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Development Sector

Armenia: Digital Data, Resilience and Policy Assessment

Connect2Recover

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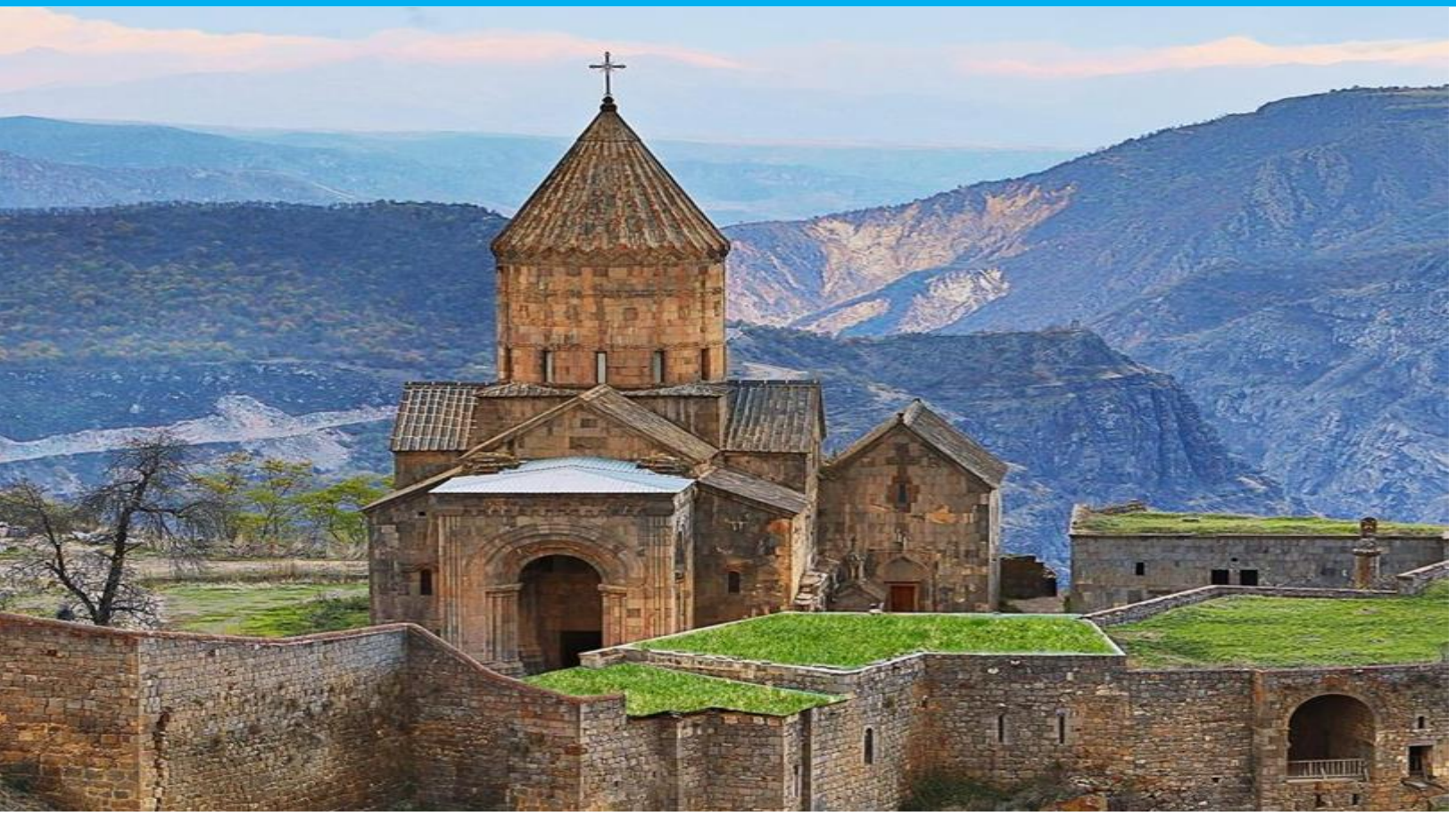

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Abbreviations

ADSL	Asymmetric Digital Subscriber Line
ARMSTAT	Statistical Committee of the Republic of Armenia
ASN	Autonomous System Number
B2B	Business-to-Business
B2C	Business-to-Consumer
B2G	Business-to-Government
B2O	Business-to-Owner
BDT	Telecommunication Development Bureau
CDMA	Code-Division Multiple Access
CEPA	European Union-Armenia Comprehensive and Enhanced Partnership Agreement
CERT	Computer Emergency Response Team
DCA	Digitalisation Council of Armenia
DDOS	Distributed Denial-of-Service
DNSSEC	Domain Name System Security Extensions
DOCSIS	Data Over Cable Service Interface Specification
DSL	Digital Subscriber Line
DSM	Digital Single Market
EaP	Eastern Partnership
EECC	European Electronic Communications Code
EIU	Economist Intelligence Unit
EU	European Union
E3	E carrier link with data rate of 34.368 Mbps
FTTB	Fibre to the Building
FWA	Fixed Wireless Access
GDP	Gross Domestic Product
GNI	Gross National Income
GoRA	Government of the Republic of Armenia (for the purpose of this report GoRA refers to all relevant decision-making bodies)
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSR	Global Symposium for Regulators
HHI	Herfindahl-Hirschman Index
HTI	High-Tech Industry
ICT	Information and Communications Technology
IMT	International Mobile Telecommunications
ISOC	Internet Society

ISP	Internet Service Provider
ITU	International Telecommunication Union
IXP	Internet eXchange Point
LTE	Long-Term Evolution
M2M	Machine to Machine
MCI	Mobile Connectivity Index
MHTI	Ministry of High-Tech Industry of the Republic of Armenia
MOOC	Massive Open Online Courses
MPLS	Multiprotocol Label Switching
NBP	National Broadband Plan
NGO	Non-Governmental Organization
PSRC	Public Services Regulatory Commission of the Republic of Armenia
SIM	Subscriber Identity Module
STM-1	Synchronous Transport Module level-1
TLD	Top-Level Domain
UMT	Universal Mobile Telecommunications System
USB	Universal Serial Bus
VDSL	Very high-speed Digital Subscriber Line

I. Executive Summary

This is a phase two and three report prepared for the Government of the Republic of Armenia (Government or GoRA) under the International Telecommunication Union (ITU) Connect2Recover initiative, which supports countries in their efforts to identify 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. Phase one of the Connect2Recover initiative comprised a report with several key findings and recommendations on data sources, resilience, and policy and regulations, that will enable countries to recover from the COVID-19 pandemic, be ready for the new normal, and be better prepared to future pandemics.

Leveraging the Connect2Recover phase one framework, this report is an assessment of Armenia's fixed and mobile broadband connectivity data, network resiliency, and digital strategies and plans. Based on the phase two landscape assessment, this report also makes Connect2Recover phase three data, resiliency, and policy recommendations that can be used by the GoRA in support of its Digitalisation Strategy and development and implementation of its proposed National Strategy for Broadband Communication.[1] The GoRA can use this report to develop, update, and effectively implement comprehensive information and communications technology (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 the ITU and other relevant organizations. This report was made possible with extensive cooperation and collaboration of the Ministry of High-Tech Industry of the Republic of Armenia (MHTI or Ministry), the Public Service Regulatory Commission (PSRC) of the Republic of Armenia, and the Union of Operators of Armenia.

A. Fixed and Mobile Connectivity Data

High-quality data is key to having an accurate picture of fixed and mobile broadband availability, adoption, and usage, and is the basis for data-driven policymaking. Based on a review of available data, the following observations can be made about available fixed and mobile broadband data in Armenia: (1) Available data on fixed broadband availability is too old to be relied upon; (2) There is no reliable public information on international gateways; (3) Available data on adoption and usage of fixed and mobile broadband and devices is available only at the country-level, undermining efforts to target programmes where needed; (4) Coverage reports from operators lack a consistent format and do not differentiate between technologies and speed tiers; and (5) Fixed and mobile broadband availability maps are available only at the settlement level and do not provide information on where service is available within the settlement. The GoRA might like to consider implementing annual data collections from network operators focusing on the availability and adoption of fixed and mobile broadband at a sufficient level of granularity, revealing speed tiers, by technology and by location (*i.e.*, the smallest census level).

In Armenia, 4G mobile coverage has now reached most of the population of the country. Likewise, fixed broadband appears to also be available across the country. However, it is not clear what mobile and fixed broadband speed tiers are actually available to customers in Armenia. In addition, it is not clear

[1] Digitalisation Strategy of Armenia 2021-2025, Annex No 1 to Decision of the Government of the Republic of Armenia, No 183-L of 11 February 2021 (available at https://www.arlis.am/).

whether fixed and/or mobile broadband is available to all consumers within a rural/urban settlement marked by the operator as covered (by indicating 'yes' or a '+' mark). In Armenia, broadband adoption rates are lower for consumers in lower income brackets and those located in rural areas. Armenia has low adoption rates for faster broadband, such as that exceeding 100 Mbps. Entry level mobile broadband is affordable for the average Armenian, but fixed broadband is still unaffordable for the average Armenian. Neither mobile nor fixed broadband is affordable for the bottom 20% of Armenian wage earners.

B. Country-Level Resilience

The Connect2Recover phase one report described three aspects of country-level resilience: (1) Critical infrastructure reliance, (2) Market resilience, and (3) Network/ISP resilience. Fixed and mobile broadband networks have proven resilient where they exist, but there have been problems in some markets, such as those lacking the basic infrastructure of the Internet such as Internet exchange points, direct access to submarine cables, and international terrestrial transmission networks.

Overall, Armenia's network proved resilient during COVID-19 with only small reductions in fixed and mobile performance in Q1 and Q4 2020. Armenia scores relatively well on critical infrastructure; however, additional investment in international gateways and Internet exchange points would further strengthen Armenia's position. In addition, Armenia might like to consider allocating more spectrum for fixed and mobile services.

