Connect2Recover: A methodology for identifying connectivity gaps and strengthening resilience in the new normal

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Acknowledgements

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Foreword

I am pleased to present the first report of the Connect2Recover initiative: A methodology for identifying connectivity gaps and strengthening resilience in the new normal.

The Connect2Recover initiative supports countries in their efforts to identify gaps and bottlenecks for the utilization of broadband networks and digital technologies to respond to and mitigate the consequences of the COVID-19 pandemic. This includes recovery following the pandemic, readiness for the "new normal", and preparedness for any future pandemics.

As we find ourselves in the second year of the COVID-19 pandemic, we have seen the dial on broadband connectivity shift sharply from "desirable" to "essential". For communities that are poorly connected, lack affordable access, or have few digital skills, the pandemic continues to catastrophically disrupt every aspect of life, from employment and education, to access to health care and essential government services.

We are proud of the partnership between ITU and the governments of Japan and the Kingdom of Saudi Arabia in the Connect2Recover initiative as a key element of the ITU community's response to the United Nations' call to Member States to "build back better".

This report includes several key findings regarding data sources, resilience, and policy and regulations. The Connect2Recover's foundational work on data, resilience, and policy can be applied to other ITU "build back better" initiatives such as those in support of education, health care, and job creation.

High-quality open data and open data collection methodologies are key to gaining an accurate picture of mobile and fixed broadband availability, adoption, and usage, and is foundational for good policy-making. On this front, at the WSIS Forum 2021, the World Bank and ITU affirmed their commitment to create an open standard for terrestrial optical fibre cable (OFC) infrastructure data and to create a digital map of terrestrial OFC infrastructure worldwide as a public good.[1] Likewise, the Connect2Recover initiative can support Giga's efforts to map connectivity demand, using schools as a base point, and identifying where there are connectivity gaps.

With this report, I am calling on all relevant stakeholders to join ITU in developing new data collection methodologies and visualizations, such as coverage maps, so that we can have a better understanding of fixed and mobile broadband availability, adoption, and usage.

I applaud governments and regulators that have implemented emergency measures to address the immediate challenges from COVID-19. Recovery and preparing for what is next requires a truly holistic and collaborative approach, aligned with the Global Symposium for Regulators (GSR) Best Practice Guidelines.

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[1]   *See* WSIS Forum 2021 Session 413 – Fiber Open Data – making data available for Africa (available at https://www.itu.int/net4/wsis/forum/2021/Agenda/Session/413).

To that end, we are calling on governments and regulators to refresh and renew their national broadband plans. Governments and regulators can use the national broadband planning process to help close the digital divide, collect trustworthy sources of data to carry out gap analysis, increase network redundancy and resiliency, and be prepared to move quickly should future disasters occur.

In this report, we detail key elements common to successful national broadband plans: (1) Good governance (2) Clear goals (3) Regular assessment of availability and adoption (4) Supply-side interventions (including investment in infrastructure) (5) Demand stimulation activities (including digital skills programmes) and (6) Monitoring and evaluation programmes.

We do have the tools we need to better prepare for the new normal. I am confident that this report can serve as a blueprint for Member States recovering from the COVID-19 pandemic, as well as those participating in the pilot phase of the Connect2Recover initiative.

Doreen Bogdan-Martin
Director, ITU Telecommunication Development Bureau

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Abbreviations

A4AI	Alliance for Affordable Internet
AAA	authentication, authorization and accounting
ANATEL	Agência Nacional de Telecomunicações
API	application programming interface
AR	augmented reality
AS	autonomous systems
ASEAN	Association of Southeast Asian Nations
ASSIA	Adaptive Spectrum and Signal Alignment, Incorporated
BDT	Telecommunication Development Bureau
BGP	Border Gateway Protocol
BHH	beside hand and head
BLER	block error rate
BSR	bad session rate
CAPEX	capital expenditure
CATI	computer-assisted telephone interviewing
CBRS	Citizens Broadband Radio Service
CDN	content delivery network
CIESIN	Center for International Earth Science Information Networks
COVID	coronavirus disease
DAU	daily active users
DDOS	distributed denial-of-service attack
DNS	domain name server
DSL	digital subscriber line
ESA	European Space Agency
ESRI	Environmental Systems Research Institute
FCC	Federal Communications Commission
FIGI	Financial Inclusion Global Initiative
FTTH	fibre-to-the-home
FWA	fixed wireless access

(continued)

Gbit/s	gigabits per second
GDP	gross domestic product
GIS	geographic information system
GNI	gross national income
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GSMA	Global System for Mobile Communications Association
GSR	Global Symposium for Regulators
HAPS	high-altitude platform station
HD	high definition
HIBS	HAPS IMT base station
HRSL	High Resolution Settlement Layer
HSPA	High Speed Packet Access
HSPA+	High Speed Packet Access Plus
HTTP	Hypertext Transfer Protocol
ICT	information and communication technology
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IMT	International Mobile Telecommunications
IoT	Internet of Things
IP	Internet Protocol
IPB	ICT price basket
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
ISOC	Internet Society
ISP	Internet service provider
IT	information technology
ITU	International Telecommunication Union
IXP	Internet exchange point
LDCs	least developed countries
LEO	low-Earth orbit

LTE	Long-Term Evolution
MAU	monthly active users
MIRA	Measuring Internet Resilience in Africa
NETP	national emergency telecommunication plan
NFCP	National Fiberisation and Connectivity Plan
NGO	non-governmental organization
OECD	Organisation for Economic Co-operation and Development
OPEX	operating expenditure
QoS	quality of service
REG4COVID	Regulation for COVID
RIPE	*Réseaux IP Européens* (European IP Networks)
RLAN	radio local area network
RTT	round-trip time
SDG	Sustainable Development Goal
SIM	subscriber identity module
SKU	student licensing plan
SMB	small or medium-sized business
SME	small or medium-sized enterprise
SNMP	Simple Network Management Protocol
SRTM	Shuttle Radar Topography Mission
STEM	science, technology, engineering, and mathematics
TCP	Transmission Control Protocol
TIC	*Telecomunicaciones Indígenas Comunitarias*
TIES	Telecommunication Information Exchange Service
TLS	Transport Layer Security
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
VR	virtual reality

WCDMA	wideband code division multiple access
WDI	World Development Indicators
WSIS	World Summit on the Information Society

1 Introduction and overview

The world has experienced unprecedented change, with the COVID-19 pandemic now in its second year. Alongside massive loss of life, the COVID-19 pandemic has resulted in a reordering of our social and economic fabric. Around the world, we have seen the dial on broadband connectivity shift sharply from "desirable" to "essential". In many respects, the COVID-19 pandemic has merely accelerated changes in usage patterns, such as increased use of cloud-based productivity and videoconferencing applications. In other respects, the COVID-19 pandemic has radically shifted where and when digital service consumption occurs – at home and nearly all the time.

In the face of lockdowns and quarantine restrictions, instant at-home access to digital infrastructure has become a basic requirement for full-fledged participation in society and the economy. Reliable and affordable fixed and mobile broadband continues to play a vital role in helping companies and citizens adapt to the COVID-19 pandemic, enabling businesses to stay open and citizens to continue working, learning, receiving medical support, socializing, and accessing entertainment remotely. This transition has been possible for those of us lucky enough to already have affordable access to fixed and mobile broadband at home. But those who have been able to seamlessly move their activities online are the privileged few.

By contrast, most people around the world lack affordable access to fixed and mobile broadband and therefore have been unable to adapt quickly and fully to the COVID-19 pandemic and the post-COVID "new normal". According to the latest ITU data, at the end of 2019 there were about 4.0 billion Internet users, or 51 per cent of the world population, meaning that 3.7 billion people are offline.[1] Less than 20 per cent of the population in LDCs use the Internet, compared with 44 per cent in developing countries. ITU data also show that globally the proportion of women using the Internet is 48 per cent, against 55 per cent of men.[2] Finally, the data corroborate the disproportionate impact of digital inequality on the following groups: (1) low-income populations (especially those residing in LDCs); (2) those located in rural areas, in small island developing States, and in landlocked developing countries; (3) those lacking literacy and digital skills; and (4) those from traditionally disenfranchised groups, such as women and girls, persons with disabilities, and ethnic minorities. The Broadband Commission for Sustainable Development has confirmed that digital inequality persists around the world, even in countries with extensive high-speed connection infrastructure.[3]

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[1]   *See* International Telecommunication Union, Telecommunication Development Bureau, "Measuring Digital Development, Facts and Figures 2020", at 7 (available at https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2020.pdf) (Facts and Figures 2020).
[2]   *See Facts and Figures 2020* at 8.
[3]   *See* International Telecommunication Union 2020. Broadband Commission for Sustainable Development, "The State of Broadband: Tackling digital inequalities, A decade for action", September 2020, at 45 (available at https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.21-2020-PDF-E.pdf)("State of Broadband").

The global COVID-19 pandemic has amplified the importance of connectivity for social and economic inclusion, and yet, as with past crises, there is a risk that it will increase inequality.[4] The pandemic has not only exposed but also exacerbated long-standing social and economic inequalities. The impact of COVID-19 on childhood education is particularly acute. UNICEF estimates that two-thirds of children and young people worldwide remain unconnected and deprived of digital technologies and services that have proved to be essential to education during the pandemic.[5] The COVID-19 pandemic has further shown that both fixed and mobile broadband are critical for social and economic inclusion and prosperity. The pandemic has also strengthened the vital role that broadband connectivity plays and the urgency for universal connectivity.

Even before the COVID-19 pandemic, there was growing recognition that Internet connectivity is foundational to human development.[6] Universal connectivity is a fundamental element of an inclusive and sustainable world, essential to improving education quality, health care quality, the standard of living, personal safety, freedom of choice, and overall life satisfaction. One cannot achieve the Sustainable Development Goals (SDGs) of the United Nations without universal, affordable broadband.[7] This includes ensuring that all citizens, including those from traditionally disenfranchised groups such as persons with disabilities, the elderly, children, youth, ethnic minorities, and women and girls, have equitable access to broadband.

Various international organizations, the Broadband Commission for Sustainable Development and national governments, have set goals for achieving universal Internet connectivity.[8] At current projections, however, it is unlikely that these goals will be met.

In partnership with the Government of Japan and the Government of the Kingdom of Saudi Arabia, ITU's Connect2Recover initiative aims to reinforce digital infrastructure and digital ecosystems of beneficiary countries, so that they can better leverage information and communication technologies (ICTs) to support COVID-19 pandemic recovery efforts and preparedness for a post-COVID normal. The partnership between ITU and the Governments of Japan and Saudi Arabia will support the Connect2Recover initiative as a key element in the ITU community's response to the call of the United Nations for Member States to "build back better".

This report is the output of phase one of the Connect2Recover initiative. It details a global methodology for identifying gaps and bottlenecks at the country level that hamper the utilization of broadband networks (and, where appropriate, narrowband networks) and digital

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[4]   *See* United Nations Development Programme, "Human Development Report 2019, Beyond income, beyond averages, beyond today: Inequalities in human development in the 21st century," at 52 (available at http://hdr.undp.org/sites/default/files/hdr2019.pdf) (UNDP Human Development Report 2019) ("In a study of Latin American countries all economic crises were followed by an increase in the poverty rate, and most were followed by an increase in inequality."); *see also* United Nations Development Programme, Humanity Divided: Confronting Inequality in Developing Countries, 2013 (available at https://www.undp .org/content/dam/undp/library/Poverty%20Reduction/Inclusive%20development/Humanity%20Divided/ HumanityDivided_Full-Report.pdf).

[5]   *See* United Nations Children's Fund and International Telecommunication Union, "How many children and young people have internet access at home? Estimating digital connectivity during the COVID-19 pandemic", UNICEF, New York, 2020 at 5 (*available at* https://data.unicef.org/wp-content/uploads/2020/11/Children -and-young-people-digital-connectivity-covid19_English.pdf).

[6]   *See,* e.g. Human Development Report 2019 at 233 (referencing 2016 United Nations General Assembly Resolution); see also Broadband Commission for Sustainable Development, *"Global Goal of Universal Connectivity: Manifesto"* ("Manifesto") (available at https://broadbandcommission.org/Documents/ BroadbandCommission_manifesto.pdf) (universal connectivity as a fundamental element of an inclusive and sustainable world).

[7]   *See* Manifesto.

[8]   *See* "State of Broadband" 2020.

technologies to respond to and mitigate the consequences of the COVID-19 pandemic. This includes recovery following the pandemic, readiness for the "new normal", and preparedness for future pandemics. The objectives of the study are to:

1. Identify and combine existing and new sources for the collection of data on broadband/narrowband and digital technology, focusing on:

    - coverage or access/availability (geographic/population)
    - adoption and usage rates
    - specific locations such as schools, healthcare facilities, and government facilities with low access/adoption/usage rates
    - specific groups, such as women and girls or persons with disabilities, that have low access/adoption/usage rates;

2. Assess the resilience of operator networks during the pandemic and steps taken by Member States to increase resilience;
3. Identify digital technologies (connectivity, devices, applications, services) to mitigate the consequences of future pandemics;
4. Describe a mechanism to stress-test operator networks under man-made and natural hazards such as pandemics;
5. Identify policies and regulations (spectrum, funding, licensing, facility access) that Member States can adopt to be better prepared for future pandemics;
6. Identify efforts and options for Member States to increase adoption of broadband and strengthen network resilience.

This report includes several key findings regarding data, resilience and policy. As we explain below, the COVID-19 pandemic has exposed gaps in data, helped broaden our view of resilience, and sharpened and re-energized our focus on closing the global connectivity gap. The report complements the ITU publication "Pandemic in the Internet age: From second wave to new normal, recovery, adaptation and resilience", which recommends actions and regulatory measures aimed at addressing the digital divide, driving digital deepening, effecting digital transformation, and building digital resilience.[9]

High-quality data is key to having an accurate picture of fixed and mobile broadband availability, adoption, and usage. It is also the basis for good policy-making; however, the available data on broadband are patchy, and tend to be particularly incomplete just where it is most needed. Up-to-date data based on open international standards and methods with a high-level of geographic specificity would be ideal, but governments can discover a lot with simple, consistent data collections from network operators, verified with trusted third-party data sources. ITU is in a unique position to convene various stakeholders to develop new data collection methodologies and visualizations, such as coverage maps.

Broadband definitions are critical to ensure that targets move in step with trends of increasingly media-rich content on the Internet. To meaningfully connect to the Internet, consumers today require at-home fixed connections supporting a full range of applications requiring high throughput (such as multiple high-definition video streams) and low latency (such as HD videoconferencing and gaming applications). Broadband definitions and policies should ensure that these experiences can be delivered to all citizens. Mobile broadband targets are best

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[9] *See* International Telecommunication Union, "Pandemic in the Internet age: From second wave to new normal, recovery, adaptation and resilience", May 2021 (available at https://www.itu.int/en/myitu/Publications/2021/05/11/08/52/Pandemic-in-the-Internet-age).

defined in terms of population coverage for a specific generation of technology, and this will be highly dependent on the current level of population coverage in a country. To build resilience, indoor coverage should be reported and improved for meaningful home access for work and education during pandemics.

Fixed and mobile broadband networks have proven resilient where they exist, but we have seen problems in markets that lack the basic infrastructure of the Internet such as Internet exchange points, direct access to submarine cables, and international terrestrial transmission networks. The COVID-19 pandemic shows us that we need to think of resilience more broadly to address the global fixed and mobile broadband gap, as well as issues like electricity. The pandemic has also taught us that a country's broadband network cannot be considered resilient if significant portions of its population cannot access the Internet at home. A well-functioning society and economy require participation of all citizens, not just those fortunate enough to have affordable Internet connectivity. Thus the World Bank has recently observed that, "as the internet becomes the central platform for much of social and economic life, providing all citizens with an opportunity to access this platform is increasingly a matter of social inclusion."[10]

The massive array of actions by governments, industry, and civil society shows us that technologies, business models, and policy and regulatory approaches already exist that could be used to close the global connectivity gap. Governments and regulators have implemented emergency measures to address the immediate challenges from COVID-19: in spectrum access (for example, special temporary licensing and accelerated release of spectrum), broadband pricing (for example, zero rating educational content and protecting services against shutoff due to non-payment), infrastructure access (accelerating access to rights-of-way) and investment (funding for broadband connections). However, emergency measures alone do not enable a country to adapt to the new normal or make it truly resilient.

A wide range of digital technologies (connectivity, devices, applications, services) can be utilized to mitigate the consequences of future pandemics. Unfortunately, these technologies are not universally available or affordable. In some countries, laws and regulations (or lack thereof) preclude or hinder the deployment of certain connectivity technologies that could be used to extend low-cost fixed and mobile broadband to unserved communities (an example is the absence of comprehensive universal service policies).

A decade after the advent of the first generation of national broadband plans, now is a good time for all countries to develop or update those plans. Recovering from COVID-19 and preparing for what is next requires a truly holistic and collaborative approach, aligned with the Best Practice Guidelines of the Global Symposium for Regulators (GSR).[11] Governments and regulators can use the national broadband planning process to help close the digital divide, increase network redundancy and resiliency, and be prepared to move quickly should future disasters from natural hazards or man-made causes occur. In this report, we detail six key elements common to successful national broadband plans: (1) good governance; (2) clear goals; (3) regular assessment of availability and adoption; (4) supply-side interventions (including investment

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[10] *See* The World Bank Group, "World Development Report 2021: Data for Better Lives", 160 (available at https://openknowledge.worldbank.org/bitstream/handle/10986/35218/9781464816000.pdf) (World Development Report 2021: Data for Better Lives).

[11] *See* Global Symposium for Regulators (GSR) 2020 Best Practice Guidelines, "The gold standard for digital regulation" (available at https://www.itu.int/en/ITU-D/Conferences/GSR/2020/Documents/GSR-20_Best -Practice-Guidelines_Final_E.pdf); *see also* Global Symposium for Regulators (GSR) 2019 Best Practice Guidelines, "Fast Forward Digital Connectivity for All (available at https://www.itu.int/en/ITU-D/Conferences/ GSR/2019/Documents/GSR19_BPG_V2_E.pdf).

in infrastructure); (5) demand stimulation activities (including digital skills programmes); and (6) monitoring and evaluation programmes. The Connect2Recover initiative encompasses five phases, as depicted in the graphic below.

Figure 1: Five-phase methodology of Connect2Recover

Phase One
- **Global methodology:** Develop a methodology for identifying gaps and bottlenecks at the country level that hamper the utilization of networks and digital technologies and identify policies to respond to and mitigate the consequences of the COVID-19 pandemic (including the recovery following the pandemic, readiness for the new normal and preparedness for any future pandemics).

Phase Two
- **Country landscape assessments:** On the basis of the global methodology, conduct country landscape assessments on the state of a country's connectivity data collection, network resiliency, and digital strategies.

Phase Three
- **National ICT strategies:** Based on the country landscape assessments, work with Member States to develop, update, and effectively implement comprehensive ICT strategies to ensure that digital infrastructure and ecosystems adequately support recovery efforts as well as the new normal, in line with global best practices and other policy tools developed by ITU and other relevant organizations.

Phase Four
- **Pilot activities:** On the basis of identified country needs, conceptualize and implement pilot activities to test specific technological solutions in line with national strategies and policies, with a particular focus on education, health, and job creation. These pilots can also be used to inform policy-making.

Phase Five
- **Deep-dive studies.** Undertake deep-dive studies in specific areas of digital policy as prioritized by the countries selected (e.g. in digital finance, e-learning, e-health, e-government, or teleworking).

We are currently seeking Member States interested in participating in phases two and three of the Connect2Recover initiative. In phase two, beneficiary countries will conduct a landscape assessment of their connectivity data collection, network and other forms of resiliency, and national digital strategy. In phase three, they will implement the following programmes:

Figure 2: Methodology: phase 2 and phase 3 of Connect2Recover

Data collection

- For countries with extensive ITU data on availability: confirm coverage using third-party data sources for mobile (e.g. Opensignal) and country surveys for fixed.

- For countries with extensive ITU data on usage: confirm usage with third-party data sources (e.g. Ookla) and surveys (e.g. EIU).

- For countries with limited/no ITU data on availability: fill in missing coverage with e.g. Giga, GSMA maps, Opensignal, OpenCellID, or estimates from satellite data (e.g. night-time lighting).

- For countries with limited/no ITU data on usage: fill in missing indicators with third-party data sources (e.g. Alexa and EIU surveys) or estimates from new data clearing houses with combined Facebook, Google, and other service provider data.

Assessing resiliency

- Check resilience of population to lockdown environments by checking levels of availability and usage in households.

- Check ISP resilience: resilience of links (number of peers), performance/QoS, DNS resilience and protection against denial-of-service attacks.

- Check resilience of critical infrastructure: power infrastructure, cable infrastructure (terrestrial and undersea), number of IXPs, top-level domain infrastructure.

- Check resilience of market: ability of market to self-regulate and keep end-user prices affordable; diversity and competitiveness of market.

National digital strategy

- Good governance: the strategy and implementing regulations are developed through an open and transparent process.

- Clear goals: a multi-year plan with clear, ambitious, and achievable policy-related commitments and quantifiable supply-side, demand-side, and network resilience targets.

- Regular assessment of availability and adoption: combine data from network operators, household surveys, third-party availability, adoption, and usage data.

- Supply-side interventions: implement clear and enforceable competition policies, allow access to more spectrum, invest in infrastructure, support community networks.

- Demand stimulation: affordable devices and services for low-income households and anchor institutions, digital skills programming, and development of locally relevant content.

- Monitoring and evaluation: open and transparent review of progress at least every two years.

We are hopeful that the foundational work done by Connect2Recover on data, resilience, and policy can be integrated and applied to other ITU "build back better" initiatives such as those in support of education, health, and job creation. For example, the Connect2Recover initiative can support Project Giga's efforts to map connectivity demand, identifying connectivity gaps and leveraging policy initiatives to extend safe, secure, and fit-for-purpose connectivity, devices, digital solutions, content, and digital skilling programmes to unserved and underserved schools and school children.[12]

This report starts out by providing an overview of data collection for broadband, narrowband, and digital technology, including data on availability, adoption, and usage at specified locations and within specified groups. Next, based on existing network operator efforts in response to the

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[12] Giga is the joint initiative between ITU and UNICEF that aims to connect every school to the Internet and every young person to information, opportunity, and choice. *See* https://gigaconnect.org/

COVID-19 pandemic, a methodology is developed for Member States to perform stress tests on operator networks and check their level of resilience. Network infrastructure resiliency in a country needs to be inclusive, so that all sectors of society, including rural areas and marginalized groups, have access to reliable, resilient infrastructure. Third, the report describes digital technologies and tools (including connectivity devices, applications, and services) that can be used to mitigate the consequences of the COVID-19 pandemic and increase preparedness for future pandemics. Fourth, it provides an overview of efforts and options to increase adoption of broadband and increase resiliency. Finally, the report identifies policies and regulations that Member States can adopt to address both short-term and long-term needs related to the COVID-19 pandemic and future preparedness and resilience.

2 Data collection

Data collection was identified as a key challenge, especially in developing countries, in the Broadband Commission's "State of Broadband" report for 2020.[13] Most of the data series for connectivity targets, covering affordability, penetration rates, and target population groups, come from national statistical agencies. Data collection is a labour-intensive process. "State of Broadband" acknowledges that there may be other methodologies that can be used to collect similar or proxy datasets to supplement this data.

Data sources on broadband and digital connectivity are available from a wide range of sources with various levels of representation of the ground truth. Each data source has some degree of inherent limitation; so, to develop a more balanced picture that combines information from suppliers and consumers, a collection methodology should ideally cross-reference data from multiple sources. The taxonomy of data sources available for broadband is shown in Figure 3.

Broadband data can be sourced from:

- Official ITU data sources – ultimately originating from countries' telecommunication ministries, regulators, and telecommunication companies
- Platform and network service companies such as Google, Microsoft, and Facebook
- Machine-collected data from monitoring services running in network switches and routers and reported to services like Nokia Deepfield and Cisco analytics
- Crowdsourced data from tools that measure signal quality and network speed, such as Opensignal, Ookla and OpenCellID
- Fixed-line and mobile coverage maps produced by telecommunication operators and third parties.

Figure 3: Taxonomy of broadband and narrowband data sources

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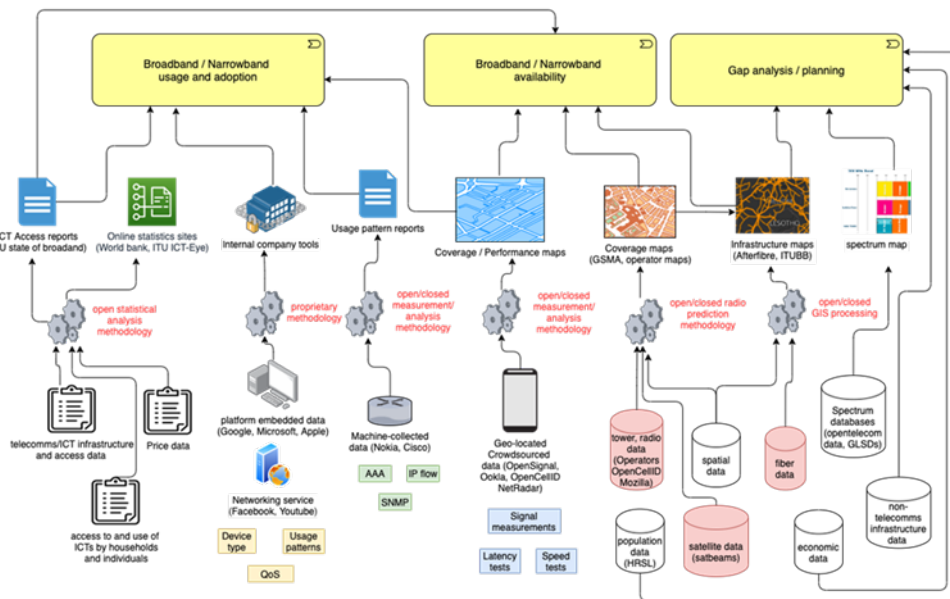
13   _See_ "State of Broadband" 2020.

Data from these sources can then be combined using an open published methodology or a closed proprietary methodology that does statistical analysis or processing to produce availability data and usage and adoption data. The data can also be used for broadband gap analysis and planning.

Data quality can be impacted by several factors. In the case of survey data, data quality is highly dependent on the quality and frequency of reporting in the country. Machine-based quantitative data collection quality is highly dependent on the reach of data collection tools. Supplementary data will serve different purposes depending on what ITU data are made available. Table 1 illustrates the type of supplementary data sources that can be used and their purpose.

Table 1: Level of reporting, supplementary sources, and purpose

Level of reporting	Example of supplementary data sources	Purpose
Complete or mostly complete data on network/infrastructure availability sent to ITU	Opensignal, GSMA coverage maps	Confirm claimed coverage in specific areas
Complete or mostly complete data on broadband usage sent to ITU	Ookla, Nokia Deepfield, DataReportal, Alexa	Confirm claimed speed by operators, enrich understanding of how country is using the Internet
Limited (e.g. not all operators represented) or no data on network/infrastructure availability	Selected accurate GSMA coverage maps, Opensignal, OpenCellID, population distribution data from Facebook Data for Good	Fill in missing coverage information or provide new coverage information (geographic and population)
Limited (e.g. not all indicators reported) or no data on broadband usage	Ookla, Internet analytics sites (DataReportal), Alexa, EIU "value of Internet" survey, A proposed New ITU data clearing house[14] (Facebook, Google, Microsoft, Apple, operators, and other Internet service providers)	Fill in missing or new usage data such as availability of devices and number of users for specific services such as social media

For cases where ICT indicators on network/infrastructure availability, broadband adoption, and usage are reported to ITU in a given year, supplementary data sources primarily serve to check the quality and reliability of the reported data. For cases where data for particular ICT indicators in a given year are missing, supplementary data sources can provide wider insight into coverage, usage, and adoption, in addition to verifying the quality and reliability of data for the available indicators. For example, out of 193 Member States, 143 provided 4G coverage in 2019 and only 73 reported Internet use data in 2019.

The sources of supply-side and demand-side data from ITU and other sources are provided in Table 2. We describe the year data collection started, the interval of data collection, its current geographic coverage, whether the methodology for data collection is open or closed, what data indicators are collected, the source of the data, and what type of data access is provided. Each data source is fully described in Appendix A, including its collection methodology and strengths and weaknesses.

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[14] This is a proposed new structure - ITU is in a unique position to convene various stakeholders to develop new data collection methodologies and visualizations and act as a trusted party to ensure that submitted third-party data follow guidelines, are reliable, and do not reveal any sensitive information.

