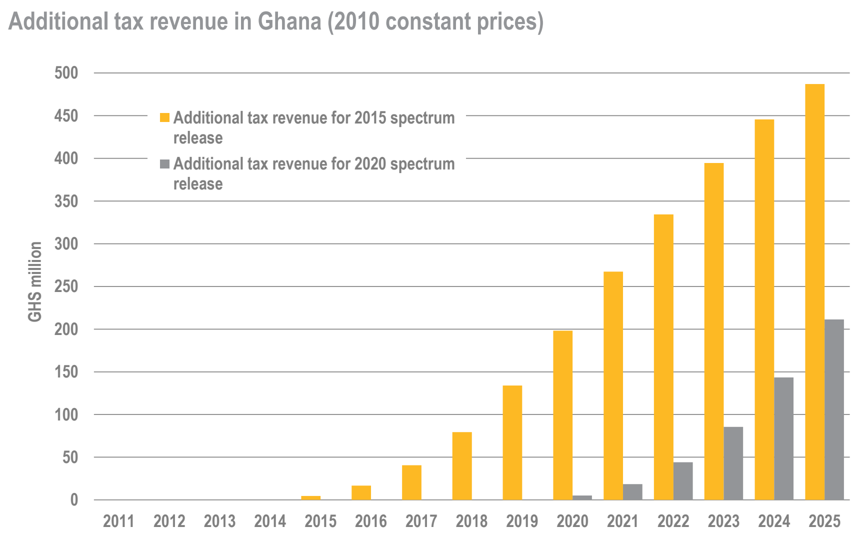
Figure E-6: Additional GDP with 2015 and 2020 spectrum release dates in Ghana, 2011 - 2025



Source: Plum Consulting

Figure E-6 also illustrates the impact of a 5-year delay in releasing the additional spectrum. If the spectrum assignment is delayed by 5 years, there will be no change in GDP until 2020, and the unrealised additional GDP due to the delay will rise from GHS 33 million (US$ 23 million) in 2015 to GHS 957 million (US$ 669 million) in 2019. In NPV terms, the forgone GDP arising from the delay will be GHS 7.6 billion[90] (US$ 5.3 billion).

Figure E-7: Additional tax revenue with 2015 and 2020 spectrum release dates in Ghana, 2011 - 2025



Source: Plum Consulting

[90] The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to GHS 9.9 billion (US$ 6.9 billion).

There will be a loss of potential tax revenues due to unrealised additional GDP. This lost tax intake will rise from GHS 5 million (US$ 3.5 million) in 2015 to GHS 134 Million (US$ 94 million) in 2019 as shown in Figure E-7. In NPV terms, the total forgone tax as a result of the delay will be GHS 1.1 billion[91] (US$ 769 million).

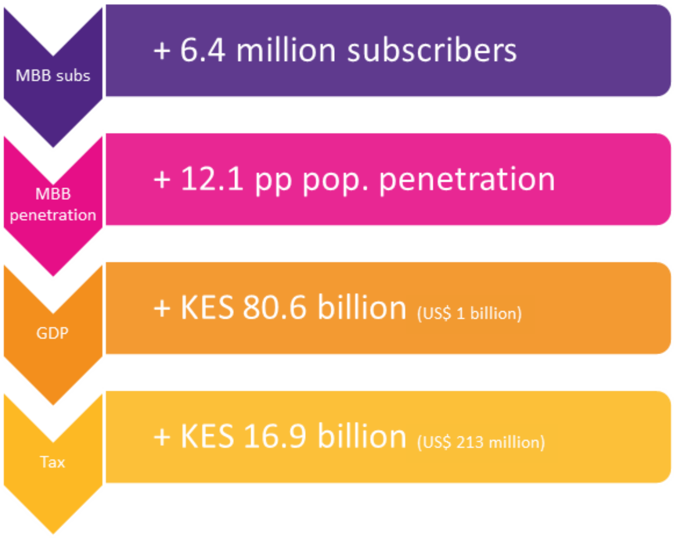
[91] The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to GHS 1.4 billion (US$ 979 million).

Appendix F: Kenya

F.1 Summary of results

Figure F-1 gives a summary of the key benefits in 2020 of releasing digital dividend and 2.6 GHz spectrum in 2015.

Figure F-1: Summary of benefits in 2020 of spectrum release in 2015



Source: Plum Consulting

The derivation of these values and market background are given below.

F.2 Background

In Kenya, around 78% of the total population lives in rural areas. Although the vast majority of Kenya's rural population relies on agriculture and is poor, urbanisation is gradually rising[92] and will help to increase the overall population's average income and disposable income. Data from the IMF[93] suggests that by 2015, GDP per capita (at 2010 constant prices[94]) will grow by around 17% from the level in 2010.

[92] Historical data from African Statistical Yearbook 2011 shows that between 2005 and 2010, urbanisation level rose from 21% to 22.2%, and this trend is expected to continue.

[93] http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/index.aspx

[94] Adjusted using GDP deflator from the IMF's World Economic Outlook database, September 2011 revision

Table F-1: Basic economic data for Kenya, 2010 and 2015

Metric	Value (2010)	Value (2015)
Population	40.5 million	46.5 million
Urbanisation level	22%	24%
GDP per capita	US$ 808 (KES 64,193)	US$[95] 945 (KES 75,155[96])

Source: IMF, UN, Plum's estimate

A combination of poor quality and poor coverage of fixed communications network means that mobile service has become a primary means of communication for most people. Mobile subscribers are willing to spend up to 7.6% of GDP per capita on the service as shown in Table F-2. Rising income and falling costs of mobile device ownership and usage[97] will make a mobile subscription more affordable to the general population. Moreover, urbanisation is also contributing to the growth the mobile market. Often, urban workers from rural areas subscribe to the service to stay in touch with their family in their hometown. By 2015, Wireless Intelligence forecast that mobile penetration will reach 78% of the population, up from 47% at end-2009.

Table F-2: Mobile market indicators in Kenya, 2010 and 2015

Metric	Value (2010)	Value (2015)
Mobile subscriptions	25 million	36.5 million
Mobile population penetration	61%	78%
Monthly mobile ARPU	US$ 4.6	N/A

Source: Wireless Intelligence

Mobile communications have become a platform for the provision of many public services including Safaricom's mobile banking platform, M-Pesa,[98] which has replaced cash as a preferred means of payment in some segments of the population[99].

Mobile subscriptions are forecast to reach 36.5 million by 2015. Of this subscription base, we estimate the number of subscriptions with a device capable of accessing mobile broadband (MBB) technologies to be around 12.6 million or 35% of the base, creating a sizeable addressable market for mobile broadband services. In total, we estimate that there will be 5.1 million potential effective MBB subscribers amongst the 12.6 million potential market in 2015.

[95] Exchange rate used by the IMF for conversion of 2010 values in World Economic Outlook, September 2011 is used.

[96] 2015 GDP per capita is stated at 2010 constant prices.

[97] http://www.cck.go.ke/resc/downloads/SECTOR_STATISTICS_REPORT_Q4_2010-11.pdf

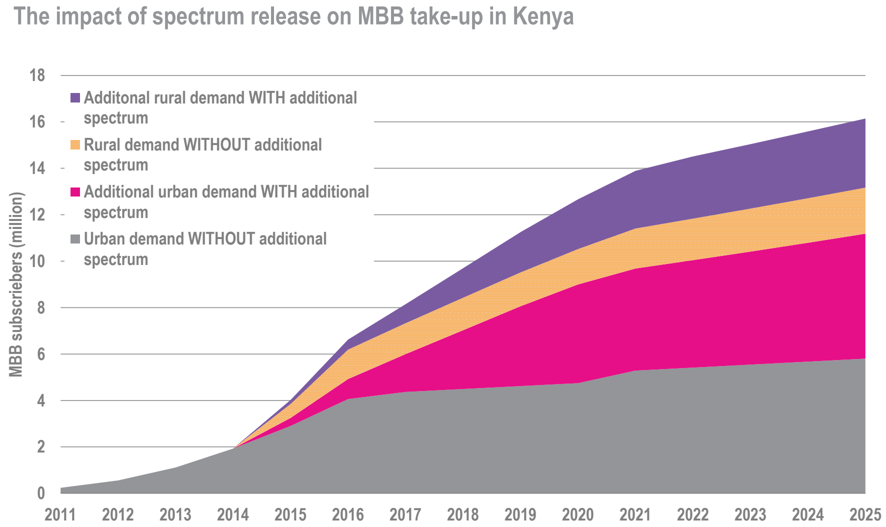
[98] http://mobileactive.org/files/file_uploads/camner_sjoblom_differences_ke_tz.pdf

[99] http://www.unhabitat.org/downloads/docs/6856_68736_SafaricomMpesa.pdf

F.3 Impact of spectrum release on MBB take-up

We forecast that the number of effective MBB subscribers in urban and rural areas will be 12.7 million by 2020, assuming additional spectrum is released, as shown in Figure F-2. By contrast, if no additional spectrum is made available, the number will only be 6.3 million. Of the 6.4-million increase in subscriber numbers, 2.1 million will be in rural areas and 4.3 million will come from urban areas. In 2025, the forecast number of subscribers is 16.1 million, assuming extra spectrum becomes available in 2015, compared to 7.8 million if no additional spectrum is released. Of the base of additional subscribers, 5.4 million subscribers will be urban and 3.0 million will be rural.

Figure F-2: MBB take-up in Kenya with and without additional spectrum in Kenya, 2011 - 2025

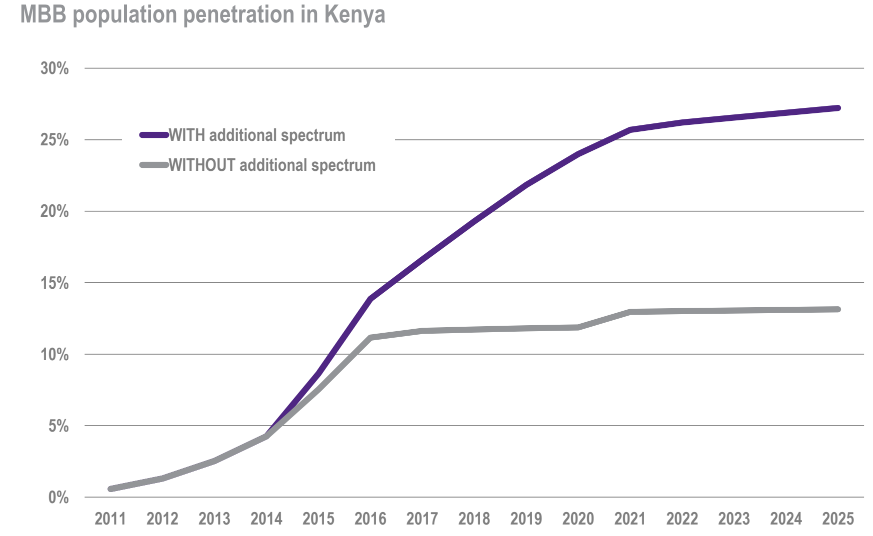


Source: Plum Consulting

There is more capacity than demand throughout the forecast period, in terms of the number of effective MBB subscribers, because Kenya has a relatively large rural population (nearly 80% of the total population). We assume that the service will be within the financial reach of a maximum of 70% of the urban population. This puts an affordability limit of 9.3 million effective mobile broadband subscribers on urban areas in 2020. Meanwhile, the enhanced urban capacity of network can accommodate up to 15.3 million subscribers.

Figure F-3 shows how MBB penetration is forecast to changes over time with and without additional spectrum. In 2020, there is a difference of 12 percentage points, and, in 2025, the difference rises to 14.1 percentage points.

