Rural Connectivity

Fibre vs. Fixed Wireless

Table of Contents

Table of Figures

Authors:
Abeer Fadhlani, Jan Van Rees and Christopher Bain

List of Abbreviations and Acronyms

3GPP	Third Generation Partnership Projects
ARPU	Average Revenue per User
AWS	Advance Wireless Services
CapEx	Capital Expenses
FDD	Frequency Division Duplex
FTTH	Fibre to the Home
FWA	Fixed Wireless Access
ITU	International Telecommunication Union
LTE	Long-term Evolution
MDUs	Multi-Dwelling Units
MIMO	Multiple-Input Multiple-output
MNOs	Mobile Network Operators
NGA	Next Generation Access
OpEx	Operating Expenses
ROI	Return on Investment
SDUs	Single-Dwelling Units
TDD	Time Division Duplex

Introduction

The need for investments in infrastructure with such rapid urgency has never been more apparent as it has during the year 2020. From online learning to virtual health care services and having essentials available at one's fingertips, broadband has proven to be the 'inconspicuous hero'. This has caused a greater concern for governments globally to be able to provide stronger, reliable and high-speed broadband internet access for the underserved rural areas. The underlying concern in closing the digital divide is no more a technical but primarily an economic challenge.

Connecting rural communities with broadband access can present a challenging business case with prospects of prolonged payback periods due to low population density and low subscriber ARPU. According to the statistics released by the UN's International Telecommunications Union (ITU), 53.6% of the global population or 4.1 billion people are using the internet by the end of 2019 (ITU Statistics, 2019)[1]. Despite the increase, there are yet an estimated 3 billion people who remain offline, majority living in the rural and remote areas of developing countries. However, during the crisis brought about by the COVID-19 pandemic, we have seen that this divide exists between cities and remote areas in some developed countries as well.

The 'coverage gap', representing 10% of the global population, do not live within the footprint of a broadband network, concentrated mostly in rural and remote areas. The remaining unconnected make up the part of what is known as the 'usage gap' which describes those who live within the reach of a broadband network but do not avail the benefits of the internet. For instance, the coverage maps can be misleading as they may show that rural residents have the access to internet, but the service may be slow, unreliable and expensive. Figure 1 shows the global percentage of the unconnected are around 53% where Sub Saharan Africa takes up a major share of the coverage gap. In Africa, only 294 million people have internet access out of a population of over 1 billion[2].

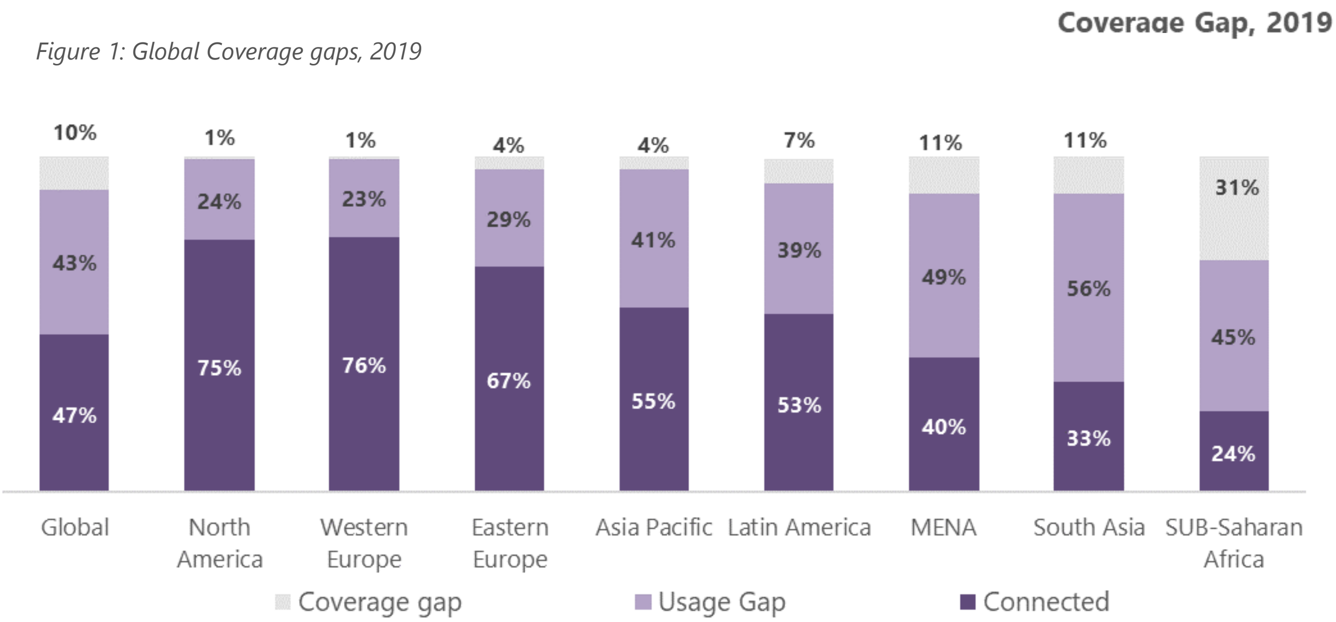


Figure 1: Global Coverage gaps, 2019

[1] ITU Measuring Digital Development. Facts and Figures 2019.