Table 2: Summary of publicly available data sources on global broadband

Data source name	Start date	Interval	Geographic coverage	Method	Data presented	Source	Data access
ITU-D telecommunication/ICT infrastructure and access data (see Appendix A 1.1)	1961	Biannual	all countries	Open	14 indicators from short questionnaire (Spring) and over 50 indicators from long questionnaire (Fall).	Government agency (Telecommunication/ICT Ministry / regulatory authority)	Country-level data available on ITU ICT-Eye
ITU-D price data (see Appendix A 1.1)	2002	Annual	all countries	Open	3 price data categories	Government agency (Telecommunication/ICT Ministry / regulatory authority)	Country-level data available on ITU ICT-Eye
ITU-D data on access to and use of ICTs by households and individuals (see Appendix A 1.1)	2002	Biannual	all countries	Open	5 indicators from short questionnaire (Spring) or 18 indicators from long questionnaire (Fall)	National Statistics offices	Country-level data available on ITU ICT-Eye
ITU broadband maps (see Appendix A 1.2)	2013	Continuous	188 countries covered (as of Nov 2020)	Open	* Transmission networks (backbone infrastructure) - terrestrial * ITU Broadband Capacity Indicators (7 indicators): https://www.itu.int/en/ITU-D/Technology/Documents/InteractiveTransmissionMaps/Misc/BroadbandTransmissionCapacityIndicators.pdf * Submarine cables * Internet exchange points (IXPs) * Satellite earth stations * GSM coverage * Distances to nearest fibre	* Terrestrial backbone infrastructure (ITU) * Population within reach overlay calculation (ITU) * Satellite earth stations (ITU) * Submarine cables (Telegeography) * Internet exchange points (Telegeography) * GSM coverage (Collins Bartholomew)	Public: map-level data TIES members: access to validation framework of networks and sources Partners: specific data made available e.g. disaster relief, Giga school mapping, FIGI, country requests

Table 2: Summary of publicly available data sources on global broadband (continued)

Data source name	Start date	Interval	Geographic coverage	Method	Data presented	Source	Data access
Project Giga (see Appendix A 1.2)	2019	Continuous	15 countries (800 000 schools)	School location using mix of data from countries and satellite data. Access dependent on ITU and coverage data methodology.	* Location of schools * 2G coverage * 3G and above coverage * >= 3 Mbit/s * < 3 Mbit/s	* School location from satellite imagery and government * Cellular coverage data from ITU	Map-level data that allows each school to be checked for coverage and speed
Opensignal (see Appendix A 2.1)	2010	Continuous	all countries: detailed data for 36 countries, poor data on remaining countries	Semi-open	* Location * Signal strength * Download/upload speed * Video performance	User app and third-party apps	Map-level data only available on app
Unwiredlabs OpenCellID (see Appendix A 2.2)	2008	Continuous	all countries: detailed data in developed countries, poor data on emerging markets/LDCs	Open	* Cell tower IDs * Signal strength * Location	User app	Downloadable open data
Ookla Speedtest (see Appendix A 2.3)	2006	Continuous (quarterly country reports)	most countries (141 countries with > 300 unique user results for mobile and 175 countries with > 300 unique user results for fixed)	Semi-open	* Download/upload speed * Latency * Data labelled as mobile/fixed * Video performance test available on iOS (tests ISP video traffic prioritization)	User app and third-party apps	Downloadable open data available to 16 web Mercator tiles (approximately 610 metres by 610 metres at the equator)

Table 2: Summary of publicly available data sources on global broadband (continued)

Data source name	Start date	Interval	Geographic coverage	Method	Data presented	Source	Data access
Nokia Deepfield (see Appendix A 2.4)	2016	Continuous (annual reports)	Countries subscribing to Deepfield service (concentrated in North America and Europe)	Closed	* Total traffic data (on-net and peering) * Video streaming trends * Videoconferencing trends * Gaming traffic trends * DDOS traffic trends	Collected from network devices reporting to Deepfield * IP flow data * BGP, SNMP data * DNS information * Router and telemetry data (e.g. AAA, IPFIX)	Public downloadable annual reports on traffic trends. Customers get access to their own detailed analytics.
GSMA Collins coverage maps by Collins Bartholomew (see Appendix A 2.5)	2010	Continuous (countries send updates)	All countries (1 000 network coverage maps)	Closed (based on unknown operator methodology)	* 2G/3G/4G/5G coverage for individual operators	* Coverage maps collected from operators according to GSMA guideline with strong/indoor and variable/outdoor signal level	Map viewable on GSMA site (100m resolution recommended)
GSMA mobile coverage maps by Masae Analytics (see Appendix A 2.5)	N/A	As requested	15 African countries (Benin, Burkina Faso, Democratic Republic of the Congo, Côte d'Ivoire, Ghana, Guinea, Lesotho, Liberia, Nigeria, Uganda, Rwanda, Sierra Leone, South Sudan, Tanzania, Zambia) combined plots of all operators	Closed (based on methodology developed at Masae Analytics with GSMA)	* 2G/3G/4G combined coverage for all operators * Population coverage in polygon (with population under 15) * Historic coverage where available * Economic data	* Site coordinates from GSMA or from OpenCellID * OpenStreetMap * ESA Africa land cover * ESRI World Imagery * SRTM Nasa * HRSL (Facebook) * WorldPop	Map viewable on GSMA Mobile Coverage Map site. Coverage analytics for polygons or points available

Table 2: Summary of publicly available data sources on global broadband (continued)

Data source name	Start date	Interval	Geographic coverage	Method	Data presented	Source	Data access
Economist Intelligence Unit (see Appendix A 2.6)	2017	Continuous (annual EIU surveys)	100 countries (80 core, 20 rotating) 91% world population	Open	56 indicators across four pillars: availability, affordability, relevance, readiness	* EIU "value of the Internet" survey * 21 other sources including Alexa, Cisco, ITU, Ookla, Opensignal	Downloadable open data and web-based country comparison tool
Alexa Internet Top 500 (see Appendix A 2.7)	2007	Continuous (summary produced monthly)	All countries	Closed	* Top 500 websites per country ranked from 1 to 500	* Browser plugin data * Webpages with Alex scripts	Public web access to top 500 sites per country
Facebook Data for Good (see Appendix A 2.9)	2017	Continuous	All countries for some data	Open for non-Facebook sourced data	* Population density maps (30m resolution) * Electrical distribution grid maps * Movement range maps * Disaster maps * Social connectedness index * Business activity trends * Commuting zones	* Satellite imagery for calculating population density * Night light satellite imagery and roads for electrical distribution maps * Facebook internal data for all other maps / statistics	Downloadable open data

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Table 2: Summary of publicly available data sources on global broadband (continued)

Data source name	Start date	Interval	Geographic coverage	Method	Data presented	Source	Data access
World Bank World Development Indicators (see Appendix A 2.8)	1970	Annual	All countries	Varied – depends on source	1600 indicators - relevant indicators: * Access to electricity (% of population) * Income share by lowest 20% and second 20% * GDP per capita * Secure Internet servers	* World bank surveys * Specialized UN agencies (e.g. ITU) * National statistics offices * Private sector * Academic studies	Browsable data with inter country comparisons on indicators for a chosen time series or downloadable open data
Google Public Data Explorer (see Appendix A 2.10)	2010	Continuous	All countries	Dependent on source data	4 708 data sets covering topics such as economics, education, health, infrastructure etc.	Multiple providers of public data such as World Bank, ITU, OECD, and Eurostat	Web-based inter-country comparison to study variable dependencies
Cisco Visual Networking Index Forecast (see Appendix A 2.11)	2015	Continuous	All countries	Dependent on source data	Global or per country projections for: * Internet users * mobile users * devices and connections * mobile vs wired * fixed broadband speeds * Wi-Fi and mobile speed * application downloads	Multiple providers such as Ookla, ITU, and telecoms and network companies used for forecasts and analyses, Cisco's own data from service providers used for validation	Annual reports

Each of these data sources will be referred to in Sections 2.2, 2.3, 2.4 and 2.5 when they are required for a specific broadband supply-side or demand-side measurement or where access for specific target communities is required.

2.1   Definitions and benchmarks

The Road Map for Digital Cooperation of the Secretary-General of the United Nations states that "meaningful participation in today's digital age requires a high-speed broadband connection to the Internet" and that every person should have "safe and affordable access to the Internet by 2030, including meaningful use of digitally enabled services."[15] The concept of meaningful universal connectivity "encompasses broadband adoption that is not just available, accessible, relevant and affordable, but that is also safe, trusted, empowering users and leading to positive impact."[16]

As the applications we use for education, health care, business, entertainment, and interacting with the government become more media-rich and bandwidth-intensive, we need to ensure that definitions for broadband access move in step with these trends. A broadband speed target set for 2025 might be completely inadequate in 2030. These definitions are critical as governments use broadband definitions to measure their progress in closing the digital divide and to develop and implement policies to address areas where progress is lacking. Setting the correct targets helps ensure that citizens become fully engaged with today's current media-rich Internet. In a simulation carried out by Nokia, the minimum bandwidth for working, learning, and playing comfortably during the COVID-19 closure of activities was estimated at 50 Mbit/s downstream.[17]

Speed targets are usually specified in Mbit/s or with phrases such as "high-speed broadband" as in the case of Ireland.[18] In some cases, these phrases do not have a speed definition, and this should be avoided. Speed can be specified separately for downloading and uploading; in cases where only one speed is provided, this generally means download speed. Latency and consumption allowances are also used in broadband definitions; the Federal Communications Commission (FCC) of the United States of America does this in its universal service programmes.[19] In many cases a specific technology is specified, such as the UK targeting 95 per cent geographical coverage of LTE by 2022,[20] but exclusive use of a specific technology to reach a coverage target is usually avoided. It is critical to make use of consistent definitions and targets to remove any ambiguity when registering progress towards meeting targets.

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[15]   *See* United Nations General Assembly, "Road map for digital cooperation: implementation of the recommendations of the High-level Panel on Digital Cooperation", Report of the Secretary-General, May 2020 (available at A/74/821 - E - A/74/821 -Desktop (undocs.org)).

[16]   *See* International Telecommunication Union 2020. Broadband Commission for Sustainable Development, "The State of Broadband 2019: Broadband as a Foundation for Sustainable Development," September 2019, at ix (available at https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.20-2019-PDF-E.pdf).

[17]   *See* Inter-American Development Bank, "The Impact of Digital Infrastructure on the Consequences of COVID-19 and on the Mitigation of Future Effects," November 2020, at 6 (available at https://publications.iadb.org/en/impact-digital-infrastructure-consequences-covid-19-and-mitigation-future-effects) (The Impact of Digital Infrastructure on the Consequences of COVID-19 and on the Mitigation of Future Effects).

[18]   *See* Ireland National Broadband Plan (available at https://www.gov.ie/en/publication/c1b0c9-national -broadband-plan/).

[19]   *See* Federal Communications Commission, Auction 904: Rural Digital Opportunity Fund Fact Sheet (available at https://www.fcc.gov/auction/904/factsheet).

[20]   *See* Mobile coverage in the UK, Briefing paper Number CBP 7069, 22 February 2019 from House of Commons library, at 3 (available at http://researchbriefings.files.parliament.uk/documents/SN07069/SN07069.pdf).

In countries with very forward-looking broadband strategies, the aggressive targets set a decade ago remain relevant today. In 2010, Malaysia set a high-speed broadband network target of 100 Mbit/s for urban areas and 20 Mbit/s for rural areas. The current target is an average speed of at least 30 Mbit/s for 98 per cent of the population by 2023. In New Zealand, the 2010 Ultra-Fast Broadband plan set targets of 100 Mbit/s down and 50 Mbit/s up for 75 per cent of the country by 2019. The new Rural Broadband Initiative aims by 2022 to provide broadband coverage of at least 20 Mbit/s for 64 000 of the 90 000 rural households identified as lacking these speeds. Chile has a very progressive approach guaranteeing a minimum speed[21] for Internet access that increases by 10 per cent each year, reducing the need for updates. Due to the increased use of symmetrical Internet technologies such as videoconferencing, which was especially popular at the height of the pandemic, one might further build upon the Chilean model by increasing fixed broadband upload speeds at a higher annual percentage (for example 15 per cent annually). This would allow operators time to gradually modify spectrum or time slicing between the downlink and uplink for broadband connections.

To meaningfully connect to the Internet, consumers require at-home fixed connections supporting a full range of applications requiring high throughput (such as multiple HD video streams) and low latency (such as HD videoconferencing and gaming applications). Broadband definitions and policies should ensure that these experiences can be delivered to all citizens. Chile, Malaysia, and New Zealand are good examples of countries that have set aggressive but achievable broadband definitions based on the connectivity goals they want to achieve for all of their citizens.

Mobile broadband access is a best-effort technology and is highly dependent on the amount of spectrum available, the technology used, the quality of the signal and congestion at the base station. It is therefore only possible to set mobile broadband targets for a specific level of technology and amount of coverage; for example, all major highways covered with 5G technology or 99 per cent of the population covered with 4G in 5 years. Targeting 100 per cent population coverage for mobile is significantly more onerous, as costs tend to rise disproportionately for infrastructure designed to reach the last 1 per cent of the population, which can otherwise be covered with other technologies such as satellites.

Performance claims for technologies such as 3G, 4G or 5G can only be made for ideal conditions. The speed that can actually be delivered over a mobile wireless network depends on a variety of factors including spectrum availability, signal attenuation, and the quality of tower backhaul. Some mobile wireless networks are optimized for coverage while others are optimized for capacity. In the 3G domain, the definitions of downlink speeds from different technologies are very loose. For example, WCDMA has a maximum speed of 384 kbit/s, HSPA has a theoretical maximum of 7.2 Mbit/s and HSPA+ (technically 3.5G) has a theoretical maximum of 21.6 Mbit/s.[22] However, typical average speeds are only 144 kbit/s.[23] The technology of 4G dictates peak speed requirements of 100 Mbit/s when moving and 1 Gbit/s when stationary.[24] However, the typical average speed achieved is 25 Mbit/s.[25] In the case of 5G technology, the

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[21]   *See* SUBTEL defines new quality standards for Internet access service (available at https://www.subtel.gob .cl/subtel-define-nuevos-estandares-de-calidad-para-el-servicio-de-acceso-a-internet/).

[22]   *See* Wikipedia article on 3G (available at https://en.wikipedia.org/wiki/3G).

[23]   *See* 5G vs 4G: what is the difference? (available at https://www.raconteur.net/technology/5g/4g-vs-5g-mobile -technology/).

[24]   *See* ITU-R, Report M.2134, Requirements related to technical performance for IMT-Advanced radio interface(s), November 2008 (available at http://www.itu.int/pub/R-REP-M.2134-2008/en).

[25]   *See* 5G vs 4G: what is the difference?

speed requirements are set by the ITU IMT-2020 standard. These are peak data rates of at least 20 Gbit/s for downlink and at least 10 Gbit/s for uplink. However, the standard's target value for user-experienced data rate is only 100 Mbit/s and 50 Mbit/s for downlink and uplink respectively,[26] and typical experienced average 5G downlink speeds are 200-400 Mbit/s.[27]

It is also important to distinguish between availability, adoption, and usage in a population (discussed in the next few sections), as some countries use these terms differently. For the sake of clarity, it is proposed to follow the schematic in Figure 4. Thus, within the *total population*, a certain fraction will have *broadband availability* (this means they have a broadband operator who can provide them with a fixed broadband connection, or they are covered by a mobile broadband signal). Within that fraction, a subset will actually *adopt* a broadband service (e.g. subscribe to a fixed broadband link or purchase a mobile broadband package). Finally, among those who have adopted broadband (i.e. subscribed to a service), there will be a certain level of broadband usage. This usage level intensity could be described in terms of the frequency of usage (e.g. daily or hourly), the amount of data used (e.g. measured in gigabytes or megabytes) or the type of services used (e.g. videoconferencing or email). For example, ITU defines an Internet user as a person who has used the Internet anytime in the previous three months.[28] Internet service providers talk about monthly active users (MAU) or daily active users (DAU)).

Adoption can also be at the level of a household or an individual; and many individuals may share an Internet connection or device to interact with the Internet.

Figure 4: Visualizing broadband availability, adoption, and usage
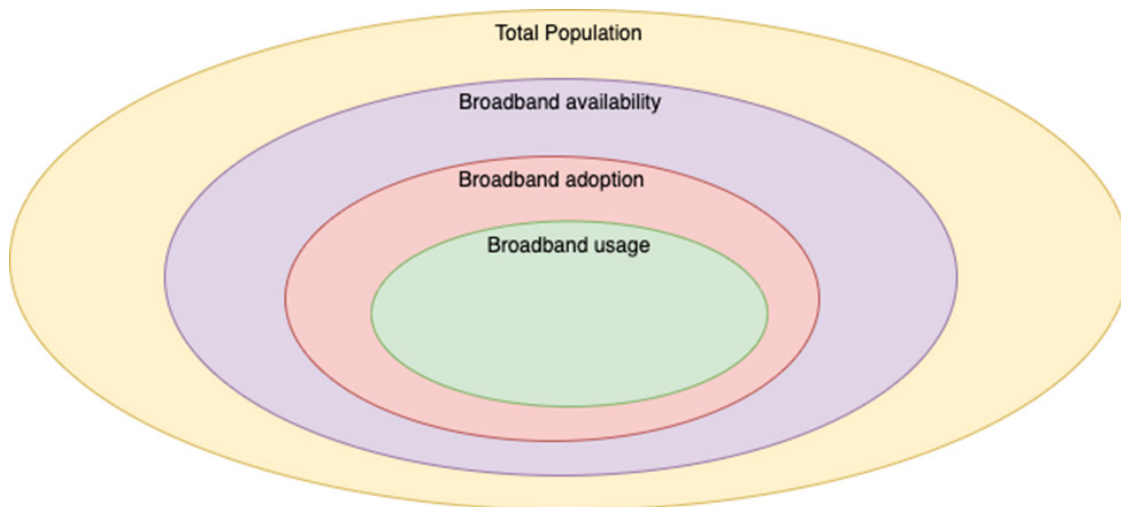
2.2 Coverage or availability and capacity (supply-side)

Governments and an array of third parties collect data and report on fixed and mobile broadband availability with different levels of geographic precision (i.e. on whether broadband is available in a particular location). Each data source has some degree of inherent limitations and, in order to develop a more balanced picture that combines information from suppliers

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[26] *See* Minimum requirements related to technical performance for IMT-2020 radio interface, November 2017 (available at https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2410-2017-PDF-E.pdf).

[27] *See* 5G vs 4G: what is the difference?

[28] *See* International Telecommunication Union, "Manual for Measuring ICT Access and Use by Households and Individuals", 2020 Edition at 154 (available at https://www.itu.int/en/ITU-D/Statistics/Pages/publications/manual.aspx).

and consumers, a collection methodology should ideally cross-reference data from multiple sources. Data on availability (ITU annually conducts an infrastructure and access survey) are usually sourced directly from fixed and mobile broadband providers and collected either by the ministry, the regulator, or a designated third-party data administrator. Consumer groups, technology companies, and other organizations also increasingly collect data on fixed and mobile broadband availability.

Fixed or mobile network coverage, access and availability can be defined as a percentage of a geographic area or as a percentage of the population reached. The coverage, access or availability gap refers to the fact that last-mile digital infrastructure has yet to reach all inhabited locales.[29] For fixed broadband access, such as fibre, availability is expressed either as a percentage of households, businesses or facilities served across the whole country or as the percentage of the geographic area or users serviced in an area, such as a census area. For mobile broadband, availability is usually expressed as the percentage of a geographic area or population covered with a specific technology such as 3G or 4G.

Averages often hide the truth about specific target groups that are underserved. For example, in a city with high levels of inequality, there could be 80 per cent fixed or mobile broadband availability meeting some minimum broadband speed requirement overall, but with 100 per cent availability in wealthier areas and only 20 per cent in low-income areas. Geographically precise or granular population coverage can help prevent these distortions. In the United States of America, for example, the FCC collects broadband data based on census blocks, which can be as small as a high-rise apartment building in a major city. Even with this geographic precision, distortions can occur, especially in rural areas where people are spread over large tracts of land. To address this concern, the FCC is moving to shape files in which network operators draw polygons around coverage areas.[30]

Mobile broadband wireless coverage has additional complexity due to the need to define an acceptable performance at the edge of the network. Operators usually define their network edge using a receive sensitivity level (the signal strength value where a certain bit error rate is achieved). There are free space and BHH (beside head and hand) guidelines for 3GPP and GSMA. For example, GSMA defines 4G free space receive sensitivity (edge of the cell) in band 20 as -93.5 dBm, with a block error rate (BLER) of less than 5 per cent.[31] The challenge is that different operators and regulators use different standards and definitions for defining this network edge, which makes understanding the ground truth challenging. This is why additional measurement sources, such as crowdsourced signal strength data, are critical to understanding the reliability of coverage maps.

What COVID-19 has taught us is that broadband access in homes is critical to enable businesses to continue operating and citizens to continue working, learning, receiving medical support, socializing, and accessing entertainment remotely. The GSMA data submission guideline[32] requests operators to send maps with data classified into strong/indoor signal and variable/

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[29] *See* World Development Report 2021: Data for Better Lives at 160.

[30] *See* Federal Communications Commission, Digital Opportunity Data Collection (available at https://www
.fcc.gov/digital-opportunity-data-collection).

[31] *See* Mobile handset testing" Appendix A (available at https://www.ofcom.org.uk/research-and-data/
technology/telecoms/mobile-handset-testing).

[32] *See* GSMA Network Coverage Maps Data Submission Guidelines at 5 (available at https://www.gsma.com/
coverage/downloads/GSMA_Submissions_Guide_2019-20.pdf)

outdoor signal. The indoor signal data is critical to understanding indoor home access where the only option for a user is mobile broadband connectivity.

Another important aspect to consider is that capacity is the outcome of dynamic interaction between supply and demand and regional markets. An area that is considered "served" and meeting minimum bandwidth requirements could become "unserved" in a matter of days or months if growth in user demand for network resources is higher than the rate at which an infrastructure provider is able to provision additional capacity over time.

Fixed broadband providers usually publish availability maps that describe what kinds of services (fibre, cable or DSL) are currently available or will be made available in the future. Verifying if these maps are accurate can be done by the regulator or a consultant who creates a representative sample set of points around the country and asks the supplier to install the promised service at each of those points. If the supplier promises to install the service within a short time frame, the data point is marked as true; if the supplier states that it is not available, the data point is marked as false. In the United States, BroadbandNow conducted such a study, showing that more than twice as many Americans lack access to broadband as the network operators reported to the FCC.[33] The FCC has now established a challenge process for third-party groups to challenge network operator data submissions.[34]

Given the importance of using multiple sources to establish the ground truth of network coverage and availability and in order to create a complete picture of the current situation in a country the following data sources with global reach can be used.

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[33] *See* John Busby, Julia Tanberk, and BroadbandNow Team, "FCC Reports Broadband Unavailable to 21.3 Million Americans, BroadbandNow Study Indicates 42 Million Do Not Have Access", BroadbandNow Research, February 3, 2020 (available at https://broadbandnow.com/research/fcc-underestimates-unserved -by-50-percent).

[34] *See* Federal Communications Commission, Press Release, "FCC Announces New Outreach to Collect Consumer Broadband Availability Experiences," March 22, 2021 (available at https://docs.fcc.gov/public/ attachments/DOC-370978A1.pdf).

Table 3: Data sources for coverage and availability

Data source	Metrics to use	Notes and caveats
ITU-D telecommunications/ICT infrastructure and access data (see Appendix A 1.1)	• Percentage of population covered by a mobile cellular network • Percentage of population covered by at least a 3G mobile network • Percentage of population covered by at least an LTE/WiMax mobile network	These are harmonized numbers based on a combination of operator coverage maps which can have quality problems as there is currently no mechanism used to check the accuracy of this coverage.
ITU broadband maps (see Appendix A 1.2)	• Distance to nearest fibre for points of interest	Distance to fibre does not reflect the true cost and effort to bring fibre to a given point.
Opensignal (see Appendix A 2.1)	• Signal strength • Download and upload speeds	Relies on widespread user adoption across a wide geographic area to provide a complete picture across the country. Low-income areas tend to use tools like Opensignal less. Crowdsourced data will more likely be useful in checking claimed coverage from operators than exposing new coverage from non-reporting countries or operators. Regulators or government-contracted service providers could complement these data sets with drive tests that use tools like Opensignal or customized coverage testing tools.
OpenCellID (see Appendix A 2.2)	• Estimated cell tower location • Location of Wi-Fi access points (not released) • Signal strength at measurement location	These data can be used to create coverage map estimations in cases where coverage data are not provided. Wi-Fi access point locations are also collected but, due to security issues, these data are not released.
GSMA coverage maps (see Appendix A 2.5)	• Coverage maps for 2G, 3G, 4G and 5G	Coverage maps produced for GSMA by Collins Bartholomew rely on operator data and there is no harmonized methodology to produce these maps or check the quality. Coverage maps produced for GSMA by Masae Analytics are more reliable, use a harmonized methodology and allow further statistical analysis such as percentage of population coverage in a geographic area.
Facebook Data for Good (see Appendix A 2.9)	• Population density	This can be used with mobile coverage maps for estimating population coverage by mobile networks in cases where these data are not provided.
EIU data (see Appendix A 2.6)	• Government initiatives to make Wi-Fi available • Private sector initiatives to make Wi-Fi available	Currently limited to 100 countries.

The following methodology is suggested for using these data sources:

• Countries with largely complete data on availability

  o For mobile network availability (request both indoor and outdoor coverage)

- – Extract mobile population coverage for 3G and 4G from ITU ICT indicators.
- – Generate a set of random sample points that cover urban, sub-urban and rural areas for the country, scaled to a few multiples of the number of base stations in each of those regions and bound by current reported coverage regions.
- – Use Opensignal to check coverage in these areas (if a point has no Opensignal measurement, re-generate a new random point).
- – Compare the GSMA reported coverage or mobile operator network coverage at the sample point (whichever is more recent) to the signal reported by Opensignal for 3G and 4G.
- – If major differences are exposed, alert the producer of the coverage map about the discrepancy and request a more accurate map. If indoor coverage maps are available from operators, apply the same correction factor to the indoor coverage.

- o For fixed-line availability

  - – Use latest regulator or ministry report on current fixed-line population coverage with breakdown in speed categories, e.g. 75 per cent population covered with at least 50 Mbit/s and 10 per cent covered with at least 100 Mbit/s. If these data are not available, survey all fixed-line providers, extract their fixed-line household/ business availability data and generate the aggregate.
  - – Generate a large set of random sample addresses that cover urban, sub-urban and rural areas for a country scaled to a fraction (e.g. 0.01 per cent) of the population that have a fixed-line connection and bound by current regions with reported fixed-line availability.
  - – Carry out a survey (see example of BroadbandNow in the United States of America[35]) where supplier is asked to install broadband at randomly generated addresses.
  - – If major differences are exposed, alert the producer of the report about the discrepancy and request a more accurate report.

- • Countries with significantly incomplete data on availability

  - o For mobile network availability (request both indoor and outdoor coverage)

    - – If the country is one of the 12 African countries in the GSMA mobile coverage maps produced by Masae Analytics (see 2.5), the 3G and 4G population coverage data are already available.
    - – For other countries, do either of the following: (a) request mobile coverage data from GSMA or (b) request coverage maps from operators, or (c) request tower and radio data from operators; if these are not available, (d) make use of tower data from Opensignal. If obtaining tower data using (c) or (d), generate a coverage map with open-source radio propagation tools such as CloudRF[36]. Note that maps from mobile operators and GSMA are not always reliable, so regenerating maps from tower data is preferable.
    - – Overlay coverage data with population density maps available from Facebook Data for Good (see 2.9) and calculate population coverage for 3G and 4G. Generate both indoor and outdoor coverage results.

  - o For fixed-line availability

    - – Request fixed-line household/business coverage from operators in the country.

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[35] *See* FCC Reports Broadband Unavailable to 21.3 Million Americans, BroadbandNow Study Indicates 42 Million Do Not Have Access.
[36] *See* CloudRF cloud-based radio propagation tool (available at https://cloudrf.com/).

- In cases where data cannot be extracted, estimates of potential fixed-line access can be made with ITU broadband maps. This allows you to check distance to fibre from sample points in areas where no fixed-line data are available.

Some good progress is being made on open data and open data collection methodologies. At the WSIS Forum 2021, the World Bank and ITU affirmed their commitment to create an open standard for terrestrial optical fibre cable (OFC) infrastructure data and to create a digital map of terrestrial OFC infrastructure worldwide as a public good.[37]

Wi-Fi data are not available from third-party data sources, due to security concerns, but the EIU does publish government and private sector efforts to make Wi-Fi available. Ultimately, we propose that third-party data sources be added as another layer on the ITU broadband maps so that availability data can be enriched, and correction factors can be automatically generated from these data.

2.3   Adoption and usage (demand-side)

Both adoption and usage data can be collected with qualitative methods such as household surveys or quantitative methods such as collecting data from specialized crowdsourced testing services or popular applications such as Facebook. Usage statistics can also reveal the speed at which users are accessing the Internet (i.e. the percentage of users accessing the Internet at specified broadband connection speeds). Microsoft United States county-level usage data is an example.

Many governments and regulators conduct household adoption and usage surveys. ITU, in turn, collects adoption and usage data from Member States on an annual basis. The ITU questionnaire – followed by many Member States – covers a wide set of questions on Internet adoption and computer ownership, such as access to a computer or tablet, whether Internet is always available in a household, using the Internet from home or work, and what household members use the Internet for (e.g. seeking health or education information, looking for a job, purchasing goods or services and so on). There are two versions of the ITU questionnaire – one short questionnaire with 5 indicators and a comprehensive questionnaire with 18 indicators. Each of the indicators has a list of associated sub-questions.

Many countries do not have the human capacity to do comprehensive semi-annual or annual surveys and may opt for longer intervals. They may do annual surveys using ITU's short questionnaire, but many countries do not complete the ITU "access to and use of ICTs by households and individuals" survey. In 2019, only 73 out of 196 countries completed this survey.

Indicators that are binary, such as access to a computer, are useful, but many other statistics are too coarse-grained to reveal the level of engagement and usage of Internet services. For example, using the Internet for education could capture both a user viewing Wikipedia and Kahn Academy videos everyday with an affordable 10 Mbit/s connection and a frustrated user who has slow, expensive access and has occasional access to Wikipedia.

Another very crude yardstick of adoption for mobile broadband is the number of mobile cellular subscriptions and Internet subscriptions. However, many users have multiple SIM cards, and statistics agencies need to estimate the number of multiple subscriptions per user. In addition,

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[37]   *See* WSIS Forum 2021 Session 413 – Fibre Open Data – making data available for Africa (available at https://www.itu.int/net4/wsis/forum/2021/Agenda/Session/413).

many subscriptions may have very low usage - not enough to count as a meaningful broadband user.