In terms of network and ISP resilience, Armenia's mobile network performed above its regional peers and its fixed network is improving steadily. Armenia was repeatedly targeted by cyber-attacks in 2020, often defacing Armenian government websites or obtaining citizens' private data.[2] Increasing the level of security of Armenian Internet infrastructure could prevent these attacks by, for example, ensuring that more of its Internet servers are secure. Armenia, however, did perform well in adopting secure DNS (DNSSEC) to prevent DNS cache poisoning.

Armenia shows both positive and negative signs of market resilience. Armenia's level of market concentration appears low for fixed line broadband but is high for mobile broadband. Armenia has a high level of spectrum concentration as well as mobile broadband coverage density. Armenia would benefit from more detailed and granular (below the settlement level) data on fixed broadband availability. Mobile broadband is affordable for all but the bottom 20% of Armenian wage earners, whereas fixed line broadband is unaffordable for the average Armenian and is especially unaffordable for the bottom 20% of wage earners. Fixed line connectivity could be made more affordable by further facilitating investment in last mile fibre access, as well as other fixed line technologies, and ensuring that more fixed and mobile last mile providers have access to affordable high-capacity wholesale fibre-based backhaul, as well as allocating more licensed and license-exempt spectrum for use by fixed wireless Internet service providers (ISPs).

[2] See The Cyber Battlefield is Just as Important: Armenia's Cybersecurity (available at https://www.evnreport.com/magazine-issues/the-cyber- battlefield-is-just-as-important-armenia-s-cybersecurity).

C. Policy and Regulation

The Ministry and the PSRC demonstrate many of the characteristics of good governance with an independent regulatory authority, ethics rules in place, open and transparent policy and regulatory practices, and extensive intra-government collaboration. The GoRA has progressive competition policies. In response to its ITU regulatory survey, the GoRA reports that all fixed and mobile network operators are privately owned, there is no dominant provider in the market for fixed or mobile broadband services, and there are no limits on foreign investment.

While a Government Digitalisation Strategy is in place, there is no National Broadband Plan or Strategy in place. The Government adopted a Digitalisation Strategy for 2021-2025 and is considering adoption of a National Strategy for Broadband Communication as a fundamental condition for implementation thereof. This Strategy could serve as the Government's blueprint for increasing digital equality, setting forth multiyear goals for fixed and mobile broadband access, adoption, and utilization and ensuring that the Government and other stakeholders are held accountable for meeting those goals. By increasing regulatory certainty and reducing risk, a National Strategy for Broadband Communication can also serve to attract additional investment in Armenia's ICT sector.

The GoRA is encouraged to develop and implement a National Strategy for Broadband Communication (hereinafter: national broadband strategy) that is aligned with the Connect2Recover framework, which can help the GoRA further goals spelled out in its Digitalisation Strategy, namely: (1) Ensuring a high quality of public service delivery; (2) Efficiency and transparency of the public administration system; (3) Development of broadband and telecommunication infrastructure; (4) Increasing the competitiveness of the private sector; (5) Decision-making necessary for economic growth; and (6) Development of digital skills for the workforce.

Within the Connect2Recover framework, the GoRA could focus policy and regulatory efforts on closing the urban-rural divide and extending high-speed fixed and mobile broadband to all of Armenia's citizens. As suggested in the ITU's Connect2Recover phase one report, fixed and mobile broadband definitions and policies should be aggressive but achievable and based on the connectivity goals the GoRA wants to achieve for all of its citizens. In addition to referencing fixed and mobile broadband definitions and policies developed by the ITU and other organizations, the GoRA could look to other upper middle income countries for guidance on broadband definitions and policies. Further, the GoRA could set affordability targets for the average Armenian income earner, as well as for the lowest 20 per cent or 40 per cent of income earners.

While fibre middle mile and last mile connectivity is available in Yerevan and other population centres, fibre middle mile and last mile connectivity is not present in many small markets and rural areas. Lack of fibre backhaul adversely impacts the ability of service providers to extend high-speed fixed broadband into underserved and unserved communities and deploy next generation 5G mobile broadband to these communities. The GoRA might consider supporting efforts to deploy middle mile and last mile fibre infrastructure to all settlements and to all premises. Further, the GoRA might consider supporting efforts to extend fibreoptic last mile infrastructure to all anchor institutions, such as schools, libraries, hospitals, police stations, and government offices. As noted in the Connect2Recover phase one report, governments can take steps to improve the commercial viability of deployments in small markets and rural areas by, 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.

The GoRA might also consider efforts to stimulate demand for fixed and mobile broadband services and applications among households and small businesses, as well as by anchor institutions and vulnerable groups. The GoRA is encouraged to consider programmes ensuring that low-cost fixed and mobile broadband services and devices are affordable to low-income individuals and households. In addition to other steps the GoRA is already taking, it might consider enabling discounted fixed broadband services for anchor institutions and vulnerable groups, such as persons with disabilities. We also encourage the GoRA to implement targets and plans for both basic and advanced digital skills programming, as well as to develop locally relevant applications and content.

II. Introduction

In May 2021, following an ITU Broadband Week event in Armenia, a series of on-site interviews were conducted with different Armenian stakeholders, which included mobile and fixed network operators – Viva-MTS, UCOM, and Rostelecom Armenia – and the State nontrade organization National Centre for Educational Technology to receive their feedback on Armenia's resilience during lockdowns caused by the COVID-19 pandemic. This marked the starting point for further research under the ITU's Connect2Recover initiative which culminated in this study. Cooperation and collaboration of the Ministry of High-Tech Industry of the Republic of Armenia (MHTI or Ministry), the Public Service Regulatory Commission of the Republic of Armenia (PSRC), the Director of the Union of Operators of Armenia, as well as the Statistical Committee of the Republic of Armenia (ARMSTAT), ISPs, the Internet Society of Armenia and the Armenian Internet Traffic Exchange Fund (ARMIX) led to the collection of an extensive amount of data, that were analysed in order to provide an impartial overview of Armenia's Internet resilience, policies and regulation and to provide recommendations on how Armenia could be better prepared and resilient to similar pandemics or other disasters caused by natural hazards or manmade in the future.

The ITU's Connect2Recover initiative supports countries in their efforts to identify 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. This includes recovery following the pandemic, readiness for the "new normal", and preparedness for any future pandemics. The Connect2Recover initiative was launched with the support of the Governments of Japan and the Kingdom of Saudi Arabia, with several more governments and other sponsors now involved.

In October 2021, the ITU published a report entitled *Connect2Recover: A methodology for identifying connectivity gaps and strengthening resilience in the new normal*, which serves as phase one of the Connect2Recover initiative.[3] The Connect2Recover phase one report includes several key findings regarding data sources, resilience, and policy and regulations. As detailed in the report, 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.

[3] See International Telecommunication Union, Connect2Recover: A methodology for identifying connectivity gaps and strengthening resilience in the new normal, October 2021 (available at https://www.itu.int/en/myitu/Publications/2021/08/10/15/06/Connect2Recover-A-methodology-for-identifying-connectivity-gaps-and-strengthening-resilience) (Connect2Recover phase one report).

The Connect2Recover initiative'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. For example, the Connect2Recover initiative can support Project Giga's efforts to map connectivity demand, identify connectivity gaps and leverage 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.[4]

In the Connect2Recover phase one report, the ITU noted that 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 policymaking; however, the available data on broadband are patchy, and tend to be particularly incomplete in rural and unserved communities where needed most. 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.

Broadband definitions are critical to ensure that targets move in step with trends of increasingly media-rich content on the Internet. Broadband access at home should be treated as a public good similar to electricity, water and sanitation. 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 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.

The Connect2Recover phase one report found that fixed and mobile broadband networks have proven resilient where they exist, but there have been 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 that resilience should be viewed more broadly to address fixed and mobile broadband gaps. 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.

Recovering from COVID-19 and preparing for what is next requires a truly holistic and collaborative approach, aligned with the Global Symposium for Regulators (GSR) Best Practice Guidelines. To that end, the ITU is 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 from natural hazards or man-made causes occur. In the Connect2Recover phase one report, the ITU detailed 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);

[4] 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/.

(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.