[2] (Veligura, Natasha ; Ka-Ki Chan, Karl; van Ingen, Ferdinand; Cufre, German;, May 2020)

As part of the 'Connect 2030 Agenda for Telecommunication/ICT Development', governments and public sectors around the world are actively taking part in aligning the best policies and practices to deliver effective internet access, thereby enabling pro-active and commercially sustainable investments by the stakeholders.

The ITU and the ATU (African Telecommunication Union) had just recently organized a frequency planning and coordination meeting to strengthen their radio broadcasting services in aims to identify new frequencies in the 87.5-108 MHz band.

All such investments in strengthening coverage are low-cost mediums to reach the remote and the unconnected communities. The timing for these developments could not have been better, especially in times of disasters and emergencies.

Recent studies show that an increase of 10% in broadband penetration yields 1.8% increase in GDP for middle income countries and a 2% increase for low-income countries[3]. In this whitepaper, we will narrow our focus on the comparison between the economic benefits stakeholders consider when choosing between fibre and fixed wireless networks to connect the rural areas.

The Rural challenge

Deployment of the infrastructure remains the biggest challenge when connecting the rural communities due to high roll out costs, lower ARPU and logistics complexities. Costs of deploying new base stations in remote areas can cost up to twice as much, three time more expensive to operate while generating average revenues ten times lower than that in urban areas[4], also depicted in Figure 2.

The general definition of rural and remote can be summarized as areas that lack basic infrastructure, low population density, difficult geographical and environmental conditions. Despite such challenges, ICT sectors around the world are working to promote economic growth by minimizing this connectivity gap in Next generation access (NGA) infrastructure.

The rapid pace of telecommunication coverage across the globe is attained through multiple wired and wireless networks, undersea fibre optic cables and communication satellite coverage. While vast majority of the overall data traffic is carried by undersea and terrestrial fibre, significant investments are still adopted to increase capacity and coverage. The benefits and disadvantages of each of the technology pose an increased concern for the regulatory

Figure 2: Benchmarked economic differences for Rural and Remote vs Urban areas

Vs Urban	Urban	Rural	Remote
Users per site	100%	-60%	-80%
Revenues per site	100%	-80%	-95%
OPEX per site	100%	+25%	+100%
CAPEX per site	100%	+5%	+30%

[3] (ITU Publications - Expert Reports, 2018)

[4] GSMA, Enabling Rural Coverage (2018)

bodies in choosing one over the other in order to reduce cost and provide the best and speedy coverage.

A Network is typically configured in three parts; National backbone/core network, middle-mile/backhaul network and last-mile or access parts. Rural and remote locations often lack this fixed network infrastructure which creates the connectivity gap. The last-mile connectivity solutions are developed to mainly address:

- The lack of Internet infrastructure availability in particular areas;
- High Internet service prices that make connectivity unaffordable for local populations.

This sets it apart from the middle-mile or Backhaul networks which transmit signals from a site to the core network. The distances between these network parts will involve considerable costs depending on the geographical reach. In terms of maintenance costs, again, the long distances between sites will add to costs due to frequent site visits and logistics.

Both technologies, wired and wireless, are used in backhaul and access parts and have been competitive as well as complementary when connecting the underserved areas.

Economics of Rural Connectivity

On the supply-side, the most vital characteristics of networks is the economies of (linear) density, where the cost per location served falls as the density rise. The opposite of this is the concern in discussion.

With land-based networks, this is in large part due to fixed (or partially fixed) costs per link distances (e.g, costs of fibre optic cable and its cost of deployment).

The drive to achieve economic efficiencies has caused the traditional ways of laying down fibre or copper, for delivering high capacity and resilient fixed broadband services, to be coupled with the available connectivity alternatives. The aim here is not only to provide coverage to remote areas, but in doing so, achieve commercial sustainability. This requires lowering costs through optimization of CapEx and OpEx of the overall infrastructure and increasing the resulting ROI of the coverage.

The most evident challenges for the development of the telecommunications/ICTs in the remote and rural areas are:

- **High installation and maintenance costs:** Due to being geographically remote, these areas lack basic infrastructure that is needed to support deployments. High construction and power related investments, transportation become underlying reason why service providers hesitate to steer this way.

- **Low population and low potential Average Revenue per User:** A severe bottleneck for broadband deployment as low coverage results in small returns and ARPU.