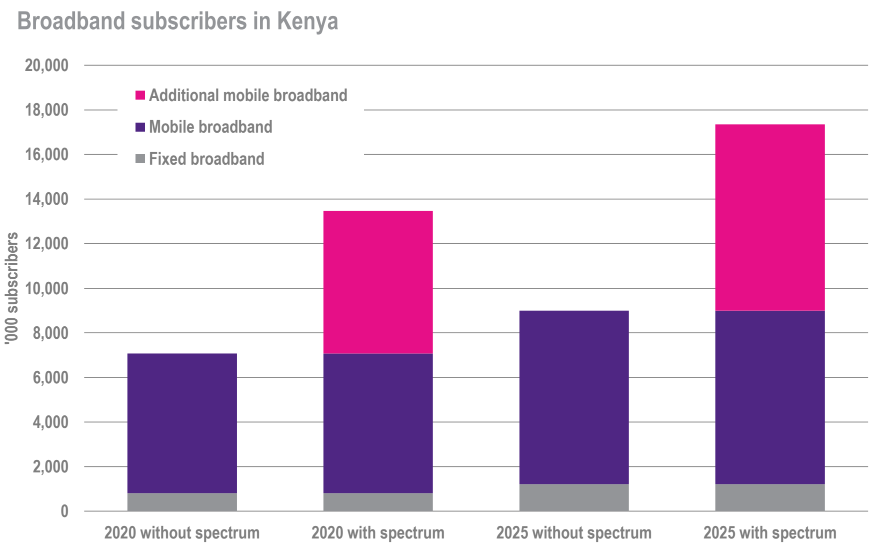
Figure F-3: Comparison of mobile broadband penetration levels in Kenya, 2011 - 2025



Source: Plum Consulting

Figure F-4 shows the forecasts for total broadband subscribers –fixed[100] and mobile. This shows the considerable impact that releasing spectrum at 800 MHz and 2.6 GHz in 2015 could have on total broadband subscriber numbers in 2020 and 2025. Our analysis suggests that Kenya could have a total of 13.5 million broadband subscribers in 2020 and 17.4 million broadband subscribers in 2025, if additional spectrum is made available.

Figure F-4: Comparison of broadband subscriber numbers in Kenya, 2020 & 2025



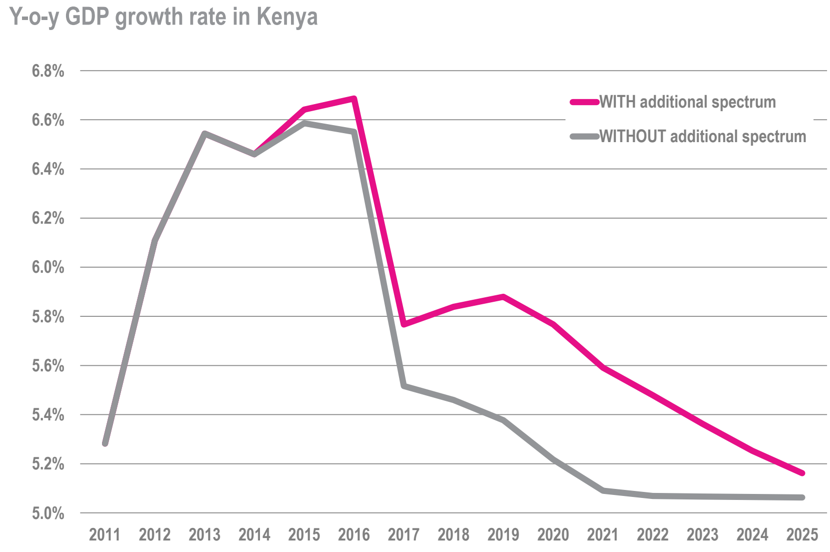
Source: Plum Consulting

[100] We assume that fixed broadband subscribers will growth linearly between 2010 and 2025 and that, by 2025, the number will be 10 times the number in 2010, which is taken from Informa.

F.4 Economic benefits

With the release of additional spectrum, the year on year (year on year) change in MBB penetration is significantly higher from 2015 to 2020 and consequently, there is a marked uplift on GDP growth. Figure F-5 compares the annual growth rate of GDP for the two scenarios – with and without spectrum.

Figure F-5: Comparison of GDP growth rates in Kenya, 2011 -2025



Source: Plum Consulting

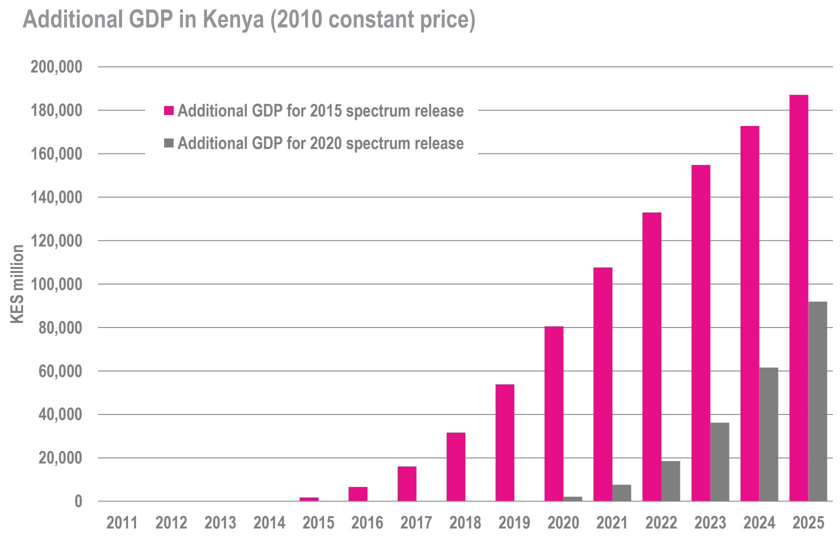
The stimulus to GDP by 2020 amounts to 1.79% which is equivalent to KES 80.6 billion (US$ 1 billion) in 2010 prices. This additional GDP will lead to more employment. 17 million people are currently in employment[101]. We estimate that 1.3 million more jobs might be created, if we assume that all GDP growth results in more jobs and not in higher wages.

Figure F-6 shows GDP increments in local currency for the period 2011 to 2025. It also shows the impact of a 5-year delay in assigning the additional spectrum. If the spectrum release is delayed by 5 years, there will be no GDP stimulus until 2020, and the unrealised additional GDP as a result of the delay will rise from KES 1.8 billion (US$ 23 million) in 2015 to KES 53.9 billion (US$ 678 million) in 2019. In NPV terms, the forgone GDP arising from the delay will be KES 409 billion[102] (US$ 5.1 billion).

[101] Plum analysis based on 2009 World Bank data. http://data.worldbank.org/indicator/SL.EMP.TOTL.SP.ZS/countries

[102] The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to KES 508 billion (US$ 6.4 billion).

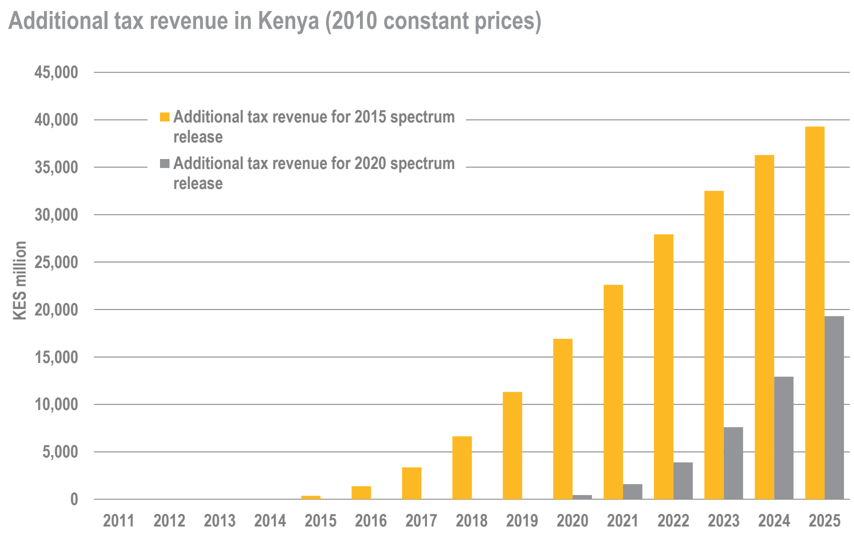
Figure F-6: Additional GDP with 2015 and 2020 spectrum release dates in Kenya, 2011 - 2025



Source: Plum Consulting

Similarly, the loss of general tax revenues due to the forgone GDP will rise from KES 376 million (US$ 4.7 million) in 2015 to KES 11.3 billion (US$ 142 million) in 2019 as shown in Figure F-7. In NPV terms, the total forgone tax as a result of the delay will be KES 86 billion[103] (US$ 1.1 billion).

Figure F-7: Additional tax revenue with 2015 and 2020 spectrum release dates in Kenya, 2011 - 2025



Source: Plum Consulting

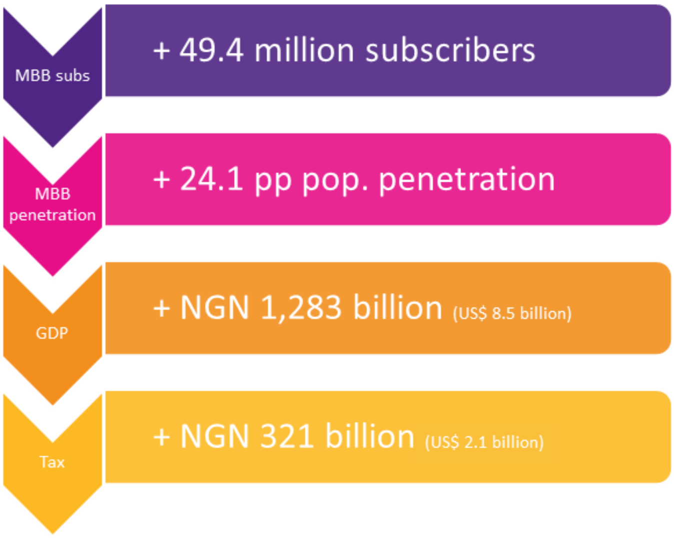
[103] The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to KES 107 billion (US$ 1.3 billion).

Appendix G: Nigeria

G.1 Summary of results

Figure G-1 provides an overview of the key benefits in 2020 of releasing 800 MHz and 2.6 GHz spectrum in 2015.

Figure G-1: Summary of benefits in 2020 in Nigeria of spectrum release in 2015



Source: Plum Consulting

The derivation of these values and market background are given below.

G.2 Background

With a population of 158 million in 2010, Nigeria is by far the most populous sub-Saharan African country. The UN expects the population base to expand further to 181 million by 2015 under a medium fertility scenario[104]. Against the backdrop of rapidly increasing urbanisation[105], this means that there will be over 95 million people living in urban areas in Nigeria in 2015.

[104] http://esa.un.org/wpp/unpp/panel_population.htm

[105] See Appendix C for urban-rural population split assumptions.

Table G-1: Basic economic data for Nigeria, 2010 and 2015

Metric	Value (2010)	Value (2015)
Population	158 million	181 million
Urbanisation level	50%	53%
GDP per capita	US$ 1,298 (NGN 195,057)	US$[106] 1,545 (NGN 232,119[107])

Source: IMF, UN, Plum's estimate

According to data from the IMF[108], GDP per capita (at 2010 constant prices[109]) is set to rise from NGN 234,000 (US$ 1,526) in 2011 to NGN 331,000 (US$ 2,050) by 2015. In line with this, average per capita income is also expected to grow.