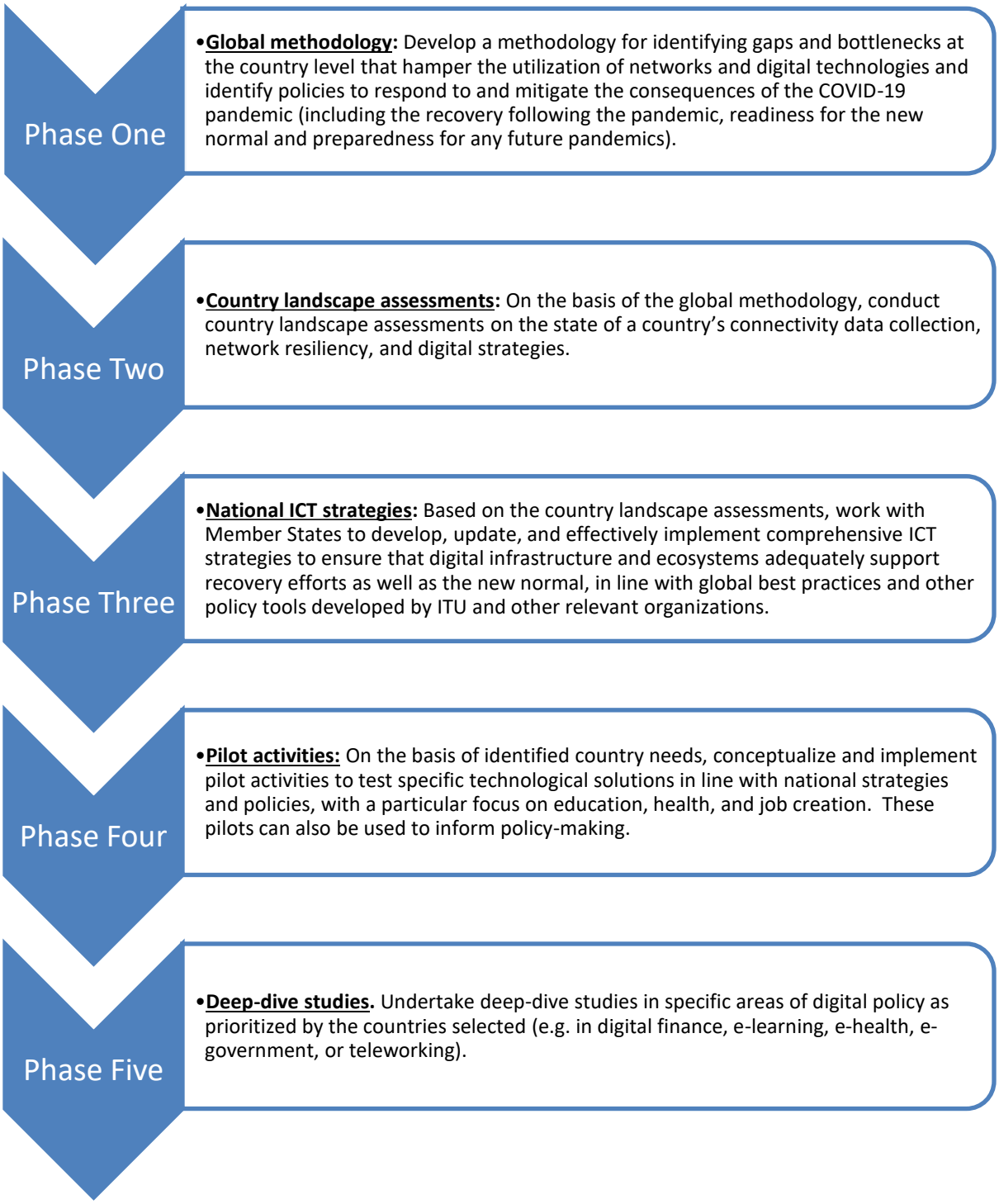

Figure 1: Five-phase methodology of Connect2Recover

Based on the request of the GoRA, this report is dedicated to a Connect2Recover phase two landscape assessment of Armenia's connectivity data collection, network and other forms of resiliency, and national digital strategy, as well as phase three recommendations in line with the schema below:

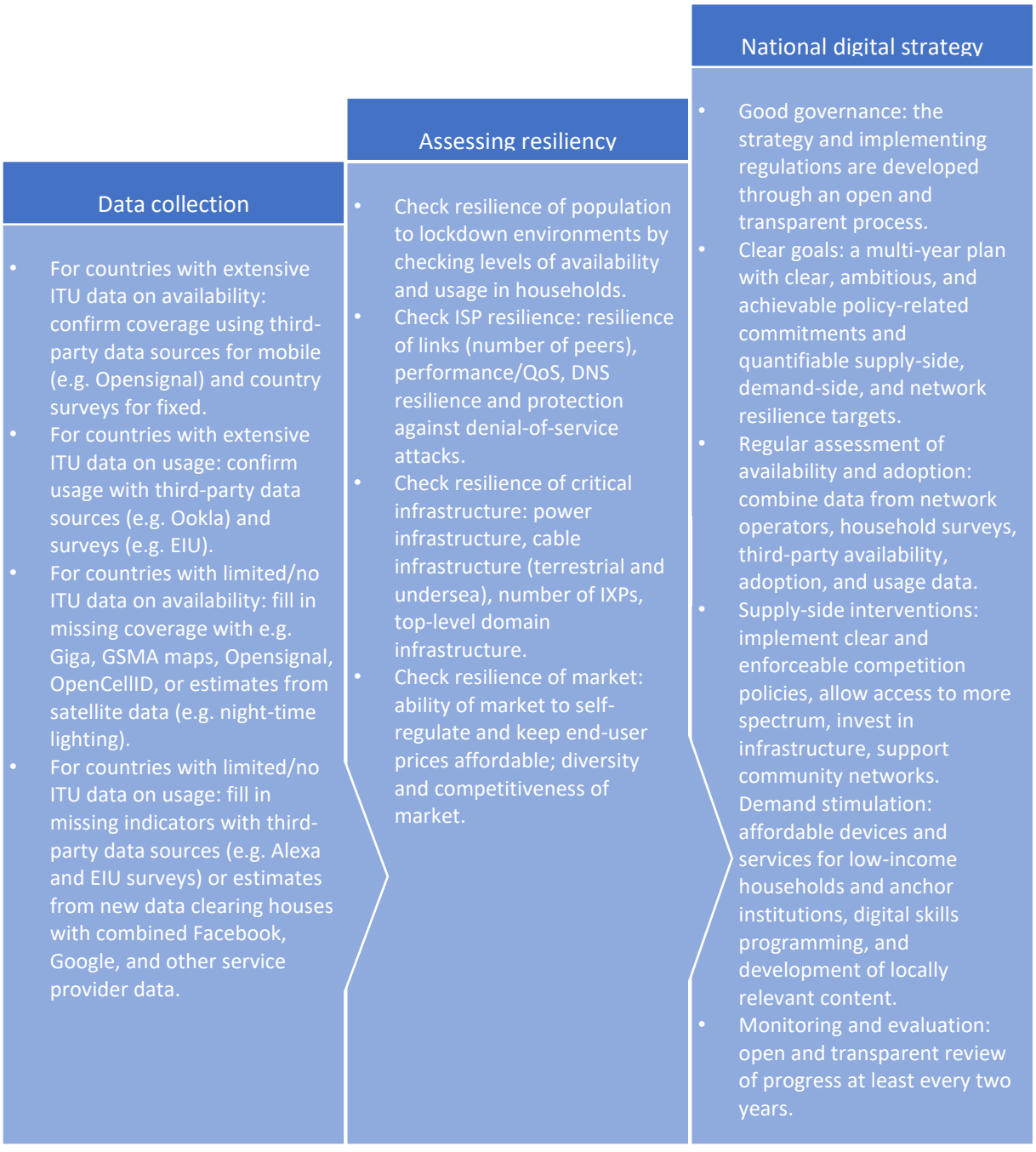

Figure 2: Methodology: phase 2 and phase 3 of Connect2Recover

III. Background on Armenia

A. Country Overview

Armenia is a landlocked country of 29,743 square kilometres located in the Caucasus region. It is bordered by Georgia to the north, Azerbaijan to the east, Iran to the south, and Turkey to the west. Armenia's borders with Turkey and Azerbaijan have been closed since the 1990s due to the Nagorno-Karabakh conflict. Automobile roadways and railways via Georgia and Iran are the principal land routes to and from the country.

Armenia's geography consists of a mix of highlands, plateaus, and hollows with most of the country being mountainous. 70% of the country's total area is situated at an altitude between 1,600 and 3,000 meters above sea level, and only 0.3% do not exceed 500 meters.[5]

Armenia is rich in mineral resources such as iron, copper, molybdenum, lead, zinc, gold, silver, antimony, and aluminium, as well as other scarce and hard-to-find metals. Iron and copper ore, especially, are exported in significant volume.

[5] See Country Report to the FAO International Technical Conference on Plant Genetic Resources by Ministry of Agriculture of the Republic of Armenia at pg. 4 (available at https://www.fao.org/fileadmin/templates/agphome/documents/PGR/SoW1/Europe/ARMENIA.pdf).

Figure 3: Map of Armenia[6]

Armenia also possesses some of the world's most diverse non-metallic minerals, including almost all types of mineral rocks. Armenia is rich in mineral water as well.

Armenia has a high human development index (ranked 81 in 2019) that has been continuously increasing since its independence.[7] It has a total population of 2.96 million people (64% urban and 36% rural) and a population density of 100 people per square kilometre. The majority of the population in both urban and rural settlements are people of working age. There is no big divide in terms of the proportion of older persons living in urban and rural settlements (16% and 12% accordingly).[8]

After the attainment of independence in 1991, following the disintegration of the Soviet Union, Armenia inherited an economy in a state of collapse. Economic and social problems were further aggravated following the 1988 earthquake and the economic blockade which began as a consequence of the conflict in Nagorno-Karabakh. The Government's efforts to remedy the situation were mostly focused on investing in human capital; comprising targeted assistance to the most vulnerable groups, ensuring access to employment and the means of production and strengthening of enterprises engaged in

[6] See Armenia (available at: https://www.un.org/geospatial/content/armenia).

[7] See Armenia. Human Development Indicators (available at http://www.hdr.undp.org/en/countries/profiles/ARM).

[8] See Statistical yearbook of Armenia – 2020 (available at: https://armstat.am/en/?nid=586&year=2020).

poverty elimination policies and programmes.[9] These policies and programmes gradually stabilized the economy and resulted in steady economic growth and transitioned Armenia from a low-income country in 1993 to lower-middle-income-country in 2003. In 2003 Armenia joined the World Trade Organization.

Further structural economic reforms, new emerging sectors of the economy, including information and communications technology (ICT), increased support from international institutions and inflow of foreign direct investments, which resulted in Armenia transitioning to an upper-middle-income-country in 2018. However, poverty in the country remains high (44% in 2019)[10] with high levels of unemployment (18.3% in 2019)[11] being a major contributing factor.

Due to the lack of job opportunities in domestic markets many Armenians are seeking job opportunities abroad, particularly in the Russian Federation. Total personal transfers from abroad amounted to 1.5 billion USD, equivalent to 10.9 per cent of Armenia's GDP, in 2019. Remittances by Armenian workers temporarily abroad accounted for more than half of these transfers, with much of the rest stemming from the large permanent Armenian diaspora abroad.[12]

B. Development of Telecommunications Market in Armenia

Armenia has a burgeoning ICT sector, which is one of the fastest growing in the country. The main sectoral law regulating telecommunications in Armenia is the **Law on Electronic Communication** enacted in 2005 (the latest amendments were introduced in 2021). The Law defines the basic concepts, sets out the general principles of regulation, the rights and obligations of the actors of the telecommunications market, as well as the regulatory objectives, the principles and rules of licensing, the basic rules of interconnection of networks, traffic exchange, and allocation of limited resources, including radio-frequency range, numbers and segments of satellite orbits.

[9] See Information provided by the Government of Republic of Armenia to the UN Commission on Sustainable Development (available at https://www.un.org/esa/earthsummit/armen-cp.htm#chap3).