- **Shortage of power supply:** This supply shortage further adds costs for the deployment with relations to battery banks and generators. The usage of generators increases OpEx. With evolving technologies, many alternatives have been introduced such as solar and wind energy producers, but this again attracts higher CapEx.

- **Lack of technical and ICT literacy:** The handling of deployment, operations and the successful penetration of telecommunication needs to be done by digitally savvy personnel. Low social and economic conditions create an environment which lacks such skills.

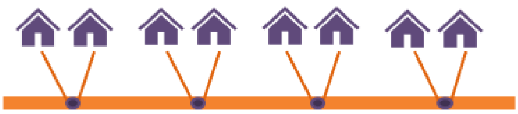
Likewise, network configurations to support internet connectivity can add considerable challenges as service providers will require high capacity backhaul infrastructure which is much more expensive to obtain in rural areas.

Fibre for rural areas and backhaul Capacity

Optical fibre is a very important technology carrying very high bandwidths using light pulses for transmitting data along a long fibre in the access network. Fixed Fibre networks are faster than other available network technologies and can be made even faster by upgrading the active equipment at either end as technology advances. A full fibre network offers many benefits over a wireless or hybrid network, for instance low latency, incredible speed, higher reliability, less vulnerable to cyber-attacks, and to some extent, cost effective for the short and medium bandwidth improvements (Figure 3).

Although Fibre may currently be the superior technical solution it does have financial drawbacks when being deployed outside of dense urban areas. The challenge of rolling out fibre in remote and rural areas is that the cost per user is much higher than in urban areas. Low population densities in the rural areas will affect the business case for network deployment as the same investment in an urban environment would result in a higher number of homes passed.

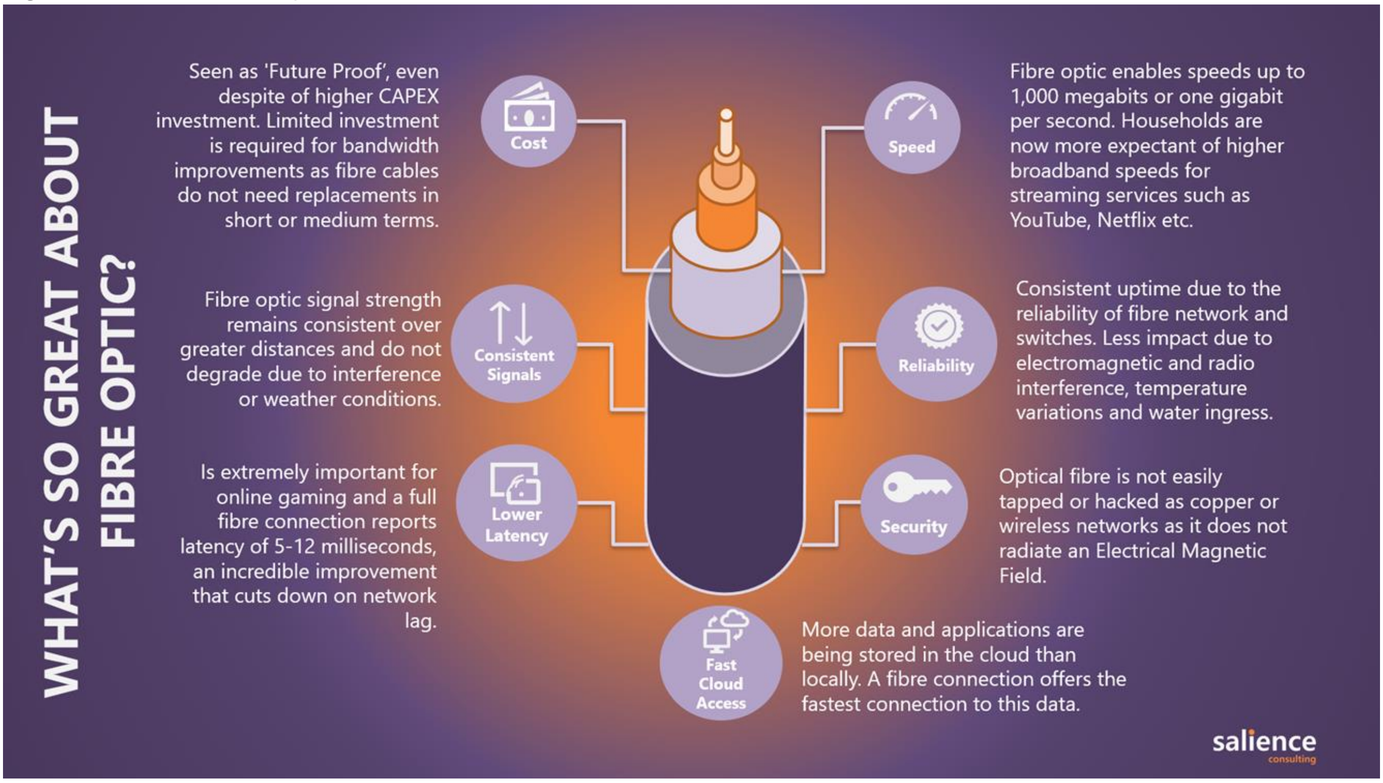
A basic example below shows the difference between the number of homes passed when the same investment is considered for both an urban and a rural deployment.