The level of engagement by users on social-media platforms such as Facebook is available in the form of Facebook quarterly reports per country on daily active users. The general level of engagement on different websites, in terms of share of total website traffic by age and gender is collected by marketing sites such as Semrush[38] or GlobalWebIndex[39] at the country level. These sites also provide data such as the most common search terms or e-commerce activity. These data are not publicly available but are available for every country through Datareportal[40] in the form of annual reports. These user data can complement in-country survey data that ask binary questions like "Do you use the Internet for streaming video?" and provide a richer view of the level of user engagement across the country.

To provide a more complete picture of adoption and usage of broadband services, surveys and complementary data sources are required. Governments can use a combination of surveys (such as those designed and used by ITU), complemented by crowdsourced tools such as Speedtest by Ookla and data available from marketing statistics gathering platforms as well as web analytics services like Alexa.

Affordability is a key driver of adoption, and the current "1 for 2" indicator produced by the Alliance for Affordable Internet (A4AI) is the most used affordability metric for broadband.[41] However, it measures affordability for the average user on the basis of gross national income per capita. As COVID-19 has shown us, the most vulnerable members of the population have suffered the most due to lack of access, and affordability needs to be checked for the lower income users as well.

In order to create a complete picture of network adoption and usage in a country and understand trends and obstacles to adoption, such as lack of affordability, the following data sources with global reach can be used.

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[38]   See https://www.semrush.com/
[39]   See https://www.globalwebindex.com/
[40]   See https://datareportal.com/
[41]   See https://a4ai.org/affordable-internet-is-1-for-2.

Table 4: Data sources for usage and adoption

Data source	Metrics used	Notes and caveats
ITU-D telecommunications/ data on access to and use of ICTs by households and individuals (see Appendix A 1.1)	• Various broadband metrics (e.g. fixed broadband: 256 kbit/s to 2 Mbit/s, 2 Mbit/s to 10 Mbit/s, terrestrial fixed wireless broadband subscriptions and mobile broadband subscriptions) • Percentage of individuals using the Internet • Percentage of households with Internet • Percentage of individuals and households with a computer • Percentage of individuals and households with a mobile cellular telephone	Adoption and usage data are the least reported data in the ITU survey. In 2019, only 73 Member States reported Internet use data.
ITU-D price data (Appendix A 1.1)	• Fixed local telephone service tariffs • Mobile cellular tariffs • Fixed (wired) broadband Internet tariffs • Mobile broadband Internet tariffs	Relatively few countries respond to the ITU ICT Price Basket Questionnaire, and most prices are collected by ITU directly from telecommunication operators.
Ookla Speedtest (see Appendix A 2.3)	• Download and upload speed (measured to nearest test server – there are 8 000 of these) • Latency (measured to nearest test server)	Most Speedtest users want to know if they are getting the speeds promised by their supplier. These tend to be advanced, engaged users of Internet services. Another common reason for using Speedtest is Internet performance issues.
EIU data (see Appendix A 2.6)	• Affordability: Examines the cost of handsets, devices and fixed-line and wireless broadband • Relevance: Examines local content and language for health, finance, commerce, entertainment, education • Readiness: Examines level of literacy and education, web accessibility, and privacy regulations.	Only available for 100 countries (80 core countries and 20 rotating countries). Survey size is limited: 4 953 people across 99 countries in 2019. Reports are produced annually.
Nokia Deepfield (see Appendix A 2.4)	• Total traffic (on-net and peering) • Video streaming, videoconferencing and gaming traffic • Denial-of-service attacks	Only has good representation in Europe and North America. Reports are produced annually.

Table 4: Data sources for usage and adoption (continued)

Data source	Metrics used	Notes and caveats
DataReportal[42]	• Device ownership • Time spent on media • Fixed and mobile Internet speeds • Share of web traffic by device	Receives data from many Internet marketing data partners such as GWI, Statista, Semrush. Data available for all countries.
Alexa Internet (see Appendix A 2.7)	• Top 500 websites ranked for each country	Summaries are produced monthly.
Cisco Visual Networking Index (see Appendix A 2.11)	• Internet user trends • Mobile user trends • Fixed broadband speed trends • Device breakdown and connection type breakdown trends • Wi-Fi and mobile network speed trends	Uses a large amount of diverse data sources including ITU and Ookla as well as data from regulators and analytics companies. Reports are produced annually.
World Bank[43]	• Income share held by lowest 20% • Income share held by lowest 40%	Annual data available with multi-year trends.
A4AI[44]	• Price as % of average income for 100 MB, 500 MB, 1 GB, 2 GB, 5 GB, and 10 GB	Produced annually. ITU and A4AI are now collaborating on ICT price data collection.

The following methodology could be applied for using these data sources:

- For countries with complete or mostly complete ITU data on adoption and usage

  o Extract all data from ITU for access to and use of ICTs by households and individuals to obtain a general overview for a country.

  o Enrich the ITU data with data from Ookla's open data portal to check the reported speeds achieved by users at various regions across the country (for fixed and mobile access). Ookla data can help identify digital divides.

  o Use data from DataReportal to understand breakdown of devices being used to access the Internet, Wi-Fi and mobile network speed trends and time spend on different media platforms.

  o Use data from Alexa to understand the top web site trends.

- For countries with missing or no ITU data on usage and adoption

  o Contact operators for fixed and mobile broadband subscription data. For mobile subscribers, apply correction factor to correct for users with multiple SIM cards.

  o Extract number of Facebook users per country from DataReportal.

  o Use a combination of Facebook users and fixed and mobile subscription data to estimate the number of Internet users in the country.

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[42] *See* https://datareportal.com/
[43] *See* World Bank Development indicators (available at https://databank.worldbank.org/source/world -development-indicators).
[44] *See A4AI Mobile Broadband Pricing (available at* https://a4ai.org/extra/mobile_broadband_pricing _gnicm-2019Q2).

- o Ookla's annual country reports can be used to check the average fixed-line and mobile access users are receiving. Ookla's open data portal can also be used to check fixed and mobile broadband performance in specific regions of the country.

- In order to check affordability for the lowest income earners in a country, data can be extracted from A4AI (derived from ITU ICT Price Basket Data) and combined with World Bank data on the proportion of GDP earned by the lowest 20 per cent and 40 per cent of income earners in the country. This follows the philosophy of SDG indicator 10.1.1, which seeks to reduce income growth inequalities and focuses on affordability for the bottom 40 per cent of income earners. A study on ICT price trends in 2020, specifically focusing on affordability for the bottom 40 per cent of incomes, has been carried out by ITU.[45] The study showed that many countries have affordable access when measured according to GNI per capita but do not have affordable access for the bottom 40 per cent of income earners.

- Nokia Deepfield and Cisco's Visual Networking Index to can be used to check general broadband usage and speed trends in a country and to ensure that marginalized groups or rural areas are not falling behind these trends.

- EIU data can be used to examine local content in local languages for health, finance, commerce, entertainment, and education.

Many of the third-party data sources that use crowdsourcing, such as Ookla or Opensignal, have poor representation in the countries that do not report usage and adoption data to ITU. The best data on adoption and usage are mostly held by Internet service companies such as Google and Facebook. We propose the best method to deal with this missing dataset is to create a data clearing house at ITU where country-level data from Internet service companies are sent, processed, and aggregated, with due regard for protecting user privacy.

2.4 Community anchor locations

Improving access, adoption, and usage rates in anchor locations such as schools, libraries, and healthcare and government facilities will improve education and health outcomes, stimulate economic activity, and strengthen resilience to lockdown conditions during a pandemic. Where high-speed broadband access has not yet reached all homes, high-speed access in schools can nonetheless improve learning outcomes and increase the effectiveness and efficiency of healthcare facilities and help healthcare workers automate records management and access services such as telehealth to get advice from remote health experts. Schools can also run after-school programmes that use high-speed broadband to offer supplementary education programmes for learners and digital skills programmes for adults. These anchor institutions can also act as connection points for spreading connectivity to the surrounding community.

Many broadband plans in countries that have had successful broadband expansion programmes have specific targets for schools, health care providers, libraries, and priority community anchor institutions. In New Zealand's 2010 Ultra-Fast Broadband plan, the target was to connect 75 per cent of New Zealanders with ultra-fast broadband (100 Mbit/s down, 50 Mbit/s up) over 10 years, concentrating on priority broadband users such as businesses, schools, and health services.[46] In Malaysia, the 2019 National Fiberisation and Connectivity Plan (NFCP) aims to provide fibre connections for 70 per cent of schools, hospitals, libraries, police stations and post offices by

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[45] *See* ITU Measuring digital development ICT Price Trends 2020 (available at https://www.itu.int/en/ITU-D/Statistics/Pages/ICTprices/default.aspx)

[46] *See* Ultra-Fast Broadband (available at https://en.wikipedia.org/wiki/Ultra-Fast_Broadband).

2022.[47] In the United States, the Goal 4 of the FCC's National Broadband Plan states that every anchor institution such as schools, hospitals, and government buildings should have affordable access to broadband service with at least 1 Gbit/s.[48]

Supplying high-speed broadband access to anchor institutions should be tightly coupled with demand-side interventions that also address affordability and digital skills. Several governments have set goals for device access and digital skills. These will vary by country and by need. The Government of Malaysia created the 1Malaysia programme focusing on low-cost devices for school children.[49] The action plan for Digital Education of the European Commission states that students who are currently in primary or secondary school or vocational training must have guarantees that they will acquire, in the educational system, the digital skills demanded by society to develop a full life.[50]

An ambitious forward-looking goal would be to reach 100 per cent of schools and other anchor institutions with 1 Gbit/s broadband service, establish digital skills development programmes at anchor institutions, and set up programmes to provide an affordable laptop or tablet to every low-income primary and secondary school student. This would ensure that the future generation has the digital skills to participate in the Fourth Industrial Revolution and resilience in the face of pandemics like COVID-19. This capacity would also make it possible for small local operators to use anchor institutions to spread connectivity to the surrounding community.

The aim of the Giga initiative, launched by UNICEF and ITU in September 2019, aims precisely to connect every school to the Internet.[51] The Giga initiative has four components: mapping, connectivity, finance, and empowerment. For Connect2Recover, the most applicable components are mapping and connectivity. Giga has started by mapping connectivity demand in partnership with governments, using schools as a base point and identifying where there are connectivity gaps. This information, combined with existing ITU mapping data, allows countries to take stock of their existing infrastructure and assess wired and wireless availability in devising appropriate solutions for connecting schools. More than 800 000 schools in 15 countries have already been mapped.

The following data sources can be used for checking access at anchor locations.

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[47] *See* The National Fiberisation and Connectivity Plan (NFCP) 2019-2023 (available at: https://www.malaysia .gov.my/portal/content/30736).

[48] *See* Federal Communications Commission, "Connecting America: The National Broadband Plan," published Mar. 17, 2010 (available at https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf).

[49] *See* https://www.freemalaysiatoday.com/category/nation/2021/01/27/najib-tells-how-2mil-students-can-get -laptops/.

[50] *See* Digital Education Action Plan (2012-2027) (available at https://ec.europa.eu/education/education-in -the-eu/digital-education-action-plan_en).

[51] *See* https://gigaconnect.org/.

Table 5: Data sources for anchor locations

Data source	Metrics used	Notes and caveats
Giga project (see Appendix A 1.3	• Location of schools • 2G coverage • 3G and above coverage • >= 3 Mbit/s • < 3 Mbit/s	Currently limited to 15 countries but growing.
GSMA coverage maps (see Appendix A 2.5	• Coverage maps for 2G, 3G, 4G and 5G	Coverage maps produced for GSMA by Collins Bartholomew rely on operator data and there is no harmonized methodology to produce these maps or check the quality. Coverage maps produced for GSMA by Masae Analytics are more reliable, use a harmonized methodology and allow further statistical analysis such as percentage of population coverage in a geographic area.
ITU broadband maps (see Appendix A 1.2	• Distance to nearest fibre interconnection point for location • Coverage maps for cellular networks are sourced from GSMA	Distance to fibre interconnection point does not reflect the real cost and effort to bring fibre to a location.

For countries that are currently covered by project Giga, there will be a rich set of data available on the level of access at schools. For other countries, a GIS study will need to be done. This will involve: (i) checking current data on school connectivity collected in the country, (ii) for the remaining schools, collecting the GPS location of all schools in the country, (iii) overlaying the 3G and 4G coverage maps to see the level of mobile coverage in those areas, and (iv) checking with operators whether fibre is available for schools. For planning purposes, in cases where a costing exercise is needed to extend fibre to a certain percentage of schools, the distance from schools to the nearest fibre can be done with ITU broadband mapping analysis tools. A similar process can be used for other anchor institutions such as health facilities and libraries.

Adoption and usage at schools and other anchor locations such as health facilities would need to be done using surveys with educators, learners, and healthcare workers.

2.5   Historically marginalized groups

Certain groups are often disenfranchised when connectivity is expanded. Here we study rates of access, adoption and usage by women and girls, persons with disabilities, and other marginalized groups that are often unique to each country.

According to the Broadband Commission, a good national broadband plan addresses special interest groups with low rates of fixed and mobile broadband adoption, such as diverse language groups, minorities, and people with specific needs.[52] Each country will handle this

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[52]   *See* Broadband Commission for Sustainable Development and Cisco, "Planning for Progress: Why National Broadband Plans Matter", June 2013 at 28 (available at https://www.broadbandcommission.org/Documents/publications/reportNBP2013.pdf

issue differently depending on cultural and social norms. For example, the FCC has broadband programmes specifically focused on tribal areas in the United States.[53]

Digital divides are common within countries. Thus, men, urban residents, and young people are more likely to be online than women, rural dwellers, and older people. Globally some 250 million fewer women than men use the Internet.[54] In low-income countries, only one in seven women is online, compared with one in five for men.[55] The digital gender gap, when measured in terms of Internet penetration, is relatively small in developed countries, more pronounced in developing countries and substantial in least developed countries.[56]

National broadband plans that specifically target programmes for ensuring equitable access for girls and woman are particularly important in rural and developing countries. The Broadband Commission noted in 2012 that only 29 per cent of countries referenced gender as an issue in their national broadband plans.[57] The report by the Broadband Commission on enhancing the inclusion of woman and girls in the information society suggests an annual audit and reporting of gender inclusion in published broadband plans.[58]

Another example of a traditionally disenfranchised population present in every country is persons with disabilities. According to the United Nations, persons with disabilities form the world's largest minority. The WHO estimates that more than one billion people worldwide – 15 per cent of the global population – are living with a disability, and 80 per cent of them live in developing countries.[59] Around the world, people with disabilities face challenges that prevent them from equitably participating in social or economic life. They may face inaccessible physical environments, barriers to vital services and information, and a lack of basic assistive technologies. Individuals with disabilities face higher poverty rates.[60] This makes it more likely that the costs of Internet subscriptions and electronic devices will be prohibitive for them.

Considering the vast potential of Internet technology to improve the lives of persons with disabilities, wider Internet access should be considered imperative. Country strategies and broadband plans should ensure that they provide statistical data on disability, Internet access, and personal income**.** This could be done by tailoring household expenditure surveys to measure and analyse the link between disability status/prevalence, Internet access, and income.

Data sources on marginalized groups are few, but the following sources can be used to check internal country divides and gender gaps.

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[53] *See* Federal Communication Commission Press Release, "FCC Modernizes Lifeline Program for the Digital Age: New Rules Will Help Make Broadband More Affordable for Low-Income Americans," Mar. 31, 2016 (available at https://docs.fcc.gov/public/attachments/DOC-338676A1.pdf).

[54] *See* World Development Report 2021: Data for Better Lives at 164.

[55] *See* World Development Report 2021: Data for Better Lives at 164.

[56] *See* ITU Digital inclusion of all (2019) (available at https://www.itu.int/en/mediacentre/backgrounders/Pages/digital-inclusion-of-all.aspx).

[57] *See* Planning for Progress: Why National Broadband Plans Matter at 25.

[58] *See Doubling digital opportunities: Enhancing the inclusion of women and girls in the information society: A report by the Broadband Commission Working Group on Broadband and Gender, at 39 (available at* https://www.unwomen.org/en/docs/2013/9/doubling-digital-opportunities-women-and-girls-in-it*)*

[59] *See* WHO World report on disability (2011), at 261 (available at https://www.who.int/publications/i/item/9789241564182); UN Factsheet on Persons with Disabilities (available at https://www.un.org/development/desa/disabilities/resources/factsheet-on-persons-with-disabilities.html).

[60] *See* WHO World report on disability at 57.

Table 6: Data sources for marginalized groups

Data source	Metrics used	Notes and caveats
Ookla Speedtest (see Appendix A 2.3)	• Download and upload speed (measured to nearest test server – there are 8 000 of these) • Latency (measured to nearest test server)	Ookla allows statistics to be extracted on fixed and mobile broadband performance for regions as small as 300x300m. This can be used to check divides in dense urban areas as well as between rural and urban areas.
EIU data (see Appendix A 2.6)	• Usage: Gender gap in Internet access, Gender gap in mobile phone access (original source data from ITU) • Policy: female e-inclusion policies	Only available for 100 countries (80 core countries and 20 rotating countries). Survey size is limited; 4 953 people across 99 countries in 2019. Reports are produced annually.

Comprehensive data sources on broadband adoption and usage by people living with disabilities are not readily available. Some countries have done their own internal surveys, but the last worldwide study was done in 2011 by the WHO, as referenced above.

Regions of interest in the country will need to be drawn up with well-defined boundaries. Ookla can then be used to extract the average speed performance within these boundaries. For example, Ookla data were used to highlight digital divides in the 20 largest cities in the United States.[61]

EIU data can be used to check the gender gap in Internet access as well as mobile phone access. The EIU female e-inclusion policy also assesses whether a country has strategies to help address gender digital divides and female Internet access and adoption.

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[61]   *See* https://jamessaxon.github.io/broadband/equity/data/2020/12/06/public-data-on-internet-equity.html

3   Stress-testing operator networks

Network stress tests are required to check the real experience of the network for users under different load conditions. This is not a matter of taking a snapshot, it requires ongoing measurement at different points in daily, weekly, and monthly cycles. Edge performance (last mile) from a user's device can be affected by signal strength, interference and congestion, whereas the middle mile and network core is typically only affected by congestion and the maximum capacity of the fixed link (which will differ widely based on technology, distance, network architecture, etc.) being reached.

Stress-testing can measure many key aspects of a link. These are:

•   throughput (usually measured in Mbit/s)
•   latency or round-trip time (usually measured in milliseconds)
•   DNS reachability.

There are many good measurement tools that can be used by operators or regulators to establish the ground truth of network performance. These include tools that run as passive or active network measurements. The advantage of passive measurements is that no extra traffic is generated; but it may capture sensitive user data that need to be anonymized.

Passive measurements may also not measure the true maximum potential performance of a link. Active measurements send an artificial stream of data to a test server – usually located in a nearby data centre – and attempt to measure the maximum performance of the network. The disadvantage of active measurements is that they generate additional data costs to the user, and they may not measure the real performance of the network if the test is performed while a user is actively using the network. Active measurements also heavily depend on the availability of in-country test servers that are well positioned to measure the true performance on the user's Internet link. Stress-testing is best done from user devices or test devices placed at the customer connection point to ensure that all bottlenecks between the user and the Internet server are included.

Measurement probes can be web-based and run by users wishing to test their network performance, or they can be installed on low-cost hardware placed at different points around cell towers, wireless access points or Ethernet endpoints to run network measurements at different times of the day.

Well-known web-based network measurement tools are the Google speed test[62] built by the measurement lab (M-lab) and the Ookla speed test.[63] Well-known measurement software tools that can be installed on low-cost hardware, such as Raspberry Pis, are BISmark[64] and Murakami.[65] Ookla has the greatest number of test servers (approximately 10 000 as of February 2020), measuring the speed of the last mile connection between a user and a test server, often hosted by their ISP. M-lab and Opensignal have a smaller number of test servers and measure more upstream effects on the network path between a user device and the server. Ookla results will

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[62]   *See* Google speed test (available at https://projectstream.google.com/speedtest)
[63]   *See* Ookla speed test (available at https://www.speedtest.net/)
[64]   *See* Project BISmark (available at http://projectbismark.github.io/)
[65]   *See* Project Murakami (available at https://github.com/m-lab/murakami)

often be significantly faster than M-lab and Opensignal; there is no single right answer. Ookla can help users understand if there are bottlenecks in their ISPs slowing down their Internet connections. M-lab and Opensignal will reveal bottlenecks in a country's Internet infrastructure.

The RIPE Atlas[66] platform consists of measurement vantage points called "probes" and measurement servers known as "anchors". RIPE Atlas is a hardware-based measurement platform, which means that the hardware used is mostly homogeneous (with different versions). Both probes and anchors can be used to run a series of active measurements. Examples of available tests are ping, traceroute, DNS, HTTP GET, TLS, etc.

Anchors have additional functions such as operating as a measurement target/collector. As of 10 April 2021, RIPE Atlas has 11 736 active probes, 359 hardware anchors and 425 virtual machine anchors across the world.[67] Anchors are probes that support a high number of incoming connections. However, in general most of the measurement infrastructure is concentrated in more developed regions. This is why most of the RIPE Atlas probes and anchors are located in the United States and Europe. In Africa, there are 231 active RIPE Atlas probes distributed in 126 Autonomous Systems (ASes) (39 of which have both IPv4 and IPv6 connectivity). They achieve a coverage of only 7.3 per cent.[68]

There are also several good tools that are focused on Wi-Fi performance, such as Cape Networks[69] and ASSIA's cloud check.[70] Performance of mobile phone networks can be checked with Opensignal.[71] The results of all tests on Opensignal are published on publicly available maps (as described in section 2.1).

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[66] *See* The RIPE Atlas platform (available at https://atlas.RIPE.net)
[67] *See* https://atlas.ripe.net/results/maps/network-coverage/
[68] *See* https://atlas.ripe.net/results/maps/density/
[69] *See* Cape Networks (available at https://capenetworks.com/)
[70] *See* ASSIA (available at https://www.assia-inc.com/)
[71] *See* Opensignal project (available at https://www.opensignal.com/)

4   Assessing resilience of operators during the COVID-19 pandemic

This section will analyse how different types of network operators in various regions and countries performed during the pandemic and look at steps to increase resilience during future pandemics. We will provide an assessment of the sufficiency and resiliency of operator networks in response to the COVID-19 pandemic as well as steps Member States and network operators are taking to increase network resiliency and improve disaster preparedness. We will describe datasets that can and have been used to understand how the Internet performed as the COVID-19 pandemic forced users to stay home, and what can be learned from these data that can help build better resilience into the Internet by service providers and network operators from the core to the edge.

4.1   Assessment of Internet resilience during COVID-19

The COVID-19 pandemic has tested the resilience of the infrastructure of the Internet. As bandwidth demand skyrocketed to meet the needs of health and emergency response but also in response to a surge in general demand, new capacity and networks were rolled out. Existing networks responded by managing demand and allowing shaping, expanding International Mobile Telecommunications (IMT) spectrum availability and flexibility, and increasing broadband speeds.[72] Network providers also worked hard to increase transmission and backhaul capacity, optimize network capacity, and deploy new 4G/5G fixed wireless access (FWA).[73] Despite all these actions, COVID-19 "intensified and exasperated the challenges of delivering LMC [last mile connectivity],"[74] increasing the visibility and severity of the digital divide.

A study by Facebook[75] using traffic from its edge network showed a worldwide step increase of about 30 per cent in network traffic after most lockdowns were in place (see Figure 3). The study also noted that North America and Europe were very resilient to the shifting demand for network access from home and the increase in videoconferencing traffic[76] during the COVID-19 crisis (see Figure 6). However, some developing countries with fewer Internet exchange points (IXPs) and lack of home access showed an increase in round-trip time, packet loss, and a degradation of network performance.[77] According to the same report, developing countries experienced different degrees of impact. Colombia's bad session rate (BSR) - a video session with a slow start or frequent stalls - increased from 10 per cent to 13.5 per cent as the COVID-19 pandemic started causing marked shifts in traffic patterns in late March 2020. However, other markets, such as Brazil, Peru and Ecuador had no noticeable change in BSR, a sign of greater resilience.[78]

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[72] https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Events2020/RED-AFR/Ses1-1-REG4COVID-19 _RED-AFR2020-Minehane.pdf

[73] https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Events2020/RED-AFR/Ses1-1-REG4COVID-19 _RED-AFR2020-Minehane.pdf

[74] https://reg4covid.wpengine.com/wp-content/uploads/2020/11/FINAL_Last-Mile-Connectivity_Covid.pdf

[75] *See* How the Internet reacted to Covid-19 – a perspective from Facebook's edge network (Oct 2020) (available at https://research.fb.com/publications/how-the-internet-reacted-to-covid-19-a-perspective-from-facebooks -edge-network/).

[76] *See* How the Internet reacted to Covid-19, Figure 6 at 4, and Figure 7 at 4.

[77] *See* How the Internet reacted to Covid-19, Figure 8 at 4, and Figure 11 at 5.

[78] *See* How the Internet reacted to Covid-19, Figure 8 at 4.

Figure 5: Relative change of global edge traffic in 2020 normalized against values on 1 March 2020. Vertical lines mark the implementation dates of lockdown measures in the largest countries
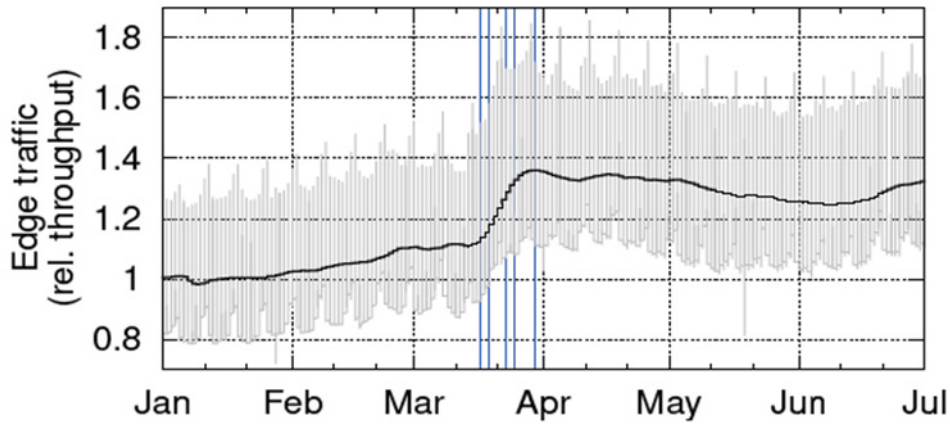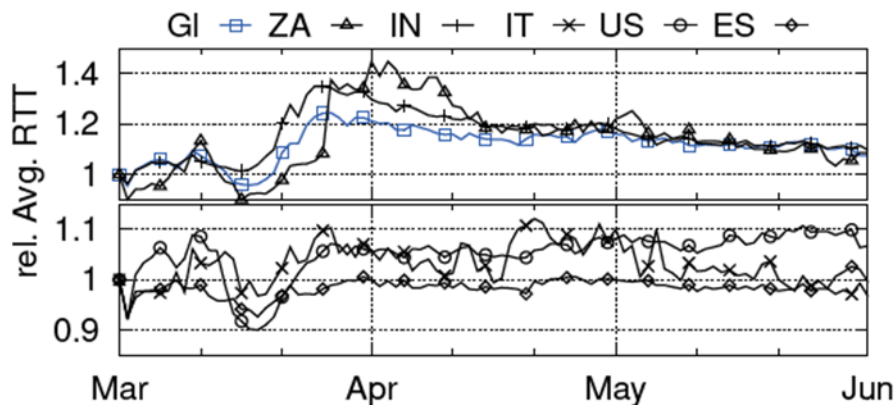

(source: T. Bottger et al, How the Internet reacted to Covid-19 – A perspective from Facebook's Edge Network).

Figure 6: Average round-trip time globally and for selected countries in 2020 normalized against values on 1 March 2020. Gl stands for global RTT

(source: T. Bottger et al, How the Internet reacted to Covid-19 – A perspective from Facebook's Edge Network).

Similar trends were noticed by the Nokia Deepfield intelligence report, which draws on data from network providers across Europe and North America.[79] Overall traffic increased by 30-50 per cent in the first weeks of the global pandemic but then stabilized to around 20-30 per cent above pre-pandemic levels. This was mostly driven by a 350-700 per cent increase in videoconferencing traffic and a 50-100 per cent increase in Netflix traffic. The Deepfield report also cited a 40 per cent increase in denial-of-service attacks.

4.2   Resilience framework for networks

There are many threats and obstacles (both internal and external) that impact Internet infrastructure and the mechanisms that affect the overall resilience of Internet services. Resilience is related to the ability of a network to maintain an acceptable level of service in the event of an outage or during a crisis.

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[79]   *See* Nokia Network Intelligence Report 2020 at 3 (available at https://www.nokia.com/networks/solutions/deepfield/network-intelligence-report/)

As shown in Figure 7, "Internet resilience" encompasses many underlying components ranging
from the resilience of physical Internet infrastructure and power infrastructure to market resilience
and quality of service (QoS) (i.e. performance, uptime, available bandwidth, etc.).