The mobile industry will be a directly affected by this combination of expanding urban population and rising disposable income. Given that mobile operators offer better coverage in urban areas, the on-going migration of people to urban areas will increase the number of people that can get a reliable access to mobile networks. Meanwhile, higher disposable income will make mobile services affordable to a greater proportion of the population. Wireless Intelligence forecasts that mobile population penetration will reach 73% by 2015, as shown in Table G-2.

Table G-2: Mobile market indicators in Nigeria, 2010 and 2015

Metric	Value (2010)	Value (2015)
Mobile subscriptions	87 million	131 million
Mobile population penetration	55%	73%
Monthly mobile ARPU	US$ 10	N/A

Source: Wireless Intelligence

As demand for mobile data services and, hence, traffic continue to surge[110], Nigerian operators have also shifted their focus to the data market. MTN, for instance, has been rolling out a fibre backbone network in order to enhance transmission capacity from base stations. In 2010, they completed 696 km of the fibre ring between Yola and Bauchi via Gombe[111]. In addition, the operator has also been active in introducing segmented data bundles to increase the appeal of its data service. Airtel, meanwhile, announced the roll-out of its 3G network in April 2011 and plans to provide population coverage of 80% by 2012[112].

[106] Exchange rate used by the IMF for conversion of 2010 values in World Economic Outlook, September 2011 is used.

[107] 2015 GDP per capita is stated at 2010 constant prices.

[108] http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/index.aspx

[109] Adjusted using GDP deflator from the IMF's World Economic Outlook database, September 2011 revision

[110] http://www.nigeriancompass.com/index.php?option=com_content&view=article&id=6512:mobile-data-traffic-growth-doubles&catid=307:information-technology&Itemid=609

[111] http://www.mtn-investor.com/mtn_ar2010/ofr_nigeria.php

[112] http://www.businessdayonline.com/NG/index.php/tech/telecoms/19695-airtel-nigeria-set-sights-on-data-market-as-competition-heightens

International bandwidth capacity has also been steadily growing. In mid-2010, Main One, a submarine cable connecting Nigeria and Ghana to Portugal, was completed and began offering commercial service to regional Internet service providers[113]. The system is capable of a transmission speed of 4.96[114] terabits per second and provides competition to the long-standing SAT-3/WASC and WACS cable systems. Another major cable system for West Africa, ACE, which will also land in Nigeria, will be launched in 2012[115]. This is expected to have the effect of lowering the cost of international bandwidth in the long run.

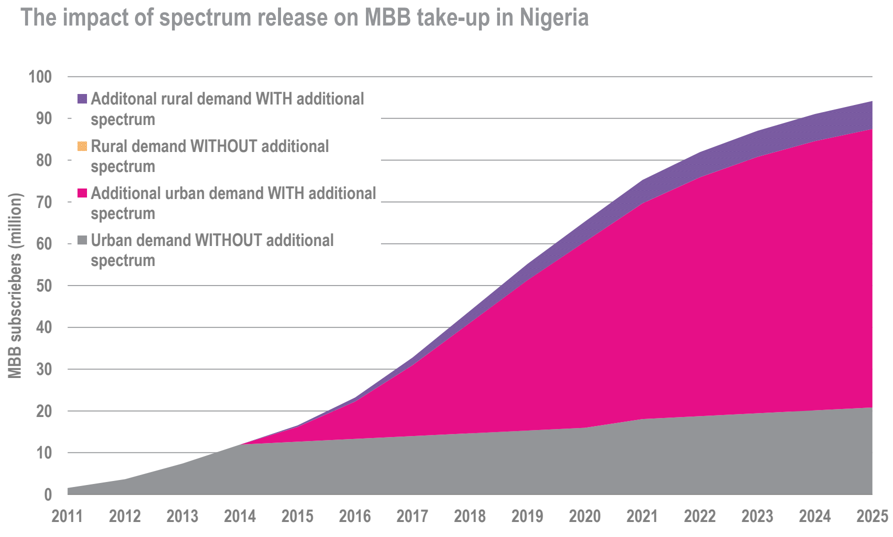
Given intensifying competition in the mobile data market and expanding international bandwidth, subscriptions with device capable of using mobile broadband service are predicted to rise and will account for over 41% of the total subscription base by 2015 – i.e. amount to 54 million subscribers[116]. Of this total, we estimate 21.5 million subscriptions will be effective MBB subscribers.

G.3 Impact of spectrum release on MBB take-up

Making additional spectrum in the 800 MHz and 2.6GHz bands available in 2015 will increase the capacity for effective MBB subscribers by over 3-fold in 2020. In total, the spectrum will give operators network capacity for up to 74 million effective MBB subscribers. Networks will only be able to support a maximum of 16 million subscribers in the absence of the extra spectrum.

The extra capacity will enable operators to offer service to support the forecast growth in the number of effective MBB subscribers. Altogether, we forecast there will be 65 million effective MBB subscribers by 2020 as shown in Figure G-2. In 2025, the total effective MBB subscriber count will have risen to 94 million assuming spectrum is released for MBB in 2015.

Figure G-2: The impact of spectrum release on MBB take-up in Nigeria, 2011 - 2025



Source: Plum Consulting

[113] http://www.telegeography.com/products/commsupdate/articles/2010/06/04/main-one-to-launch-on-1-july/

[114] http://www.mainonecable.com/network

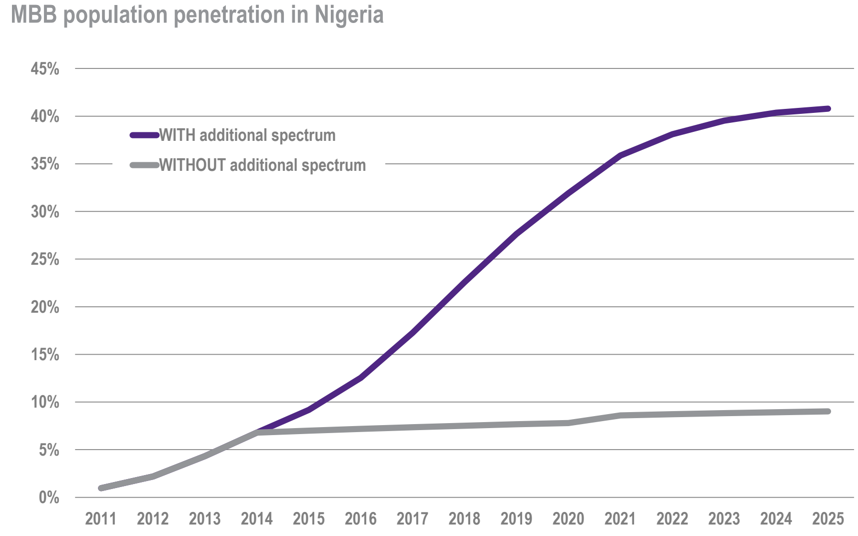
[115] http://www.rnw.nl/africa/bulletin/ace-africa-cable-go-online-late-next-year-france-telecom

[116] Plum estimate based on Wireless Intelligence data

The UN forecasts that urbanisation level will remain below 65% throughout the modelling period[117]; however, the ratio of urban to rural demand is expected to be disproportionately higher than the 65:35 urban-to-rural population split as shown in Figure G-2. This is because we assume that there will only be one subscriber per household in rural areas due to income constraint. Therefore, the total addressable market in rural areas is the total number of households under mobile network coverage, which is at most 25% of the number of rural population.

Figure G-3 provides a comparison of the changes in MBB penetration with and without additional spectrum. The stimulus to penetration rises from 24 percentage points in 2020 to 32 percentage points in 2025.

Figure G-3: Comparison of mobile broadband penetration levels in Nigeria, 2011 - 2025



Source: Plum Consulting

Figure G-4 shows the forecast for total broadband subscribers – fixed[118] and mobile with and without extra spectrum in the 800 MHz and 2.6GHz bands. The impact of releasing additional spectrum is very significant. For example, in total, the country is forecast to have will have 67 million broadband subscribers in 2020, if additional spectrum is made available and 17.6 million if not.

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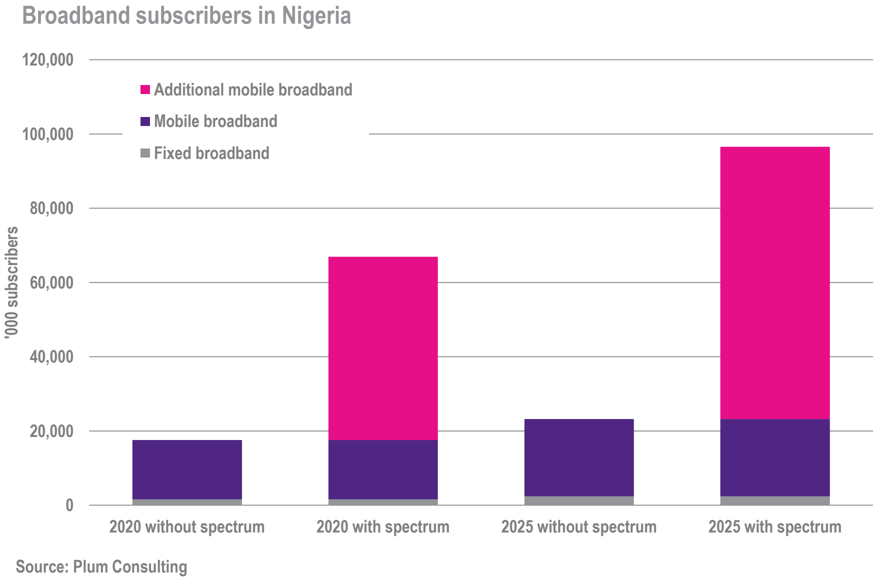
117 http://esa.un.org/wup2009/unup/p2k0data.asp

118 We assume that fixed broadband subscribers will growth linearly between 2010 and 2025 and that, by 2025, the number will be 10 times the number in 2010, which is taken from Informa.

Figure G-4: Comparison of broadband subscriber numbers in Nigeria, 2020 & 2025



Augmented mobile broadband penetration that accompanies the increase in the number of effective MBB subscribers will have a positive impact on the annual growth rate of GDP and hence governmental tax revenues.

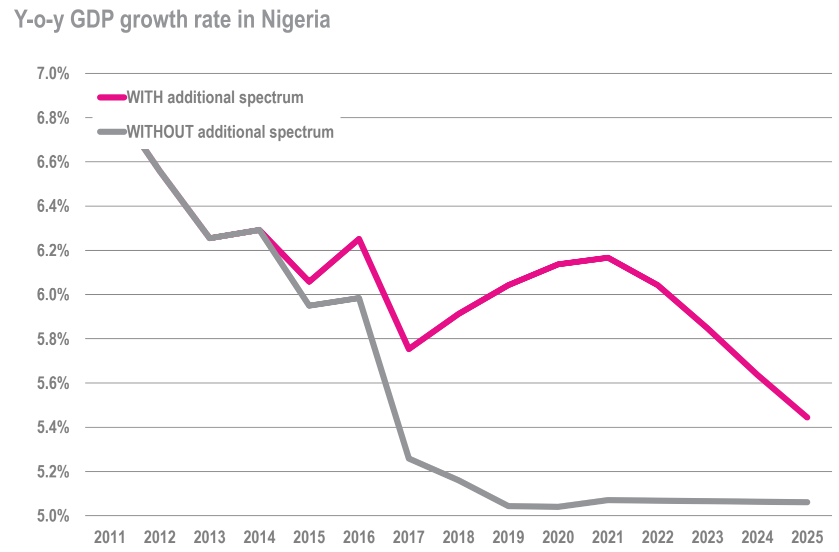
G.4 Economic benefits

The forecast broadband take up enabled by spectrum release is estimated to result in around a 1.1-percentage-point increase in non-oil GDP growth by 2020 as illustrated in Figure G-5. In absolute terms, this is equal to NGN 1,283 billion (US$ 8.5 billion). Year on year non-oil GDP growth will still be around 0.4 percentage points higher in 2025, even though much of the early effect of MBB penetration on GDP growth is assumed to have disappeared by then.