Urban Deployment: Homes Passed = 8

Rural Deployment: Homes Passed = 3

Figure 3: Benefits of Fibre Optic



Source: Salience research

The urban deployment will result in a lower cost per home passed than the rural deployment as there is a higher number of households sharing the same investment. The civil works costs for trenching can be as high as 70% of the total deployment cost impacting the cost / density relationship. This can result in fibre deployment in rural areas being on average 80% more expensive per Home Passed. The re-use of existing third-party infrastructure through the purchase or lease from third party can help to reduce these costs (the lease or purchase of existing duct or aerial routes).

Therefore, markets with population primarily concentrated in rural locations, the increased costs of adding coverage will likely have a disproportionately high negative impact on profitability. The number of Multi Dwelling Units (MDUs) compared to Single Dwelling Units (SDUs) are generally higher in urban areas compared to rural areas and this also is a factor.

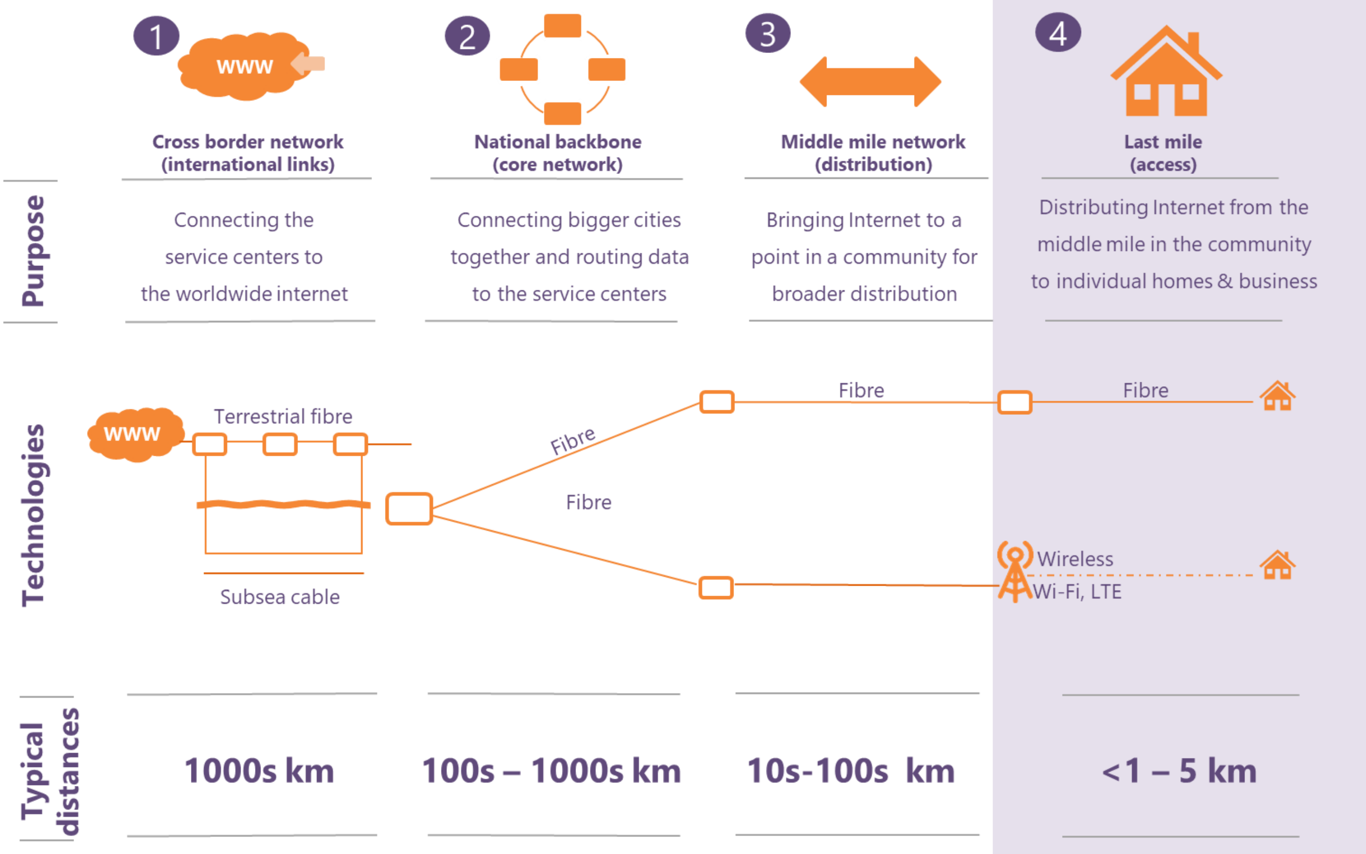
Based on our experience while working with regulatory bodies in different regions, we point out the three key inputs considered for investment to deliver additional coverage:

1. *The revenue opportunity;*
2. *Incremental operating costs (OPEX) incurred;*
3. *Incremental capital costs (CAPEX).*

The most common and preferred means of connectivity is through the use of both fixed and wireless broadband networks backhauled over fibre.