Figure 7: Hierarchical representation of resilience (based on work done by Afrinic/ ISOC project: MIRA)
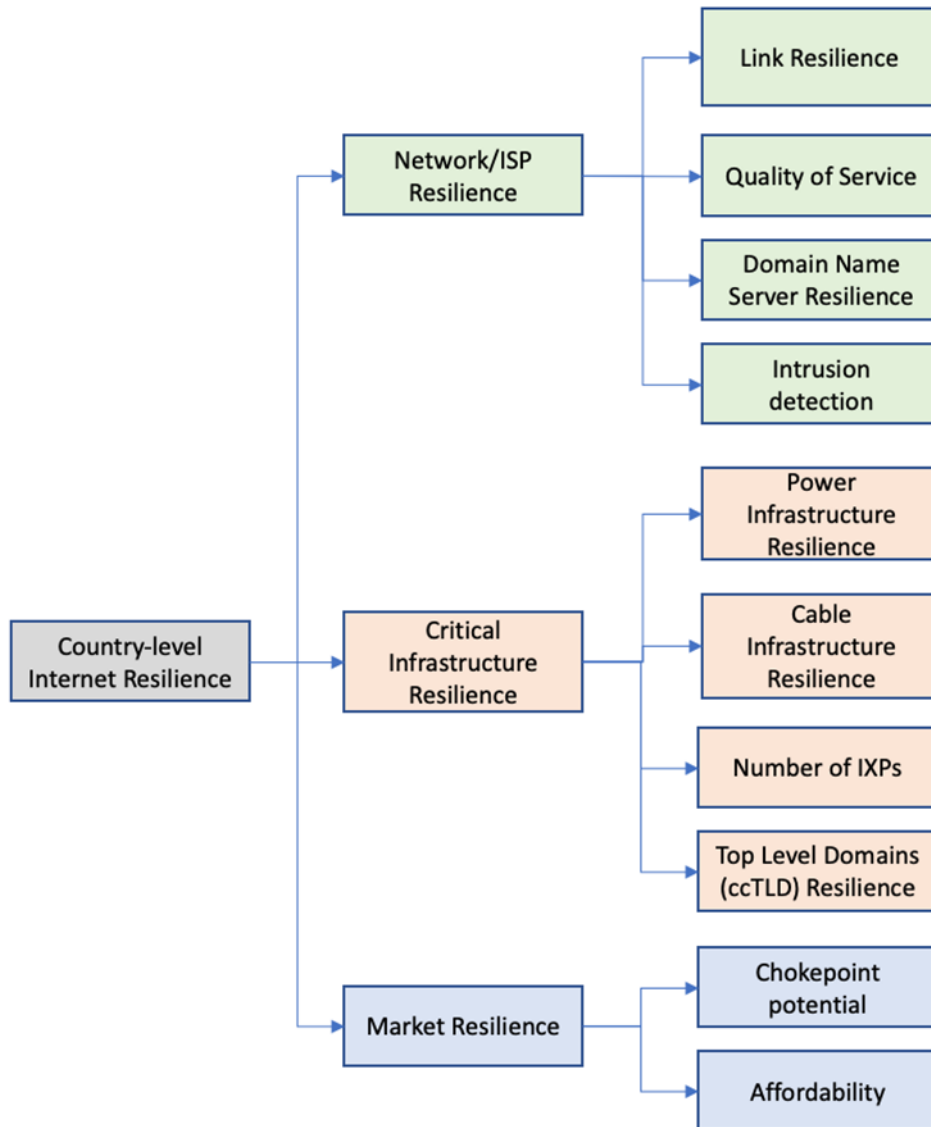
Hierarchical components of resilience:

- *Country-level Internet resilience*: the ability of a country to provide Internet services to
  its citizen at an acceptable level of service in the face of faults and challenges to normal
  operations.
- *Critical infrastructure resilience*: the resilience of the power infrastructure, the Internet
  cable infrastructure (both terrestrial and undersea), and the availability and efficiency
  of IXPs and the country code top-level domain (ccTLD) infrastructure – this is in-country
  hosted infrastructure using a top-level domain reserved for the country.
- *Market resilience*: the ability of the market to self-regulate and provide affordable prices
  to end-users while remaining diverse and competitive.

- *Network/ISP resilience*: the ability of a network/Internet service provider (ISP) to continue providing an acceptable level of service in the event of an outage or during crises. It is made up of various components such as the resilience of physical links, logical/peering links, performance/QoS of links, and the availability of multiple domain name servers (DNS) and intrusion detection systems against threats such as denial-of-service attacks.

The following indicators are key to checking the level of resilience in a country:

- The availability and stability of the physical infrastructure, which includes power stations, undersea or terrestrial fibre, landing stations, and last mile access networks.
- The QoS of the network from the end-user's perspective and the stability of the network in terms of reachability, throughput, and latency to selected target servers.
- The availability and performance of Internet service components, the most critical being the DNS ecosystem and intrusion detection systems.
- The presence and efficiency of IXPs and the local peering fabric.
- The resilience of the ISP market; i.e. the level of concentration towards specific autonomous systems (AS) and affordability.

5   Digital technologies that mitigate the impact of future pandemics

There are many technologies that can provide an increased level of resilience and help mitigate the negative consequences of future pandemics. In this section, we identify and assess various technology options available to network operators looking to extend affordable broadband access to underserved and unserved communities, including traditional fibre, coaxial cable and copper infrastructure, various fixed and mobile terrestrial wireless solutions, geostationary and low-Earth orbit satellites, and other emerging and experimental technologies.

In this section, we also discuss the devices that customers use to connect to the Internet. These include mobile devices, such as smartphones and feature phones, personal computers, laptops, and tablets, which typically connect to the Internet over a Wi-Fi connection, and modems and routers used to connect to fixed broadband services. In addition, we discuss a full range of productivity applications and services, including some which have proven particularly useful during the COVID-19 pandemic. The table below summarizes connectivity, device, and application and service options.

Table 7: Technologies that can provide an increased level of resilience and help mitigate the consequence of future pandemics

Connectivity	Devices	Applications/services

– First mile
 	
   – Submarine cables
   – Landing stations
   – Satellite dishes
   – Cross-border micro-wave
 	
– Middle mile
 	
   – Fibre backbone
   – Microwave links
   – Internet exchange points
   – Content distribution networks
 	
– Last mile
 	
   – Mobile network
   – Fixed network
   – Fibre/copper
   – Fixed wireless
   – HAPS, HIBS and satel-lite
	– Mobile devices
	
	   – Smartphones
	   – Feature phones
	
	– Tablets/laptops
	
	   – Low-cost devices
	
	– Broadband connectivity
	
	   – Routers
	   – Modems
	
	– IoT devices
		– For emergency response
		
		   – Emergency alerts
		   – Nearest connectivity application
		
		– For productivity
		
		   – Education
		   – Health care
		   – Agriculture
		   – Business

5.1 Connectivity technologies

The broadband network value chain (or building blocks), to develop universal, affordable, and high-quality broadband Internet access, comprises four broad segments: first mile, middle mile, last mile, and invisible mile. This is depicted in the visual in Figure 8, adapted from the Broadband Commission's "moonshot" report on Africa (Broadband Commission for Sustainable Development, 2019).[80]

Figure 8: The four segments of the broadband network value chain (Source: The World Bank Group)
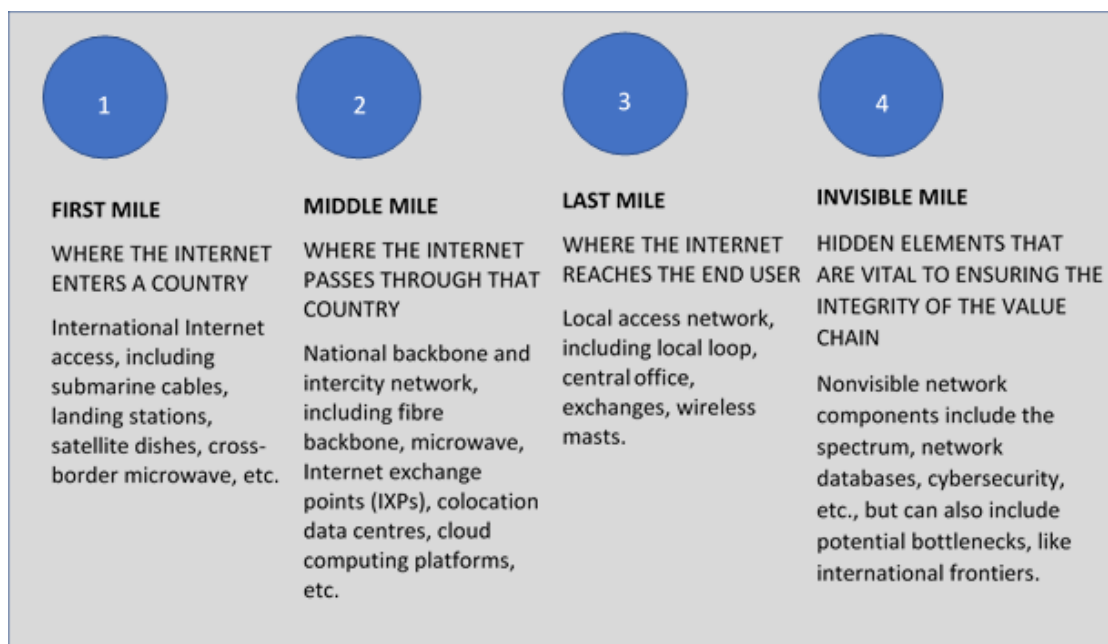
All parts of the value chain need to be present to deliver fixed or mobile Internet access. Equally important are supporting infrastructure (for example, data centres and a reliable electricity supply) and the devices that are used to access the Internet. It is also critical, as discussed in section 6, to ensure that middle mile, first mile and invisible mile elements have sufficient redundancy, and that last mile elements have resilience built in, such as back-up power.

The first mile is where the Internet enters a country.[81] The network components are international Internet access and include submarine cables, landing stations, satellite dishes, cross-border microwave and fibre links, domain name registration, and so on. Countries need to be connected to undersea cables or via cross-border terrestrial links (particularly for landlocked countries). Most coastal countries now have direct access to submarine cable systems.[82]

The middle mile is where the Internet passes through a country.[83] The network components are the national backbone and intercity networks, including the fibre-optic cables or copper wires,

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[80]   *See* Broadband Commission report, "Connecting Africa Through Broadband: A strategy for doubling connectivity by 2021 and reaching universal access by 2030" at 36 (available at https://www .broadbandcommission.org/Documents/working-groups/DigitalMoonshotforAfrica_Report.pdf).
[81]   *See* Digital Moonshot for Africa Report at 36-37.
[82]   *See* ITU Interactive Terrestrial Transmission Information Superhighway Maps (available at https://www.itu .int/itu-d/tnd-map-public/).
[83]   *See* Digital Moonshot for Africa Report at 36, 38

microwave, satellite links, IXPs, colocation data centres, cloud computing platforms, and so on. Once connected to high-speed Internet at the border, countries require fibre backbones to carry Internet traffic from the border to urban and rural centres throughout the country and backhaul or metro networks to extend further. Satellite transmission remains important in some small island developing States and in rural and remote locations that lack access to terrestrial first or middle-mile networks. While most countries now have IXPs and more IXP locations are being added, many low and middle-income countries, including small island developing States, do not have their own IXPs.[84] For these countries, their domestic Internet traffic is exchanged through points outside their respective country, usually through fibre or satellite across international hubs, to reach their destination.

The last mile is where the Internet reaches the end-user.[85] Once high-speed Internet arrives at a population centre, via the first and middle miles, network operators provide mobile or fixed Internet access services to consumers, businesses, and governments. Network components include: the local loop, which historically was comprised of copper cables but now increasingly uses fibre for-last mile connections in urban or suburban areas; central office exchanges; wireless masts for fixed and mobile wireless connectivity; and satellite, in remote locations where terrestrial networks cannot be economically deployed.[86] There are also new developments that enable network operators to cost-effectively deploy high-speed last mile networks to locations outside population centres. For example, new high-capacity terrestrial FWA solutions, which are described in more detail below, can be utilized in more places, and other innovative solutions (such as high-altitude platform stations (HAPS) using drones and balloons) are being piloted. In addition, new low-Earth orbit (LEO) satellite solutions promise to bring Internet connections with lower latency and higher throughput to locations around the world.[87]

As discussed above, Internet access is either fixed or mobile. The primary benefits of mobile last mile access are the ability to be mobile and the ability to connect with a low-cost device. The primary benefit of fixed last mile access is the ability to affordably consume large amounts of data on a high throughput, low latency connection.

To deliver mobile connectivity, network operators deploy wireless technologies based on the 3rd Generation Partnership Project (3GPP) family of technology standards. A new generation of mobile wireless technologies is developed roughly once per decade, so that fourth generation (4G) mobile technologies were largely deployed from 2010 to 2020, and new fifth generation (5G) mobile technologies will be largely deployed from 2020 to 2030. Long-term evolution (LTE), which was designed from the beginning to support data communications, was first introduced with 4G mobile technologies and is now the basis for 5G mobile technologies. These are designed to enable high-density, high-throughput, and low-latency use cases, supporting

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[84]   *See* Telegeography Internet Exchange Map (available at https://www.internetexchangemap.com/); *see also* World Development Report 2021, at 159.

[85]   *See* Digital Moonshot for Africa Report at 36, 40.

[86]   *See* The Last-mile Internet Connectivity Solutions Guide: Sustainable Connectivity Options for Unconnected Sites. Geneva: International Telecommunication Union, 2020. Licence: CC BY-NC-SA 3.0 IGO (available at https://assets.foleon.com/eu-west-2/uploads-7e3kk3/16601/the_last_mile_internet_connectivity_solutions _guide.3b7086016604.pdf).

[87]   *See* Broadband Commission for Sustainable Development, "Working Group on Technologies in Space and the Upper-Atmosphere Identifying the potential of new communications technologies for sustainable development", September 2017 (available at https://www.broadbandcommission.org/Documents/ publications/WG-Technologies-in-Space-Report2017.pdf).

a range of industrial, enterprise, and consumer applications.[88] The GSMA provides a helpful dashboard tracking global progress on 5G deployments, projecting that they will account for as many as 1.2 billion connections by 2025.[89]

While the introduction of 5G is exciting, it is important to remember that new communication technologies are designed for urban markets where demand and wealth concentrate. The lack of economies of scale makes it difficult to deploy these technologies profitably in rural areas, with lower average incomes and population densities. Indeed, mobile wireless networks in rural areas with low population densities are often provisioned to provide basic coverage and are not designed to handle high-throughput connectivity. This should be an important consideration as 5G wireless technologies are rolled out over the next decade.[90]

To deliver fixed broadband access to prospective customers, a network operator will consider a variety of available technologies – from satellite communication technologies and terrestrial fixed wireless technologies to fibre-optic connections. High-capacity fibre-optic and wired technologies, along with emerging higher frequency wireless technologies, are typically the most cost-effective technologies for highly dense suburban and urban areas. Satellite communication technologies are typically the most cost-effective solution for the remotest rural areas. In between, network operators will use terrestrial (i.e. non-satellite) fixed wireless technologies for last mile access. These fixed wireless technologies operate on low-band (e.g. TV white spaces[91]), mid-band (e.g. 3.5 GHz and 5 GHz bands), and high-band spectrum (e.g. millimetre-wave bands). The low bands are good for long-range connections in rural locations and the high bands are good for short-range, high-throughput connections in urban locations.

The table below summarizes different last mile access technologies that a network operator could utilize to bring broadband access to customers.

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[88] One interesting development in the mobile wireless industry is the emergence of Open RAN Radio architectures that disaggregate hardware and software elements in 5G networks. By virtualizing network elements in the cloud, an Open RAN network architecture promises to introduce more competition, increase flexibility, and reduce costs for network operators, which will have implications for where 5G networks can be cost-effectively deployed.

[89] *See* https://www.gsma.com/futurenetworks/ip_services/understanding-5g/; *See also* https://www.5gamericas.org/wp-content/uploads/2021/02/Latin-America-2.16.21.pdf (tracking 5G deployments in the Americas).

[90] Hart, Kim, "A 5G Reality Check", Axios, Oct. 2, 2018 (available at https://www.axios.com/5g-adoption-verizon-4g-future5549772d-0ca3-4fba-b14e-d455b9d596f1.html).

[91] The TV white spaces are frequencies that have not been assigned or are otherwise not being used by broadcasters and other licensees in the VHF and UHF broadcast bands.

Table 8: Last mile access technologies for bringing broadband access to customers

Broadband Technology	Typical Throughput	Speed	Latency	Reliability	Cost Economics	Coverage	Notes	Examples
Fiber to the Home	50 Mbps to 1 Gbps	Green	Green	Green	Red	Red	Pros: Future proof Cons: High capital costs	AT&T, Comcast, Verizon
5G Fixed Wireless*	5-500 Mbps	Green	Green	Green	Green	Green	Pros: Mature technology ecosystem Cons: Requires licensed spectrum, high entry barriers	Mobile Operators
Other Fixed Wireless Solutions*	5-500 Mbps	Green	Green	Green	Green	Green	Pros: Lowest-cost options, low barriers to entry, can be non-line-of-site Cons: Immature ecosystem	Wireless ISPs
LEO Satellite	5-100 Mbps	Green	Green	Yellow	Yellow	Yellow	Pros: Low latency, high throughput Cons: Still in trials, tech & bus model unproven, expensive CPE.	StarLink, OneWeb, Telesat, Amazon
GEO Satellite	2-50 Mbps	Red	Red	Yellow	Yellow	Green	Pros: Ubiquitous coverage Cons: High cost, low throughput, high latency.	Hughes, Iridium

One can see how an Internet service provider would utilize different technologies and products for customers located in different urban, suburban, and rural areas. The mix of technologies used will depend on the area(s) of intended service. Internet service providers operating in urban areas will primarily deploy fibre-optic networks, complemented with wireless technologies in higher spectrum bands, offering more throughput and the ability to serve more customers simultaneously. In rural areas ISPs will rely more on fixed wireless technologies, using lower spectrum bands that have signals that can travel over longer distances. Pricing of technologies, the average incomes of prospective customers, and the availability of public subsidies also impact decision-making on the technology mix.

The invisible mile consists of the hidden elements that are vital to ensuring the integrity of the value chain.[92] This includes the network components that are not visible, including the radio spectrum, network databases (for example, for numbering), cybersecurity, and so on, but can also include potential bottlenecks such as market concentration, multilayered taxation of activities, lack of access to rights-of-way, and inefficient regulations including transborder regulatory issues. Section 7 addresses an important aspect of the invisible mile – policy and regulation.

5.2   Devices

As discussed above, most people around the world connect to the Internet over mobile devices – smartphones and feature phones – whether connected directly to a mobile network or through a Wi-Fi connection. Currently, 55.7 per cent of the world's population connects to the Internet from a mobile phone.[93] DataReportal has partnerships with web analytics companies and can provide a breakdown of device use for any country. Increasingly, people also need laptops, tablets, and other larger form factor devices that better optimize online and offline productivity applications used for education and employment. Moreover, alongside mobile broadband, fixed broadband connectivity has proven a necessity during global COVID-19 pandemic lockdowns. Fixed broadband, which can be based on fibre, terrestrial wireless, or satellite

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[92]   *See* Digital Moonshot for Africa Report at 42
[93]   *See* Digital 2021 Global Overview Report (available at https://datareportal.com/reports/digital-2021-global -overview-report).

connectivity, requires modems and routers located at the customer's premises to connect (most often over a Wi-Fi connection) to the Internet. A combination of fixed and mobile broadband is fast becoming the desired new normal globally.

While the cost of devices has been declining over time,[94] it still remains a significant barrier to connectivity for many people around the world. According to the same study, "[n]early 2.5 billion people live in countries where the most affordable smartphone costs more than a quarter of the average monthly income."[95] It explains that "[i]n Africa, devices were least affordable at 62.8 per cent of average monthly income compared with 11.7 per cent in the Americas and 16.2 per cent in Asia-Pacific (excluding India). With India included the Asia-Pacific figure jumps to 87.4 per cent owing to the country's role as an outlier with a very large population and high costs."[96] Below, we discuss policies to promote adoption of digital technologies by minimizing the cost of connectivity and devices, especially for low-income consumers.

5.3   Services and applications

The COVID-19 pandemic further demonstrated the importance of connectivity and how certain services and applications "give citizens access to opportunities, allow governments to deliver much needed services, and enable businesses to thrive."[97] Some services and applications were already in use pre-COVID-19, but their frequency of use increased during the pandemic. Others services gained new users as a result of the pandemic. Large-scale remote working in education, health care and other work settings meant that use of Zoom, Skype, Microsoft Teams, Google Meet, and other similar services increased dramatically, as did reliance on them for day-to-day operations. In the United States alone, use of teleconferencing apps grew by 300 per cent, and online gaming by 400 per cent as children were confined indoors.[98] Social media platforms were used to both spread information and combat misinformation and "fake news" in an effort to keep the public well informed. Digital platforms such as Amazon, Netflix, and YouTube formed partnerships to "restrict video streaming quality globally in order to help reduce network congestion."[99]

Economic recovery was a central focus to many services and applications that were made available during the pandemic. The development of contact tracing apps allowed for faster emergency response rates, targeted to help slow the spread of COVID-19 while allowing people to engage in-person in the economy. Although the use of these apps varied from country to country, state to state and even city to city, they supported a return to normal social and economic activity during and following periods of lockdown. However, the low penetration of smart phones required to run the contact tracing apps precluded many countries from deploying such apps. Even South Africa, with the highest smartphone penetration in Africa (between 55 per cent and 60 per cent) falls short of the required population uptake of 60 per

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[94]   *See* The World Bank Group, Broadband Strategies Toolkit at Section 6.4.3 (available at https://ddtoolkits .worldbankgroup.org/broadband-strategies/driving-demand/achieving-affordability#section-276).

[95]   *See* Alliance for Affordable Internet, "From Luxury to Lifeline, Reducing the cost of mobile devices to reach universal internet access," at 4, August 5, 2020 (available at https://a4ai.org/research/from-luxury-to-lifeline -reducing-the-cost-of-mobile-devices-to-reach-universal-internet-access/). For this study, the Alliance for Affordable Internet looked at device affordability in 70 countries with a combined population of over five billion people.

[96]   *See* From Luxury to Lifeline, Reducing the cost of mobile devices to reach universal internet access, at 4.

[97]   https://reg4covid.wpengine.com/wp-content/uploads/2020/11/FINAL_Last-Mile-Connectivity_Covid.pdf

[98]   https://reg4covid.itu.int/wp-content/uploads/2020/06/ITU_COVID-19_and_Telecom-ICT.pdf

[99]   https://reg4covid.itu.int/wp-content/uploads/2020/06/ITU_COVID-19_and_Telecom-ICT.pdf

cent that makes contact tracing effective countrywide.[100] Nonetheless, even in countries with lower smartphone penetration, contact tracing can be used in urban areas or in large company or government organizations to prevent local outbreaks of COVID-19.

The push to create more robust digital economies to mitigate financial losses resulting from lockdowns caused a surge of investment in digital payments systems and infrastructure, the digitization of SME retail operations, and the provision of telehealth and remote education services.[101]

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[100] *See* Assessment of contact tracing option for South Africa at 18 (available at https://www.africaportal.org/documents/20705/Contact-tracing-survey-report-David-Johnson-Oct2020.pdf)
[101] https://reg4covid.itu.int/wp-content/uploads/2020/06/ITU_COVID-19_and_Telecom-ICT.pdf

6 Efforts to increase availability, adoption, and resilience

A variety of stakeholders, from government and the private sector to civil society, have implemented a wide range of efforts to address the COVID-19 pandemic. ITU's Global Network Resiliency Platform (#REG4COVID) is a place where ICT regulators, policy-makers and other interested stakeholders can share information, viewing what initiatives and measures have been introduced around the world to help ensure communities remain connected during the COVID-19 crisis.[102] The Global Network Resiliency Platform has identified hundreds of initiatives, as catalogued in three recent ITU reports.[103] Some are the work of governments, but most have been voluntarily set up by companies and non-profit organizations. An ITU report, "Pandemic in the Internet age: From second wave to new normal, recovery, adaptation and resilience", provides additional details on efforts to address the COVID-19 pandemic's immediate impact, the recovery phase, and the new normal.[104] The table below highlights some of these initiatives.

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[102] *See* https://reg4covid.itu.int/.

[103] *See* International Telecommunication Union, "Last Mile Connectivity in the Context of COVID-19, REG4COVID Discussion paper," November 2020 (available at https://reg4covid.wpengine.com/wp-content/uploads/2020/11/FINAL_Last-Mile-Connectivity_Covid.pdf); International Telecommunication Union, "Pandemic in the Internet Age: communications industry responses," June 2020 (available at https://reg4covid.itu.int/wp-content/uploads/2020/06/ITU_COVID-19_and_Telecom-ICT.pdf); International Telecommunication Union, "First Overview of Key Initiatives in Response to COVID-19," May 2020 (available at https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/REG4COVID/2020/Summary_Key_Covid19_Initiatives.pdf).

[104] *See* International Telecommunication Union, "Pandemic in the Internet age: From second wave to new normal, recovery, adaptation and resilience", May 2021 (available at https://www.itu.int/en/myitu/Publications/2021/05/11/08/52/Pandemic-in-the-Internet-age).

Table 9: Initiatives around the world to increase availability, adoption, and resilience

Emergency measures	Affordability	Availability	Spectru policy	Content distribution
• Mobilization of national emergency telecommunication plans (including emergency alerts) • Deploying resources to handle traffic increases • Allocation of toll-free numbers for emergency services	• Discounted services and devices for low-income consumers • Commitment not to shut off service for unpaid bills • Free connectivity at community centres • Free outdoor public Wi-Fi hotspots • Free 4G/Wi-Fi routers for students • Zero-rated education and other content • Reduced sale tax on broadband services • Free device charging schemes	• Acceleration of network deployments in rural areas • Release of additional capacity on mobile, fixed wireless, and satellite networks • Expedited deployment of fixed wireless networks • Extended connectivity for health care providers and schools • Waiver of rights-of-way (leeway) fees	• Rapid issuance of spectrum temporary authorizations • Accelerated allocations and assignments • Extension of spectrum licence terms • Minimizing licensees' regulatory and reporting obligations	• Government information and advisories • Television and radio stations disseminating health, safety, and educational content • Creation of local news platforms • Applications to disseminate health information. • Commitments from platform companies to limit spread of COVID-19 disinformation

7   Policies and regulations to prepare for future pandemics

The COVID-19 pandemic has been unlike anything we have experienced since the influenza pandemic from more than a century ago. It has been unprecedented in its longevity, scope, and impact, measured in lives lost and in economic and social upheaval. As has been well documented elsewhere, the COVID-19 pandemic has also caused an acceleration in the take-up of online productivity applications, including document collaboration and videoconferencing, for remote work, learning, access to medicine, and other basic needs. In addition, as the world has locked down, e-commerce has thrived. We have entered a "new normal". Few would now debate whether high-speed fixed and mobile connectivity and online cloud-based applications are necessary for basic social and economic participation. All of this has led to a re-assessment of how governments prepare for future pandemics.

The COVID-19 pandemic should re-energize efforts to close the global connectivity gap and reposition all of society to be ready for whatever is next. As we discuss below, this begins with reinvigorating efforts to develop and update national broadband plans and strategies. Governments should assess and update definitions and targets for broadband availability, adoption overall, and adoption by traditionally disenfranchised groups, such as women and girls and persons with disabilities. Utilizing ITU as a convenor, we can take a multi-stakeholder approach to improve the collection of data on fixed and mobile broadband and narrowband availability, adoption, and usage. Next, governments should make efforts to increase the availability of fixed and mobile broadband and narrowband connectivity. This includes opening more spectrum, but also implementing clear and enforceable competition policies and investing in infrastructure to spur the market. In collaboration with the private sector and civil society, governments should also redouble efforts to implement demand stimulation activities, including efforts to address service and device affordability, promote basic and enhanced digital skills, and produce locally relevant content and applications. Finally, because we know that other disasters – whether the result of natural hazards or man-made causes – will strike in the future, every national authority should have a national emergency telecommunication plan in place. Each of these topics is addressed in turn.

7.1   Reinvigorating national broadband plans

As observed by the Broadband Commission, digital inequality persists around the world, even in countries with high-speed connectivity infrastructure.[105] When examining global trends, digital inequality is disproportionately impacting people who are: (1) low-income; (2) located in rural areas; (3) lacking literacy and digital skills; (4) over 50 years old; and (5) from disenfranchised groups such as women and girls, persons with disabilities, and ethnic minorities.[106] The COVID-19 pandemic has shone a bright light on these inequalities. The appearance and spread of COVID-19 accentuated connectivity and digitization gaps, causing a widening of

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[105]   *See* "State of Broadband" 2020 at 45.
[106]   *See* World Development Report 2021: Data for Better Lives at (the bottom 40 per cent of the national income
        distribution).

the digital divide across many dimensions.[107] Paradoxically, the rapid progress in technologies could actually lead to an increase in digital inequality over time.[108] Addressing digital inequality, therefore, should be at the top of any government's agenda.

Advocacy Target One of the Broadband Commission for Sustainable Development is for all countries to have a funded national broadband plan or strategy, or to include broadband in their universal access and service (UAS) definition by 2025. Numerous resources are available to governments developing national broadband strategies. The World Bank has a Broadband Strategies Toolkit that policy-makers, regulators, and other relevant stakeholders can use as a guide as they address issues related to broadband development.[109] In 2012, the ITU Telecommunication Development Bureau (BDT) developed best practices for national broadband plans, digital agendas, and digital strategies.[110] In 2013, the Broadband Commission published a report on national broadband plans.[111] In its latest annual report, the Commission places a particular focus on what governments can do to reduce digital inequality.[112] The Alliance for Affordable Internet in its latest Affordability Report details the linkage between high-quality national broadband plans and progress on affordability and describes key components of successful national broadband plans.[113]

Each of these resources and reports takes a slightly different approach, but they share many common themes. A well-formed broadband plan acts as the government's blueprint for addressing digital inequality. While there have been a variety of efforts to develop best practices for national broadband plans, each country should develop its own plan based on its unique needs. Successful national broadband strategies have certain attributes in common: they are the result of a transparent process involving input from a wide range of actors, they set clear targets, they implement both supply and demand-side interventions, they conduct regulatory reviews, and they implement policy changes based on those reviews.[114] This approach aligns with the GSR's Best Practice Guidelines of 2019.[115]

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[107] *See* The Impact of Digital Infrastructure on the Consequences of COVID-19 and on the Mitigation of Future Effects (available at https://publications.iadb.org/publications/english/document/The-Impact-of-Digital -Infrastructure-on-the-Consequences-of-COVID-19-and-on-the-Mitigation-of-Future-Effects.pdf)

[108] *See UNDP Human Development Report 2019* at 199-219 (discussing technology's potential for divergence and convergence and observing that we are seeing converging access to basic technologies but diverging access to enhanced technologies).