This additional GDP will lead to more employment. 47 million people are currently in employment[119]. We estimate that 6.3 million more jobs might be created, if we assume that all GDP growth results in more jobs and not in higher wages.

[119] Plum analysis based on 2009 World Bank data. http://data.worldbank.org/indicator/SL.EMP.TOTL.SP.ZS/countries

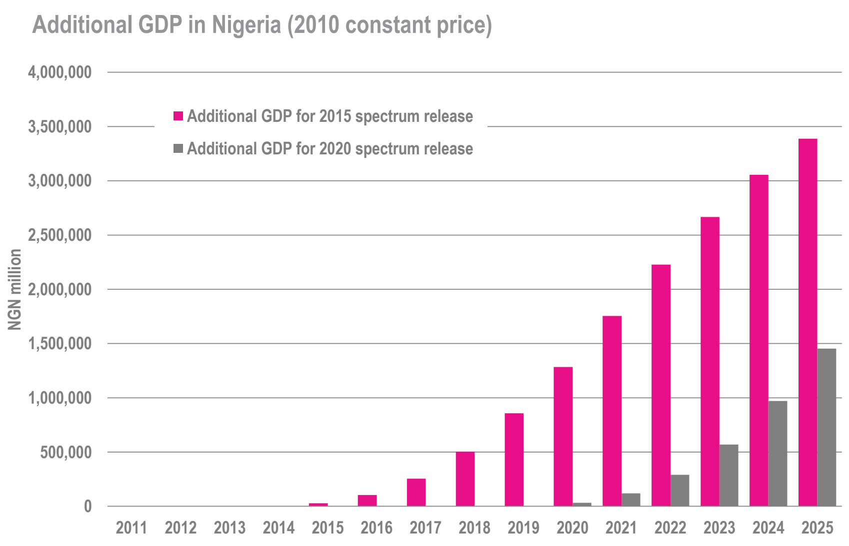
Figure G-5: Comparison of GDP growth rates in Nigeria, 2011 -2025



Source: Plum Consulting

The annual stimulus to non-oil GDP is shown in Figure G-6 together with the impact of a 5-year delay in releasing the spectrum. If the delay occurs, there will be no GDP improvement until 2020, and the unrealised additional GDP will increase from NGN 28 billion (US$ 186 million) in 2015 and NGN 857 billion (US$ 5.7 billion) in 2019. In NPV terms, the forgone GDP arising from the delay will be NGN 7,072 billion[120] (US$ 47 billion).

Figure G-6: Additional GDP with 2015 and 2020 spectrum release dates in Nigeria, 2011 - 2025

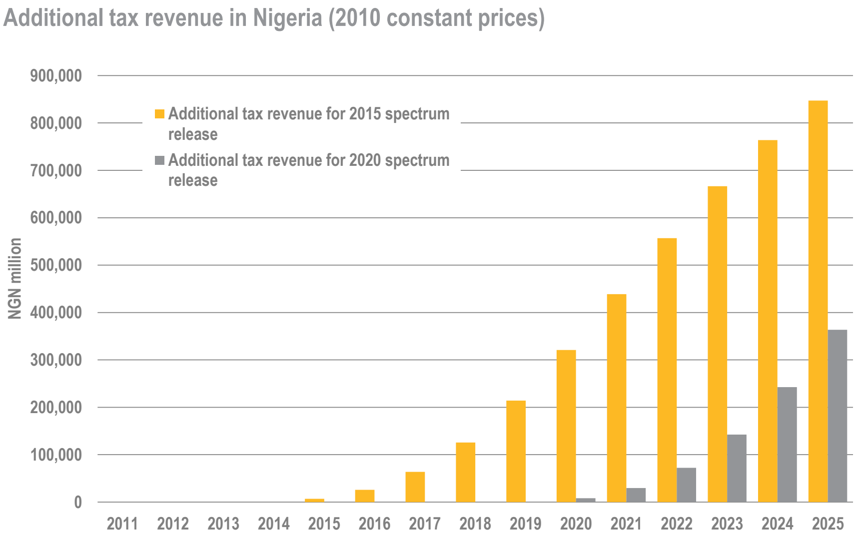


Source: Plum Consulting

[120] The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to NGN 9,524 billion (US$ 63 billion).

There will also be a loss of potential tax revenue, which amounts to NGN 7 billion (US$ 47 million) in 2015 and NGN 214 billion (US$ 1.4 billion) in 2019. In NPV terms, the total forgone tax as a result of the delay will be NGN 1,768 billion[121] (US$ 11.8 billion).

Figure G-7: Additional tax revenue with 2015 and 2020 spectrum release dates in Nigeria, 2011 - 2025



Source: Plum Consulting

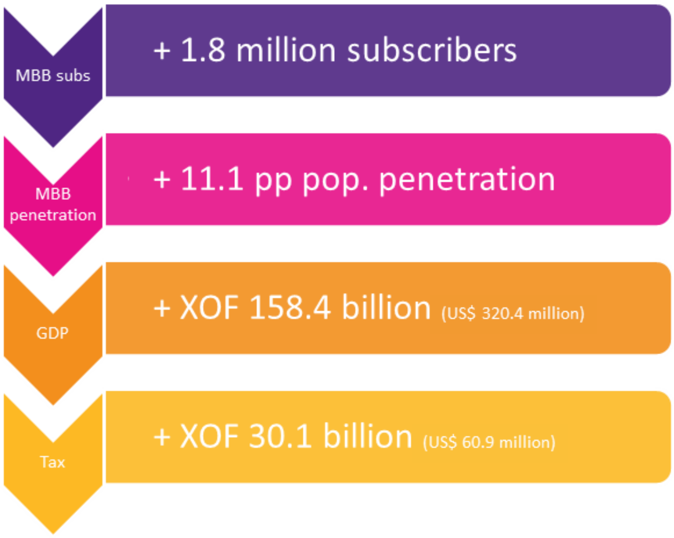
[121] The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to NGN 2,381 billion (US$ 15.8 billion).

Appendix H: Senegal

H.1 Summary of results

The key benefits in 2020 of releasing additional spectrum in 2015 are shown in Figure H-1.

Figure H-1: Summary of benefits in 2020 in Senegal of spectrum release in 2015



Source: Plum Consulting

The derivation of these values and market background are given below.

H.2 Background

Following the outbreak of the global financial crisis in 2008, the Senegalese economy began to recover in 2010, thanks to improvements in global economic conditions as well as to measures adopted by the government to boost the level of national economic activities[122]. In fact, the economy is expected to continue to grow despite the risks associated with the EU debt crisis. According to the country's finance minister, GDP growth rate will continue to be in excess of 4% in 2011 and 2012[123]. Increased electricity production and investments in infrastructure will the two key growth drivers. This kind of state's stimulation of domestic consumption and investments will help to underpin the growth of GDP per capita in coming years.

[122] http://www.africaneconomicoutlook.org/en/countries/west-africa/senegal/

[123] http://www.businessweek.com/news/2011-09-13/senegal-s-economy-to-grow-4-4-in-2012-as-power-output-rises.html

Table H-1: Basic economic data for Senegal, 2010 and 2015

Metric	Value (2010)	Value (2015)
Population	12.4 million	14.2 million
Urbanisation level	48%	51%
GDP per capita	US$ 980 (XOF 484,446)	US$[124] 1,099 (XOF 543,332[125])

Source: IMF, UN, Plum's estimate

Even though GDP per capita (at 2010 constant prices[126]) is not projected to grow significantly between 2010 and 2015, willingness to pay for mobile service appears to be high. Mobile users spend 10% of GDP per capita on their mobile subscription. This should stand mobile networks in good stead to expand their market further. According to Wireless Intelligence, mobile penetration was just over 66% in 2010, leaving ample room for growth for operators. In fact, the mobile market is expected to almost double in size between 2010 and 2015 as shown in Table H-2.

Table H-2: Mobile market indicators in Senegal, 2010 and 2015

Metric	Value (2010)	Value (2015)
Mobile subscriptions	8.3 million	16 million
Mobile population penetration	66.2%	111.9%
Monthly mobile ARPU	US$ 8.6	N/A

Source: Wireless Intelligence

More recently operators have been allocating more resources into the development of in high-speed mobile service. Expresso Telecom launched its 3G network in 2010 and became a competitor to Sonatel in the mobile broadband space[127]. Given the poor fixed-line infrastructure in the country, both Expresso and Sonatel are expected to benefit, as the demand for broadband service grows.

Of the 16 million mobile subscribers that Wireless Intelligence forecasts for Senegal in 2015, we estimate that 5.2 million will be potential effective mobile broadband subscribers. In other words, these 5.2 million subscriptions are subscriptions that will access their service through an MBB-compatible device and are, hence, in the market for MBB service. In total, the number of effective MBB subscribers is projected to be 2.1 million.

H.3 Impact of spectrum release on MBB take-up

We forecast that the number of effective MBB subscribers in urban and rural areas will total 5.7 million by 2020, assuming additional spectrum is released, as shown in Figure H-2. On the other hand, if no additional spectrum is issued, the number will only be 3.9 million. Of the 1.8 additional subscribers,

[124] Exchange rate used by the IMF for conversion of 2010 values in World Economic Outlook, September 2011 is used.

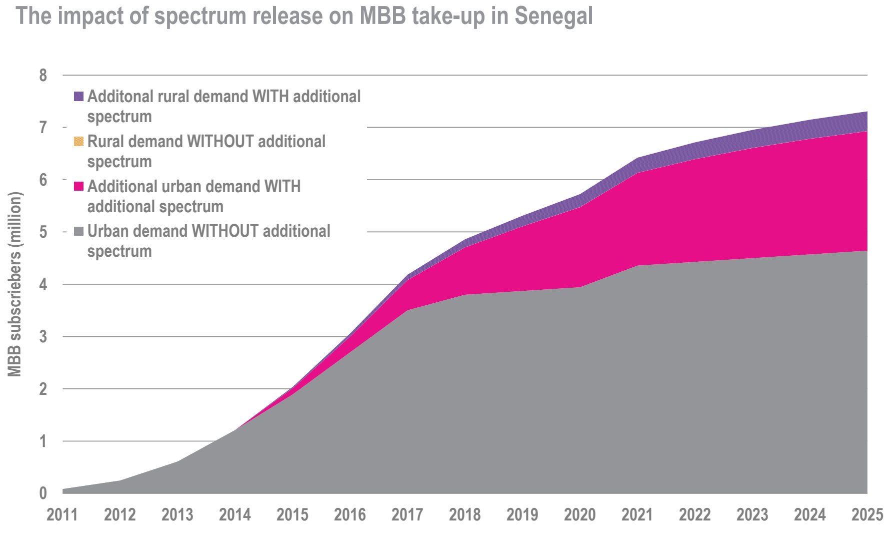
[125] 2015 GDP per capita is stated at 2010 constant prices.

[126] Adjusted using GDP deflator from the IMF's World Economic Outlook database, September 2011 revision

[127] http://www.telecompaper.com/news/expresso-senegal-launches-3g-with-presidential-endorsement

1.5 million will be in urban areas and 0.3 million will come from rural areas. In 2025, the forecast number of subscribers is 7.3 million, assuming extra spectrum becomes available in 2015, compared to 4.6 million if no additional spectrum is released. Of the base of additional subscribers, 2.3 million subscribers will be urban and 0.4 million will be rural.