In overcoming the digital divide, it is important not only to provide internet access to households, but also to ensure the connection is fast enough to serve the purpose of adapting to advanced ICT services, health, education and achieving the maximum benefits. Thus, as the bandwidth of an individual cell site goes up, the coverage area is reduced, thereby making fibre optic cable an underlying requirement.

Figure 4: Broadband Infrastructure Value Chain and reach for Fibre and FWA Connectivity



In most cases we have seen that it is generally more acceptable to deploy fibre through poles and overhead cables rather than underground installation, which is more cost effective especially if the poles are shared with other utilities.

However, in cases of dense housing cluster, the cost of access may be comparable to that of urban areas. Hence, the last mile fibre is only suitable where the middle mile access is also brought through fibre, as shown in Figure 4.

The Evolution of Fixed Wireless Access Technology

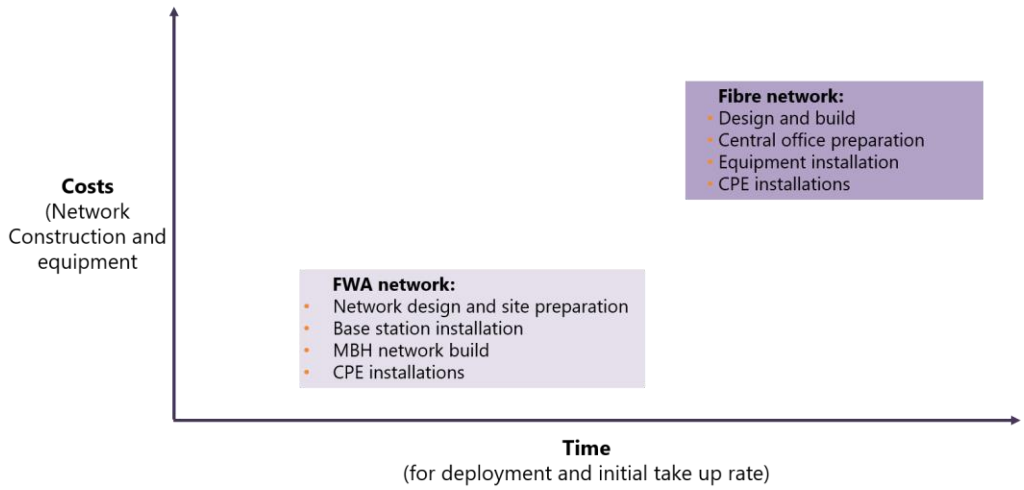
Fixed wireless access (FWA) networks are commonly used as a substitute to wired connections or in complement when connecting the last mile, i.e. the final connectivity, relatively of short distance, between the service provider and the customer premises. Fixed wireless by definition is a system used to connect two fixed locations with a radio or wireless link.

FWA in comparison eliminates some of the physical infrastructure and overall deployment costs, but for it to be competitive, the wireless technology needs to provide high speed fibre-like performance at better cost economics. Nonetheless, the innovations in wireless technologies have proven to complement fixed broadband deployment to connect remote regions in an economical and easier way. Increasing capacity offered by greater spectrum allocations and advancements in 4G/5G networks, is driving higher network efficiency in terms of cost per gigabyte (Figure 5).

Wireless connections are increasingly becoming the most preferred option in expanding the network coverage to rural areas, especially in the time of disruption brought about by the pandemic.

Both developed and developing markets are now using the new wider frequency bands like MIMO in their network designs. Alternatively, 3D beamforming, another 5G technology, could be useful if deployed in a hilly terrain, but otherwise is used in urban high-rise areas. Since 2018, 4G has overtaken 2G becoming the leading mobile technology across the world. Meanwhile, 5G has already

Figure 5: Fibre vs. FWA - Costs and time to build



become a reality in many countries, like Korea, the United States and Saudi Arabia leading in the 5G deployment.

Philippine's Globe Teleco, is a good recent case study for faster deployment of FWA to topographical and logistically challenged areas. Globe marked Philippines to be the first country to experience commercial fixed wireless connectivity in South Asia and second in the entire continent after South Korea[5] .