[109] *See* World Bank Group, Broadband Strategy Toolkit (available at https://ddtoolkits.worldbankgroup.org/ broadband-strategies).

[110] *See* International Telecommunication Union, "Trends in Telecommunication Reform 2012: Smart Regulation for a Broadband World", May 2012 (available at https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-TTR .13-2012-PDF-E.pdf).

[111] *See* Planning for Progress: Why National Broadband Plans Matter.

[112] *See* "State of Broadband" 2020 at 59-66.

[113] *See* Alliance for Affordable Internet (2020). The Affordability Report 2020. Web Foundation, at 18 (available at https://1e8q3q16vyc81g8l3h3md6q5f5e-wpengine.netdna-ssl.com/wp-content/uploads/2020/12/ Affordability-Report-2020.pdf)(A4AI Affordability Report 2020).

[114] *See* A4AI Affordability Report 2020; *see also* The World Bank Group, Broadband Strategy Toolkit (observing that "countries with high rates of broadband penetration have comprehensive broadband policies that coordinate both supply- and demand-side actions.") (available at https://ddtoolkits.worldbankgroup.org/ broadband-strategies/node/26#section-76).

[115] *See* Global Symposium for Regulators (GSR) 2019 Best Practice Guidelines.

Below we list and describe six key elements common to successful national broadband plans:

Good governance	- A country's national broadband plan should be developed through an open and transparent process. - A single entity in government should lead, but inter-governmental coordination is key to gaining needed support and for successful implementation of the plan. - Create a space for limited trials of new regulatory models and technologies – "sandboxes" – can be a good way for try out new approaches prior to permanently implementing the new regulatory approach countrywide. - Processes and methodologies to collect and present availability, usage and adoption data should be open and transparent.[116]
Clear goals	Develop a multi-year national broadband plan with clear, ambitious and achievable policy-related commitments and quantifiable supply-side, demand-side, and network resilience targets.
Regular assessment of availability and adoption	- Combine data from network operators and household surveys, along with third-party data on availability, adoption, and usage. - Fixed and mobile broadband data should be collected at least on an annual basis with more frequent reporting to track specific interventions.

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[116] The ITU-D ICT Statistics data collection process is a good example of an open and transparent process. The ITU-T also has a long history of creating open standards for telecommunications networks.

(continued)

Supply-side interventions	• Implement clear and enforceable competition policy.
	o Policies should maximize competition throughout the supply chain.
	o Policies should both promote competition and protect against abuse of market power.
	• Open up more spectrum for fixed and mobile connectivity.
	• Invest in infrastructure.
	o Core network infrastructure, such as backbone networks, Internet exchange points and submarine cables can be funded through private investment and through public-private partnerships.
	o In the absence of viable private-sector investment, governments should consider investing in core network infrastructure, with access sold on a non-discriminatory (wholesale open access) basis.
	o In instances of market failure (such as in high-cost rural areas), governments can subsidize deployment of fixed and mobile last-mile networks.
	– Separate programmes should be created for fixed and mobile services.
	– Fund recipients should be required to deploy broadband throughout the concession area.
	– Subsidies should be open to all qualified competitors and available on a technology-neutral basis.
	– Subsidies should be allocated through a competitive process, such as reverse auctions.
	– Fund recipients should be held accountable for meeting quantifiable targets and should be rewarded for beating buildout deadlines.
	o Mechanisms for funding universal service subsidies should minimize marketplace distortions and ensure that funds are not diverted to other government programmes.
	o Universal service funds should be independently administered.
	• Consider policies promoting community-based network operators, especially in rural areas.
	• Consider social-purpose spectrum licences to support community networks in locations where licensed spectrum is not being used.
	• Ensure that citizens from traditionally disenfranchised groups, such as persons with disabilities, the elderly, children, youth, ethnic minorities, and women and girls, have equitable access to fixed and mobile broadband, as well as other digital services.

(continued)

Demand stimulation activities	• Ensure that low-cost fixed and mobile broadband services and devices are available to low-income individuals and households. • Enable discounted services for anchor institutions (such as schools and libraries, healthcare centres, government offices, police and fire stations, and community centres) and marginalized groups (such as persons with disabilities, the elderly, children, youth, women and girls, and indigenous populations). • Implement both basic and advanced digital skills programming. • Support programmes developing locally relevant applications and content .
Monitoring and evaluation programmes	• Include a monitoring and evaluation programme from the outset. • Collect fixed and mobile broadband data at least once a year, with more frequent reporting to track specific interventions. • Hold an open and transparent assessment and review of progress at least every two years. • Be prepared to course-correct, and update the plan in response to changed conditions.

In addition, Member States should have national emergency telecommunication plans in place that include contingency plans for a full range of disasters from natural hazards or man-made causes. ITU's Digital Regulation Platform provides regulators with guidance on many of these points.[117]

As the Broadband Commission notes, the process of developing a national broadband plan will depend on a country's unique political and economic characteristics, as well as legal constraints. However, the steps below – adapted from prior reports from the Broadband Commission, Cisco and ITU[118] – can be used as a guide to consider the various elements of a national broadband plan:

1. *Determine the convening and implementing bodies:* Which governmental organization will convene stakeholders to develop and implement the plan? Which governmental organization(s) will be responsible for implementation?
2. *Determine the extent of consultation:* Will you take an informal approach (limited input from groups associated with convening agency), a consultative approach (one or more open public consultations on the draft plan), or an actively consultative approach (workshops, public consultations, and joint reviews of drafts)?
3. *Landscape assessment, benchmarking, and identification of hard constraints:* Include an assessment of fixed and mobile broadband availability and adoption, competitive landscape, etc.
4. *Goal setting:* Establish goals and targets for the national broadband plan (e.g. speed, coverage and adoption targets).

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[117] *See* International Telecommunication Union Digital Regulation Platform (available at https://digitalregulation .org/).
[118] *See* Planning for Progress: Why National Broadband Plans Matter at 59; Trends in Telecommunications Reform 2015 Getting Ready for the Digital Economy, 2015 (available at https://www.itu.int/dms_pub/itu-d/ opb/pref/D-PREF-TTR.16-2015-PDF-E.pdf).

5. *Identify data sources for monitoring and evaluation:* Locate public data sources and ensure that agreements are put in place to access other data sources required to monitor availability, adoption, and usage. Create a dashboard to monitor progress.
6. *Identify possible policy and marketplace interventions***:** What policy and marketplace interventions will ensure that goals can be met?
7. *Match and filter policy actions based on impact and feasibility***:** What policy actions are likely to have the greatest impact relative to effort?
8. *Plan launch and implementation:* Prepare the draft plan, conduct public consultation, publicly launch plan, and commence implementation.

Today, approximately 174 countries worldwide have a broadband plan of some sort, with several others currently in the process of adopting one.[119] In addition, some regional broadband plans have been developed, such as in the ASEAN region.[120] While some countries have developed new or updated national broadband plans, many countries have shifted that focus to other matters. These include upgrading their universal access and service (UAS) definitions or terms of service or developing broader digital transformation strategies and plans in which connectivity is one of the core components among other major issues. [121]

7.2   Practising good governance

Key recommendations

- National broadband plans should be developed through an open and transparent process.
- A single entity in government should lead, but inter-governmental coordination is key to gaining needed support and for successful implementation of the plan.
- Limited trials of new regulatory models and technologies – "sandboxes" – can be a good way to try out new approaches prior to countrywide authorization.
- Processes and methodologies to collect and present availability, usage and adoption data should be open and transparent.

A prerequisite for good policy-making includes a stable, transparent, and impartial (and ideally independent) regulator, not subject to undue influence by particular market actors.[122] A country's national broadband strategy should be developed through an open and transparent process that involves participation and input from all relevant stakeholders from governmental organizations, the private sector and civil society; takes into account other policies and broader

[119] *See* "State of Broadband" 2020 at 13.
[120] For example, the countries of the Association of Southeast Asian Nations (ASEAN) adopted an ASEAN ICT Masterplan in 2015 (AIM 2015) and subsequently updated that plan in 2020 to focus more on consumer choice, quality, and pricing. That plans seeks to move beyond focusing only on connectivity, to identifying and supporting communities that are isolated or underserved; and focusing on increasing the demand, usage, affordability, and connectivity of broadband services across ASEAN. *See* ASEAN ICT Master Plan 2020 (available at https://www.asean.org/storage/images/2015/November/ICT/15b%20-%20AIM%202020_Publication_Final.pdf); *See also* Final Review: ASEAN ICT Masterplan 2020 (available at https://asean.org/storage/V4.-Final-Draft-_-AIM2020_Review_FInal_Draft_19Nov2020.pdf).
[121] *See* "State of Broadband" 2020 at 14.
[122] *See* Broadband Commission Working Group on Financing and Investment, "Creating a Favourable Environment for Attracting Finance and Investment in Broadband Infrastructure", A Report by the Broadband Commission Working Group on Financing and Investment, at 19-21 (available at https://www.broadbandcommission.org/Documents/reports/WG-Fin-Invest-2014.pdf) (Broadband Commission Working Group on Financing and Investment Report).

digital strategies; and takes a collaborative approach to regulation.[123] Prior to publishing the strategy, the government should conduct a public consultation in which a draft strategy is made available for public comment. There might be multiple rounds of comments and separate consultations for different aspects of a draft national broadband plan. In addition, a variety of other mechanisms can be used to stimulate stakeholder input, including field hearings, workshops, and advisory committees comprised of government, the private sector, and civil society for specific issue areas (e.g. spectrum policy) or industry verticals (e.g. agriculture).

A single focal point in government – such as the telecommunications ministry or regulator – should take the lead to develop the country's national broadband plan and coordinate and monitor its implementation. Intra-governmental coordination is critical to gain needed buy-in from other parts of government that will be tasked with supporting and, in some cases, implementing aspects of the national broadband plan. For example, the broadband policy-maker might need to coordinate with the country's competition authority, consumer protection authority, financial regulator, ministry of education, ministry of health, ministry of agriculture, ministry of defence, energy regulator, and others.

Pilot projects (regulatory sandboxes) can play an important role in ongoing research and development efforts related to broadband deployment. Such projects can help to demonstrate the viability of a new technology, service, or approach. A good example of a regulatory sandbox is the Managed Spectrum Park license in New Zealand.[124]

7.3   Developing clear definitions and targets

> #### Key recommendations
>
> - Fixed and mobile broadband definitions and policies should be aggressive but achievable and based on the connectivity goals the government wants to achieve for all its citizens.
> - Affordability targets for fixed and mobile broadband could be set at 2 per cent of income for the lowest 20 per cent of income earners if they are in developed countries, or the lowest 40 per cent of income earners if they are in emerging markets and least developed countries.

As highlighted in section 2.1, to meaningfully connect to the Internet, consumers require at-home fixed connections supporting a full range of applications requiring high throughput (e.g. multiple HD video streams) and low latency (e.g. HD videoconferencing and gaming applications). In addition, consumers demand mobile connectivity where and when they need it. Fixed and mobile broadband definitions and policies should be aggressive but achievable and based on the connectivity goals the government wants to achieve for all of its citizens.

Moreover, governments could adopt targets for affordability that are more nuanced than those currently in use. As discussed in section 2.3, to ensure that fixed and mobile broadband are affordable for the lowest income earners in a country, a government could set affordability

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[123] *See* World Bank Group, Broadband Strategies Toolkit (available https://ddtoolkits.worldbankgroup.org/ broadband-strategies/node/26).

[124] *See* New Zealand Managed Spectrum Park Licenses (available at https://www.rsm.govt.nz/licensing/licences -you-must-pay-for/managed-spectrum-park-licences/).

targets at 2 per cent of income for the lowest 20 per cent of income earners, if they are in developed countries, or the lowest 40 per cent of income earners, if they are in emerging markets and least developed countries. A study on ICT price trends in 2020, specifically focusing on affordability for the bottom 40 per cent of incomes, has been carried out by ITU.[125] The study showed that many countries have affordable access when measured according to GNI per capita, and yet the bottom 40 per cent of income earners in those countries do not have affordable access.

7.4   A multistakeholder approach to assessing availability and adoption

Key recommendation

- Fixed and mobile broadband data should be collected at least on an annual basis with more frequent reporting to track specific interventions.
- ITU is well positioned to convene a multistakeholder programme bringing together organizations with insights into broadband or narrowband availability, adoption, and usage.

We suggest annual reporting as a minimum requirement, or biannual reporting in developed countries. When specific interventions are put in place, such as connecting a certain percentage of schools by a target date, quarterly reporting may be required. In addition, data on availability, adoption and usage should be open and methodologies used to generate these data should be open to scrutiny and challenge. Ideally, these data should be made available on a country-level dashboard and map. These data can also help keep the global ITU broadband map up to date. Useful data sources that can be taken as a starting point have been highlighted in section 2 of this report.

As highlighted in section 2 on data collection, less than 50 per cent of Member States provide ITU with their data on usage and adoption. Likewise, many of the third-party data sources with publicly available data also have poor coverage in these countries. However, Internet service providers such as Google and Facebook and network operators collect data which can help provide highly valuable insights into Internet usage trends in a country. We believe ITU is well positioned to convene a multistakeholder programme bringing together organizations that can provide insights into broadband or narrowband availability, adoption, and usage. These data can be combined in such a way that privacy is protected while giving sufficient resolution to help countries understand the current country-wide and regional status of access.

7.5   Supply-side interventions to increase availability

While recent reports point to global mobile network coverage as evidence that there should be less focus on supply-side interventions and more focus on the demand side,[126] consumers will increasingly demand both fixed and mobile broadband connectivity. They will demand broadband connectivity that is meaningful, i.e. an affordable, high-speed, low-latency connection with no data caps. One of the key challenges to achieving universal broadband coverage or availability is that the average cost of deploying broadband networks rises as population density

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[125]   *See* ITU Measuring digital development ICT Price Trends 2020.
[126]   *See* World Development Report 2021: Data for Better Lives at 163.

declines. This undermines the commercial viability of deploying networks in small markets and rural areas. As we explain in more detail below, governments can take steps to improve the commercial viability of deployments in small markets and rural areas; for example, adopting policies that promote and protect competition in the sector, increasing the supply of spectrum used to deploy fixed and mobile wireless networks, investing in and promoting the use of shared infrastructure, promoting new technologies and business models, and subsidizing the deployment of last-mile fixed and mobile infrastructure in instances of market failure.

7.5.1   Clear and enforceable competition policies

Key recommendations

- Policies should maximize competition throughout the supply chain.
- Policies should both promote competition and protect against abuse of market power.

A key element of any successful broadband plan is promoting competition. Markets with high rates of fixed and mobile broadband availability and adoption also tend to be markets with high rates of competition throughout the supply chain and within and between technology platforms – in the first mile, middle mile, last mile and even with respect to the invisible mile. As observed by the World Bank, "liberalization and promotion of competition among facilities are the best ways to guarantee lower costs."[127] A wide range of laws and regulations can promote effective competition, including: (1) market liberalization; (2) universal licensing; (3) non-discriminatory wholesale access to competing operators' networks (including unbundling and interconnection) and services (e.g. backhaul); (4) accounting and structural separation for vertically integrated network operators; (5) promotion of infrastructure sharing (e.g. at towers, data centres, etc.); (6) non-discriminatory and low-cost access to rights-of-way (for example, roads, railways, pipelines, or electricity transmission lines); and (7) dig-once policies, ensuring that construction projects include the installation of fibre. As discussed below, regulators can also use spectrum policy to promote competition and design universal service programmes to avoid marketplace distortions and harness the power of competition.

Effective competition also needs effective protection, particularly in nascent markets at the early stages of opening.[128] Competition rules that offer protection from anticompetitive behaviour by a dominant incumbent or a collusive group need to be in place and enforced before an investor decides to enter a market. Effective competition requires two main elements: a) clear rules, and b) effective enforcement by the appropriate authorities. The anti-competitive practices likely to be proscribed, either by general competition, if it exists, or by telecommunication legislation, usually include, among others: predatory pricing, undue price discrimination, excessive pricing, margin squeeze, refusal to supply, and other strategies to foreclose the market.[129]

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[127]   *See* World Bank Group, Broadband Strategies Toolkit (https://ddtoolkits.worldbankgroup.org/broadband -strategies/node/26#section-77).
[128]   *See Broadband Commission Working Group on Financing and Investment Report* at 21-22.
[129]   *See Broadband Commission Working Group on Financing and Investment Report* at 21-22.

7.5.2   Opening up spectrum

Key recommendation

- Open up more spectrum for fixed and mobile connectivity.

As discussed previously, most of the world's population is accessing the Internet on a mobile or fixed wireless connection. For this reason, spectrum policy or the way in which regulators manage their national radio frequencies is critically important for achieving universal connectivity goals. Smart spectrum policy can literally change the cost economics of deploying wireless networks[130], expanding access to underserved and previously unserved communities, increasing competition, and reducing costs for consumers.[131] To support network operator deployments, regulators make spectrum available across a range of low-band, mid-band, and high-band frequencies to support fixed and mobile terrestrial and satellite-based communications. This diversity is key to addressing connectivity gaps and improving affordability. It is noteworthy that many regulators' efforts to open up more spectrum have accelerated during the COVID-19 pandemic, reflecting both the urgency of this moment and the importance of spectrum access to achieving digitalization goals.

Spectrum is being made available on an exclusive use basis for mobile operator 5G networks. To maximize 5G use cases and deliver both capacity and coverage to users, spectrum above 24 GHz and below 6 GHz is being allocated and licensed for International Mobile Telecommunications (IMT).[132] As noted in a recent Inter-American Development Bank report, the millimetre-wave bands above 24 GHz, with ample unallocated, unassigned, or otherwise unused contiguous spectrum, are ideal for the deployment of 5G technologies capable of delivering up to 20 Gbit/s connections. These bands are ideal for "securing transmission capacity in hotspot areas where users are concentrated, such as urban centres, stadiums, stations, and airports, but it is not appropriate for nation-wide 5G networks."[133] 3GPP, the 5G standardization body, has also recommended that spectrum below 6 GHz be made available for 5G networks, to support use cases requiring wide-area coverage.[134] Spectrum below 2 GHz and between 6 GHz and 24 GHz

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[130] By opening up more large swaths of spectrum across complementary low, mid, and high band spectrum, a regulator will enable a wireless network operator to optimize the placement of towers and other network infrastructure and thereby enable the network operator to serve more customers in more places at lower costs.

[131] See, e.g. Edward J. Oughton, Niccolo Comini, Vivien Foster & Jim Hall, "Policy Choices Can Help Keep 4G and 5G Universal Broadband Affordable, World Development Report 2021", Background Paper (available at http://documents1.worldbank.org/curated/en/658521614715617195/pdf/Policy-Choices-Can-Help-Keep-4G-and-5G-Universal-Broadband-Affordable.pdf).

[132] 5G Americas provides recommendations on a variety of spectrum bands that it believes could be made available for IMT licensing. See 5G Americas Whitepaper, "5G Spectrum Vision," November 2019 (available at https://www.5gamericas.org/wp-content/uploads/2019/07/5G_Americas_5G_Spectrum_Vision_Whitepaper-1.pdf).

[133] See Antonio García Zaballos, Enrique Iglesias Rodríguez, Kyoung Woo Kim, Soontae Park, "5G: the driver for the next-generation digital society in Latin America and the Caribbean", Inter-American Development Bank 2020, at 5 (available at https://publications.iadb.org/publications/english/document/5G_The_Driver_for_the_Next-Generation_Digital_Society_in_Latin_America_and_the_Caribbean.pdf) (5G: the driver for the next-generation digital society in Latin America and the Caribbean).

[134] See 5G: the driver for the next-generation digital society in Latin America and the Caribbean at 5.

is less attractive for 5G because these bands are heavily utilized by other licensed users.[135] The United States is an example of a country that has successfully made spectrum bands that are above 24 GHz or below 6 GHz available for 5G licensing.[136] Likewise, Asian countries including China, Japan, and the Republic of Korea are allocating both bands to 5G IMT.[137]

At the same time, more spectrum is also being made available on a non-exclusive unlicensed or licence-exempt basis for Wi-Fi, Bluetooth, and a variety of other technologies used for providing fixed wireless access (FWA), as well as for radio local area networks (RLANs). Today, approximately 60 per cent of the world's IP traffic originates over a Wi-Fi connection.[138] Moreover, Cisco predicts that approximately 60 per cent of 4G traffic and 70 per cent of 5G traffic will be offloaded to Wi-Fi connections.[139] Wi-Fi 6, based on the IEEE 802.11ax industry standard, can deliver a maximum data rate of up to 9.6 Gbit/s and allows new and existing Wi-Fi networks increased speed and capacity supporting multiple devices utilizing next-generation applications requiring high throughput and low latency. Wi-Fi 6 is well-suited to supporting HD video streaming, Wi-Fi calling, smart home devices, hotspot access, automation of city-wide services, augmented reality (AR) and virtual reality (VR) applications, health monitoring devices, wearables, and seamless roaming, as well as off-loading potential for 4G and 5G mobile networks.[140] The economic benefits of opening up these bands are well documented.[141] In the United States, the FCC recently adopted a decision to open up 1 200 MHz of spectrum (5925-7125 MHz) in the 6 GHz band to enable use of wider channels and meet growing demand for unlicensed spectrum.[142] Several other regulators – across all regions – have commenced consultations on opening up some or all of the 5925-7125 MHz band for unlicensed access.[143]

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[135] Spectrum below 2 GHz is being used by mobile operator 4G networks, as well as a variety of other uses, thereby constraining the amount of contiguous spectrum that could be made available for 5G. Spectrum between 6 GHz and 24 GHz are being used for other purposes, such as satellite and point-to-point microwave connections.

[136] *See* Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, GN Docket No. 12-268, Report and Order, 29 FCC Rcd 6567 (release June 2, 2014) (available at https://docs.fcc.gov/public/attachments/FCC-14-50A1.pdf) (600 MHz band); *See* Federal Communications Commission Press Release, "FCC Concludes First High-Band 5G Airwaves Auctions," released May 28, 2019 (available at https://docs.fcc.gov/public/attachments/DOC-357702A1.pdf) (24 and 28 GHz bands); *see also* Federal Communications Commission Press Release, "FCC Concludes Largest Ever Spectrum Auction, Advancing American Leadership in 5G," released March 12, 2020 (available at https://docs.fcc.gov/public/attachments/DOC-363000A1.pdf) (upper 37 GHz, 39 GHz, and 47 GHz bands); *See* Federal Communications Commission Press Release, "FCC Acts to Free Up C-Band Spectrum for 5G Services," released February 28, 2020 (available at https://docs.fcc.gov/public/attachments/DOC-362743A1.pdf) (3.7-4.2 GHz bands); In the Matter of Promoting Investment in the 3550-3700 MHz Band, FCC 18-149, Report and Order 33 FCC Rcd 10598, released October 24, 2018 (available at https://docs.fcc.gov/public/attachments/FCC-18-149A1.pdf) (the 3.5 GHz Citizens Broadband Radio Service (CBRS) band).

[137] *See* 5G: the driver for the next-generation digital society in Latin America and the Caribbean at 5.

[138] *See* Dynamic Spectrum Alliance, "How to Realize the Full Potential of 6 GHz Spectrum: A White Paper," published October 2020, at 5 (referencing the Cisco VNI Global IP Traffic Forecast, 2017–2022)(available at http://dynamicspectrumalliance.org/wp-content/uploads/2020/11/DSA-How-to-realise-the-full-potential-of-6-GHz-Spectrum-Whitepaper.pdf).

[139] *See* How to Realize the Full Potential of 6 GHz Spectrum: A White Paper at 5.

[140] *See* How to Realize the Full Potential of 6 GHz Spectrum: A White Paper at 7.

[141] *See* 6 GHz unlicensed access to add USD 163.5 billion to Brazil economy, reveals Dynamic Spectrum Alliance, released 25 November 2020 (available at http://dynamicspectrumalliance.org/wp-content/uploads/2020/11/2020-11-PR08_DSA_6GHZ-Brazil-report_FINAL.pdf).

[142] *See* Federal Communications Commission Press Release, "FCC Adopts New Rules for the 6 GHz Band, Unleashing 1,200 Megahertz of Spectrum for Unlicensed Use," released April 23, 2020 (available at https://docs.fcc.gov/public/attachments/DOC-363945A1.pdf). The United States FCC has also opened up several other bands for unlicensed or license-exempt access, including a total of 21.2 GHz of spectrum above 95 GHz (so-called Spectrum Frontiers). *See* In the Matter of Spectrum Horizons, ET Docket No. 18-21, First Report and Order, FCC 19-19, released March 21, 2019 (available at https://docs.fcc.gov/public/attachments/FCC-19-19A1.pdf).

[143] *See* How to Realize the Full Potential of 6 GHz Spectrum at 12-13.

While more licensed and unlicensed spectrum is being allocated to support next-generation wireless applications, it is becoming increasingly difficult for regulators to move incumbent users from their existing assignments and clear that spectrum for new uses and users. Fortunately, the emergence of various types of spectrum sharing technologies enable regulators to allow wireless network operators access to new spectrum bands without displacing incumbent government users and commercial licensees. These spectrum sharing regimes are made possible by the emergence of spectrum sensing capabilities and cloud-based spectrum sharing databases that can dynamically assign unused frequencies while protecting incumbent users from harmful interference. As discussed above, the FCC has leveraged these dynamic spectrum sharing systems to allow secondary access to TV white spaces, 3.5-3.65 GHz CBRS, and 6 GHz spectrum.[144] In Peru, the Ministry of Transport and Communications has proposed allowing tiered access to some or all of the 3.3-3.8 GHz spectrum.[145] About a dozen other countries already allow access to the TV white spaces, and several other regulators, including ANATEL in Brazil, the Communications Authority of Kenya, and the Nigerian Communications Commission and National Broadcasting Commission have conducted consultations to open up the TV white spaces in their countries.[146] Another interesting development is the introduction by Ofcom, the United Kingdom's regulator, of new Local Access and Shared Access licences.[147] Local conditions will dictate which spectrum bands can be shared in a particular country. Interference management, cross-border coordination, and other critical issues must be considered.

Regulators are also licensing more spectrum for geostationary orbit and non-geostationary orbit satellite communications, as well as experimental high-altitude platform stations (HAPS) and HAPS IMT base stations (HIBS). These technologies promise connectivity with higher throughput and lower latency than is available from traditional geostationary satellite constellations. They are suitable for use in remote locations where terrestrial connectivity cannot be cost-effectively deployed, providing direct connectivity to consumers and IoT devices as well as backhaul connectivity to last-mile fixed and mobile wireless networks. The FCC has made a series of decisions paving the way for high-speed broadband to be provided by numerous non-geostationary orbit satellite constellations, including OneWeb, SpaceX, Kuiper, Telesat,

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[144] The terminology and complexity of allowing dynamic spectrum access varies by spectrum band. To protect incumbent users and others with licensed spectrum rights, the TV white spaces utilize a TV White Space Database, the CBRS band utilizes a Spectrum Access System (SAS), and the 6 GHz band utilizes an Automatic Frequency Coordinator (AFC) (for outdoor transmissions). The Dynamic Spectrum Alliance has published an interesting paper on Automated Frequency Coordination (available at http://dynamicspectrumalliance.org/wp-content/uploads/2019/03/DSA_DB-Report_Final_03122019.pdf).

[145] *See* Ministerial Resolution No. 0796-2020-MTC/01.03, 3 November 2020 (available at https://www.gob.pe/institucion/mtc/normas-legales/1322679-0796-2020-mtc-01-03).

[146] *See* Agencia Nacional de Telecomunicacoes (ANATEL), "ANATEL approves consultation on idle spectrum (white spaces)," 28 May 2020 (available at https://antigo.anatel.gov.br/institucional/component/content/article?id=2594); Communications Authority of Kenya, Authorisation of the Use of TV White Spaces as part of a Dynamic Spectrum Access Framework, February 2020 (available at https://ca.go.ke/wp-content/uploads/2020/03/Authorisation-of-the-use-of-TV-White-Spaces.pdf); Public Notice: Draft Guidelines on the Use of Television White Space (TVWS) in Nigeria, December 2019 (available at https://ncc.gov.ng/media-centre/public-notices/760-public-notice-draft-guidelines-on-the-use-of-television-white-space-tvws-in-nigeria#:~:text=The%20Nigerian%20Communications%20Commission%20%28NCC%29%2C%20in%20conjunction%20with,present%20the%20draft%20Guidelines%20to%20all%20Industry%20Stakeholders).

[147] *See* Ofcom, Local Access Licence: Guidance document, (available at https://www.ofcom.org.uk/__data/assets/pdf_file/0037/157888/local-access-licence-guidance.pdf); Shared Access License, Guidance document (available at https://www.ofcom.org.uk/__data/assets/pdf_file/0035/157886/shared-access-licence-guidance.pdf).

and others.[148] HAPS providers, e.g. HAPSMobile, have conducted their first test flights.[149] These providers' connectivity solutions are at various stages of development, but each of the companies is committed to deploying global offerings, with a focus on helping to close the global broadband gap.

Data on spectrum use can be published and open and kept up to date. A good example of a dashboard that makes it possible to check the current users of any spectrum band is New Zealand's Register of Radio Frequencies.[150] This allows a new user who requires spectrum to check what frequencies could be made available for new uses.