[10] See Poverty headcount ratio at $5.50 a day (2011 PPP) (% of population) (available at https://data.worldbank.org/indicator/SI.POV.UMIC?locations=AM.%20For%20upper-middle-income%20countries%20relative%20poverty%20line%20is%20set%20by%20the%20World%20bank%20at%20$5.50%20a%20day%20to%20correspond%20an%20income%20level.%20International%20Poverty%20Line%20is%20set%20at%20$1.90%20a%20day%20and%20continue%20to%20represent%20extreme%20poverty.-AM).

[11] See Statistical yearbook of Armenia – 2020 (available at https://armstat.am/en/?nid=586&year=2020). According to ILO estimates, unemployment rate exceeded 20%.

[12] See Rapid Assessment of the Employment Impact and Policy Responses of the COVID-19 Pandemic on Armenia at pg. 13 (available at https://www.ilo.org/wcmsp5/groups/public/---europe/---ro-geneva/---sro-moscow/documents/publication/wcms_762029.pdf).

In addition, the following legal acts govern the telecommunications, information, communications, and broadcasting sectors in Armenia:[13]

- Law on Public Services Regulatory Authority (2003) - the legal act specifies procedure for the establishment of the regulatory body for public services and its operation.
- Law on Television and Radio (2000) - primary legal act governing the TV and radio broadcasting sector.
- Law on Licensing (2005) - primary legal act governing the licensing procedures across all sectors, including telecommunications.
- Law on Protection of Economic Competition (2000) - the legal act specified competition policy across all sectors, including telecommunications.
- Law on Electronic Document and Electronic Digital Signature (2004) - the legal act establishes legal framework that recognizes electronic documents and electronic digital signatures.
- Law on Personal Data Protection (2015) - the legal act establishes legal framework for the protection of personal data.

On the institutional level, the responsibilities of the respective bodies are distributed as follows:

- **Ministry of High-Tech Industry** (MHTI) represents the line ministry and policy maker for the electronic communications sector. It is a central body of executive authority that develops and implements the Government's policy in the spheres of communication, information, information technology and information security, postal services, licensing, granting of permits and military industry. The MHTI is responsible for information technology, Internet content, spectrum allocations and monitoring, technical standards setting, and formulation of universal service/access policy goals.

- **Public Services Regulatory Commission** (PSRC) is the multi sector independent regulatory authority. Its regulatory scope includes electronic communications and broadband. The PSRC has jurisdiction over quality of service, interconnection rates, licensing, numbering, price regulation, and spectrum assignments. The PSRC shares jurisdiction with both the MHTI and state entities over consumer protection, cybersecurity, and privacy and data protection. In cases provided by the law, PSRC has an obligation to coordinate with the competition authority of Armenia. PSRC is an independent body with an independent budget, financed by regulatory fees.

- **Digitalisation Council of Armenia** (DCA, created in 2019) is a deliberative body under the auspices of the Deputy Prime Minister's Office, which is responsible for economic development and serves as the Government's Chief Information Coordinator. The DCA is chaired by the Deputy Prime Minister and is composed, among others, of the Chief of Staff of the Prime Minister's Administration, the Minister of High-Tech Industry, the Minister of Economy and other officials.

[13] Information provided by the Government of Republic of Armenia in its 2020 ITU Regulatory Survey response.

In addition to these organizations, which have a direct role to play in the broadband market, other government organizations play a supporting role. These include the Ministry of Territorial Administration and Infrastructure (especially in terms of network construction), the Ministry of Justice (with an extensive role in public service delivery), and the Ministry of Economy, among others.

In 2008, the Armenian government adopted the ICT Sector Development Concept Paper (focused, inter alia, on development of a national ICT broadband backbone network and promotion of school connectivity), followed by the e-Society development action plan for 2010-2012 and the e-Governance Strategic Programme for 2014-2018.

The current development approach is articulated in the **Digitalisation Strategy for 2021 - 2025** adopted in February 2021. The strategy envisages digital transformation through the introduction and development of innovative technologies, cyber security, data policy and e-services, as well as e-government systems, coordination of digitalisation processes, creation of common standards and digital environment, as well as initiatives promoting the use of digital technologies in the private sector of the economy and the development and implementation of programmes promoting the use of electronic tools by the public. The strategy is aimed at ensuring a high quality of public service delivery, efficiency and transparency of the public administration system, development of broadband and telecommunication infrastructure, increasing the competitiveness of the private sector, decision-making necessary for economic growth, and development of digital skills for the workforce.

A **National Strategy for Broadband Communication** is currently being developed as part of the Digitalisation Strategy implementation.

Armenia is connected to the Trans-Asia-Europe fibre-optic cable via Georgia. Additional international service is available by microwave radio relay and landline connections to other countries of the Commonwealth of Independent States, the Moscow international switch, and by satellite. The main network backbones of Armenian are built using E3 or STM-1 lines and via microwave links across the whole country with many passive retranslations.

General telecommunications services in Armenia, including satellite connections, mobile telephony services and Internet connectivity for many years were solely provided by the Armenia Telephone Company (ArmenTel),[14] which was initially state owned. In 1995, ArmenTel was privatized and re-sold several times. Moreover, in 1997 it was given 15-year monopoly rights on domestic and international telecommunications services in the country (until the end of 2012). However, the PSRC liberalized the telecommunication sector in October 2007 and other operators were allowed to compete in the market. According to the PSRC's decision, ArmenTel had relinquished the monopoly on all telecommunication and telephone services, including satellite services, voice via the Internet (IP telephony) and video transmission services.[15] In 2007, ArmenTel was re-sold again and is now wholly owned by VimpelCom Ltd., a Russian-Norwegian company. "Telecom Armenia" CJSC (formerly ArmenTel) currently operates under the Beeline brand. Currently, there are 183 internet service providers (ISPs) in Armenia, including

[14] Referenced as a historically dominating operator in the Law on Electronic Communications.

[15] See «АрменТел» лишен монополии в сфере международной передачи данных и международной звуковой связи (available at https://newsarmenia.am/news/politics/arm1-20061218-41620130/).

mobile network operator MTS Armenia CJSC (Viva-MTS), two mobile and fixed network operators ("Telecom Armenia" CJSC (Beeline) and UCOM CJSC) and fixed network operator – GNC-ALFA CJSC (Rostelecom Armenia). These operators control 95% of the broadband market in Armenia. Market share breakdown by operator and by technology is presented below.[16]

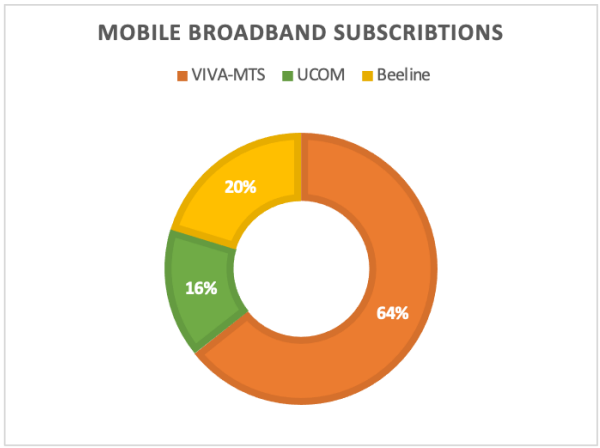

Figure 4: Mobile broadband subscriptions

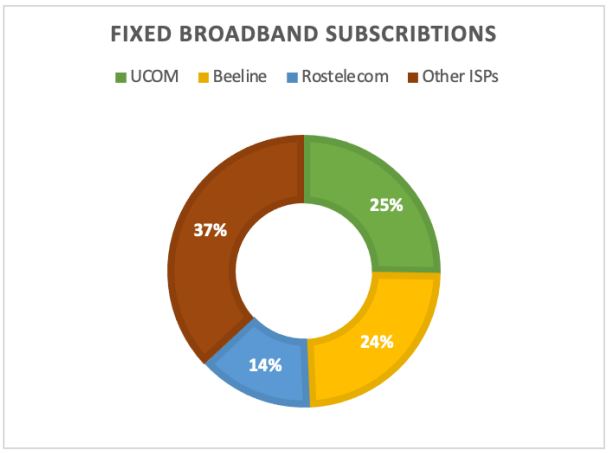

Figure 5: Fixed broadband subscriptions

Three mobile operators together cover 100% of Armenia's urban and rural settlements. 59% out of 1002 settlements have mobile broadband coverage (3G, 4G+/LTE-A) of all three operators. However, when it comes to 4G+/LTE-A, only 64 settlements (or 6.4%) are covered by all three mobile network operators. These are mostly cities with 62% of the total population.[17] In terms of provision of mobile communication, Viva-MTS plays a leading role with over 2 million subscribers and has 64% of the market. The second largest mobile operator is Beeline with 20% of the market share and approximately

[16] Estimations are made based on the data provided by the PSRC and quarterly reports of the operators.

[17] Statistics provided by the PSRC.

900,000 subscribers. UCOM ends the list with about 600,000 subscribers.[18] Performance of these operators is monitored by the PSRC and a quarterly report is posted on each operator's website. The three operators offer voice and data services (including LTE and LTE+). 5G mobile infrastructure has not yet been launched in Armenia.

According to the PSRC, 570 settlements (56.9%) are connected to broadband middle mile, out of which 513 settlements (or 51.2%) are connected to fibre-optic networks based on FTTx technology. The number of subscribers of fixed broadband Internet services amounted to about 430,000 (2020) or 14.5% of the population (approximately 52.27% of households).[19] Through the largest fixed broadband network operator (fibre-optic networks), Rostelecom, Armenia has 92% coverage of the territory for Business to Business (B2B), Business to Office (B2O), Business to Government (B2G) services based on MPLS network access, and Business to Consumer (B2C) coverage with Fibre-to-the-Home (FTTH) access network is available only in 19 cities.[20]

Cybersecurity remains an issue in Armenia, which is ranked 90th (2021) in ITU Global Cybersecurity Index.[21] In 2020, Armenia experienced a series of massive cyber-attacks (phishing, spear-phishing, attacks using email, social messengers and networks, DDoS attacks, website defacements, and hacks). Personal data of thousands of Armenian citizens, data and documents of the Armenian government institutions and electronic systems, including the electronic document management system used for interagency communication within the Armenian government, were made publicly available, and many government websites were defaced, breached or taken offline for extended periods of time.[22] This highlights the importance of strengthening the capacity of the Armenian national Computer Emergency Response Team (CERT) to prevent, stop, and address incidents and to strengthen national legislation on cybersecurity.