From the Middle East, the MNOs in Oman (both Omantel and Ooredoo) have deployed 5G as an add-on to their LTE networks in the beginning of 2020. During the year, 5G had gained 2% market share compared to other fixed broadband technologies and fixed wireless connections made up 35% of total connections in Oman.

Radio Access Technology for rural areas

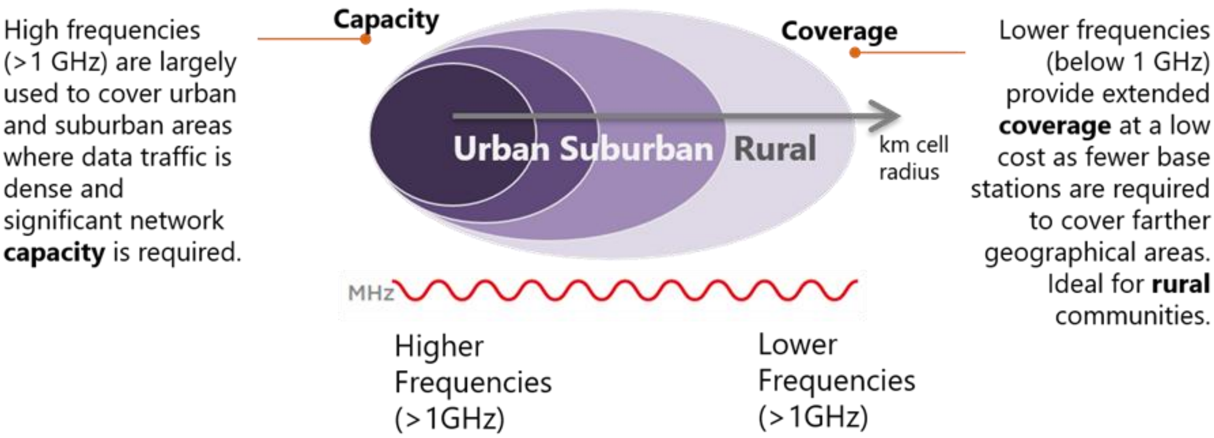
When considering spectrum demand for rural connectivity, it is important to consider the different industry verticals of the technology in question. The 3GPP radio access technology standards provide improved coverage to that of the fibre networks and also include radio innovations like LTE air interface, carrier aggregation, advance modulation schemes and multi-antenna technologies. With such improvements, FWA is able to deliver fibre like performance (although they also result in high capex costs).

FWA systems support a wide range of frequency bands around and below 1GHz to capacity bands above 3GHz. Lower frequencies below 1GHz have further reach and penetrate walls better, while frequencies above 1GHz allow regulators to offer larger portions of the spectrum and thus carry capacity (Figure 6). Besides the existing mobile bands such as 900 MHz (and sometimes also 700 and 800 MHz), 1800 and 2100 MHz (or the US equivalents such as 850 MHz , 1900 MHz and AWS), in general, there are three main frequency bands defined with sufficient spectrum for higher capacity (mobile/fixed) wireless broadband such as:

- 2.3GHz (100 MHz available)
- 2.6 GHz (190 MHz available)
- 3.5 GHz (about 400 MHz or more available depending on the country).

These mid-band spectrum ranges deliver widespread coverage and provide fibre like broadband performance.

Figure 6: Spectrum bands – Capacity vs. Coverage



[5] (GLO, 2019)

In terms of the throughput, 3GPP radio technologies offer exceptional advantage and are optimized for providing broadband services. These three frequency bands are used frequently by either proprietary technology or LTE (mostly TDD though in the 2.6 GHz band both TDD and FDD are being used). Going forward this will be more and more 5G based providing a step forward in terms of performance. While 4G offers hundreds of megabits per second, 5G is expected to steer the performance to gigabits per second.

Economic considerations of FWA

We have seen that fibre deployment is costly to implement when connecting the last mile due to multiple costs especially where the population is widely dispersed. Our studies suggest that the last hundred meters mainly attract 90% of the costs.

The general mass market approach based on fixed wireless is difficult and many people are actually misguided to believe that that case is great. Wireless can deliver high speed but the cost per GB delivered in orders of magnitude are much higher than FTTH. So, ultimately many users will end-up on the FTTH network and are only temporary customers for a fixed wireless player. Fixed wireless networks with enough capacity and a low enough cost per GB require a lot of spectrum and thus mmWave bands with very limited coverage.

The total initial costs of FTTx per broadband line are much higher than that of FWA. Looking at CAPEX only, the fibre costs $500-$1000 per subscriber while wireless would on average cost 70% lower. Although, such costs are reduced with the implementation of radio innovations once the initial investment costs have been absorbed.

When designing the networks, stake holders face a trade-off between the range and the capacity consideration, which determines the severity of operating costs. For instance, long ranged systems will not require many cell sites, which contributes to lower costs in terms of operation and maintenance of the system, but less capacity. Therefore, when choosing the wireless systems, the cost for terminals will also contribute to the per channel cost.