7.5.3   Investment in infrastructure

Key recommendations

- Core network infrastructure, such as backbone networks, Internet exchange points, and submarine cables, can be funded through private investment and through public-private partnerships.
- In the absence of viable private sector investment, governments should consider investing in core network infrastructure, with access sold on a non-discriminatory (wholesale open access) basis.
- In instances of market failure (such as in high-cost rural areas), governments can subsidize deployment of fixed and mobile last mile networks:

  o Separate programmes should be created for fixed and mobile services

  o Fund recipients should be required to deploy broadband throughout the concession area

  o Subsidies should be open to all qualified competitors and available on a technology-neutral basis

  o Subsidies should be determined through a competitive process, such as reverse auctions

  o Fund recipients should be held accountable for meeting quantifiable targets and should be rewarded for beating buildout deadlines.

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[148] *See,* e.g. In the Matter of WorldVu Satellites Limited Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb NGSO FSS System, Declaratory Ruling and Order, 32 FCC Rcd 5366, June 23, 2017 (available at https://docs.fcc.gov/public/attachments/FCC-17-77A1.pdf); Space Exploration Holdings, LLC, Application for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System, IBFS File No. SAT-LOA-20161115-00118, Memorandum Opinion, Order, and Authorization, 33 FCC Rcd 3391, March 29, 2018 (available at https://docs.fcc.gov/public/attachments/FCC-18-38A1.pdf); Kuiper Systems, LLC Application for Authority to Deploy and Operate a Ka-band Non-Geostationary Satellite Orbit System, IBFS File No. SAT-LOA-20190704-00057, Order and Authorization, 35 FCC Rcd 8324, July 30, 2020 (available at https://docs.fcc.gov/public/attachments/FCC-20-102A1_Rcd.pdf); *see also* Federal Communications Commission Press Release, FCC Boosts Satellite Broadband Connectivity and Competition in the United States, issued November 15, 2018 (available at https://docs.fcc.gov/public/attachments/DOC -355102A1.pdf).

[149] *See* HAPSMobile Inc., "HAPSMobile Successfully Completes Latest Test Flight of its Unmanned Aircraft Designed for Stratospheric Telecommunications Platform Systems", released 30 July 2020 (available at https://www.hapsmobile.com/en/news/press/2020/20200730_01/).

[150] *See* New Zealand Radio Spectrum Management portal (available at https://rrf.rsm.govt.nz/smart-web/smart/ page/-smart/domain/client/SearchClient.wdk?fromHome=Yes).

- Mechanisms for funding universal service subsidies should minimize marketplace distortions and ensure that funds are not diverted to other government programmes.
- Universal service funds should be independently administered.

Making fixed and mobile broadband available to all of the world's population is, "above all, an infrastructure investment challenge."[151] A recent ITU report estimates that USD 428 billion additional investment is required over 10 years to extend 4G-equivalent mobile connectivity to 90 per cent of the world's population aged 10 years and above.[152] This estimate includes the cost of metro and backbone infrastructure, network operation and maintenance, mobile infrastructure CAPEX, satellite coverage in rural areas not feasibly served by 4G, policy and regulation, and ICT skills and content. Another report, from the Tony Blair Institute for Global Change, estimates that if the cost of devices is included in the figure, USD 446 billion would be needed.[153] This would produce a return of approximately USD 8.7 trillion in direct economic benefit to the developing world.[154] The ITU estimate does not include the cost of extending fixed broadband directly to homes and businesses. According to ITU, there are approximately 15.2 fixed broadband subscriptions per 100 people around the world, and 11.5 per 100 people in developing markets.[155] Significant investment will be required to make fixed broadband universally available, and one can expect a significant return from investing in universal fixed broadband. ITU provides an ICT Infrastructure Business Planning Toolkit that can be useful in assessing the long-term sustainability of network expansion.[156]

Another ITU report shows that both fixed and mobile broadband return significant economic benefit, but at different stages of economic and sectoral development. Mobile broadband delivers its greatest benefits in the early stages of sectoral development, while fixed broadband does so at advanced stages. According to this report, the economic impact of mobile broadband tends to decline with penetration, whereas the economic impact of fixed broadband increases.[157] For example, a 10 per cent increase in fixed broadband penetration would deliver 2.94 per cent increase in GDP in Europe's high-income countries, but a negligible benefit in Africa.[158] Conversely, a 10 per cent increase in mobile broadband penetration would deliver 2.46 per

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[151] *See* International Telecommunication Union, Telecommunication Development Bureau, "Connecting humanity: Assessing investment needs of connecting humanity to the Internet by 2030", at 4, August 2020 (available at https://www.itu.int/myitu/-/media/Publications/2020-Publications/Connecting-Humanity.pdf).

[152] *See* Connecting humanity: Assessing investment needs of connecting humanity to the Internet by 2030 at 5.

[153] *See* Tony Blair Institute for Global Change, "The Progressive Case for Universal Internet Access: How to Close the Digital Divide by 2030", March 2, 2021, at 22 (available at https://institute.global/sites/default/files/articles/The-Progressive-Case-for-Universal-Internet-Access-How-to-Close-the-Digital-Divide-by-2030.pdf).

[154] *See* The Progressive Case for Universal Internet Access: How to Close the Digital Divide by 2030 at 25-26.

[155] *See* International Telecommunication Union, Telecommunication Development Bureau Statistics (available at https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx).

[156] *See* ITU publishes new ICT Infrastructure Planning Toolkit, November 21, 2019 (available at https://news.itu.int/itu-publishes-new-ict-infrastructure-business-planning-toolkit/).

[157] *See* International Telecommunication Union, "How broadband, digitization and ICT regulation impact the global economy, Global econometric modelling", November 2020 (available at https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-EF.BDR-2020-PDF-E.pdf).

[158] *See* How broadband, digitization and ICT regulation impact the global economy, Global econometric modelling at 7.

cent increase in GDP in Africa, but a negligible benefit in Europe's high-income countries.[159] In a region like Latin America the economic benefits of increasing fixed and mobile broadband penetration are roughly equal.[160]

While most countries now have first-mile infrastructure in place, there are instances in which middle-mile infrastructure, such as national backbone and intercity links, as well as IXPs, has not been deployed on a nationwide basis (i.e. it only interconnects larger population centres). For example, the World Bank estimates that 250 000 kilometres of fibre-optic backbone is still needed in Africa.[161]

Network operators and service providers play a critical role as key investors in broadband networks, through continued and increased levels of commitment to expand network coverage beyond urban population centres – essentially funding from existing operations, through cost reductions, and by raising capital from commercial banks and private investors. ITU has published an infrastructure business planning toolkit, which provides helpful guidance to network operators looking to invest in ICT infrastructure.[162] It is worth noting that high-quality data on broadband availability, adoption, and usage can help investors make well-informed decisions about where to deploy fixed and mobile networks and maximize return on investment.

The World Bank has observed that achieving commercially sustainable investment in underserved communities will require innovations that lower the CAPEX and OPEX of towers and infrastructure overall, while enhancing demands for fixed and mobile broadband services, and corresponding market growth.[163] Policy and regulation plays an important role in helping equipment vendors and network operators reduce the cost of CAPEX and OPEX. For example, spectrum policies allowing access to plentiful low, mid, and high-band spectrum give equipment manufacturers the certainty they need to develop more efficient next-generation products and can help network operators to optimize placement of infrastructure so as to maximize coverage and capacity. Likewise, regulations easing tower siting, access to rights-of-way and placement of conduit can also help reduce costs.

Even with greater efficiencies and policy incentives, some areas will not have scope for profitable deployment of networks and services, and therefore the market alone will not support investment needed for universal broadband. In such cases, governments can take an increasing role as "investors" in broadband infrastructure, in order to ensure that they can achieve their national development agendas. Governments have adopted various approaches to funding these plans: dedicated funds, universal service funds, direct government subsidies and grants, government equity and loans, public-private partnerships, and investment tax zones.[164]

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[159] *See* How broadband, digitization and ICT regulation impact the global economy, Global econometric modelling at 11.

[160] *See* How broadband, digitization and ICT regulation impact the global economy, Global econometric modelling at 7, 11.

[161] *See* World Development Report 2021: Data for Better Lives at 162.

[162] *See* ITU Infrastructure Business Planning Toolkit, 2019 (available at https://news.itu.int/itu-publishes-new-ict-infrastructure-business-planning-toolkit/).

[163] *See Digital Moonshot for Africa Report* at 110.

[164] According to the Broadband Commission Working Group on Financing and Investment, Sovereign Wealth Funds (SWFs) are another possible source of financing for telecommunication infrastructure projects. SWFs are investment funds owned by the governments of sovereign states and funded mainly by foreign exchange and reserve assets. *See* Broadband Commission Working Group on Financing and Investment Report at 16.

Malaysia is an example of a country that has successfully directed public investment towards the deployment of first mile and middle mile infrastructure.[165] Indeed, there are numerous examples of governments investing in national optical fibre networks and other shared infrastructure. Governments award a contract to one or more private sector entities, selected through a transparent and competitive process. The middle mile network operator is required to provide access to its network on a non-discriminatory basis.

Universal service funds act as a last resort when other efforts fail to incentivize network operators to extend affordable fixed and mobile broadband services to unserved and underserved communities – places where profitable services cannot be made available or affordable. A wide range of universal service funds have been created, focused on extending services to high-cost rural areas, reducing the cost of services for low-income consumers and other disenfranchised groups such as ethnic minorities and persons with disabilities, and ensuring that schools, health care providers, and other community anchor institutions have high-speed connectivity.

In recent years, we have seen a great deal of innovation in universal service funds. For example, in the United States the Federal Communications Commission has implemented a system of reverse auctions for determining support amounts for serving unserved rural and other high-cost areas. These auctions are conducted on a competitive and technology-neutral basis, and bidders are given preferences based on speed, latency, and usage allowances.[166] Auction winners are required to serve all customers within a defined geographic area and must build out their networks in a specified period of time.[167] Other regulators, in New Zealand for example, require subsidy recipients to prioritize higher bandwidth (e.g. at least 1 Gbit/s fibre) connections to anchor institutions, such as schools and libraries, healthcare clinics, government offices, police and fire stations, and other community institutions.[168]

One note of caution is that many governments' universal service funds have proven unsuccessful.[169] To increase their likelihood of success, universal service funds need to include appropriate guard rails. Funds collected for universal service programmes should not be diverted to unrelated programmes. Separate programmes should be created for fixed and mobile services. Fund recipients should be required to deploy broadband throughout the concession area. Subsidies should be open to all qualified competitors and available on a technology-neutral basis. Subsidies should be determined through a competitive process, such as the FCC's reverse auctions mechanism (discussed above). Fund recipients should be held accountable for meeting quantifiable targets and should be rewarded for beating buildout deadlines. Mechanisms for funding universal service subsidies should minimize marketplace distortions and ensure that funds are not diverted to other government programmes. Finally, universal service funds should be administered independently, with appropriate fiscal oversight.

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[165] *See* National Broadband Initiatives in Malaysia at slide 3 (available at https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/3_2%20-%20Briefing%20to%20ITU_ACMA%20on%20NBImra.pdf).
[166] *See* Federal Communications Commission, Auction 904: Rural Digital Opportunity Fund Fact Sheet (available at https://www.fcc.gov/auction/904/factsheet). The auction used a multi-round, descending clock auction format in which bidders indicated in each round whether they would commit to provide service to an area at a given performance tier and latency at the current round's support amount.
[167] *See* Federal Communications Commission, Auction 904: Rural Digital Opportunity Fund Fact Sheet (available at https://www.fcc.gov/auction/904/factsheet).
[168] *See* Ultra-Fast Broadband (available at https://en.wikipedia.org/wiki/Ultra-Fast_Broadband)
[169] *See* World Development Report 2021: Data for Better Lives at 163.

ITU's Digital Regulation Platform provides additional guidance on the development of universal service funds.[170]

7.5.4 Explore community-based network operators

<u>Key recommendations</u>

- Consider policies promoting community-based network operators, especially in rural areas.
- Consider social-purpose spectrum licences to support community networks in locations where licensed spectrum is not being used.

While still modest in terms of size and geographical scope, a growing number of community networks and social-purpose operators are showing promise for connecting communities where traditional operators cannot cost-effectively provide coverage or affordable access. Community networks operate on the following core principles:

- *Collective ownership:* network infrastructure are managed as a common resource
- *Social management*: network infrastructure is operated by community members
- *Open design:* the network implementation and management details are public
- *Open participation:* anyone can extend the network if they follow the network principles
- *Locally relevant content:* development and promotion of local content is done in local languages.

Community networks[171] can be operationalized, wholly or partly, through individuals and local stakeholders, NGOs, private sector entities, and/or public administrations. They are mostly structured as a cooperative where any surplus is reinvested in the network or pays dividends to cooperative members. Some markets, in the United States for example, have a deep history of community networks going back to the early days of electrification and telephony. In the United States, these network operators – still numbering close to 1 000 – grew up in rural agricultural communities and adopted a cooperative business model leveraging existing farmers' cooperatives. The United States National Telecommunications Cooperative Association still has 850 independent, community-based telecommunication company members leading innovation in rural and small-town America.[172]

Despite this, one of the main barriers to the adoption of an enabling regulatory framework for community networks or social-purpose operators is that few people know they exist. This applies not only to the rural communities that are most likely to benefit, but also to policy-makers, regulators, and development organizations. Lack of awareness is compounded by the view that access markets can be sufficiently well-served only by a handful of large-scale national fixed and mobile network operators competing to provide services of sufficient coverage and quality, and at an affordable price. The experience of the United States has shown the opposite

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[170] *See* International Telecommunication Union Digital Regulation Platform, Universal access to digital technologies and services (available at https://digitalregulation.org/universal-access-to-digital-technologies-and-services-2/).

[171] *See* the Global Information Society Watch 2018 publication on "Community Networks" (available at: https://www.giswatch.org/community-networks).

[172] *See* National Telecommunications Cooperative Association, "Who We Are" (https://www.ntca.org/ruraliscool/who-we-are).

to be the case – some of these rural markets can only be served by non-profit community-based network operators.

There is a growing body of evidence (see for example the GISWatch report[173] on community networks, which includes 43 individual country reports) that documents how expanding the telecommunications operator ecosystem to include community networks and embedding them in national broadband plans could help provide affordable access to more vulnerable communities. Two successful recent case studies of community networks – one providing fixed connectivity and the other providing mobile connectivity – are highlighted below.

Guifi.net - which received the European Broadband Award for the best innovative model of financing, business and investment in 2015 - is in Spain and supports thousands of individual participants and 26 local for-profit and non-profit telecom operators sharing a common infrastructure, with a fibre/wireless backbone and multihoming Internet connections, providing Wi-Fi and fibre-to-the-home (FTTH) fixed broadband connectivity. The nodes of the network are contributed by individuals, companies, and administrations that freely connect to an open network of telecommunications and extend the network wherever the infrastructure and content might not otherwise be accessible. Guifi.net allows for a wide set of different business models to exist around an infrastructure commons, and this flexibility has been the secret of its success. As of February 2021, Guifi.net had 36 959 active nodes and about 70 172 km of wireless links.

Community Cellular Networks in Oaxaca, Mexico, nominated for a WSIS award in 2019, is another example of a community-based mobile network. In 2013 the joint efforts of Rhizomatica, REDES A.C. and a community radio network in a small village called Talea de Castro, in the State of Oaxaca, made it possible to create an indigenous mobile telecommunications network completely operated, owned, and managed by the community itself. The cellular network belongs entirely to the community, which decides who is responsible for the managing the network, how it will operate, and even how much service costs. Currently, the service is licensed through a cooperative called *Telecomunicaciones Indígenas Comunitarias* A.C. (TIC A.C.), comprised of 14 operating communities, which cover 63 localities. TIC A.C. also has an operational team that accompanies individuals and communities seeking to build, manage, and operate their own communication networks.

As of July 2020, Community Cellular Networks has provided daily service to more than 3 500 people despite some of the harshest conditions for building communications networks in Mexico. In 2021, Community Cellular Networks, which has been allocated 10 MHz in the 850 MHz band, won a court case that exempts it from paying spectrum fees. In addition, the government regulations provide low-cost satellite capacity to local operators like those that are part of TIC AC. Rhizomatica now functions as a local and international organization to support communities that want to build and maintain self-governed and owned telecommunication infrastructure; they are involved in policy and regulatory advocacy, open-source technology development for GSM networks and capacity building.

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[173] *See* GISWatch 2018 publication on Community Networks at 3.

7.5.5 Digital inclusion

Key recommendation

- Ensure that citizens from traditionally disenfranchised groups, such as persons with disabilities, the elderly, children, youth, ethnic minorities, and women and girls, have equitable access to fixed and mobile broadband, as well as other digital technologies.

As discussed above, the COVID-19 pandemic has strengthened the vital role that broadband connectivity plays and the urgency for universal connectivity. To achieve this connectivity means ensuring that all citizens, including those from traditionally disenfranchised groups, such as persons with disabilities, the elderly, children, youth, ethnic minorities and women and girls, have equitable access to broadband and to other digital technologies.

Over the last few decades, an increasing number of national governments have enacted laws and regulations improving access to technology. Laws, policies, and regulations in many countries now ensure that devices, products and services are usable by everyone on an equal basis, regardless of their gender, age, ability, or location. In addition, standards have been developed and harmonized to secure accessible, scalable, and affordable ICTs. Moreover, technology companies have implemented features in their products that increase access to their products. Many of these features, such as closed captioning, speech to text, and text to speech, were originally niche products and features designed to increase access for specific groups (in some cases, created to comply with legal and regulatory obligations). They have since found wider adoption among the general population and have proven to be competitive differentiators for technology companies. Microsoft's development of the adaptive controller for Xbox is another such example.[174] As Microsoft points out, "when everybody plays, we all win." Innovation and creativity are key in the ICT sector to ensure that digital information, products, and services are universally designed and usable by most of the world's population. Such products are accessible by design, with accessibility a consideration from the very beginning of design and throughout development.

ITU has developed a toolkit and self-assessment system entitled *"Towards building inclusive digital communities"*, which helps policy-makers and stakeholders build inclusive digital communities globally by providing a holistic understanding and knowledge of ICT and digital accessibility principles and implementation requirements.[175] This report details guidelines and best practices encompassing laws and regulations, political buy-in, standards, public procurement, training, monitoring, and e-government. This resource enables countries and organizations to run a self-assessment and obtain an immediate overview on the level of their ICT accessibility implementation. As countries look to establish and refresh their national broadband plans, they should include in their plans efforts to address the needs of six target groups – children, youth, older persons, persons with disabilities, indigenous people, and women and girls – that ITU considers to be part of digital inclusion.

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[174] *See* https://www.xbox.com/en-US/accessories/controllers/xbox-adaptive-controller.
[175] *See* International Telecommunication Union, "Towards building inclusive digital communities, ITU toolkit and self-assessment for ICT accessibility implementation, 2021 (available at https://www.itu.int/dms_pub/itu-d/opb/phcb/D-PHCB-TOOLKIT.01-2021-PDF-E.pdf).

7.6   Demand stimulation activities

Even when fixed and mobile broadband is available, many people do not subscribe. According to the GSMA, for mobile broadband services, 3.3 billion people around the world live in areas covered by mobile broadband networks but do not use mobile Internet. This "usage gap" is more than four times greater than the coverage gap.[176] According to the World Bank, "although 3G coverage gap has shrunk by more than half over the last five years thanks to successful rollout of last-mile infrastructure on the supply-side, the usage gap has remained remarkably stable, indicating the persistence of barriers on the demand-side."[177] The GSMA observes that unaffordability, low levels of literacy and digital skills, a perceived lack of relevance, and safety and security concerns are the most important barriers to mobile Internet use from a consumer point of view.[178] Even in places like the United States, about one quarter of consumers do not subscribe to home broadband, even when it is available to them, and rates of subscription are lower for consumers who are older, lower-income, or members of ethnic minorities.[179] Many of the data sources listed in section 2.3 (data sources for adoption and usage) can help highlight the level of usage and adoption by communities separated by rural and urban divides or economic divides. Addressing these barriers is critical to further reducing the usage gap and driving digital inclusion.[180] Below, we discuss how governments are stimulating demand for fixed and mobile broadband services.

7.6.1   Addressing affordability

> Key recommendations
>
> • Ensure that low-cost fixed and mobile broadband services and devices are available to low-income individuals and households.
> • Provide for discounting of services for anchor institutions (schools and libraries, health care centres, government offices, police and fire stations, and community centres) and marginalized groups (persons with disabilities and indigenous populations).

7.6.1.1 Affordability of services

ITU has set a target for the prices of entry-level fixed and mobile broadband services to be kept below 2 per cent of monthly gross national income (GNI) per capita. For mobile services, mobile

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[176] *See* GSMA, "Connected Society: State of Mobile Internet Connectivity 2019", at 7 (available at https://www.gsma .com/mobilefordevelopment/wp-content/uploads/2019/07/GSMA-State-of-Mobile-Internet-Connectivity -Report-2019.pdf#:~:text=THE%20STATE%20OF%20MOBILE%20INTERNET%20CONNECTIVITY%202019 %20In,achievement.%20Allow%20me%20to%20share%20with%20you%20some) (State of Mobile Internet Connectivity 2019).

[177] *See* World Development Report 2021: Data for Better Lives at 161.

[178] *See* State of Mobile Internet Connectivity 2019 at 33, Figure 14.

[179] *See* Pew Research Center, Internet/Broadband Fact Sheet (available at https://www.pewresearch.org/ internet/fact-sheet/internet-broadband/#home-broadband-use-over-time).

[180] *See* State of Mobile Internet Connectivity 2019 at 7.

broadband is affordable if 1.5 GB of data are available below that level.[181] Fixed broadband service is considered affordable if it provides at least 5 GB of monthly data consumption on a connection providing at least 256 kbit/s at that price level.[182]

While fixed and mobile broadband are indeed affordable by these measures in many markets, in most that is not the case for the average person.[183] Some have questioned whether a 2 per cent affordability threshold is too high. The World Bank states, "it is only when the cost per gigabyte of data drops below 0.5per cent of gross national income (GNI) per capita that data consumption reaches and eventually exceeds the 1 gigabyte threshold" (supported by the Alliance for Affordable Internet).[184] The World Bank further points out that data consumption is very sensitive to market prices and service affordability.[185]

Even in markets with affordable fixed and mobile broadband (however that affordability is determined), there will be many low-income consumers for whom fixed and mobile broadband remains unaffordable. As averages can mask inequality, these countries also will have consumers with below-average income for whom these services are unaffordable. A good example of this can be seen in Brazil, where both fixed and mobile broadband are considered affordable for the average income earner. Brazil is ranked as the 9th most economically unequal country in the world.[186] According to the OECD, in 2013 the average monthly income in the country was USD 1 598 and the median income was USD 1 095.[187] In 2015, the total income of the country's richest 5 per cent was the same as that of the remaining 95 per cent.[188] Even though both its fixed and mobile broadband is considered affordable by the Alliance for Affordable Internet's measures, Brazil has segments of its population for which broadband is still unaffordable. Based on our analysis of ITU and World Bank data, the bottom 20 per cent of income earners in Brazil would have to pay 11.6 per cent of their income for mobile broadband and 6.5 per cent for fixed broadband.[189] Furthermore, fixed and mobile broadband would be unaffordable even for the 40 per cent of income earners in Brazil (at 3.2 per cent and 2.28 per cent, respectively).

A study on ICT price trends in 2020 was carried out by ITU, specifically focusing on affordability for the bottom 40 per cent of income earners.[190] The study found that many developing and developed countries where entry-level mobile or fixed-broadband baskets were affordable for the average earner had a significant share of the population, in the bottom 40 per cent of income earners, that could still not afford them. In addition to implementing the supply-side efforts discussed above, which will reduce the cost of network inputs and enable operators to deliver

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[181] *See* International Telecommunication Union, "Measuring digital development ICT Price Trends 2019," at 5 (available at https://www.itu.int/dms_pub/itu-d/opb/ind/D-IND-ICT_PRICES.01-2019-PDF-E.pdf) (Measuring digital development ICT Price Trends 2019). The Alliance for Affordable Internet's measure for mobile broadband affordability requires 1 GB of data for 2% or less of GNI per capita. *See* Alliance for Affordable Internet, "UN Broadband Commission Adopts A4AI "1 for 2" Affordability Target," January 23, 2018 (available at https://a4ai.org/un-broadband-commission-adopts-a4ai-1-for-2-affordability-target/).

[182] *See* Measuring digital development ICT Price Trends 2019 at 5.

[183] *See* International Telecommunication Union Price Indices 2019 (available at https://www.itu.int/net4/itu-d/ipb/#ipbrank-tab).

[184] *See* World Development Report 2021: Data for Better Lives at 166.

[185] *See* World Development Report 2021: Data for Better Lives at 167.

[186] *See* Wikipedia article on List of countries ranked by income inequality (available at https://en.wikipedia.org/wiki/List_of_countries_by_income_equality).

[187] *See* OECD Income Distribution Dataset (available at https://stats.oecd.org/Index.aspx?DataSetCode=IDD).

[188] *See* Oxfam article, Brazil: extreme inequality in numbers (available at https://www.oxfam.org/en/brazil-extreme-inequality-number).

[189] *See* ITU ICT Price Basket Rankings available at https://www.itu.int/net4/itu-d/ipb/#ipbrank-tab; see also Economics data from the World Bank (available at https://data.worldbank.org/indicator/SI.DST.FRST.20?locations=BR).

[190] *See* ITU Measuring digital development ICT Price Trends 2020.

more affordable services to more people, governments are also implementing programmes to make fixed and mobile broadband service more affordable for low-income consumers. For example, the United States has implemented universal service programmes that enable qualified low-income consumers (those that qualify for federal income-based programmes, such as food stamps, free and reduced lunches for school children, subsidized housing, etc.) to receive discounted fixed and mobile broadband services.[191] The discounts are set by the FCC and people in tribal (indigenous) areas can receive larger discounts. Fixed and mobile broadband providers participating in this programme are reimbursed for the cost of providing these discounts. In addition, as part of its response to the COVID-19 pandemic, the United States Congress passed legislation and the FCC is implementing a programme to provide discounted broadband service and devices to a broader cross-section of low-income households impacted by the current economic recession.[192]

Governments have also implemented programmes to fund connectivity for anchor institutions, such as schools, libraries, health care centres, government offices, police and fire stations, and community centres. For example, the Government of Malaysia has a programme to connect schools and community centres to high-speed broadband.[193] In the United States, the FCC has programmes enabling schools and libraries and health care providers to receive discounted connectivity, with discounts based on the level of poverty in the community and whether it is a rural community.[194]

7.6.1.2 Affordable devices

As discussed above, the cost of devices is also a well-recognized barrier to broadband adoption. Conformity and interoperability help equipment manufacturers produce standardized devices at scale, increase choice, and reduce costs for consumers.[195] To help reduce the cost of devices for consumers, the Alliance for Affordable Internet recommends that governments: (1) reduce or eliminate taxes on low-cost connectivity devices; (2) create programmes to discount the cost of devices for low-income consumers and target groups like school children; and (3) support programmes to spread out the cost of devices over time.[196] In the absence of such action, the Alliance for Affordable Internet warns that "the cost of devices will be a drag on the post-pandemic recovery."[197]

Several types of taxes impact the cost of devices, including value-added taxes, sales taxes, customs duties, and technology-specific taxes.[198] The GSMA reports that sector-specific taxes and fees comprise 10 per cent of mobile sector revenues in the Asia-Pacific, Middle East and

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[191] *See* Federal Communication Commission Press Release, "FCC Modernizes Lifeline Program for the Digital Age: New Rules Will Help Make Broadband More Affordable for Low-Income Americans," Mar. 31, 2016 (available at https://docs.fcc.gov/public/attachments/DOC-338676A1.pdf); see also https://www.fcc.gov/general/lifeline-program-low-income-consumers.

[192] *See* Presentation by Kris Monteith, Chief of the Federal Communications Commission's Wireline Competition Bureau, Emergency Broadband Benefit Program Presentation, February 17, 2021 (available at https://docs.fcc.gov/public/attachments/DOC-370058A1.pdf).

[193] *See* The National Fiberisation and Connectivity Plan (NFCP) 2019-2023 (available at: https://www.malaysia.gov.my/portal/content/30736).

[194] *See* https://www.fcc.gov/general/e-rate-schools-libraries-usf-program.

[195] *See* information on the ITUs Conformity and Interoperability Programme (available at https://www.itu.int/en/ITU-D/Technology/Pages/ConformanceandInteroperability.aspx).

[196] *See From Luxury to Lifeline, Reducing the cost of mobile devices to reach universal internet access* at 4-5.

[197] *See From Luxury to Lifeline, Reducing the cost of mobile devices to reach universal internet access* at 16.

[198] *See* "State of Broadband" 2020 at 20. *See also* GSMA, "Rethinking mobile taxation to improve connectivity", 2019 (available at https://www.gsma.com/publicpolicy/wp-content/uploads/2019/02/Rethinking-mobile-taxation-to-improve-connectivity_Summary_ENG-1.pdf).