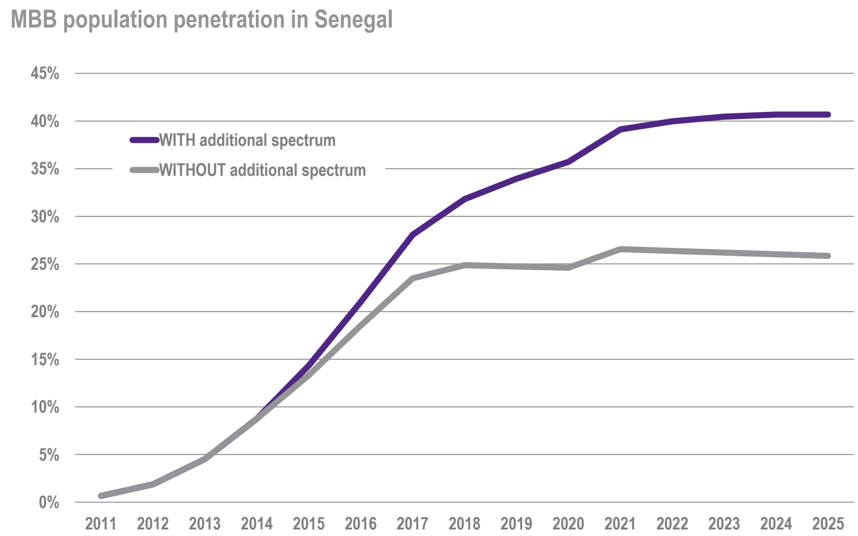
Figure H-2: The impact of spectrum release on MBB take-up in Senegal, 2011 - 2025



Source: Plum Consulting

Figure H-3 shows how MBB penetration is forecast to changes over time with and without additional spectrum. In 2020, there is a difference of 11 percentage points, and, in 2025, the difference rises to 15 percentage points

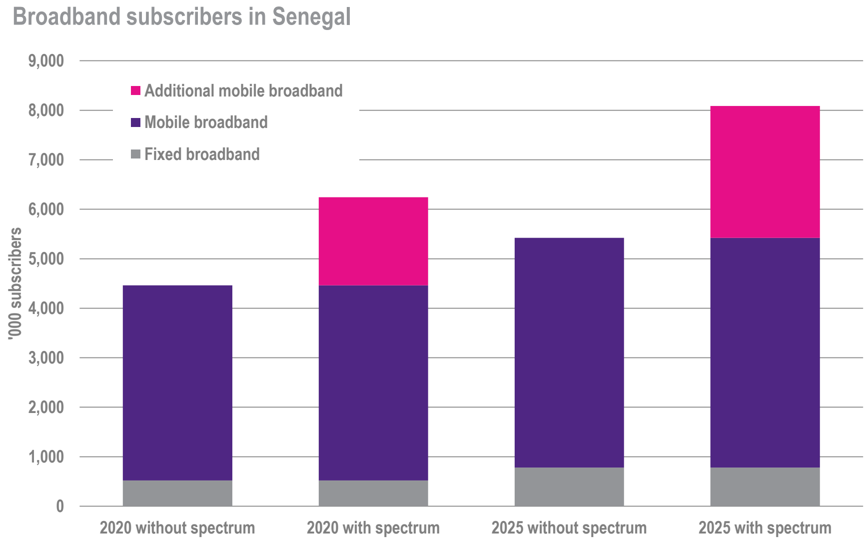
Figure H-3: Comparison of mobile broadband penetration levels in Senegal, 2011 - 2025



Source: Plum Consulting

Figure H-4 shows the forecasts for total broadband subscribers – fixed[128] and mobile. This shows the considerable impact that releasing spectrum at 800 MHz and 2.6 GHz in 2015 could have on total broadband subscriber numbers in 2020 and 2025. Our analysis suggests that Senegal could have a total of 6.2 million broadband subscribers in 2020 and 8.1 million broadband subscribers in 2025, if additional spectrum is made available.

Figure H-4: Comparison of broadband subscriber numbers in Senegal, 2020 & 2025



Source: Plum Consulting

H.4 Economic benefits

The increase in mobile broadband penetration that stems from the expansion of effective MBB subscriber base will have the effect of raising the annual GDP and governmental tax revenues. There will be a positive change on annual GDP growth rate as illustrated in Figure H-5. Assuming that additional spectrum is released, the growth rate of GDP[129] in 2020 will be 0.49 percentage points higher than the level that is expected under the scenario without spectrum. In absolute terms, this is equal to XOF 158 billion (US$ 320 million). Even in 2025, when much of the early effect on GDP growth of MBB penetration has fallen away[130], the GDP growth rate uplift of 0.15 percentage points will remain.

This additional GDP will lead to more employment. 4.6 million people are currently in employment[131]. We estimate that 271,000 more jobs might be created, if we assume that all GDP growth results in more jobs and not in higher wages.

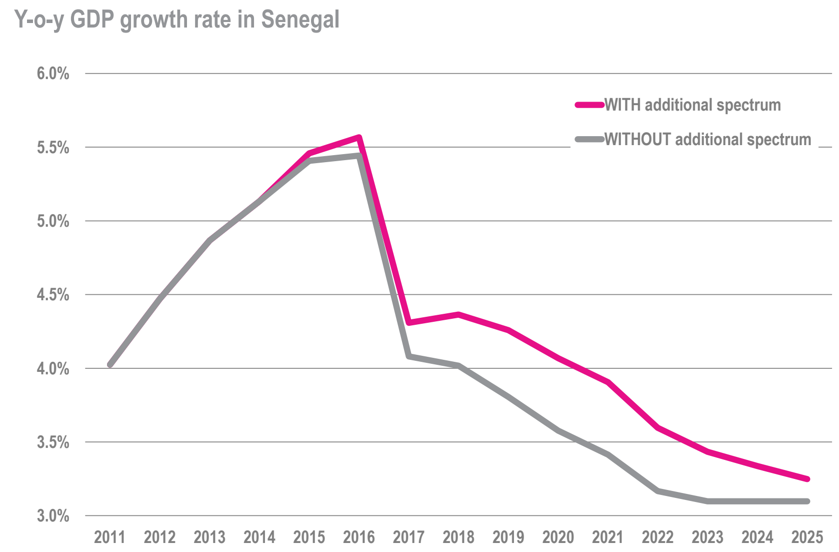
[128] We assume that fixed broadband subscribers will growth linearly between 2010 and 2025 and that, by 2025, the number will be 10 times the number in 2010, which is taken from Informa.

[129] Contribution from mining and quarrying sector is excluded from this GDP, since the impact of increased MBB penetration on industries in this category is small.

[130] We assume that the positive GDP impact of a rise in MBB penetration only lasts 5 years.

[131] Plum analysis based on 2009 World Bank data. http://data.worldbank.org/indicator/SL.EMP.TOTL.SP.ZS/countries

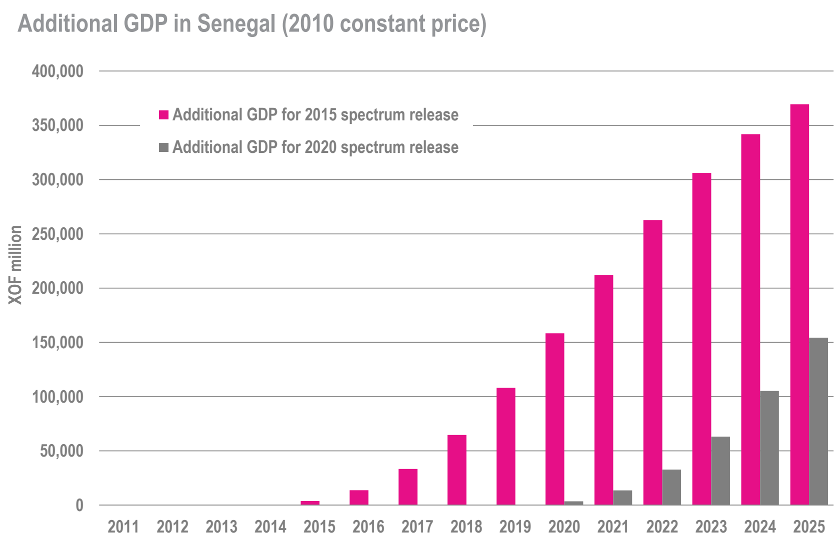
Figure H-5: Comparison of GDP growth rates in Senegal, 2011 -2025



Source: Plum Consulting

Figure H-6 shows GDP increments in local currency for the period 2011 to 2025.

Figure H-6: Additional GDP with 2015 and 2020 spectrum release dates in Senegal, 2011 - 2025



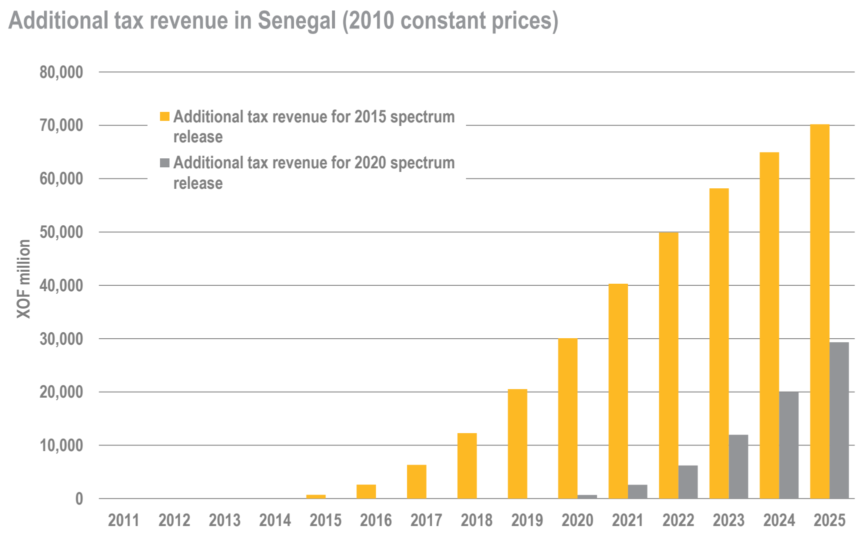
Source: Plum Consulting

If the release of the additional spectrum is delayed by 5 years, there will be forgone GDP increase, which amounts to XOF 841 billion[132] (US$ 1.7 billion) in NPV terms. Correspondingly, there will be a

[132] The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to XOF 1,114 billion (US$ 2.3 billion).

loss of potential tax revenue to the government amounting to XOF 160 billion[133] (US$ 324 million) in NPV terms.

Figure H-7: Additional tax revenue with 2015 and 2020 spectrum release dates in Senegal, 2011 - 2025



Source: Plum Consulting

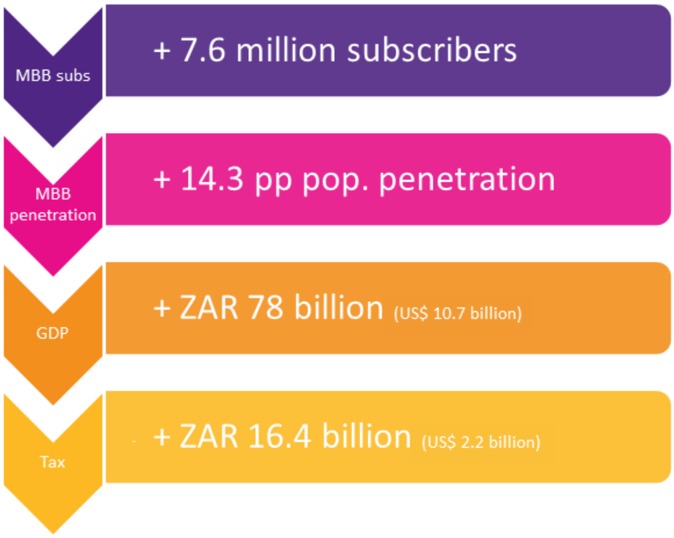
[133] The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises XOF 212 billion (US$ 429 million).