Armenia's open data policy is closely connected with the country's participation in the Open Governance Partnership – the initiative which aims to make the system of governance transparent, accountable, innovative, and participatory. Since 2011, Armenia implemented four national action plans that covered social, legal, financial, community, mining, and other sectors of the economy. Namely, action plans contain Armenia's commitment to digitalize various governmental databases, create e-government with such elements as e-documentation and e-statistics, standardization of official websites' content, as well as to make declarations, budget formation, and the procurement process transparent and publicly available.[23] To date, these action plans do not contain any commitments directly related to ICT sector development. Though ICT statistics and data on Internet penetration in

[18] Estimations are made based on the data provided by the PSRC and quarterly reports of the operators.

[19] Estimates are made based on the PSRC statistics.

[20] Data provided by Rostelecom Armenia.

[21] See ITU Global Cybersecurity Index (available at https://www.itu.int/epublications/publication/global-cybersecurity-index-2020/en/). Armenia was ranked on the basis of the 3rd party information as no response to the questionnaire was provided by the national authorities.

[22] See The Cyber Battlefield is Just as Important: Armenia's Cybersecurity (available at https://www.evnreport.com/magazine-issues/the-cyber-battlefield-is-just-as-important-armenia-s-cybersecurity)

[23] See Open Government Partnership: Armenia action plans (available at https://www.ogp.am/en/plan/).

Armenia are accessible through PSRC and ISPs' websites, important elements of open data in the ICT sector are missing. Those include, but are not limited to, broadband infrastructure maps, detailed interactive combined maps on availability of different Internet services per settlement, operators' statistics on ICT adoption, and usage. In this sense, a National Strategy for Broadband Communication, which is currently being developed, may be a good starting point for introducing an open data policy into the ICT sector.

C. Impact of COVID-19 Pandemic

Before the COVID-19 pandemic, Armenia's annual economic growth was strong, averaging 6.8% during 2017 – 2019. Economic progress was derailed in 2020. Armenia suffered a severe COVID-19 outbreak, with a surge in the first quarter of 2021, ranking 33rd globally in recorded cases per million population.[24] The state of emergency, restrictions on the freedom of movement, and close-down of public transport, shops, restaurants etc. introduced in late March 2020 had an immediate and direct impact on the sectors affected. Meanwhile, the conflict with Azerbaijan escalated to a heavy military confrontation at the end of September 2020. These twin shocks led to a sharp economic contraction and increased poverty, especially among the urban populations.

Armenia's economy contracted by 7.4% in 2020. Services - trade and the hospitality sector - were most affected, contracting by 10% year-on-year. Inflation remained subdued through most of 2020 but accelerated in December and reached 5.3% in February 2021. The government's budget deficit widened sharply to 5.1% of GDP in 2020 (from 0.8% in 2019), driven by increased spending associated with the government's pandemic response, higher military spending, and depressed tax revenues.[25]

The pandemic's impact on vulnerable households was only partially mitigated by the government's COVID-19 response. According to World Bank estimations, the poverty rate (measured at the upper-middle-income economy poverty line) jumped to over 51% in 2020.[26] On 25 June 2020, the Prime Minister of Armenia announced that 70,000 employees would lose their jobs (mainly from lockdowns in a number of economic sectors) during the period from March to May; that is 11.5% of all employees who lost their jobs. During May 2020, at least 50,000 of these former employees were reinstated.[27]

Due to the coronavirus outbreak, all educational institutions in Armenia were asked in early March to switch to distance learning to ensure the continuity of studies. The solutions introduced by schools and universities were a mixture of online, remote, distance, and digital learning modes, such as by organizing lessons broadcast via a new educational TV channel called 'Hybrid Edu'; using tools like Zoom, Moodle, Blackboard, Google Hangouts and WhatsApp; and integrating materials from MOOCs via Coursera. All

[24] See SDG Investor Platform. Armenia (available at https://sdginvestorplatform.undp.org/country/armenia).

[25] See World Bank in Armenia. Country context (available at https://www.worldbank.org/en/country/armenia/overview#1.).

[26] See World Bank in Armenia. Overview (available at https://www.worldbank.org/en/country/armenia/overview#3.)

[27] See Rapid Assessment of the Employment Impact and Policy Responses of the COVID-19 Pandemic on Armenia (available at https://www.ilo.org/wcmsp5/groups/public/---europe/---ro-geneva/---sro-moscow/documents/publication/wcms_762029.pdf.)

measures taken were temporary solutions geared towards short-term results. The pandemic strengthened the demand for development of a quality distance learning culture.

In response to COVID-19, the Armenian Government took several measures to mitigate economic risks and social impact, and to ensure post-pandemic recovery. Some examples of measures taken were: exemption of advance tax payments for the second quarter of 2020; reduction of penalties for non-payment of customs duties; refinancing and subsidized loans for micro, small, and medium enterprises; lump-sum allowances for employees and sole proprietors engaged in highly affected sectors; one-time grants for high-tech companies; targeted assistance to families with children, individuals who lost jobs, and pregnant women; subsidized natural gas and electricity bills for households; and student tuition fees reimbursement.[28]

Support to Armenian healthcare was provided by the Armenians leaving abroad. A series of online meetings were organized among diaspora medical professionals and their Armenian colleagues to exchange expertise in treating COVID-19 patients, on recent trends in the COVID-19 pandemic and efficient modes of treatment.[29]

Despite the variety of measures taken by the GoRA, only one submission was received from Armenia to the ITU's REG4COVID Platform on the measures taken to mitigate the impact of the pandemics. Namely, Beeline introduced free calls to the hotline of the Ministry of Health and delayed payments to postpaid subscribers. The ITU's REG4COVID platform gathers policy and regulatory best practices to improve COVID-19 responses through information and communications technologies (ICTs).[30] This site gathers and shares information on steps that governments, network operators and other digital services providers, as well as civil society, have taken to respond to the COVID-19 pandemic. Organizations in Armenia are encouraged to submit information on steps they have taken to address challenges that have emerged during the COVID-19 pandemic.

IV. Data Collection and Validation

Key recommendations

- Create **up-to-date fibre maps** annually for all operators and provide these to the ITU
- Improve quarterly reports published by operators
    - Provide **population coverage** (as percentage) at the **smallest census level**
    - Provide **speed tiers** available with **total number of subscribers** in each tier at the smallest census level

[28] See Programs to address the economic impact of COVID-19 (available at https://www.gov.am/en/covid19./) and Programs to address the social impact of COVID-19 (available at https://www.gov.am/en/covid-19-cragrer./).

[29] See Armenian diaspora supports to COVID-19 response (available at https://sdgs.un.org/partnerships/armenian-diaspora-supports-covid-19-response).

[30] See ITU REG4COVID Platform (available at https://reg4covid.itu.int/.)

- Provide **downloadable coverage maps** to facilitate attraction of investments and the ability of third parties or consultants to carry out broadband gap analysis
- Improve data on **anchor locations** by providing the **location and speed tier subscription** for each anchor location. Supplement this data with **ongoing monitoring** to measure true speed performance at each location.

In order to collect data required to understand the level of broadband access, the process as per the Connect2Recover methodology report was adopted. The set of available ITU data on the broadband coverage, availability and capacity, adoption and usage, as well as any data on community anchor locations or historically vulnerable groups was first consulted. This data was then checked for completeness and complemented with a mix of data from the GoRA, operators, and the regulator, as well as other 3rd party data sources.

The stakeholders consulted are provided in Table 1.

Table 1: List of stakeholders consulted, and data sources collected

Stakeholder	Data collected
ITU	World Telecommunication/ICT Indicators Database, Digital Development Dashboard (See Appendix D), Global Cybersecurity Index, ICT Price Baskets, ITU Transmission Map, ITU Broadband Transmission Capacity Indicators, ITU Telecommunications/ICT Regulatory Survey, G5 Benchmark Report, ICT Regulatory Tracker Report. Mapping of anchor locations is done by ITU Giga mapping team
Armenian Government, industry and civil society organizations:	
Ministry of High-Tech Industry of the Republic of Armenia - *request*	Provided replies to questionnaire on policy and regulation, including the Digitalisation Strategy; helped to receive data on the status of connectivity of hospitals and schools
Public Services Regulatory Commission of the Republic of Armenia – *data from website, follow-up requests*	Provided data on current cable ecosystem, statistics on broadband availability and adoption, insights on licensing and spectrum allocation, Internet penetration
Statistical Committee of the Republic of Armenia (ARMSTAT) – *data from website*	National statistics on telecommunication sector performance, on population and demography; data collected by ARMSTAT through households' surveys
ISPs (Viva-MTS, UCOM, Beeline, Rostelecom Armenia) – *data from websites, on-site interviews and follow-up requests*	Broadband coverage maps and related tables of services availability per settlement; reports on technical-economic indicators of the mobile and fixed services in the public electronic communications network
ARMIX – *requests*	Data on IXP performance
Internet Society of Armenia – *requests*	DNS ecosystem

Stakeholder	Data collected
Union of Operators of Armenia – *requests*	Director of the Union played a role of Connect2Recover national coordinator, provided overall help in getting data required for the research
3rd party data:	
World Bank in Armenia – *reports, request*	Results of WB survey on Internet adoption and usage, thematic reports
Ookla	Data on mobile and fixed networks performance[31]
World Bank Open Data	Statistics on electricity[32]
CyberGreen	Country Cybersecurity Profile[33]
GSMA	Mobile Connectivity Index[34]
Other UN agencies websites	Country profile, statistics, reports

A. ITU Data Status

In terms of ITU survey and mapping data, a summary of the data available from all sources in provided in Table 2. A portion of the data is up to date and available for 2020, but some key data items are missing:

- There is no data on ICT skills
- Data on age groups of Internet users and ICT access at home is only available for 2016
- There is a lack of up-to-date data on Internet subscriptions using different technologies
- Infrastructure mapping data used on the ITU interactive transmission maps is out of date (between 2011 and 2013)

Table 2: ITU data sources used and their status in Armenia (text in brackets is the short title for ITU data source)

Data sub areas	Comments on data	Year	Data tables or presentation
Telecommunication/ICT infrastructure and access survey (ITU access survey)	No up-to-date data on: fixed-telephone subscriptions in urban areas; cable modem Internet subscriptions; satellite Internet subscriptions;	Mix of data from 2019 - 2020	World Telecommunication/ICT Indicators Database[35], ICT-

[31] See Ookla country summary (available at: https://www.speedtest.net/global-index).