Deployment of a dedicated FWA for niche markets

On other hand, where a FWA network deployment is considered, the competition between fibre and FWA presents a different scenario and a difficult choice. On one side, we have seen that FTTH delivers better-quality service and many more GBs for the same price (lower cost per GB, although, FTTH obviously comes with a major upfront CAPEX). However, an attractive way for mobile operators to expand their networks would be by selling excess capacity as a product piggybacking on their existing network.

The main business case for fixed wireless is for MNOs who anyhow deploy a mobile network and can offer fixed wireless services at almost no additional investments. In this case it is more of selling excess capacity of a mobile network (LTE and/or 5G) to fixed users. The resulting revenue per GB here is much lower, but as long as the excess capacity can be produced without additional investments, it still becomes viable business case.

In many rural areas, mobile has been the dominant form of connectivity. This is due to a key competitive strength for the MNOs that allows the operators to sell fixed wireless connectivity as a product on either their existing spectrums or on the systems and assets of an independent third party. This in turn requires minimum or no CapEx costs, improves efficiency, allows improved coverage, and a quicker deployment.

Therefore, only in specific niche markets, a dedicated fixed wireless proposition would be attractive, mainly where FTTH deployment is not an option and where there are no mobile networks present through which Fixed wireless could be serviced.

A number of enterprises, such as Telenor Norway, have recently adopted the use of separate dedicated LTE spectrum and existing mobile masts to provide connectivity to many of Norway's hard to serve rural and isolated communities.

Spectrum choice when connecting the last mile.

The frequency bands used in FWA need to be strongly related to band strategies, business development, user needs and existing network conditions of operators. Millimeter-wave (mmWaves) are higher frequency bands, like 24-29GHz, providing large bandwidth and therefore a lower cost per GB at high capacity. The biggest challenge is the limited coverage that is caused by the loss of signals due to obstacles such as vegetation, buildings and other interferences. Hence, a deep fibre optic network to poles in the street will still be required and only the last few hundred meters would be connected wirelessly. This

Figure 7: Technology head-to-head Comparison

	Fixed network	Wireless network	
Technology	**Fiber to the home FTTH**	**Mobile Broadband LTE/5G**	**Fixed Wireless**
Passive layer	Fiber optic cable overhead and trenched	Cellular Towers	Towers or Wireless Mesh
Active layer	GPON or Active Ethernet	3G/4G/5G Dedicated line-of-sight	Wi-Fi / WiMAX
Realistic Speed & Performance	100-1000+ Mbps	10-50Mbps	5-50 Mbps
Future Proof ? Can deliver Next Generation Access (NGA)	Long term	Short/Medium term	Short/Medium term
Capacity (Suitability for heavy load like intensive video streaming)		Low	Low
Deployment speed	Slow	Fast	Fast
Cost to Deploy	500-1000 USD per household for urban, 1000-5000 USD for rural	Dependent on the village/catchment size, recent US FCC fund provided 400 USD per HH	Dependent on the size of the village and technology
Cost to Operate	Low	Medium/ High	Medium
Suitability for rural deployment?	Only in the case of availability of fiber reach - usually helped by other utility fibers nearby or availability of ducts/poles to reach the village	Yes, but with speed limitations. Gaining popularity due to known technology and synergies	Yes, but with speed limitations. More suitable for operators that don't have access to dedicated spectrum

Source: Salience research

only makes economic sense if the last drop wire is very costly or difficult to deploy.

This brings us back to mid-band spectrum, like the very popular 3.5 GHz band (Sub-6GHz for 5G) which can provide much better coverage than the mmWave by reducing the cost of efficiency of a wireless last mile connection. Other cost elements that also need to be taken into consideration are the rental, power consumption and spectrum licenses that may drive the OpEx of FWA to become higher than that of FTTx.

Conclusion – Taking a holistic approach

Both technologies in discussion require a fibre optic backbone network and a core network. The cost of the FTTH access network is highly dependent upon the available passive infrastructure, like utility poles, and the average distance between homes. Small villages along a fibre optic backbone with homes clustered in the village centre and utility poles can offer a good FTTH business case, whereas, dispersed rural homes far from any fibre optic backbone might be more cost-efficiently served by FWA.

Both can offer high speed Internet access but FTTH can sustain cost-efficiently high permanent loading, like intensive video streaming, while FWA quickly reaches capacity constraints when a large number of users would like to use high quality video streaming at the same time resulting in major upgrade costs on FWA.

For high-capacity work from home and home learning, FTTH is more suitable in case of modest distances between homes if the deployment costs can be kept lower by using existing passive infrastructure such as utility poles.