Appendix I: South Africa

I.1 Summary of results

The key benefits in 2020 of releasing additional spectrum in 2015 are shown in Figure I-1.

Figure I-1: Summary of benefits in 2020 in South Africa of spectrum release in 2015



Source: Plum Consulting

The derivation of these values and market background are given below.

I.2 Background

South Africa is one of the richest countries in sub-Saharan Africa. Despite its reputation as an exporter of precious stones, the country's two largest sectors are manufacturing and financial services, including insurance and real estate. These two sectors contributed to around a third of its GDP between 2005 and 2010[134], while mining and quarrying's share of the GDP was consistently less than 9%. In addition, unlike most other sub-Saharan African countries, it relies very little on agriculture and resembles a developed country more closely in its GDP composition.

According to data from the IMF[135], the country's GDP per capita (at 2010 constant prices[136]) was ZAR 53,265 (US$ 7,274) in 2010, and this will rise further to ZAR 60,081 (US$ 8,205) by 2015.

134 http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Yearbook%202011_web.pdf

135 http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/index.aspx

136 Adjusted using GDP deflator from the IMF's World Economic Outlook database, September 2011 revision

Table I-1: Basic economic data for South Africa, 2010 and 2015

Metric	Value (2010)	Value (2015)
Population	50.1 million	51.8 million
Urbanisation level	62%	66%
GDP per capita	US$ 7,274 (ZAR 53,265)	US$[137] 8,205 (ZAR 60,081[138])

Source: IMF, UN, Plum's estimate

In line with a relatively high GDP per capita mobile penetration rates are high. According to Wireless Intelligence, in 2011, South Africa has a mobile penetration rate of 105%, and this value is forecast to grow to 145% by 2015. In absolute terms, these percentages translate to 63 million subscriptions in 2011 and 75 million subscriptions in 2015.

Table I-2: Mobile market indicators in South Africa, 2010 and 2015

Metric	Value (2010)	Value (2015)
Mobile subscriptions	52.7 million	74.7 million
Mobile population penetration	104.8%	145.0%
Monthly mobile ARPU	US$ 22	N/A

Source: Wireless Intelligence

It is expected that mobile data service will increase in popularity as smartphones and other mobile broadband-compatible devices become more affordable[139] - there are already smartphones selling for around $120 in the market[140]. In 2010, nearly a quarter of the recorded 8 million devices sold in South Africa were smartphones[141]. It is projected by Wireless Intelligence that by 2015, there will be 40 million subscriptions with device capable of using MBB services, and we estimate that 40% of this total will be potential effective MBB subscribers.

I.3 Impact of spectrum release on MBB take-up

In South Africa, we assume the 800 MHz and 2.6 GHz bands are released and start to be used in 2014[142]. The extra capacity will be able to support 33 million additional effective MBB subscribers in 2020. We estimate, based on our traffic assumptions, that not all of the additional capacity will be required however. Based on the demand forecasts around 8 million more effective mobile subscribers

[137] Exchange rate used by the IMF for conversion of 2010 values in World Economic Outlook, September 2011 is used.

[138] 2015 GDP per capita is stated at 2010 constant prices.

[139] http://www.mtn-investor.com/mtn_ar2010/ofr_sa.php

[140] For example, Vodacom has already introduced the Vodafone 858 smart as part of its high-speed, affordable smartphone line-up, which is retailed at ZAR 999 (US$ 122).

[141] http://www.vodacom.com/pdf/annual_reports/ar_2011.pdf

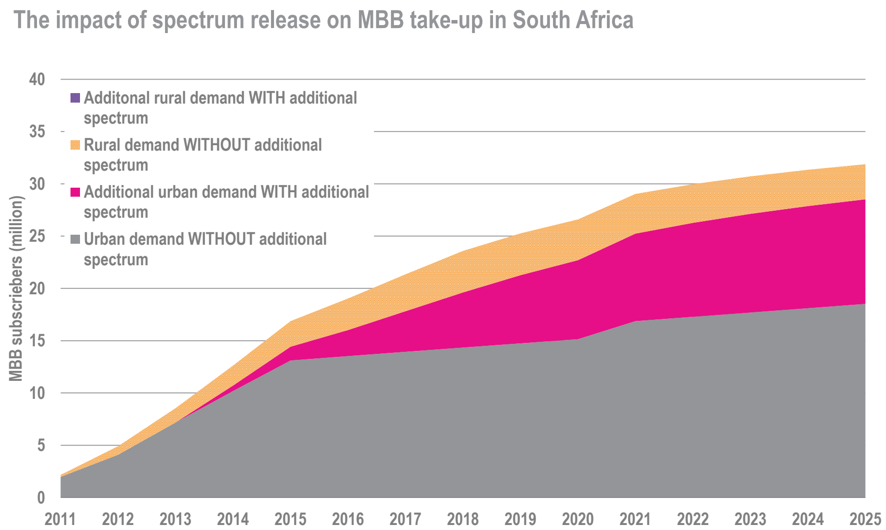
[142] Plans are more advanced for the 800 MHz band than elsewhere.

will be supported by the additional spectrum in 2020. This count will rise to 10 million in 2025, as shown in Figure I-2.

The extra demand will come exclusively from urban areas because, unlike other sub-Saharan African countries, in South Africa there is already sufficient capacity from the existing base stations in rural areas to accommodate our forecasts of future demand. Demand in rural areas is also expected to be low. This is partly due to the high and rising levels of urbanisation in the country. It is forecast that by 2025 around 75% of the population will live in urban areas[143]. In addition, we assume that income inequality[144] will persist so that each rural household will only be able to afford one MBB subscription[145].

The impact on urban demand is less than say in Nigeria because networks in South Africa have many more base stations and population levels and hence densities are not as high.

Figure I-2: The impact of spectrum release on MBB take-up in South Africa, 2011 - 2025



Source: Plum Consulting

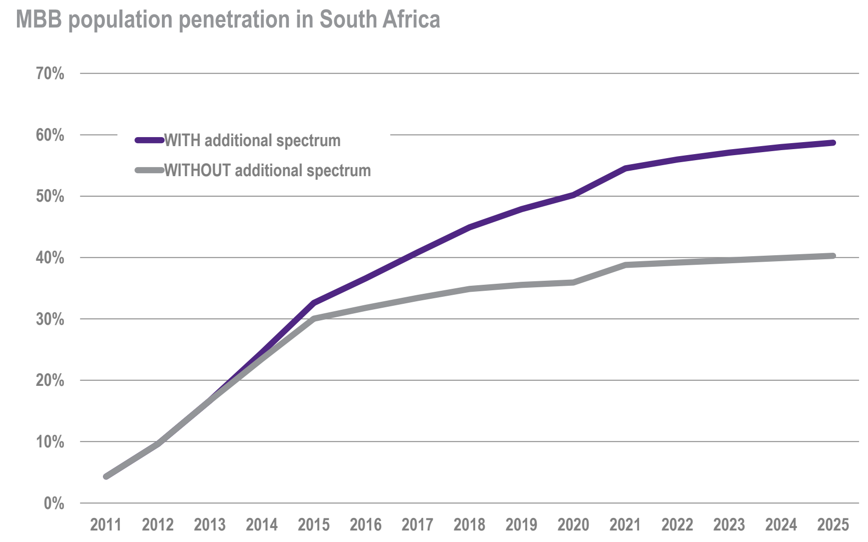
Figure I-3 shows a comparison of the levels of MBB penetration that South Africa that will be achieved under the scenario with additional spectrum and under the scenario without additional spectrum. The difference in penetration grows from 14 percentage points in 2020 to 18 percentage points in 2025.

143 Plum's estimate based on historical trend

144 Rural income per capita between 2005 and 2008 was consistently around a quarter of urban income per capita: http://www.oecd.org/dataoecd/7/13/46955111.xls

145 There are 4.4 persons in a household based on Household statistics from ITU and population data from the African Statistical Yearbook 2011 as well as 2001 Census data for South Africa.

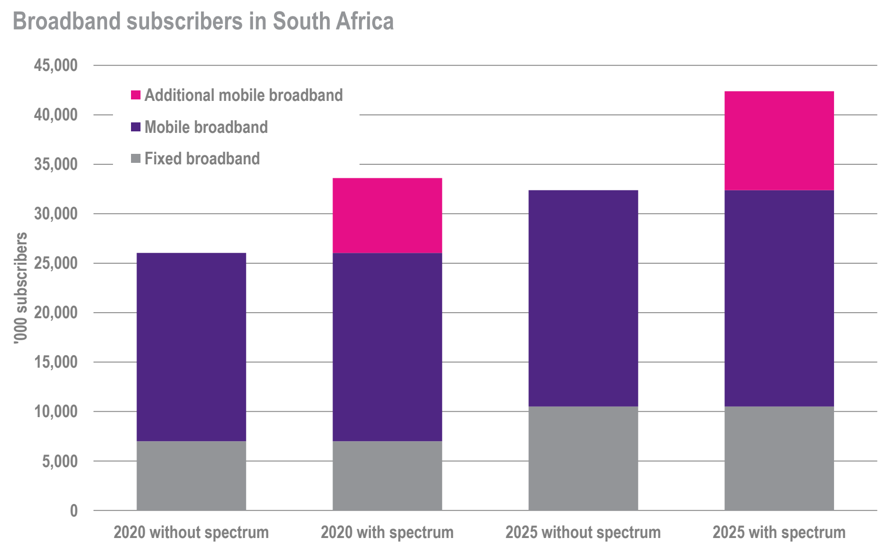
Figure I-3: Comparison of mobile broadband penetration levels in South Africa, 2011 - 2025



Source: Plum Consulting

Releasing spectrum in the 800 MHz and 2.6GHz bands to mobile operators in 2014 will result in a sizeable increase in the number of effective MBB subscribers. As can be seen from Figure I-4 mobile access will dominate and by 2020, there could be 34 million broadband subscribers (fixed[146] and mobile), if there is additional spectrum but only 26 million if the spectrum is not released.

Figure I-4: Comparison of broadband subscriber numbers in South Africa, 2020 & 2025



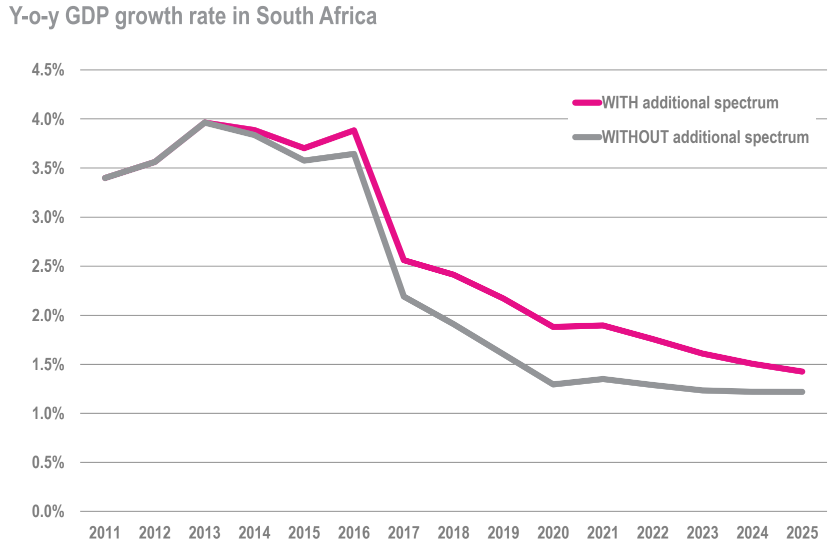
Source: Plum Consulting

[146] We assume that fixed broadband subscribers will growth linearly between 2010 and 2025 and that, by 2025, the number will be 10 times the number in 2010, which is taken from Informa.