[32] See World bank: Access to electricity (available at: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS).

[33] See Cybergreen country cybersecurity profiles (available at: https://stats.cybergreen.net/).

[34] See GSMA Mobile Connectivity Index (available at: https://www.mobileconnectivityindex.com/).

[35] See World Telecommunications/ICT Indicators Database for full set of data, available with TIES access (available at: https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx).

Data sub areas	Comments on data	Year	Data tables or presentation
	VoIP traffic (minutes); mobile cellular telephone users; satellite-TV subscriptions.		Eye[36], Digital Development Dashboard[37]
Access to and use of ICTs by households and individuals (ITU usage survey)	Data on age groups of Internet users and ICT access at home is outdated. No data on ICT skills	Mix of data from 2016-2020	World Telecommunication/ICT Indicators Database, ICT-Eye, Digital Development Dashboard
Price basket questionnaire (ITU prices)	Up-to-date and complete	2020	World Telecommunication/ICT Indicators Database, ICT Price Baskets (IPB)[38], Digital Development Dashboard
Infrastructure mapping requests (ITU mapping)	Provides coverage and backbone data but very out of date	Mix of data from 2011-2013	ITU interactive transmission maps[39]
ITU Telecommunication/ICT Regulatory Survey (ITU regulation survey)	Comprehensive biennial survey of country ICT laws and regulations; is up-to-date and complete, although some discrepancies were observed	2020	G5 Benchmark[40], ICT Regulatory Tracker[41]

B. Broadband Coverage and Availability Data

In order to understand the availability of both mobile and fixed data in Armenia as well as the quality of the links, this report uses a mix of ITU sourced data as well as data obtained directly from the regulator and ISPs in Armenia and 3rd party data. The status of the data is presented in Table 3.

[36] See ITU ICT-Eye (available at: https://www.itu.int/net4/itu-d/icteye).

[37] See ITU Digital Development Dashboard (available at: https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/Digital-Development.aspx). Captured in Appendix D.

[38] See ITU ICT Price Baskets (IPB) (available at https://www.itu.int/net4/ITU-D/ipb/).

[39] See ITU interactive transmission maps (available at https://www.itu.int/en/ITU-D/Technology/Pages/Interactive-Transmission-Maps.aspx). Please note that transmission maps are collected using primary sources using an annual country request or using public domain sources. Fibre maps are viewable on the web site but not downloadable. However, the ITU mapping team have full access to the GIS data for the maps and can carry out analysis such as distance from fibre nodes to facilities.

[40] See ITU G5 Benchmark (available at https://app.gen5.digital/benchmark/metrics).

[41] See ITU ICT Regulatory Tracker (available at https://app.gen5.digital/tracker/metrics).

Table 3: Status of broadband coverage and availability data in Armenia

Data sub areas	Comments on data	ITU	Year	Armenia	Year	3rd party	Year
Mobile availability **(population and geographic coverage): 2G, 3G, 4G, 5G**	Country level 2G, 3G/3G+, 4G/4G+ population coverage summary, City/village level coverage (yes/no) available but no downloadable coverage map, or smallest census level population coverage percentage available, 5G not yet in place	ITU access[42]	2019-2020	PSRC, ISPs	2021	Collins Bartholomew (GSMA)[43]	2020
Fixed availability **(population and geographic coverage): Fibre (FTTP, FTTH), Cable (DOCSIS 3.0, 3.1), DSL/VDSL, FWA (Fixed Wireless Access)**	ITU transmission maps, data on backhaul service (yes/no) available at Marz level from two operators and percentage city with fibre to the home at city level from one operator. No detailed data on population coverage at small census level. Only partial data on technology used.	ITU mapping[44]	2019-2020 2011, 2013	PSRC, ISPs	2021		
Availability of different speed categories for mobile and fixed	No consistent data captured on speed categories. ISPs mention they have regulated speed tariffs from 10 Mbps to 200 Mbps but can reach 300 Mbps on fibre links.	-		ISPs	2021		

The ITU "Telecommunication/ICT infrastructure and access" survey on mobile availability from 2019 states that 100% of the population is covered by at least a 3G mobile network and 99.3% of the population is covered by at least a 4G network. More recent data was obtained from the PSRC from 2021 that shows 100% population coverage for both 3G and 4G. Coverage maps from 2021 are provided by GSMA and produced by Collins Bartholomew for all operators and are stored at the ITU for internal use but are not available for download. Operators also provide coverage maps online but they are not downloadable and cannot be used for analysis. Operators provide "Yes" or "No" answers to coverage in cities and villages but do not specify the threshold required for a town or city to be considered covered. 5G is not yet available anywhere in Armenia.

[42] See ITU Digital Development Dashboard. Captured in Appendix D.

[43] See GSMA coverage maps produced by Collins Bartholomew (available at: https://www.gsma.com/coverage/). Note: Maps are updated annually in December and free maps are available to view online but GIS maps need to be purchased from Collins Bartholomew. The ITU purchases these coverage maps to carry out broadband studies such as checking mobile coverage of facilities.

[44] See ITU Interactive Transmission Network Maps.

Statistical data on fixed broadband availability is not collected by the ITU; only data on fixed broadband subscriptions is collected. However, the ITU does collect fibre maps from operators through an annual request for information or using public sources. This data can be used to check population or location of interest distances to fibre nodes. The fibre data provided to the ITU for Armenia is dated and ranges from 2011 to 2013 for the three fibre operators: GNC-Alfa CJSC, Fibrenet LLC, and Beeline (ArmenTel). ISPs in Armenia provide fibre availability in very different formats. Rostelecom provides data on percentage of homes or offices with fibre available for cities and claims coverage of 92% of the country if rural backhaul and city last mile are combined. UCOM and Beeline provide data on the cities or villages where they have backhaul and middle mile fibre as a simple "yes" or "no" (not the fraction of population reached) and what last mile technology they have available in those areas.

For data on availability of different fixed speed categories, no consistent data is captured by any ISP. Rostelecom states that it has regulated speed tariffs that range from 10 Mbps to 200 Mbps, fibre links that can reach 300 Mbps in some areas, and customer Ethernet interfaces that can reach 1Gbps.

The level of detail of data provided by operators can be improved by specifying the coverage of the population at the smallest census level as well as the technology available and speed tiers available for potential customers.

C. Broadband Adoption and Usage

The status of broadband adoption and usage data is shown in Table 4.

Table 4: Broadband adoption and usage data in Armenia

Data sub areas	Comments on data	ITU	Year	Armenia	Year	3rd party	Year
Mobile adoption: number of data subscribers, over-subscription	Country-level data and ISPs' data on: number of mobile phones' active number of subscribers with Internet access number of BB Internet access subscribers number of mobile BB Internet access subscribers number of fixed BB Internet access subscribers. No data on mobile over-subscription. World Bank's data on Internet access at home by type of settlements, income groups of households and type of Internet connection used.	ITU access[45]	2020	ARMSTAT's Yearbook, PSRC, ISP quarterly reports	2019	World Bank's representative survey	2019
Fixed adoption: number of subscribers							

[45] See World Telecommunications/ICT Indicators Database for full set of data, available with TIES access.

Data sub areas	Comments on data	ITU	Year	Armenia	Year	3rd party	Year
Level of Internet usage	Data available on distribution of Internet users per age groups and sex, per sex, per vulnerable groups and sex. World Bank's data on: frequency of Internet usage by gender, in the last 3 months by gender, per income groups; share of Internet users performing an activity within the last 3 months.	ITU access[46]	2019	ARMSTAT's household survey	2019	World Bank's representative survey	2019
Network speeds and QoS	ITU data on subscriptions to 256 kbps - 2 Mbps, 2 Mbps - 10 Mbps, >= 10 Mbps Ookla data on user experienced speeds for mobile and fixed	ITU access[47]	2020			Ookla	Q3 2021
Pricing data: pricing analysis for mobile and fixed	Up to date pricing data available from the ITU price basket questionnaire	ITU price baskets[48]	2008-2020			World Bank income data	2020
Device ownership (percentage of population): smartphone, tablets, laptops	Computer and mobile phone ownership per sex, age groups and vulnerable groups	ITU access[49]	2019-2020	ARMSTAT's household survey	2019		

The ITU access survey provides high level subscription data for both mobile and fixed networks and is shown in Table 5.

The data shows that fixed adoption in Armenia was 14.52% in 2020. There is widespread backhaul and middle mile broadband available in each administrative region according to fixed operators but the level of last mile fixed access to consumers is not well known. Fixed Internet subscriptions grew from 385,704 (13.04%) in 2019 to 430,407 (14.52%) in 2020; fixed broadband services for households could, however, be as high as 50.82% using the current average household size of 3.5 Armenians per household.[50] Fibre-to-the-home subscriptions was only in 21.8% of households in 2019. Mobile Internet subscriptions grew from 2,445,149 (82.67%) to 2,475,449 (83.54%); however, no data is available on the number of over-subscriptions (where subscribers have more than one SIM card). ARMSTAT's yearbook publishes similar data with some more detail on country-level data.

[46] See ITU Digital Development Dashboard (Percentage of population using the internet). Captured in Appendix D.

[47] See ITU Digital Development Dashboard (Mobile and fixed broadband subscriptions). Captured in Appendix D.