For low capacity, but reasonably high speed, Internet access from widely dispersed homes, FWA, especially when piggybacking on a mobile network, is typically the more cost-efficient solution. For MNOs aiming to expand their networks, it almost always makes sense to add a Fixed Wireless service in the rural areas using excess capacity. Effective marketing strategies should also be accompanied to prioritize coverage and stability for rural areas over throughput as opposed to that of fibre.

This brings in additional customers with very marginal investments as long as the mobile network isn't being overloaded by the fixed wireless users. A typical mobile user might use 3-8 GB/month (and maybe 20-30 GB in the most advanced 5G mobile case) while fixed wireless user will quickly consume 50-500 GB and, if they can, even more due to massive video streaming behaviour, as on fixed broadband. Delivering those high volumes on a mobile network quickly becomes a difficult business case so any Fixed Wireless case has to find ways to manage the total usage through quote and fair-use policies to make sure enough customers can be served at a reasonable cost.

Further, FWA can be a great entry strategy, for players who want to enter a market, attract customers and subsequently roll-out FTTH to the main customer concentrations and re-use the fixed wireless infrastructure as high capacity mobile 5G network.

From our experience we have seen that in many countries it is often cheaper to deploy a fibre optic drop wire than to deploy a mmWave fixed wireless solution. Tipping point in the US, for instance tends to be around $1,000. In most African, Middle East, and Central Asian markets it is much cheaper to use a fibre drop if a fibre network needs to be deployed anyhow.

As a consequence, a deep fibre network will be needed to connect the small cells and it might become even more attractive to deploy FTTH all the way.

Dedicated Fixed wireless networks are really a kind of in-between solution which can be useful in very specific cases. Clearly, with in depth knowledge we help stakeholders identify and address the last-mile connectivity challenges through design, planning and implementation, including identifying unconnected regions and providing expert guidance on the selection of organic technical, financial and regulatory solutions.

References

Genaro Cruz, G. T. (2018). *GSMA, Enabling Rural Coverage - Regulatory and policy recommendations to foster mobile broadband coverage in developing countries*. London EC4N 8AF.

GLO. (2019). *Globe 5g, Fixed Wireless Access Strategy Augments infrastructure Limitations to Connect PH Homes*. Retrieved from Globe.com.ph.

GLO. (2019). *Globe Ph*. Retrieved from https://www.globe.com.ph/about-us/newsroom/consumer/globe-5g-fixed-wireless-access-strategy-connect-ph-homes.html#gref

GSMA. (2018). *Fixed Wireless Access: economic portential and best practices*.

ITU Publications - Expert Reports. (2018). *The Economic contribution of broadband, digitization and ICT regulation*. Geneva: Places des Nations.

Veligura, Natasha ; Ka-Ki Chan, Karl; van Ingen, Ferdinand; Cufre, German;. (May 2020). *COVID-19's Impact on the Global Telecommunications Industry*. IFC, TMT, Global Infrastructure.

GLO. (2019). *Globe Ph*. Retrieved from https://www.globe.com.ph/about-us/newsroom/consumer/globe-5g-fixed-wireless-access-strategy-connect-ph-homes.html#gref

Authors

Abeer Fadhlani

Group Head of Finance

Abeer has over 8 years of experience in financial management, budgeting and forecasting. She also has deep knowledge and expertise of local and international corporate tax regulations and related compliance.

She has been with Salience for over 5 years managing and reporting financial data to top management and working closely with telecom experts. She manages the finance and compliance department for Salience's MENA & European entities.

Abeer plays an active role in telecom project valuations, operations and client management across the regions.

JAN VAN REES

Mobile Infrastructure Expert

Jan is an ICT Technical Expert with over 30 years of experience.

Jan's area of specialization includes the field of mobile communication, wireless, broadband and satellites. Jan has been involved in the roll out of telecommunication networks all around the world, both in very high-density cities as well as in remote and rural areas. With his broad and deep technical and business expertise in telecommunications he has been working with both the Operator and the Regulatory side of the business. He has assisted many operators with roaming set-up and optimization of roaming for GSM, 3G/UMTS and LTE.

Jan has extensive experience in the Middle East, including Saudi Arabia where he assisted development of the technology roadmap for mobile broadband, spectrum use for mobile, fixed broadband, IMS, FTTH, NGN, core transmission network and VAS&OSS.

CHRIS BAIN

Telecom Infrastructure Expert

Chris is an expert with more than 20 years' experience.

Chris has been planning and designing telecom infrastructure since 2008 for multiple clients and has identified telecommunications & security requirements for new development projects. He has evaluated and approved all planning aspects of passive infrastructure roll out plan including outside plant civil works and optical fibre network.

He plays a key role within the Salience team responsible for coordinating the design of all telecom infrastructure disciplines for a major project within Bahrain. For our client in Tajikistan, Chris provided a technical concept design and BoQ for a FTTH project within two major cities.

Chris has also represented the company in joint working groups to produce technical guidelines for a Gulf Cooperation Council member state.

Connecting communities

salience consulting