I.4 Economic benefits

A comparison of the forecast GDP growth rates for the cases with and without spectrum is shown in Figure I-5.

Figure I-5: Comparison of GDP growth rates in South Africa, 2011 - 2025



Source: Plum Consulting

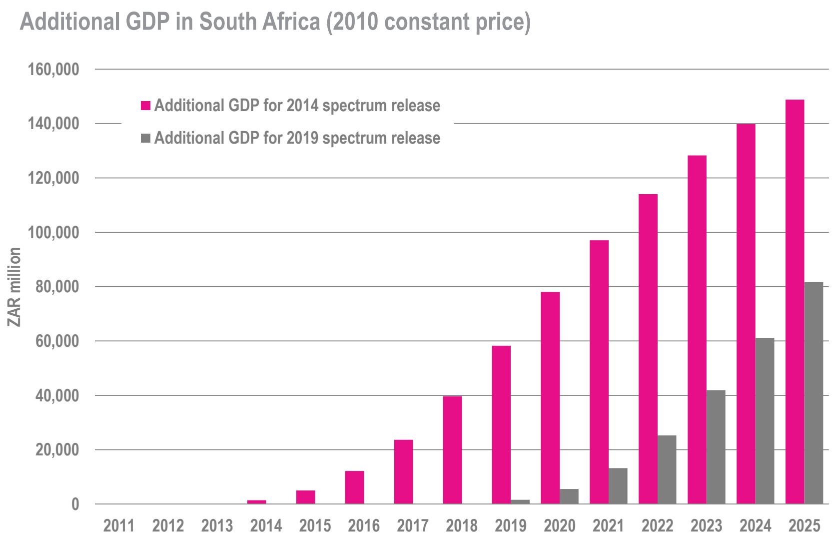
Compared to the scenario, in which no additional spectrum is issued, GDP[147] in 2020 will be 2.4% higher. This is equivalent an increment of ZAR 78 billion (US$ 10.7 billion) in absolute terms. This rises to ZAR 149 billion (US$ 20.3 billion) in 2025. Figure I-6 shows GDP increments in local currency for the period 2011 to 2025.

This additional GDP will lead to more employment. 14.6 million people are currently in employment[148]. We estimate that 1 million more jobs might be created, if we assume that all GDP growth results in more jobs and not in higher wages.

[147] Contribution from mining and quarrying sector is excluded from this GDP, since the impact of increased MBB penetration on industries in this category is small.

[148] Plum analysis based on 2009 World Bank data. http://data.worldbank.org/indicator/SL.EMP.TOTL.SP.ZS/countries

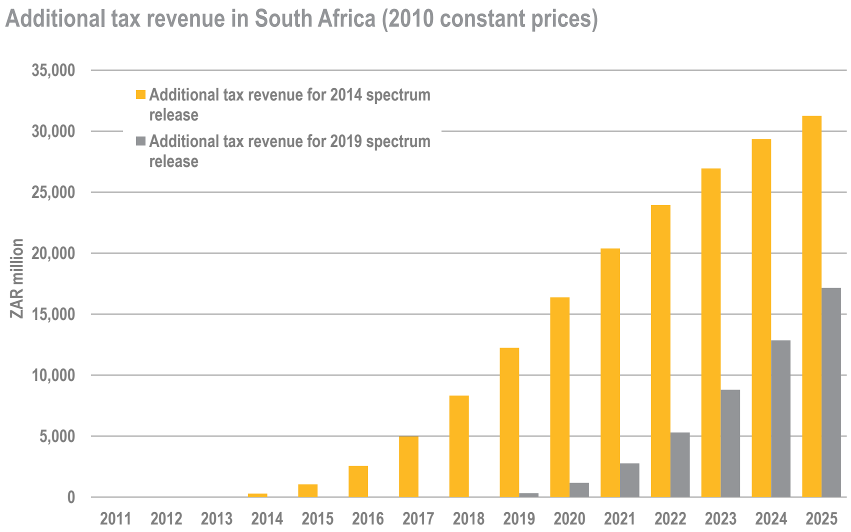
Figure I-6: Additional GDP with 2015 and 2020 spectrum release dates in South Africa, 2011 - 2025



Source: Plum Consulting

A 5-year delay in spectrum release results in forgone GDP amounting to ZAR 355 billion[149] (US$ 48.5 billion) in NPV terms. There will be a corresponding loss of potential tax revenue to the government amounting to ZAR 75 billion[150] (US$ 10.2 billion).

Figure I-7: Additional tax revenue with 2015 and 2020 spectrum release dates in South Africa, 2011 - 2025



Source: Plum Consulting

149 The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to ZAR 427 billion (US$ 58.3 billion).

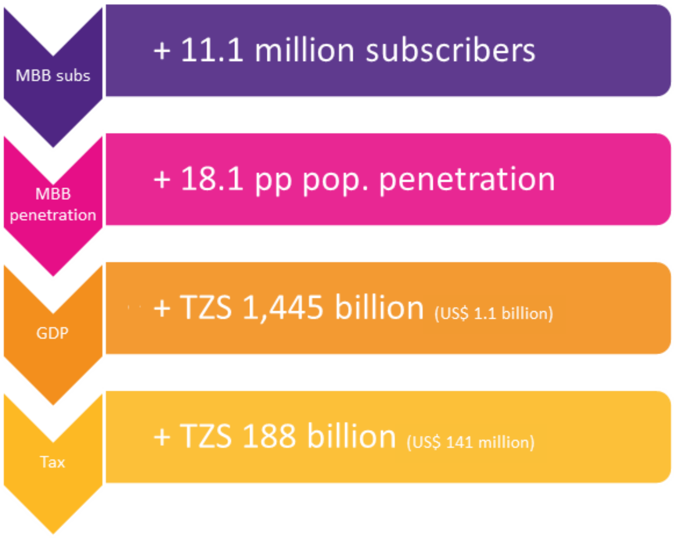
150 The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to ZAR 90 billion (US$ 12.3 billion).

Appendix J: Tanzania

J.1 Summary of results

Figure J-1 gives a summary of the key benefits in 2020 of releasing additional spectrum in 2015.

Figure J-1: Summary of benefits in 2020 in Tanzania of spectrum release in 2015



Source: Plum Consulting

The derivation of these values and market background are given below.

J.2 Background

Tanzania displays many economic and demographic characteristics of countries in the East African region. Just over 26% of its total population lives in urban areas in 2011, and the vast majority of its rural population earns a living from agriculture[151].

[151] http://www.ruralpovertyportal.org/web/guest/country/home/tags/tanzania

Table J-1: Basic economic data for Tanzania, 2010 and 2015

Metric	Value (2010)	Value (2015)
Population	44.8 million	52.5 million
Urbanisation level	26%	28%
GDP per capita	US$ 545 (TZS 729,166)	US$[152] 689 (TZS 920,898[153])

Source: IMF, UN, Plum's estimate

According the data from the IMF[154], GDP per capita (at 2010 constant prices[155]) will grow from TZS 792,166 (US$ 545) to TZS 920,898 (US$ 689) between 2010 and 2015.

Limited fixed telecommunications infrastructure[156] means that many people have come to rely on mobile technology to stay in touch with others as well as to conduct business. The falling costs of mobile phones[157] and the effect of competition on service charges[158] are lowering the barrier to mobile ownership and usage. As a result, mobile penetration has risen steadily in the past 3 years. At end-2008, penetration was 31%, according to Wireless Intelligence. However, by end-2010, this was already 46%. The number is forecast to rise further to reach 66% by 2015, taking the total mobile subscription base to 35 million.

Table J-2: Mobile market indicators in Tanzania, 2010 and 2015

Metric	Value (2010)	Value (2015)
Mobile subscriptions	21 million	35 million
Mobile population penetration	46%	66%
Monthly mobile ARPU	US$ 3.2	N/A

Source: Wireless Intelligence

Future declines in the price of mobile broadband-compatible (MBB) devices[159] will further help to increase the take-up of data service. By 2015, we expect that 31% of the whole subscription base, or 10.7 million subscriptions, will be subscriptions with a MBB-enabled device, forming a sizeable addressable market for mobile broadband service. We estimate that, altogether, there will be 4.3 million potential effective MBB subscribers amongst these subscriptions.

[152] Exchange rate used by the IMF for conversion of 2010 values in World Economic Outlook, September 2011 is used.

[153] 2015 GDP per capita is stated at 2010 constant prices.

[154] http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/index.aspx

[155] Adjusted using GDP deflator from the IMF's World Economic Outlook database, September 2011 revision

[156] In March 2011, there were under 200,000 fixed lines compared to over 21 million mobile subscriptions according to the national regulator: http://www.tcra.go.tz/publications/telecomStatsMarch11.pdf

[157] http://www.ist-africa.org/home/default.asp?page=doc-by-id&docid=4322

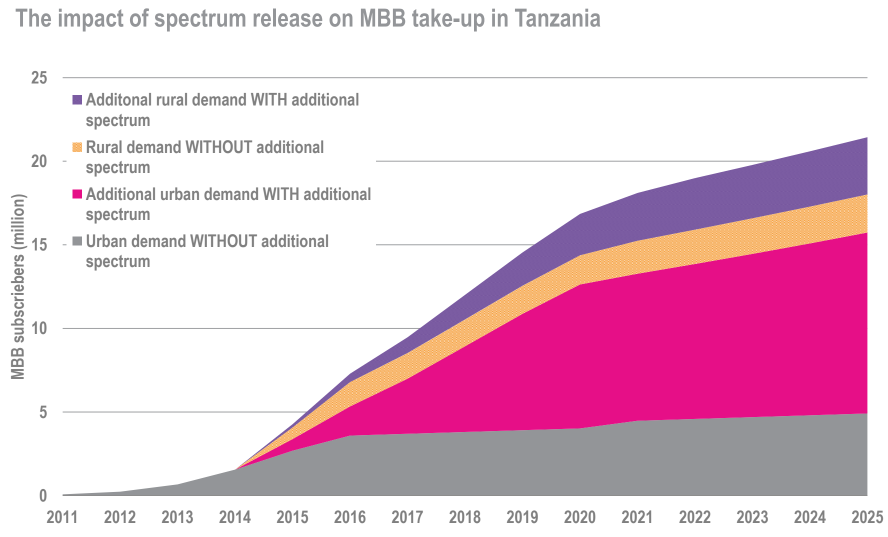
[158] http://ar10.millicom.com/_assets/downloads/pdfs/Africa.pdf

[159] http://thenextweb.com/africa/2011/08/21/affordable-smart-phones-to-drive-africas-internet-adoption/

J.3 Impact of spectrum release on MBB take-up

In total, the number of effective MBB subscribers in urban and rural areas is forecast to be around 17 million by 2020 as shown in Figure J-2, assuming the spectrum at 800 MHz and 2.6 GHz is released. There is a 11-million increase in subscriber volume as a result of the spectrum release; 2.5 million will originate from rural areas and 8.6 million will be from urban areas. By 2025, if extra spectrum becomes available in 2015, there will be 14 million additional subscribers, 11 million subscribers will be urban and 3 million will be rural.