[48] See World Telecommunications/ICT Indicators Database for full set of data, available with TIES access.

[49] See World Telecommunications/ICT Indicators Database for full set of data, available with TIES access.

[50] See Average size of Armenian household (available at: https://population.un.org/Household/index.html#/countries/51).

Table 5: ITU access indicators for broadband subscriptions in Armenia

Indicator	Original Source	2019	2020
Fixed networks:			
Fixed broadband subscriptions per 100 inhabitants	Calculated	13.04%	14.52%
Fixed-broadband subscriptions	Ministry of High-Tech Industry of Armenia	385,704	430,407
Fibre-to-the-home/building Internet subscriptions	Ministry of Transport; Communication and Information Technologies of Armenia	226,298 (21.8% of households)	
Other fixed (wired)-broadband subscriptions	Ministry of Transport; Communication and Information Technologies of Armenia	40,116	
Subscriptions to fixed-broadband and fixed-telephone bundles.	Ministry of Transport; Communication and Information Technologies of Armenia	63,662	
Subscriptions to fixed-broadband; fixed-telephone and pay-TV bundles.	Ministry of Transport; Communication and Information Technologies of Armenia	83,171	
Mobile networks:			
Active mobile-broadband subscriptions per 100 inhabitants	Calculated	82.67%	83.54%
Active mobile-broadband subscriptions	Ministry of High-Tech industry of Armenia	2,445,149	2,475,449
Prepaid mobile-cellular telephone subscriptions	Ministry of High-Tech industry of Armenia	3,097,446	
M2M mobile-network subscriptions	Ministry of High-Tech industry of Armenia	114,440	

The World Bank issued a report in May 2020[51] that uncovered the type of Internet connections used at home for rural and urban Armenians (see Figure 6). This study did not provide a breakdown of the type of fixed broadband connections used but in a separate World Bank report,[52] it was revealed that three-quarters of householders in Armenia do not have a fibre network passing their house, based on consultations with service providers. The report also revealed that 700 out of 952 rural settlements (73.5% of rural settlements) are not connected to fibre backhaul networks. Note Armenia has 1,002 settlements; 50 settlements are urban and 952 are rural.[53] Hence it is highly likely that rural fixed broadband is mostly DSL or ADSL. Urban areas had a 1.6:1 ratio of fixed to mobile subscribers whereas rural areas had a 1.07:1 ratio of fixed to mobile subscribers showing a far larger reliance on mobile access in rural areas of Armenia.

[51] See World Bank, ICT Usage in Households, by Individuals and in SMEs in Armenia, issued May 2020 (not publicly available).

[52] See World Bank Options to improve rural broadband connectivity in Armenia (not publicly available).

[53] See Armstat data on settlements (available at https://armstat.am/en/?nid=82&id=2256).

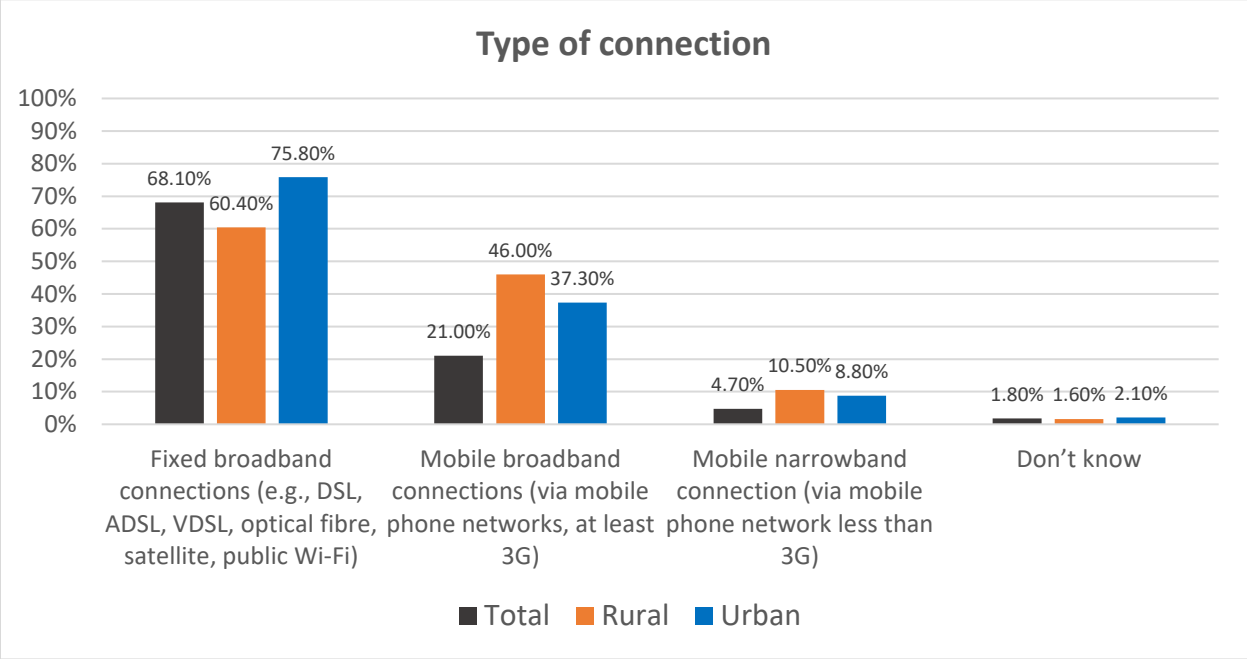

Figure 6: Types of Internet connections used at home (source: World Bank survey of ICT adoption in Armenia, 2019)

The World Bank report also studied the reasons for not having access to the Internet at home amongst the share of unconnected households. The strongest reason (50% of the share of surveyed households) given was that they don't need the Internet because it's not useful or not interesting. The section on local language content (see Section V.B.1), that shows low levels of apps in local languages, could help provide insight on this response. The second strongest reason for not having access to the Internet at home (19%) was that equipment costs were too high. The weakest reason (2%) was due to broadband not being available in the area.

The level of Internet usage for individuals and households is reported in the "ITU Access to and use of ICTs by households and individuals survey." Internet usage was last collected in 2019. In the ITU survey, users are asked if they have used the internet in the last three months and where they have used the internet; this includes home, work, another person's home etc. 66.54% of Armenians were reported to be using the Internet by the Statistical Committee of Armenia.; this dropped by 1.7% from 68.24% in 2018. In addition, 76.39% of households in Armenia had at least one individual using the Internet; this increased by 8.81% from 67.58% in 2018. The reason for the drop in the number of individual Armenians using the Internet is still not known but the increase in household's with at least one individual using the internet, despite the decrease in internet usage across the entire population, can be explained by the increased level of broadband availability from mobile or fixed operators to homes in Armenia and home usage not only being concentrated in urban homes.

ARMSTAT's 2019 household survey revealed that 71.32% of Armenians were using the Internet in the 12 months prior to the study. A more detailed Internet usage breakdown by age, gender, and for vulnerable groups is captured in the ARMSTAT household survey (discussed in Section IV.E). This survey shows (see Figure 7) that the largest Internet user group is 15-24 year olds, with 95% having used the Internet in the 12 months prior to the study. Older persons, over the age of 75, show low rates of

Internet usage; only 15% had used the Internet in the 12 months prior to the study. The 2019 Internet usage figures from the ITU are slightly lower than the 2019 Internet figures in this report but this is because they were captured at different times and using different samples.

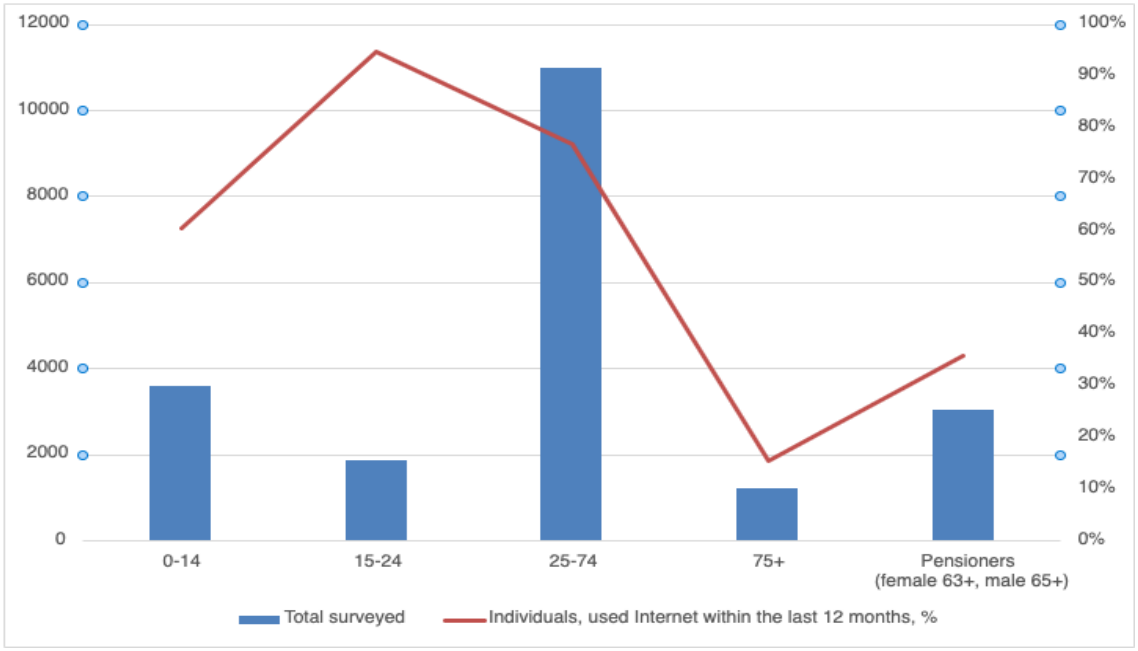

Figure 7: Internet usage breakdown by age (source: ARMSTAT's 2019 household survey)

The "ITU Access to and use of ICTs by households and individuals survey" captures the subscriptions speed in three speed categories (see Table 6 which was last updated in 2020). These indicators capture subscriptions for fixed links; mobile links cannot provide speed guarantees. The subscription data shows uptake of fixed broadband services for individuals at 14.5% or 50.75% of households (using the current average household size of 3.5 Armenians per household). A large fraction of the links (39.7%) are under 10 Mbps and are likely using older fixed technology such as ADSL. Ookla speedtest data, measured from users' devices (discussed in Section V.A), shows an average downlink performance of 36.25 Mbps for fixed networks and an average downlink performance of 33.13 Mbps for mobile networks. As fixed links are upgraded to fibre, average fixed link speeds should increase rapidly.