North Africa, and sub-Saharan Africa regions, but only 4 per cent in Europe and Latin America.[199] The World Bank reports that "despite low purchasing power of their populations, low-income countries on average impose the highest duties on mobile phones."[200] Each country takes its own approach, but these taxes can suppress demand for connectivity devices, especially when they are sector-specific and are designed to maximize revenues. In these cases, the device taxation approach taken "runs counter to maximizing broadband adoption."[201] High taxes can also run at cross purposes to other government programmes designed to promote supply and demand for digital devices. On the other hand, governments that reduce taxes (or even provide tax credits) for deployment of broadband networks and the sale of connectivity services and devices can spur demand.[202]

Several countries have implemented programmes to ensure that low-income consumers and school children can have access to low-cost smartphones and laptops. Successful programmes often aim at a triple target: devices, connectivity and digital skills. For example, the Malaysian Communications and Multimedia Commission has subsidized the cost of smartphones for the bottom 40 per cent of income earners in rural areas, alongside programmes subsidizing the cost of deploying fixed and mobile first, middle, and last mile networks in rural and insular areas.[203] In addition, the 1Malaysia programme provided 1.7 million low-cost netbooks to rural residents, school pupils and higher learning institution students who lacked devices.[204] Under the *Hogares Conectados* programme, the Costa Rican *Superintendencia Telecomunicaciones* provides every Costa Rican household with not only fixed-line Internet access but also the devices needed to get online and use the Internet.[205] Families eligible for the programme typically include those who are poor, indigenous, disabled, elderly, or low-income entrepreneurs.[206] Spain's *Educa en Digital* programme is providing half a million devices with connectivity to schools that will make them available to vulnerable students.[207] As part of its response to the COVID-19 pandemic, the United States Congress passed legislation and the Federal Communications Commission is implementing a programme enabling network operators to provide discounted broadband service and laptops to low-income households impacted by the current crisis.[208] In addition, many device manufacturers have made low-cost device SKUs specifically targeted at the lower end of the market and for education.[209]

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[199] *See* Rethinking Mobile Taxation to Improve Connectivity at 1-2.

[200] *See* World Development Report 2021: Data for Better Lives at 165.

[201] *See* The World Bank Group, Broadband Strategies Toolkit, at section 6.4.4 (available at https://ddtoolkits.worldbankgroup.org/broadband-strategies/driving-demand/achieving-affordability#section-276).

[202] *See* The World Bank Group, Broadband Strategies Toolkit, at section 6.4.4 (available at https://ddtoolkits.worldbankgroup.org/broadband-strategies/driving-demand/achieving-affordability#section-276) (using the examples of Sweden, Pakistan, and Malaysia).

[203] *See* https://www.mcmc.gov.my/en/sectors/universal-service-provision.

[204] *See* https://www.freemalaysiatoday.com/category/nation/2021/01/27/najib-tells-how-2mil-students-can-get-laptops/.

[205] *See* https://sutel.go.cr/pagina/programa-2-hogares-conectados-0.

[206] *See* https://sutel.go.cr/pagina/programa-2-hogares-conectados-0.

[207] *See* the Spanish Ministry of Education and Vocational Training (available at http://www.educacionyfp.gob.es/prensa/actualidad/2020/06/20200616-educaendigital.html). In 2019, the Spanish National Statistical Institute found that among households with children in Spain there were 792 048 without electronic devices and 284 243 without an Internet connection.

[208] *See* Presentation by Kris Monteith, Chief of the Federal Communications Commission's Wireline Competition Bureau, Emergency Broadband Benefit Program Presentation, February 17, 2021 (available at https://docs.fcc.gov/public/attachments/DOC-370058A1.pdf).

[209] For example Windows devices (https://www.microsoft.com/EN-US/EDUCATION/devices/default.aspx/); Chrome devices (https://edu.google.com/products/chromebooks/), and devices specifically developed for emerging markets, such as from Positivo (https://positivobghgroup.com/en/) and jp.ik (https://www.jpik.com/en/page/devices/).

Recognizing that the cost of devices can be a barrier to connectivity, several companies have implemented rent-to-own programmes that allow consumers to spread the cost of devices over time. For example, M-KOPA in Kenya, which pioneered the pay-as-you-go model of in-home solar power systems, now sells pay-as-you-go smartphones and other electronic devices, in partnership with Safaricom and Samsung.[210] A GSMA report highlights programmes in India, Kenya, Rwanda, and other markets, and provides recommendations on how to implement rent-to-own programmes.[211] These models provide dual value as they also can be a pathway to bankability and lower interest rates for low-income consumers lacking credit profiles.

7.6.2 Digital skills

<u>Key recommendations</u>

- Governments should set targets for a specified percentage of their population to acquire digital skills.
- Governments should consider partnerships with community-based organizations and private-sector organizations to deliver digital skills programming.

Lack of digital skills remains a significant barrier to technology adoption. World Bank household surveys conducted in 22 countries show that the reasons most frequently cited by people for not taking up data services are related to digital literacy.[212] The GSMA conducts a survey of the top barriers to mobile Internet use in low and middle-income countries. It found that lack of literacy and skills, along with safety and security concerns, ranked slightly higher than affordability for consumers surveyed in almost all regions.[213] One can expect the same to be true for fixed broadband.[214] Lack of digital skills impacts both youth and adults (especially older adults). A discussed above, the COVID-19 pandemic has had a profound impact on children, many of whom lack Internet access at home. A child without Internet access and a connectivity device at home who is sent home from school and subjected to lockdown is less likely to be able to acquire digital skills. The digital skills gap for older people also has been exacerbated by the COVID-19 pandemic, as they are forced to make vaccine and other medical appointments online, often without the skills to do so.[215]

Digital skills, therefore, are critical for people to be able to fully benefit from digital services – in essence, understanding how to use technology. The Broadband Commission's Advocacy Target 4 is for 60 per cent of youth and adults to have achieved at least a minimum level of proficiency

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[210] *See* https://m-kopa.com/products/).
[211] *See* The GSMA, Accelerating Smartphone Ownership in Emerging Markets, July 2017 (available at https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/07/accelerating-affordable-smartphone-ownership-emerging-markets-2017.pdf).
[212] *See* World Development Report 2021: Data for Better Lives at 164.
[213] *See* State of Mobile Internet Connectivity 2019 at 33, Figure 14.
[214] According to a PEW Research Center Survey, about a third of United States non-Internet users (34%) did not go online because they had no interest in doing so or did not think the Internet was relevant to their lives. Another 32% of non-users said the Internet was too difficult to use. *See* PEW Research Center, "Who's not online and why", Sept. 25, 2013 (available at https://www.pewresearch.org/internet/2013/09/25/whos-not-online-and-why/).
[215] *See* Kellen Browning, *"Seniors Seeking Vaccines Have a Problem: They Can't Use the Internet"*, The New York Times, February 28, 2021 (available at https://www.nytimes.com/2021/02/28/technology/seniors-vaccines-technology.html). *See also* Humana Foundation, "Aging Connected: Exposing the Hidden Connectivity Crisis for Older Adults", at 19 (available at https://agingconnected.org/wp-content/uploads/2021/02/Aging-Connected_Exposing-the-Hidden-Connectivity-Crisis-for-Older-Adults.pdf).

in sustainable digital skills by 2025.[216] The European Commission's goal is for 70 per cent of adults to have basic digital skills by 2025.[217]

The World Bank has observed that "[d]igital literacy programs with a higher chance of sustainability are either sponsored by a private company, the partnership of an NGO and a private company, a public-private partnership, or a public-private partnership including an NGO; on the other hand, if a project is exclusively sponsored by the public sector, chances are that it will not be sustainable."[218] Such partnerships will be critical for governments to ensure that more of their citizens have the digital skills they need to participate online.

7.6.3   Local content

> Key recommendations
>
> - Governments should work with the private sector and civil society to develop local content and applications, including through sponsorship of technology incubators.

Finally, it is important that consumers have access to content that is relevant to them and available in their first language. The World Bank has observed that "users purchase broadband services and devices in order to gain access to the complementary services and content. In fact, for the population at large, the network infrastructure is less important on a day-to-day basis than the availability of relevant and useful online services and applications that allow them to access, create, and share content."[219] According to the GSMA, consumers who are not online often report that there is not enough content in their own language or that the Internet is not relevant enough for them.[220] A good demonstration of this problem is the number of Setswana Wikipedia articles. Setswana is spoken by the majority of people in Botswana and as a first language by 4.1 million South Africans (8.0 per cent of the country according to the last 2011 census) but there are only 721 Setswana articles.[221]

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[216] State of Mobile Internet Connectivity 2019 at 32.

[217] *See* Samuel Stolton and Jorge Valero, "Commission in bid to ensure '70% of EU adults' have digital skills," Euractiv, July 1, 2020 (available at https://www.euractiv.com/section/digital/news/commission-in-bid-to-ensure-70-of-eu-adults-have-digital-skills/).

[218] *See* World Bank Group, Broadband Strategies Toolkit (available at https://ddtoolkits.worldbankgroup.org/broadband-strategies/driving-demand/strategies-promote-broadband-demand#section-309).

[219] *See* World Bank Group, Broadband Strategies Toolkit (available at https://ddtoolkits.worldbankgroup.org/broadband-strategies/driving-demand/developing-applications-drive-broadband-demand).

[220] *See* State of Mobile Internet Connectivity 2019 at 57.

[221] Wikipedia multilingual statistics (available at https://meta.wikimedia.org/wiki/List_of_Wikipedias; statistics as at 19 August 2021).

While the English language continues to dominate the Internet,[222] numerous efforts are under way to encourage the development of relevant content in more local languages.[223] For example, the Internet Society is working with governments, local entrepreneurs, and civil society to develop Internet content in local languages.[224] Governments can play an important role in developing local content and local applications by requiring that e-government applications are locally developed and available in local languages. There are also examples of governments funding technology incubators, which develop applications for the local market (and upskill the workforce).[225] Technology companies have various efforts underway to enable consumers to translate content into their local languages.[226] Moreover, an increasing array of online tools (YouTube, TikTok, etc.) enable the creation of user-generated content, in local language. As Internet content becomes more relevant, consumers will be more willing and able to productively use their Internet access.

7.7   Effective monitoring and evaluation programmes

<u>Key recommendations</u>

- Include a monitoring and evaluation programme from the outset.
- An open and transparent assessment and review of progress should occur at least every two years.
- Be prepared to course-correct and update the plan in response to changed conditions.

The successful implementation of broadband rollout programmes, guided by a national broadband plan, depends heavily on monitoring and evaluation programmes being in place, on regular public reviews, and on the willingness to make policy changes when necessary to keep the plan on track. While at least 174 countries now have a national broadband plan, more work must be done to monitor and evaluate the current state of implementation of these plans.[227] In some cases, even after publishing and endorsing a national plan, government transitions and competing priorities lead to situations where national plans are no longer effectively being implemented and/or targets need to be revised in order to have an impact on broadband availability and adoption.[228]

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[222] *See* Usage Statistics and Market Share of Content Languages for Websites (available at https://w3techs.com/technologies/overview/content_language).

[223] For example. the Internet Society works with governments, local entrepreneurs, and civil society on efforts to develop Internet content in local languages (available at https://www.internetsociety.org/blog/2016/08/local-content-in-local-languages-matters/). In addition, technologies companies have various efforts underway to enable consumers to translate content into their local languages. *See,* e.g. tools like Google Translate (https://translate.google.com/); Bing Translator (https://www.bing.com/translator/); Microsoft Translator (https://translator.microsoft.com/); *see also* Microsoft's Local Language Program Bridges Languages, Cultures and Technology, February 02, 2021 (available at https://news.microsoft.com/2012/02/21/microsofts-local-language-program-bridges-languages-cultures-and-technology/).

[224] *See* https://www.internetsociety.org/blog/2016/08/local-content-in-local-languages-matters/.

[225] *See,* e.g. the Government of Colombia's Apps.Co programme promoting digital entrepreneurship through training and mentorship (available at https://www.apps.co/).

[226] *See,* e.g. tools like Google Translate (https://translate.google.com/); Bing Translator (https://www.bing.com/translator/); Microsoft Translator (https://translator.microsoft.com/); *see also* Microsoft's Local Language Program Bridges Languages, Cultures and Technology, February 02, 2021 (available at https://news.microsoft.com/2012/02/21/microsofts-local-language-program-bridges-languages-cultures-and-technology/).

[227] *See* "State of Broadband" 2020 at 14.

[228] *See* "State of Broadband 2020" at 14.

The most effective national broadband plans have regular reviews and iterations.[229] The Alliance for Affordable Internet found three leading emerging market countries in its annual affordability survey – Malaysia, Colombia, and Costa Rica – that demonstrate the impact that national broadband plans have on Internet affordability and the importance of iterative reviews in achieving excellence in this domain.[230] Malaysia, Colombia, and Costa Rica earned the highest scores this year of any countries on the Alliance's survey for the quality of targets within their national broadband plans and the widespread impact of these targets. In these three countries, their broadband plans set targets, led the sector, and left evidence of impact in their wake. In Costa Rica, the national broadband plan details a procedure for reviewing progress over the duration of the plan's lifespan, including biennial updates published by the Ministry. These activities ensure that the national broadband plan is not a one-off event but rather is the launching point for further and continued activity in the sector.[231] As a result, the Alliance for Affordable Internet recommends that a national broadband plan should have a stated plan for transparent assessment and review that occurs at least every other year.[232] We agree that such a review should happen at least every two years.

7.8   Emergency preparedness

<u>Key recommendation</u>

- Member States should have national emergency telecommunications plans in place that include contingency plans for a full range of disasters caused by natural hazards or manmade.

It is widely accepted that information and communication technologies are one of the major pillars for disaster management and risk reduction. Monitoring hazards and delivering vital information in a timely manner is critical for both decision-making and emergency response. National emergency telecommunication plans (NETPs) establish standard operating procedures, promote coordination, and allow for swift and efficient emergency response.[233] Ratification of the Tampere Convention and waiving regulatory barriers that impede the use of trans-border telecommunication resources for disasters, allows emergency response teams to access the tools and resources they need to provide prompt support. International conventions such as Tampere help facilitate prompt telecommunication assistance to mitigate the impact of a disasters by ensuring relief workers have access to vital communications links. Including a contingency plan in a country's NETP helps to establish operational procedures in relation to the use of telecommunications/ICT resources and capacity in response to a particular hazard.

Moreover, many countries lack awareness about the benefits and opportunities of investing in the implementation of multi-hazard early warning systems (MHEWS) with a people-centred approach, which brings together different stakeholders for a coordinated practice. This

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[229] *See* Trends in Telecommunications Reform 2015 Getting Ready for the Digital Economy at 192-211.
[230] *See* A4AI Affordability Report 2020 at 22.
[231] *See* A4AI Affordability Report 2020 at 22.
[232] *See* A4AI Affordability Report 2020 at 36.
[233] More information on national emergency telecommunications plans can be found on the ITU's website (see https://www.itu.int/en/ITU-D/Emergency-Telecommunications/Pages/NETPs.aspx#:~:text=A%20National%20Emergency%20Telecommunication%20Plan%20%28NETP%29%20is%20an,the%20disaster%20management%20cycle%20beyond%20the%20ICT%20sector).

approach helps address challenges in building a system that allows countries to deliver relevant alerts in a timely manner to empower communities threatened by multiple hazards, including pandemics, to act on time and in an appropriate manner. To achieve this, countries should assess their own needs to invest in having appropriate technical and financial resources and/ or coordination mechanisms that support the development and implementation of MHEWS at a local or national level.

An early warning system has been internationally defined as "an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities, systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events."[234]

In this context, an MHEWS has the ability to address several hazards and/or impacts of similar or different types in situations where hazardous events may occur alone, simultaneously, cascading or cumulatively over time, and taking into account the potential interrelated effects. To be effective, a MHEWS needs to actively involve the people and communities at risk, raise awareness about the importance of risk knowledge, facilitate public education, disseminate messages and warnings efficiently, and ensure that there is a constant state of preparedness so early action is enabled.

While emergency situations involving natural hazards or man-made causes commonly result in massive devastation to ICT infrastructure, the COVID-19 pandemic has demonstrated that pandemics can impact telecommunication networks and the delivery of online services very differently. The COVID-19 pandemic saw a major increase in data traffic on both wired and wireless networks due to higher online communications demand during times of confinement spurred by online education, remote work, and an increase in both communication via the Internet as well as usage of online entertainment services. The COVID-19 pandemic has crucially demonstrated the need of having in place MHEWS that use all technologies available to keep people informed about different hazards that can affect lives and livelihoods while recovering from this critical situation. These systems have the capacity to support recovery efforts by facilitating the exchange of life-saving information that will increase resilience of the most vulnerable communities as well as the general public.

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[234] United Nations (2016). Report of the Open-ended Intergovernmental Expert Working Group on Indicators and Terminology Related to Disaster Risk Reduction (OIEWG) (A/71/644), adopted by the General Assembly on 2 February 2017 (A/RES/71/276)

8   Conclusion

In this report, we have detailed a global methodology for identifying gaps and bottlenecks at the country level that hamper the utilization of broadband networks and digital technologies to respond to and mitigate the consequences of the COVID-19 pandemic. We have shown how the COVID-19 pandemic has exposed gaps in data, helped broaden our view of resilience, and sharpened and re-energized our focus on closing the global connectivity gap. Below we highlight key takeaways from this report:

- Up-to-date fixed and mobile broadband data that use open international standards and methods with a high-level of geographic specificity is the ideal, but governments can reveal a lot with simple, consistent data collections from network operators, verified with trusted third-party data sources. ITU is in a unique position to convene various stakeholders to develop new data collection methodologies and visualizations, such as coverage maps.

- The COVID-19 pandemic shows us that we need to think about resilience more broadly to address the global fixed and mobile broadband gap, as well as issues like electricity. The pandemic has also taught us that a country's broadband network cannot be considered resilient if significant portions of its population cannot access the Internet at home. A well-functioning society and economy requires the participation of all of its citizens, not just those fortunate enough to have affordable Internet connectivity.

- Governments and regulators have implemented an incredible array of emergency measures to address the immediate challenges from COVID-19. However, emergency measures alone do not enable a country to adapt to the new normal or make it truly resilient.

- In the wake of the global COVID-19 pandemic, now is a good time for all countries to develop or update national broadband plans. Governments and regulators can use the national broadband planning process to help close the digital divide, increase network redundancy and resiliency, and be prepared to move quickly should future disasters from natural hazards or man-made causes occur.

ITU looks forward to working with Member States interested in participating in the pilot phase of the Connect2Recover initiative.

Appendix A. Current available data sources on broadband

1   Data sources that are used for current ITU reporting

1.1   ITU-D ICT Statistics Division

ITU identifies, defines, and produces international official statistics covering the telecommunication/ICT sector for 193 Member States across the world. There are also other specialized agencies, such as the UN and the World Bank, that produce statistics covering their respective field of operations and include ICT statistics from ITU in their set of data.

ITU collects telecommunication/ICT data (shown in Appendix B) for 196 countries worldwide. These can be divided into three key sets of data:

- Telecommunication/ICT infrastructure and access data collected annually through two questionnaires (one short and one long).[235]
- Price data collected through an annual questionnaire.[236]
- Data on access to and use of ICTs by households and individuals collected annually through short or long questionnaires.[237]

ITU verifies and harmonizes the data received from countries and collects missing values from government web sites and operators' annual reports, particularly for countries that do not reply to the questionnaires. In some cases, market research data are also used to cross-check and complement missing values. Data availability varies between the different types of indicators:

- Most countries collect telecommunication/ICT infrastructure and access data, particularly for key indicators such as cellular population coverage, the number of mobile cellular subscriptions, fixed telephone lines and Internet subscriptions. As an example of the level of reporting on indicators in this category, in 2019, 143 out of 193 Member States reported 4G population coverage.
- Relatively few countries respond to ITU's ICT Price Basket Questionnaire, and most prices are collected by ITU directly from the main national telecommunication operators.
- Less than half of the countries carry out surveys to collect ICT household data, and many of those do not provide all indicators, especially data on the use of ICTs by individuals. These "demand-side" data are important for measuring the use and impact of ICTs, and serve as a complement to the infrastructure ("supply-side") data. In 2019, only 73 Member States reported the number of Internet users.

Data collected by ITU are maintained in a central database and disseminated as follows:

- The World Telecommunication/ICT Indicators Database[238]

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[235] *See* Handbook for the Collection of Administrative Data on Telecommunications/ICT, 2020 Edition (available at https://www.itu.int/en/ITU-D/Statistics/Pages/publications/handbook.aspx).

[236] *See* Manual for Measuring ICT Access and Use by Households and Individuals, 2020 Edition.

[237] *See* Manual for Measuring ICT Access and Use by Households and Individuals, 2020 Edition.

[238] *See* World Telecommunication/ICT indicators database (available at https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx).

- The ITU ICT Eye[239]
- Various analytical (regional, global, and thematic) reports such as Facts and Figures, the ICT Price Basket and Digital Trends[240]
- Publications and databases produced by other international organizations and projects that are captured at the Partnership on Measuring ICT for Development.[241] These partner organizations also make these data publicly available on sites such as the World Bank Development Indicators[242] and the United Nations Statistical Yearbook[243]
- The Google Public Data Explorer.[244]

Methodology limitations:

- Geographic or population coverage data depend on coverage maps provided by operators or by GSMA's official mapping partner, Collins Bartholomew. There are no universal definitions for the coverage edge of a 2G/3G/4G/5G network and hence the data are inconsistent.
- Mobile subscription data do not reflect the number of users connecting to the network, due to the widespread use of multiple SIM cards.
- Data collected directly from operators are only obtained from the main incumbent national operators, so they do not reflect connectivity that is also available from smaller local or regional operators.
- Many countries do not complete the pricing questionnaire, so ITU relies on data collected directly from operators. This often only reflects pricing data from the main national operators and not the smaller regional operators, who may provide better pricing.

1.2   ITU broadband maps

ITU-D actively creates broadband maps (https://itu.int/go/Maps), in the form of an ICT-data mapping platform, to take stock of national backbone connectivity which includes optical fibre, microwave links, satellite earth stations and Internet exchange points as well as other key metrics for the ICT sector.

The ITU broadband map also provides location intelligence that can provide information such as distance to nearest fibre and a full GIS tool that can be used for ICT development. The map currently depicts data from over 480 operators, with 19 775 notes and over 3.5 million km of network infrastructure.[245] To aid in providing intelligent location-based information, the map also includes earth topography, population density, distances to nodes, satellite earth stations and Internet Exchange points.

Connectivity data for the ITU broadband maps come from the following sources:[246]

- Internet backbone infrastructure (source: ITU)
- IXPs (source: TeleGeography)

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[239] *See* The ITU ICT Eye (available at https://www.itu.int/ITU-D/ICTEYE/Indicators/Indicators.aspx).
[240] *See* ITU-D ICT Statistics publications (available at https://www.itu.int/en/ITU-D/Statistics/Pages/publications/default.aspx).
[241] *See* Partnership on Measuring ICT for Development (available at https://www.itu.int/en/ITU-D/Statistics/Pages/intlcoop/partnership/members.aspx).
[242] *See* World Bank Indicators (available at http://data.worldbank.org/).
[243] *See* United Nations Statistical Yearbook (available at http://unstats.un.org/unsd/syb/).
[244] *See* The Google Public Data Explorer (available at https://www.google.com/publicdata/directory).
[245] *See* Last-mile Internet Connectivity Solutions Guide: Sustainable connectivity options for unconnected sites.
[246] *See* Framework and Methodology for the ITU World Terrestrial Transmission Map Project (available at https://www.itu.int/en/ITU-D/Technology/Documents/InteractiveTransmissionMaps/Misc/MapFrameworkMethodology.pdf)

- Submarine cables (source: TeleGeography)
- Satellite earth stations (source: ITU).

There is also a formal validation procedure where the ITU regional offices ask members or operators to validate information contained in the map.

Data layers presented:

o Internet backbone infrastructure (undersea and terrestrial)

o IXPs

o Satellite earth stations

o Population density

o GSM coverage.

Methodology limitations:

o Fibre infrastructure data are still incomplete for some African countries

o GSM coverage data are not accurate in some countries.

1.3   Project Giga

ITU and UNICEF have joined forces on project Giga, launched in 2019, in a bid to connect every school to the Internet by 2030. Giga also serves as a platform to create the infrastructure necessary to provide digital connectivity to an entire country, for every community, and for every citizen. It is about using schools to identify demand for connectivity, as well as using schools as an analogy for learning and connecting.

The Giga initiative consists of four pillars: mapping, connecting, finance, and empowerment. For Connect2Recover, the most applicable component is mapping and connectivity. The mapping component is done in partnership with governments. Giga has started by mapping connectivity demand, using schools as a base point, and identifying where there are connectivity gaps. This information, combined with existing ITU mapping data, allows countries to take stock of their existing infrastructure and assess wired and wireless availability when assessing appropriate solutions for connecting schools. Already more than 800 000 schools in 15 countries have been mapped and are viewable live at www.projectconnect.world.

The connectivity component is done in partnership with industry, and is based on the mapping results. Giga will determine the best possible technical solutions available to provide schools with the required connectivity, and countries with safe, secure, reliable, fit-for-purpose infrastructure to support future digital development needs. This includes determining the best possible solutions for last-mile connectivity.

Data collected:

o Location of schools

Data presented:

o 2G connectivity

o 3G and above connectivity

o Above 3 Mbit/s

o Below 3 Mbit/s

Methodology limitations:

o   Currently only 15 countries

o   Relies on GSM coverage data which may not be universally accurate for all countries.

2   Complementary data sources on availability, adoption, and usage

2.1   Opensignal

Opensignal is an independent mobile analytics company specializing in "quantifying mobile network experience."[247] Opensignal's objective is to report as accurately as possible the real-world mobile experience as recorded by mobile network users.

The Opensignal application can help a user check where they can get a better phone signal (cellular or Wi-Fi). In so doing, the application measures signal strength, data speed and reliability and shares this information with Opensignal over multiple geo-referenced points as the user moves. Opensignal can then use this collated information to produce independent maps of carrier coverage and performance and rank services of operators. The methodology used to collect and analyse the data is published openly. These data are made available to users or organizations as maps with multiple geo-referenced signal strength measurements.

Crowdsourced tools like Opensignal rely on widespread user adoption across a wide geographic area to provide a complete picture across the country. Higher-income users tend to use Opensignal more to check the quality of their link and compare this with competitors whereas low-income areas tend to use tools like Opensignal less.

The methodology[248] used to collect and process data is semi-open in the sense that it describes the measurement process used but not in enough detail to fully duplicate the system and produce comparable results.

Data collected:

o   Location at each data point (while app is active)
o   Signal strength
o   Download and upload speed (if test is run)
o   Video performance (if test is run).

Methodology limitations:

o   In many developing countries data are still very limited, e.g. compare Figure 9 (South Africa) and Figure 10 (Democratic Republic of the Congo) – in many areas only tourists have created data points.

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[247] *See* Opensignal about page (available at https://www.opensignal.com/about-us).
[248] *See* Opensignal methodology (available at https://www.opensignal.com/methodology-overview)
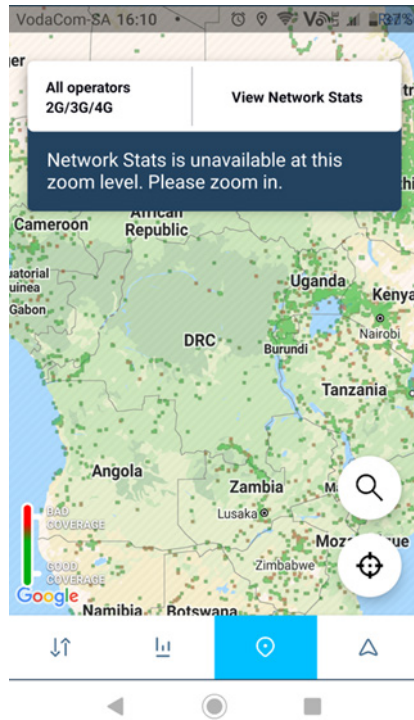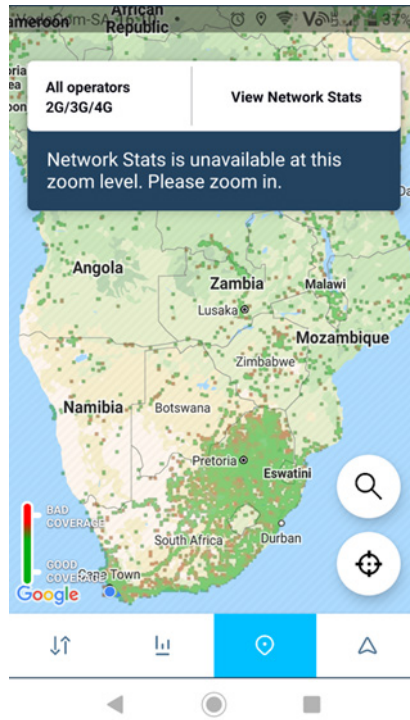
Figure 9: Opensignal data in South Africa

Figure 10: Opensignal data in the Democratic Republic of the Congo

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of ITU and of its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

2.2   OpenCellID

OpenCellID by Unwired Labs is a collaborative community project that collects GPS positions of cell towers and their corresponding location area identity. OpenCellID publishes an aggregate dataset of cell locations licensed under a Creative Commons Attribution-ShareAlike 4.0 International Licence with the intention of promoting free use and redistribution of the data.

These data are primarily contributed by smartphone users who have installed apps, such as OpenCellID or OpenCellID Client, and commercial tracking devices such as black boxes, but also by wholesale data donation by corporations. This is then collected and transferred into the OpenCellID API database. Their dataset is extensive in developed countries (e.g. they have approximately 6.5 million total cells collected for the United States and 523 295 cells collected for South Africa[249]). However, in many developing countries their dataset is still small (e.g. in the Central African Republic, they only have 1 020 cells).

Unwired also collect data on Wi-Fi access points through their partners, third-party organizations; however, these data are not licensed under a creative commons licence. Unwired's main commercial offering is a location service that does not use GPS but relies on their extensive geo-referenced data set dataset of cell towers, Wi-Fi access points and IP addresses.

They are also able to produce worldwide maps of cell data (shown in *Figure 11*) and Wi-Fi data (shown in *Figure 12*) using their database.

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[249]   *See* OpenCellID statistics (available at http://www.opencellid.org/stats.php).