Figure J-2: The impact of spectrum release on MBB take-up in Tanzania, 2011 - 2025

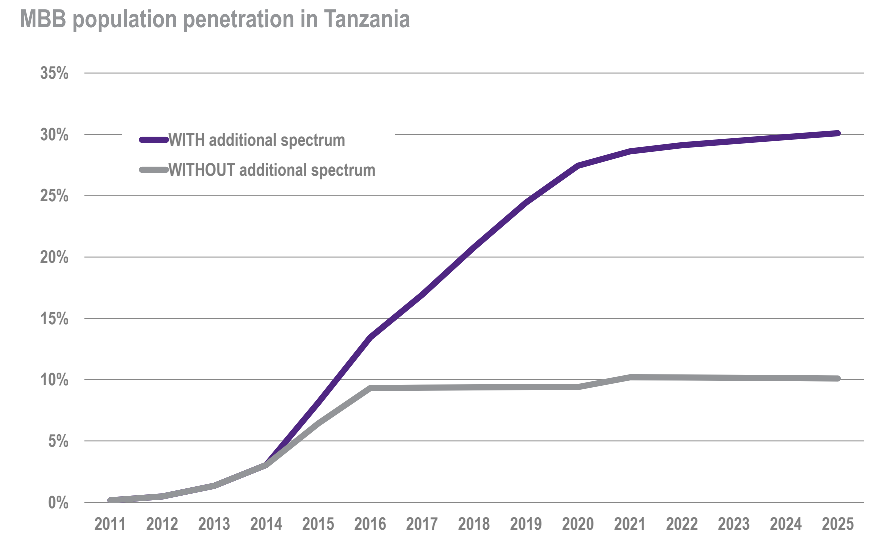


Source: Plum Consulting

The available capacity provided by the 800 MHz and 2.6 GHz spectrum exceeds the forecast demand because the assumed affordability constraint is hit in rural areas and the urban population is relatively small. In urban areas we assume that a maximum of 70% of the urban population will be able to afford the service, which puts an affordability limit of 12.7 million effective mobile broadband subscribers on urban areas in 2020 while, the enhanced urban capacity of network can support up to 14.3 million subscribers.

Figure J-3 shows the change of MBB rate over time for the scenario, in which spectrum is released, and the scenario, in which it is not. In 2020, there is a difference of 18 percentage points, and, in 2025, the difference rises to 20 percentage points.

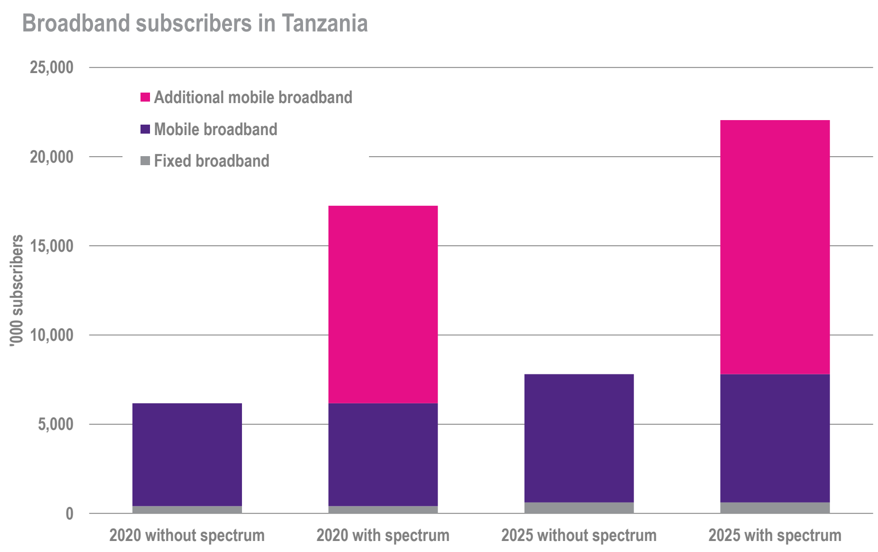
Figure J-3: Comparison of mobile broadband penetration levels in Tanzania, 2011 - 2025



Source: Plum Consulting

Figure J-4 shows that making extra spectrum in the 800 MHz and 2.6 GHz bands will have a significant effect on the total number of broadband subscribers - fixed[160] and mobile. We forecast that in total the country will have 17 million broadband subscribers in 2020, if additional spectrum is made available, but without the spectrum, there will only be 6 million broadband subscribers.

Figure J-4: Comparison of broadband subscriber numbers in Tanzania, 2020 & 2025



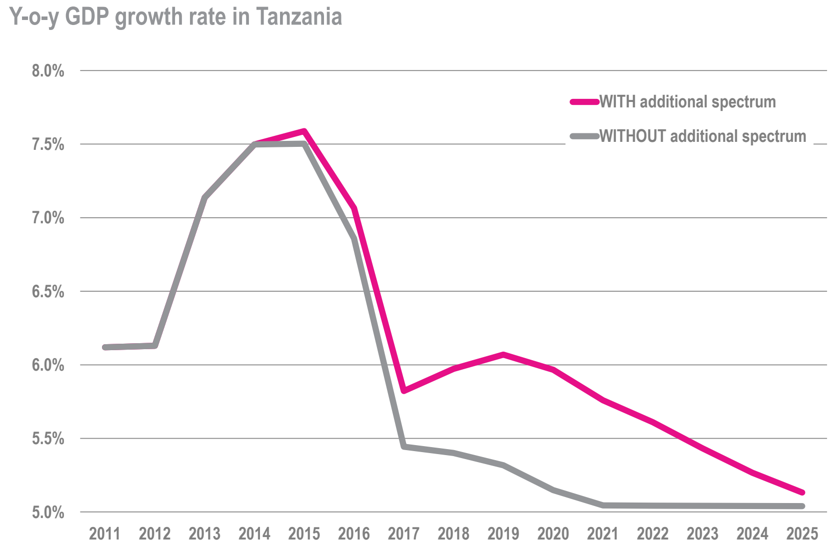
Source: Plum Consulting

[160] We assume that fixed broadband subscribers will growth linearly between 2010 and 2025 and that, by 2025, the number will be 10 times the number in 2010, which is taken from Informa.

J.4 Economic benefits

The rise in mobile broadband penetration that accompanies the increase in the number of effective MBB subscribers will have the effect of augmenting the annual GDP and hence governmental tax revenues. There will be a significant positive change on annual GDP growth rate as illustrated in Figure J-5.

Figure J-5: Comparison of GDP growth rates in Tanzania, 2011 -2025



Source: Plum Consulting

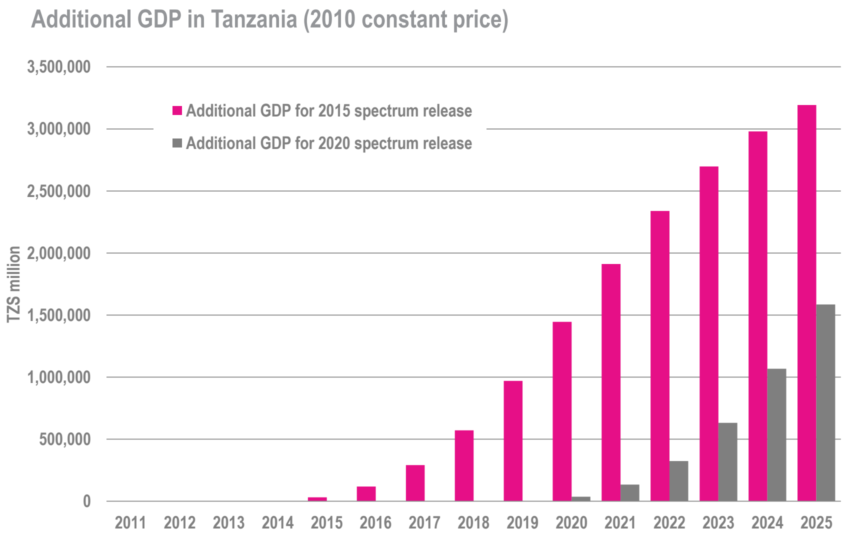
Under the scenario with additional spectrum, GDP[161] in 2020 will be 2.7% higher than the level that is expected under the scenario without spectrum. In absolute terms, this is equal to TZS 1,445 billion (US$ 1.1 billion). GDP uplift in 2025 is estimated to be TZS 3,193 billion (US$ 2.4 billion).

This additional GDP will lead to more employment. 1.9 million people are currently in employment[162]. We estimate that 216,000 more jobs might be created, if we assume that all GDP growth results in more jobs and not in higher wages.

[161] Contribution from mining and quarrying sector is excluded from this GDP, since the impact of increased MBB penetration on industries in this category is small.

[162] Plum analysis based on 2009 World Bank data. http://data.worldbank.org/indicator/SL.EMP.TOTL.SP.ZS/countries

Figure J-6: Additional GDP with 2015 and 2020 spectrum release dates in Tanzania, 2011 - 2025



Source: Plum Consulting

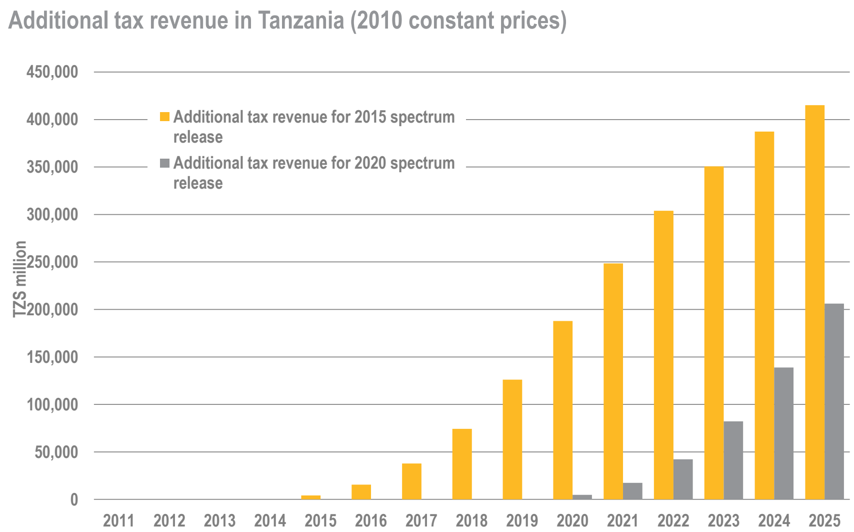
Figure J-6 also shows the impact of a 5-year delay in assigning the additional spectrum. If the delay occurs, there will be no GDP improvement until 2020, and the unrealised additional GDP arising from the delay will grow from TZS 32 billion (US$ 24 million) in 2015 to TZS 970 billion (US$ 725 million) in 2019. In NPV terms, the forgone GDP arising from the delay will be TZS 7,192 billion[163] (US$ 5.4 billion).

The loss of potential tax revenues due to unrealised additional GDP will rise from TZS 4 billion (US$ 3 million) in 2015 to TZS 126 billion (US$ 94 million) in 2019 as shown in Figure J-7. In NPV terms, the total forgone tax as a result of the delay will be TZS 935 billion[164] (US$ 699 million).

[163] The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to TZS 8,796 billion (US$ 6.6 billion).

[164] The cut-off period for this NPV calculation is 2025. If this is extended to 2030, the value rises to TZS 1,143 billion (US$ 854 million).

Figure J-7: Additional tax revenue with 2015 and 2020 spectrum release dates in Tanzania, 2011 - 2025



Source: Plum Consulting