Figure 11: Cellular towers detected by user devices
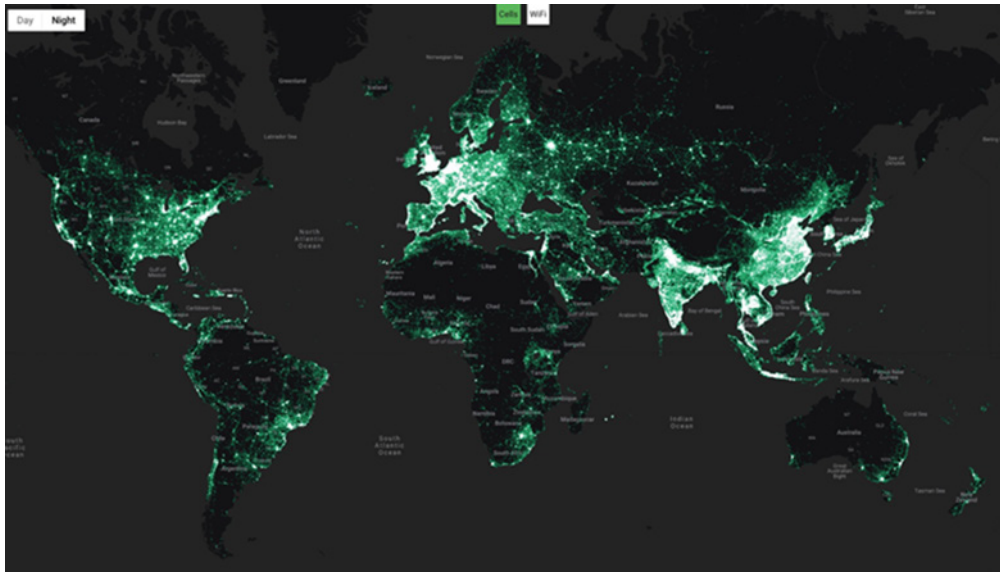
Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of ITU and of its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Data collected (for OpenCellID):

o   Location at each data point (while app is active)

o   Cell tower ID detected.

Methodology limitations:

o   In many developing countries data are still extremely limited.

Figure 12: Wi-Fi access points detected by users' devices and third-party applications

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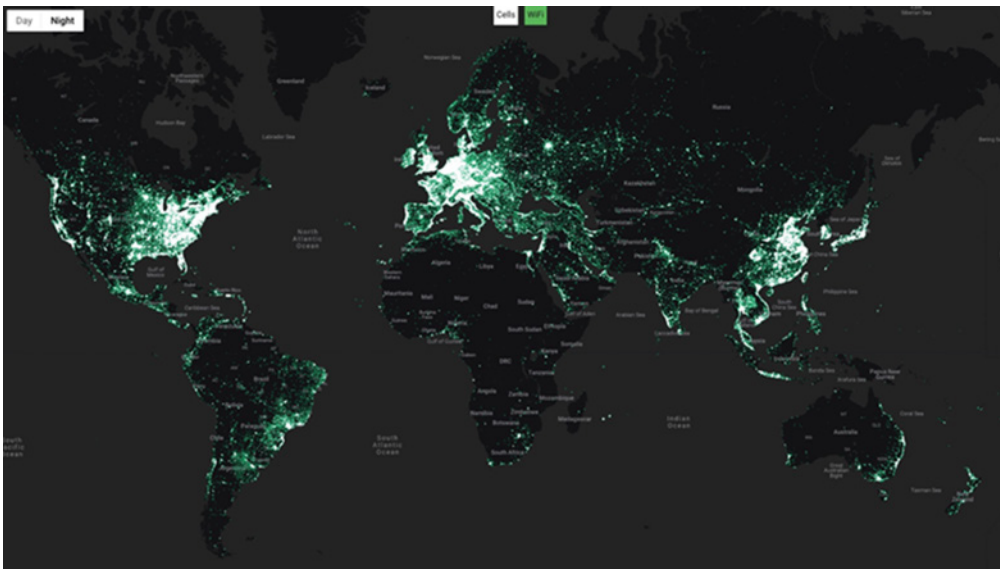
2.3   Ookla

Speedtest.net, also known as Speedtest by Ookla, is a web service that provides free analysis of Internet access performance metrics, such as connection data rate and latency. It is the flagship product of Ookla, a web testing and network diagnostics company founded in 2006.

The service measures the data throughput (speed) and latency (connection delay) of an Internet connection against any of around 10 000 geographically dispersed servers (as of February 2020)[250]. Test servers need to meet certain minimum performance requirements; as of January 2021, the minimum bandwidth requirement for a test server was 1 Gbit/s.[251] The distribution of these test servers is shown in Figure 13. Each test measures the data rate for the download direction, i.e. from the server to the user computer, and the upload data rate, i.e. from the user's computer to the server. These tests are effectively testing the last-mile access speed as most of the tests are on-net measurements to a test server hosted by the service provider. However, in parts of the world with low Internet penetration rates, such as the Democratic Republic of the Congo, speed tests will often be measuring off-net speed to a test server hosted on another network; this may even be in another country in the case of satellite connectivity. The tests are performed within the user's web browser or within apps. As of March 2021, over 34 billion speed tests had been completed.[252]

The Speedtest methodology[253] is semi-open and describes how data are collected and what data are filtered to remove measurements of poor quality, but it does not provide enough information to allow reproduction.

Figure 13: The distribution of test servers across the world
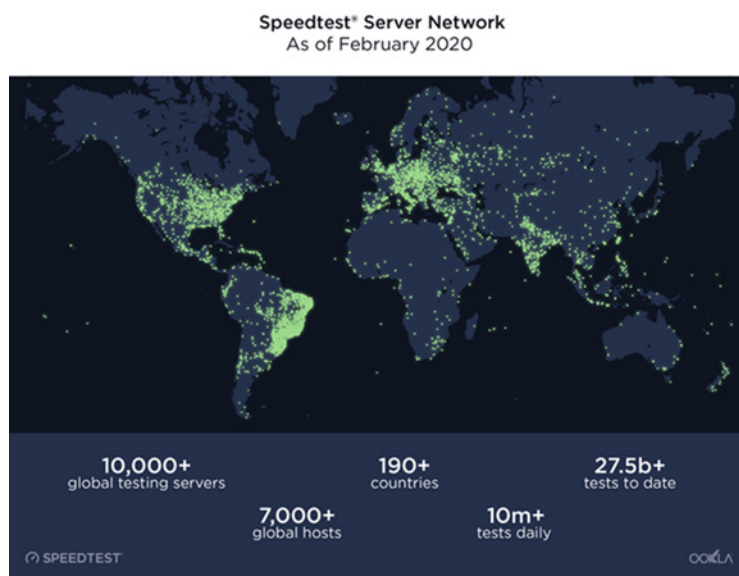
Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of ITU and of its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

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[250] *See* How the Speedtest Server Network Supports Millions of Tests While Providing the Most Accurate Results, February 20220 (available at https://www.speedtest.net/insights/blog/speedtest-server-network/).

[251] *See* Speedtest Server Requirements (available at https://support.ookla.com/hc/en-us/articles/234578628-Speedtest-Server-Requirements).

[252] *See* Speedtest about page (available at https://www.speedtest.net/about).

[253] *See* Speedtest methodology (available at https://www.speedtest.net/awards/methodology).

Speedtest.net formerly used the HTTP protocol for speed tests but now uses TCP sockets and a custom protocol for communication between servers and clients. Ookla recently launched Ookla Open Datasets (Ookla for Good) to make critical data available for others who are trying to improve the state of networks worldwide.

This has been used by the University of Chicago to show unequal access in Chicago.

Data collected:

o   Download and upload speed (measured to nearest test server out of some 8 000)
o   Latency (measured to nearest test server).

Methodology limitations:

o   Not all countries have sufficient test servers nearby; this may affect the performance of the last-mile test. See Figure 13 for the distribution of test servers.

2.4   Nokia Deepfield

Nokia Deepfield provides network intelligence, analytics, and detection of denial-of-service attacks. It is designed to help customers improve their network performance and security for broadband and IoT networks. It also provides insights into cloud and content delivery network (CDN) services.

Deepfield applications use a common software platform for data processing and can be hosted on-premises by a customer or as a cloud-based service. The platform ingests data from many different sources in a customer network. The followed data are sent by network devices, such as routers and switches, and network services running on cloud-based or bare metal servers:

•   IP flow-related datasets (xflow data)
•   Border Gateway Protocol (BGP) and simple Network Management Protocol (SNMP) data
•   DNS information (from DNSflow)
•   Router and telemetry datasets such as RADIUS/Authentication, Authorization and Accounting (AAA), Internet Protocol Flow Information Export (IPFIX) and Google's Remote Procedure Calls (gRPCs).

Nokia Deepfield is extensively used across Europe and North America. Data from Deepfield was used to check macro network trends during the COVID-19 pandemic.

Data collected:

o   IP flow data
o   BGP and SNMP data
o   DNS information
o   Radius/AAA, IPFIX and gRPC data

Methodology limitations:

o   Data are limited to Europe and N. America and a few scattered uses in other parts of the world
o   Detailed data are only available to customers, only high-level reports are created for public use.

2.5   GSMA mobile coverage maps

GSM coverage mapping for GSMA's coverage maps is carried out by operators or third parties. Most coverage maps are calculated by operators and submitted to Collins Bartholomew, who produce the country maps for GSMA (https://www.gsma.com/coverage). GSMA has guidelines[254] on receive thresholds that should be used for indoor and outdoor coverage but there is no methodology to verify the accuracy of the map other than looking for obvious coverage exaggerations, such as implausible coverage in a mountainous region.

GSMA has also worked with Masae Analytics to produce a set of mobile coverage maps for 2G, 3G and 4G technology (https://www.mobilecoveragemaps.com/). The public online mapping tool shows the geographic coverage on a map and allows a user to check the percentage of population coverage for different technologies in a census region or check the closest distance to a 2G, 3G or 4G signal.

The maps are produced using mobile operator site coordinates collected and received by GSMA or, where that is not available OpenCellID. Other data that are used are ESA Africa land cover data, ESRI World Imagery, OpenStreetMap for building and road networks, and Shuttle Radar Topography Mission Data from Nasa. For population statistics, the High-Resolution Settlement Layer data produced by CIESIN is used as well as WorldPop data.

The core challenge with coverage maps is the lack of information about the parameters used to produce the maps (e.g. what receive signal thresholds are used or what propagation model is used). This means that we currently do not reliably know global population coverage for any cellular technology.

Data produced

- Geographic 2G/4G/4G cellular coverage data – viewable online
- Population coverage statistics.

Methodology limitations:

- Process and parameters used to produce the maps are not available publicly
- No information given on when OpenCellID estimates site locations are used. In these cases, accuracy will be affected.

2.6   Economist Intelligence Unit (EIU)

The Economist Intelligence Unit (EIU) is the research and analysis division of the Economist Group, providing forecasting and advisory services through research and analysis, such as monthly country reports, five-year country economic forecasts, country risk service reports, and industry reports. The EIU provides country, industry, and management analysis worldwide.

In 2016, Facebook commissioned the EIU Inclusive Internet Index[255] that compares countries according to their enabling environment for adoption and productive use of the Internet. The index outlines the current state of Internet inclusion across 100 countries, and aims to help

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[254] *See* GSMA coverage map submission guidelines (available at https://www.gsma.com/coverage/downloads/GSMA_Submissions_Guide_2019-20.pdf).

[255] *See* The Inclusive Internet Index 2020 Methodology report (available at https://theinclusiveinternet.eiu.com/assets/external/downloads/3i-methodology.pdf).

policy-makers and influencers gain a clearer understanding of the factors that contribute to wide and sustainable inclusion.

The index contains 56 indicators across 4 categories:

Availability: This category captures the quality and breadth of available infrastructure required for access. The category also looks at Internet use, the quality of the Internet connection, and the type and quality of infrastructure available for Internet and electricity access in both urban and rural areas of the country.

Affordability: This category examines the cost of accessing the Internet and considers initiatives, whether private or public, to lower costs, or other ways to promote access. The category includes factors that focus on price, such as the cost of a handset or fixed-line broadband, and the competitive environment for wireless and broadband operators.

Relevance: This category considers the value of being connected, in terms of useful services and content and the availability of local content. The category measures the availability of local content, such as whether basic information or government services are available online in the local language. It also measures whether content and services that stimulate economic activity, such as those relating to health, finance, commerce or entertainment, are available online.

Readiness: This category measures the capacity among Internet users to take advantage of being online. The category looks at measures such as the level of literacy and education, the level of web accessibility, privacy regulations, the level of trust in different sources of information found online, national e-inclusion policies for women, and spectrum policy.

For each category, a score is calculated from a weighted average of the underlying indicator scores. Scores are then scaled from 0 to 100, where 100 represents the strongest environment for the adoption and productive use of the Internet. The overall country score (adjusted) is a weighted average of the category scores.

In 2018, 2019 and 2020 the EIU created the Value of Internet survey to assess the value of the Internet to people in all index countries. The survey was conducted among 4 953 people across 99 countries, who were interviewed using local languages. Both CATI (computer-assisted telephone interviewing) and online methodologies were employed, depending on the market. Quotas were set at the country level using standard census criteria to ensure consistent sampling and representation, and to allow for reliable cross-country comparisons.

EIU country research data produced

- Availability

    - o   Government initiatives to make Wi-Fi available (EIU country research)
    - o   Private sector initiatives to make Wi-Fi available (EIU country research)
    - o   Availability of basic information in the local language (EIU country research)
    - o   Availability of e-government services in the local language (EIU country research).

- Relevance

    - o   e-Finance content (EIU country research)
    - o   Value of e-Finance (EIU "Value of the Internet" survey)
    - o   e-Health content (EIU country research)

- o Value of e-health (EIU "Value of the Internet" survey)

- o e-Entertainment usage (EIU "Value of the Internet" survey)

- o Value – e-Commerce (EIU "Value of the Internet" survey).

- Readiness

  - o Open data policies (EIU country research)

  - o Support for digital literacy (EIU country research)

  - o Level of web accessibility (EIU country research)

  - o Privacy regulations (EIU country research)

  - o Trust in online privacy (EIU "Value of the Internet" survey)

  - o Trust in government websites and apps (EIU "Value of the Internet" survey)

  - o Trust in non-government websites and apps (EIU "Value of the Internet" survey)

  - o Trust in information from social media (EIU "Value of the Internet" survey)

  - o e-Commerce safety (EIU "Value of the Internet" survey).

- Policy

  - o National female e-inclusion policies (EIU country research)

  - o Comprehensive female e-inclusion plan (EIU country research)

  - o Female digital skills training plan (EIU country research)

  - o Female STEM education plan (EIU country research)

  - o Government e-inclusion strategy (EIU country research)

  - o National broadband strategy (EIU country research)

  - o Funding for broadband buildout (EIU country research)

  - o Spectrum policy approach (EIU country research)

  - o Technology-neutral policy for spectrum use (EIU country research)

  - o Unlicensed spectrum policy (EIU country research)

  - o Government efforts to promote 5G (EIU country research).

Data produced

- 56 indicators across 4 categories: availability, affordability, readiness and policy.

Other external data used for indicators

- Alexa Internet, Cisco, Gallup, Google, GSMA, International Energy Association (IEA), ITU, Ookla, Opensignal, TeleGeography, United Nations Conference on Trade and Development (UNCTAD), United Nations Development Programme (UNDP), United Nations Educational, Scientific and Cultural Organization (UNESCO), World Bank, country ministries, national statistics offices, city administrative offices, national telecommunications authorities, domestic news websites and industry associations.

The Inclusive Internet Index is carried out in 80 core countries with 19 rotating countries that change each year. The countries represent approximately 91 per cent of the world's population and 96 per cent of global GDP.

Methodology limitations:

- Internet usage based on ITU data which often suffer from poor country reporting or lack of data.
- No indication is given of cases where regression is used to predict index values for countries with missing data.
- Many countries are not represented where the need for more accurate data is the highest, e.g. the Democratic Republic of the Congo. 100 out of 193 countries represented.

2.7   Alexa Internet

Alexa Internet, Inc. is an American web traffic analysis company based in San Francisco. A key metric published from Alexa Internet analytics is the Alexa Traffic Rank, also known as Alexa Rank or Global Rank by Alexa Internet. It is designed to be an estimate of a website's popularity. As of May 2018, Alexa Internet's tooltip for Global Rank says the rank is calculated from a combination of daily visitors and page views on a website over a three-month period.

The Alexa Traffic Rank can be used to monitor the popularity trend of a website and compare the popularity of different websites.

The traffic rank used to be determined from data collected from users who had the Alexa toolbar installed on their browser. As of 2020, Alexa does not use a toolbar; instead, it uses data from users that have installed any of numerous browser extensions, and from websites that have the Alexa script installed on their webpages.

Data produced

- Top 500 ranked websites by country.

Derived data

- Concentration of websites using country-level domains: This measures the proportion of websites in the top 25 most-visited websites that use a country code top-level domain (ccTLD). The higher the proportion, the more likely it is that there are popular websites catering to local content needs.

2.8   World Bank World Development Indicators

World Development Indicators (WDI) is the World Bank's premier compilation of international statistics on global development. Drawing from officially recognized sources and including national, regional, and global estimates, the WDI provides access to approximately 1 600 indicators for 217 economies, with some time series extending back more than 50 years. The database helps users find information related to development, both current and historical. The topics covered in the WDI range from poverty, health, and demographics to GDP, trade, and the environment.

The website provides access to data as well as information about data coverage, curation, and methodologies, and allows users to discover what type of indicators are available, how they are collected, and how they can be visualized to analyse a specific development trend.

Indicators that are made available are based on World Bank Group surveys, data collection efforts and many other sources such as:

- UN specialized agencies (e.g. ITU)
- National statistics offices
- Organizations with a specific research or monitoring focus
- Private sector
- Academic studies.

The World Bank's Open Data site provides access to the WDI database free of charge to all users. Users can browse the data by country, indicators, topics, and via the WDI Data Catalog.[256] The WDI database can be accessed directly via the WDI Data bank[257], a query tool where users can select series, economies, and time periods, and do bulk downloads in Excel or CSV, or via API. In addition, data can be programmatically accessed using Stata, R, and Python modules

2.9   Facebook

Facebook had 2.74 billion active users worldwide as of January 2021.[258] The number of Internet users worldwide is currently 4.66 million,[259] and the number of Internet users in China is approximately 988 million as of December 2020.[260] This leaves 3.67 million active Internet users excluding China. With few Facebook users in China (most make use of WeChat), the proportion of non-Chinese Internet users making use of Facebook is approximately 75 per cent (assuming Facebook have already attempted to remove duplicate accounts). This makes Facebook a good proxy to where Internet is available.

Facebook publishes active country-level and regional active accounts in their quarterly reports but do not make any more detailed data available. Facebook collect user location, bandwidth consumed, and devices used to access the Internet for their internal usage and do release some aggregated versions of these data for public-good efforts.

Facebook has created the Facebook Data for Good programme to provide data that can be used for recovery efforts after disasters from natural hazards or man-made causes, for disease prevention during pandemics, and for energy access and economic growth. The programme includes tools from de-identified data on their platform as well as tools they developed using satellite imagery and other publicly available sources. Privacy is protected using techniques such as aggregation and differential privacy.

The following maps and datasets are made available:

- *Population density maps:* A partnership with the Center for International Earth Science Information Network (CIESIN) at Columbia University, using computer vision techniques to identify buildings from publicly accessible mapping services. Maps are available at 30-metre resolution. Maps are available for all African countries apart from South Sudan, Sudan, Somalia, and Ethiopia, which are intentionally omitted.

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[256] *See* World Bank Data Catalog (available at http://datacatalog.worldbank.org/).
[257] *See* World Bank Data Bank (available at http://databank.worldbank.org/data/source/world-development -indicators).
[258] *See* Digital 2021 by DataReportal at page 93 (available at https://datareportal.com/?utm_source=Statista &utm_medium=Data_Citation_Hyperlink&utm_campaign=Data_Partners&utm_content=Statista_Data _Citation).
[259] *See* Digital 2021 at page 1.
[260] *See* Number of Internet users in China from December 2008 to December 2020 (available at https://www .statista.com/statistics/265140/number-of-internet-users-in-china/).

- *Electrical distribution grid maps:* Facebook produced a model to help map global medium-voltage (MV) grid infrastructure, i.e. the distribution lines which connect high-voltage transmission infrastructure to consumer-serving low-voltage distribution. The data found here are model outputs for six select African countries: Malawi, Nigeria, Uganda, Democratic Republic of the Congo, Côte d'Ivoire, and Zambia. The grid maps are produced using a new methodology that employs various publicly available datasets (night-time satellite imagery, roads, political boundaries, etc.) to predict the location of existing MV grid infrastructure. The model documentation and code are also available, so data scientists and planners globally can replicate the model to expand model coverage to other countries where these data are not already available.

- *Movement range maps:* Movement range maps inform researchers and public health experts about how populations are responding to physical distancing measures. These datasets have two different metrics: Change in Movement and Stay Put. The Change in Movement metric looks at how much people are moving around and compares it to a baseline period that predates most social distancing measures. The Stay Put metric looks at the fraction of the population that appears to stay within a small area surrounding their home for an entire day. Public data are available for 14 countries in a visualized format[261] and in CSV format for most countries in the world[262].

- *Disaster maps:* Facebook partners with disaster relief efforts by organizations like UNICEF and the World Food Programme or universities and researchers on a case-by-case basis to show where disaster-affected populations are located, how they are moving, and whether they have access to cellular networks and power. The maps can be generated within 24 hours of a disaster from natural hazards or man-made causes, and are updated daily as the situation on the ground unfolds.

- *Social connectedness index:* The index provides researchers with connectedness scores, but not the number of links between two places or any of the underlying data. The dataset uses sampling, differential privacy noise, and normalization to protect privacy. The data can help in identifying and even potentially predicting infection clusters. They can also help policy-makers understand the extent to which social capital and online interactions between different areas can facilitate social distancing. Data are available between GADM1 (Level 1 of Global Administrative Areas) regions in all countries and between all counties in the United States.

- *Inclusive Internet Index:* This is done in partnership with the EIU and is described in section 2.6.

- *Business Activity Trends:* Business Activity Trends help quantify how businesses are affected by crisis events around the world such as disasters from natural hazards, man-made causes and disease outbreaks. In the COVID-19 context, these trends can be used by economists and other researchers to understand the rate at which businesses remain open or have closed in response to stay at home orders or lockdown. Access is provided on a case-by-case basis.

- Commuting Zones: Facebook Commuting Zones are geographic areas where people live and work. Similar to commuting zones built by the United States Department of Agriculture, Facebook's zones can cross political boundaries and can be useful to understand local economies, determine areas in which people spend most of their time, and demonstrate how diseases might be transmitted. Each Commuting Zone includes its shape, as well as metrics about its economic and commuting characteristics. Access is provided on a case-by-case basis.

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[261] *See* COVID-19 Mobility Data Network (available at https://www.covid19mobility.org/).

[262] *See* Facebook Movement Range Maps (available at https://data.humdata.org/dataset/movement-range -maps).

2.10   Google

Google's search engine market share in 2019 was more than 90 per cent.[263] Given that there were 4.39 billion Internet users in 2019, this amounts to approximately 4 billion users using Google or 52 per cent of the world's population. In 2021, Android's mobile operating system market share is 71.9 per cent. The current number of smartphone users is 3.8 billion[264] and the approximate number of Android users is 2.73 billion, similar to the number of Facebook users. This makes Google and Facebook equally the largest source of qualitative data on Internet usage across the world.

Google does not provide any public datasets related to Internet usage, but they do contribute to several other useful open datasets. During COVID-19, one the most used open Google datasets d was the Community Mobility Report.[265] This aims to provide insights into what has changed in response to policies aimed at combating COVID-19. The reports chart movement trends over time by geography, across different categories of places such as retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential locations. They make use of location data from users' phones when they choose to track their location.

Google also provides a public data explorer[266] that provides public data and forecasts from a range of international organizations and academic institutions including the World Bank, ITU, OECD, and Eurostat. These can be displayed as line graphs, bar graphs, cross sectional plots or on maps.

For planning networks, Google has provided probably the most valuable public resource in the form of Google Earth satellite imagery and Google Street maps.

2.11   Cisco

Cisco has the largest market share in network switches and routers. In the first quarter of 2020, it controlled 51 per cent of the market. Cisco's products and services focus on three market segments—enterprise, service provider, midsize and small business. Cisco provides IT products and services across five major technology areas: networking (including Ethernet, optical, wireless and mobility), security, collaboration (including voice, video, and data), data centre, and the Internet of Things.

Cisco produces an annual Internet report[267] and a Visual Networking Index Forecast[268] with global forecast/analysis that assesses digital transformation across various business segments (enterprise, public sector, commercial/SMB, and service provider). The initial report covers fixed broadband (Ethernet and Wi-Fi) and mobile (3G, 4G, 5G) networking. Quantitative projections are provided on the growth of Internet users, devices, and connections as well as network performance and new application requirements. Qualitative summaries on the impact

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[263] *See* Search engine market share (available at https://gs.statcounter.com/search-engine-market-share).

[264] *See* Number of smartphone users worldwide (available at https://www.statista.com/statistics/330695/number -of-smartphone-users-worldwide/).

[265] *See* Google Community Mobility Reports (available at https://www.google.com/covid19/mobility/).

[266] *See* Google Public Data Explorer (available at https://www.google.com/publicdata/directory).

[267] *See* Cisco Annual Internet Report (available at https://www.cisco.com/c/en/us/solutions/executive -perspectives/annual-internet-report/index.html).

[268] *See* Cisco VNI Forecast Widget (available at https://www.cisco.com/c/dam/m/en_us/solutions/service -provider/vni-forecast-widget/forecast-widget/index.html).

of strategic technology trends (SD-WAN, edge compute, data centre/cloud, AI/ML, IoT, 5G, Wi-Fi, security, etc.) are also included.

The methodology[269] used for these forecasts has been developed based on a combination of analyst projections, in-house estimates and forecasts, and direct data collection. The analyst projections for broadband connections, video subscribers, mobile connections, and Internet application adoption come from SNL Kagan, Ovum, Informa Telecoms & Media, Infonetics, IDC, Gartner, AMI, Verto Analytics, Ookla Speedtest.net, Strategy Analytics, Screen Digest, Dell'Oro Group, Synergy, comScore, Nielsen, Maravedis, Machina Research, ACG Research, ABI Research, Media Partners Asia, IHS, ITU, CTIA, UN, telecommunication regulators, and others. Cisco uses these as a basis for its own estimates for application adoption, minutes of use, and kilobytes per minute. The adoption, usage, and bit-rate assumptions are tied to fundamental enablers such as broadband speed and computing speed. All usage and traffic results are then validated using data shared with Cisco from service providers.

Cisco's current Internet forecast for 2023 is as follows:[270]

- 5.3 billion Internet users (66 per cent of global population), up from 3.9 billion in 2018 (51 per cent of global population).
- 5.6 billion total mobile users (70 per cent of global population), up from 4.9 billion (65 per cent of global population) in 2018.
- 29.3 billion global devices and connections (3.6 devices and connections per capita), up from 18.4 billion devices and connections in 2018 (2.4 devices and connections per capita).
- 45 per cent of all networked devices will be mobile connected globally and 55 per cent will be wired or connected over Wi-Fi.
- Nearly 11 per cent of the global mobile connections will have 5G connectivity.
- The average global fixed broadband speed will be 110.4 Mbit/s, up from 45.9 Mbit/s in 2018, a 2.4-fold growth.
- The average global Wi-Fi speed will be 91.5 Mbit/s, up from 30.3 Mbit/s in 2018, a 3-fold growth.
- The average global mobile (cellular) speed will be 43.9 Mbit/s, up from 13.2 Mbit/s in 2018, a 3.3-fold growth.
- Globally, 5G speeds will reach 574.6 Mbit/s, a factor of 13 increase over the average mobile connection today.
- There will be 299.1 billion global mobile application downloads, up from 194 billion global mobile application downloads in 2018.

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[269] *See* Cisco Visual Network index: Forecast and Methodology, 2016-2021 (available at https://www.reinvention .be/webhdfs/v1/docs/complete-white-paper-c11-481360.pdf).

[270] *See* Cisco Annual Internet Report (2017-2023) FAQ (available at https://www.cisco.com/c/en/us/solutions/ collateral/executive-perspectives/annual-internet-report/q-and-a-c67-482177.html).

Appendix B. ITU telecommunication/ ICT indicators and questionaries

Below is an overview of the questionnaires used for Member States.[271]

Name of question-naire	Short World Telecom-munication/ ICT Indicators (WTI) questionnaire	Long World Telecom-munication/ ICT Indicators (WTI) questionnaire	ICT Price Basket (IPB) Questionnaire	Short Question-naire on ICT Access and Use by Households and Individ-uals	Long Ques-tionnaire on ICT Access and Use by Households and Individ-uals
Addressed to	Government agency in charge of telecommu-nications/ICT (Ministry, regulatory authority)	Government agency in charge of telecommu-nications/ICT (Ministry, regulatory authority)	Government agency in charge of telecommu-nications/ICT (Ministry, regulatory authority)	National Statistical Offices	National Statistical Offices
Format	Online	Online	Online	Online	Excel
Periodicity	Annually	Annually	Annually	Annually	Annually
Collection period	March/April	September	March/April	March/April	September
Number of indicators	14	66	3 main sets of ICT prices (mobile cellular, mobile broadband and fixed broadband)	5	18 core indicators, including many clas-sificatory variables
Data pub-lished	June and December	June and December	June and December	June and December	December
Sample question-naire	Click here (pdf format)	Click here (pdf format)	Click here (pdf format)	Click here (pdf format)	Click here (excel for-mat)
Definition of indicators in 6 languages	Click here (pdf format)	Click here (pdf format)	IPB Rules (pdf format)	Click here	Click here (pdf format)

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[271] *See* ITU data collection and questionnaires (available at https://www.itu.int/en/ITU-D/Statistics/Pages/datacollection/default.aspx).

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