Table 6: ITU access indicators - subscription speeds

Speed category	Number of subscriptions
256 kbit/s to less than 2 Mbit/s	2,106 (0.5% of fixed subscriptions)
2 Mbit/s to less than 10 Mbit/s	168,843 (39.2% of fixed subscriptions)
Equal to or above 10 Mbit/s	259,458 (60.3% of fixed subscriptions)
Total	430,407 (14.5% of the population)

The "ITU Price basket questionnaire" provides a rich set of indicators to confirm the affordability of connectivity in Armenia. Affordability is checked by comparing the average price of a 1.5 GB mobile package and a 5 GB fixed package to the GNI per capita for Armenia and ensuring that this is less than

2%. This data can be combined with World Bank data on the income share of the bottom 20% and bottom 40% of income earners to ensure that access is affordable for the entire country. The data is shown in Table 7. This shows that mobile access is generally affordable for most Armenians, but fixed broadband is still too expensive for most Armenians (discussed in Section V.B.3).

Table 7: Broadband affordability for Armenia using ITU price basket data and World Bank income data

Price basket indicator	GNI p.c.
1.5 GB mobile BB % GNI p.c.	0.96%
1.5GB mobile BB % GNI p.c. bottom 40%	1.25%
1.5 GB mobile BB % GNI p.c. bottom 20%	2.13%
5 GB fixed BB % GNI p.c.	3.19%
5 GB fixed BB % GNI p.c. bottom 40%	4.16%
5 GB fixed BB % GNI p.c. bottom 20%	7.09%

The "ITU Access to and use of ICTs by households and individuals survey" captures three key indicators related to device ownership shown in Table 8. According to this data, the proportion of households with access to a mobile phone or a computer has decreased between 2016 and 2019 and between 2018 and 2019, respectively. The proportion of individuals who are using a computer also decreased between 2016 and 2019.

Table 8: Device ownership in ITU ICT access survey

Indicator	Original Source	2019	Previous value	Previous year
Proportion of households with a mobile cellular telephone	The Statistical Committee of the Republic of Armenia	92.46%	97.72%	2016
Estimated proportion of households with a computer	The Statistical Committee of the Republic of Armenia	57.87%	62.24%	2018
Proportion of individuals who used a computer (from any location) in the last 12 months	The Statistical Committee of the Republic of Armenia	59.26%	67.93%	2016

ARMSTAT's 2019 household survey also reports computer usage and mobile phone ownership for gender and age ranges over a period of 12 months prior to the study (gender divides will be discussed in Section IV.E). The household survey showed that 78.86% of Armenians own a mobile phone and 59.85% used a computer. The largest group of computer users was 15-24 year olds with 80.98% having used a computer. Only 12.44% of older persons (75+) had used a computer in the 12 months prior to the study. Mobile phone ownership was more widespread across age ranges; 95.91% of 15-24 year olds owned a

mobile phone, 94.46% of 25-74 year olds owned a mobile phone, and 54.17% of older persons (75+) owned a mobile phone (see Figure 8).

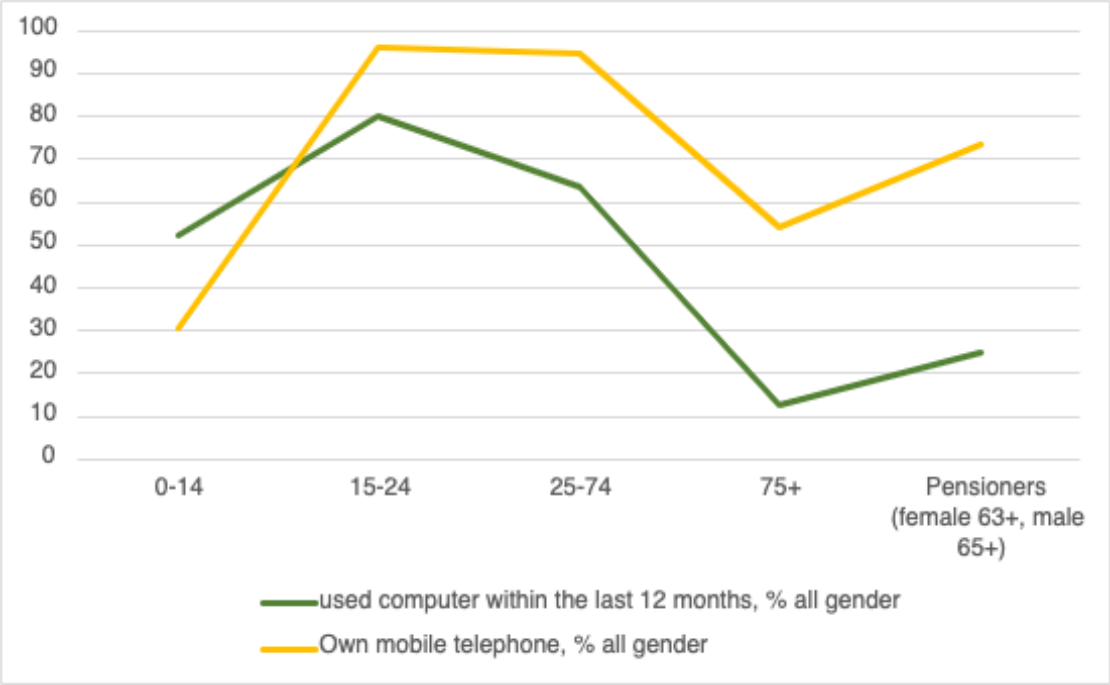

Figure 8 : Computer usage and mobile phone ownership breakdown by age (source: ARMSTAT's 2019 household survey)

D. Community Anchor Locations

Improving access, adoption, and usage rates in anchor locations such as schools, libraries, 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 and/or in public libraries 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.

The status of data on anchor locations in Armenia is shown in Table 9.

Table 9: Data on anchor locations in Armenia

Data sub areas	Comments on data	ITU	Year	Armenia	Year	3rd party	Year
Location of primary, secondary, tertiary education facilities	Partially available: no GPS location of all schools, no data on network speed performance. According to the Government, all schools are connected. According to information published on the websites of the regional authorities, there are few unconnected schools	ITU Giga mapping team	2021	Ministry of Education, Science, Culture and Sports through MHTI. Regional (Marzes) authorities' websites	2021	Open Street Maps: crowdsourced data on location of education facilities	2021
Location of Healthcare facilities such as clinics and hospitals	Data on health facilities is available, GPS location is found based on addresses (in cases if facility's location could not be found, GPS location of the settlement is used instead), status of connectivity, network speed performance, and ISPs that provide connectivity are available. Almost all health facilities are connected, but not all of them are connected meaningfully in terms of network speed performance	ITU Giga mapping team	2021	Ministry of Health through MHTI	2021		
Other anchor locations e.g., libraries and government buildings	Data on libraries is incomplete: out of 673 (2019) only 283 libraries are identified. In the most cases settlement's name is given instead of exact location. Most libraries don't have Internet connections, but there is a process underway to connect them.			ISOC Armenia, Union of Operators of Armenia, regional (Marzes) authorities' websites	2021		

The Armenian government stated that all schools have Internet connections and most of them are connected to fixed broadband, but survey data (provided by the Ministry of Education through the MHTI) has shown that many schools still have very poor links. Often an entire school is served by a slow mobile link. An initial survey was sent to Armenia's 1,402 schools out of which 1,158 schools provided replies thereto. 500 schools reported availability of broadband Internet and only 204 or 18% of these schools have a fixed broadband Internet connection. 73 schools or 6% reported no connectivity (see Table 10). The quality and speed of these connections have not yet been collected.

Table 10: School connectivity status as reported (as of October 2021)

	Number of secondary schools (2020/2021 academic year)	Number of schools provided replies	Schools reported no Internet connection, %	Schools connected to broadband, %	Schools connected to mobile broadband, %	Schools connected to fixed broadband, %
REPUBLIC OF ARMENIA	**1402**	**1158**	**6%**	**43%**	**12%**	**18%**
Yerevan City	252	152	1%	60%	11%	39%
Aragatsotn Marz	120	107	3%	47%	13%	32%
Ararat Marz	112	105	1%	14%	3%	8%
Armavir Marz	120	72	14%	26%	10%	29%
Gegharkunik Marz	124	116	8%	61%	27%	28%
Lori Marz	163	149	3%	52%	7%	17%
Kotayk Marz	101	90	18%	33%	10%	16%
Shirak Marz	163	133	0%	0%	35%	0%
Syunik Marz	117	111	24%	24%	6%	6%
Vayots Dzor Marz	48	45	0%	100%	100%	0%
Tavush Marz	82	78	0%	96%	1%	0%

Responses to the survey demonstrate that in terms of providing universal broadband connectivity Shirak, Vayots Dzor, and Tavush Marzes are leading with Internet available in all schools participating in the survey. At the same time, according to the Shirak Marz' website, at least 2 rural schools (which probably did not reply to the survey) have no connectivity and the status of connectivity is not mentioned for another 11 schools.[54] There is no indication that some schools are not connected on Vayots Dzor and Tavush Marzes' websites.[55]

[54] *See* Educational organisations. Shirak Marz (available at: http://shirak.mtad.am/educational/)

[55] *See* Educational organisations. Vayots Dzor Marz (available at: http://vdzor.mtad.am/educational/) and Tavush Marz (available at: http://tavush.mtad.am/educational/).

In terms of providing a meaningful connectivity (mobile or fixed broadband with at least 20 Mbps download speed[56]), Vayots Dzor and Tavush Marzes seem to be leading with Gerharkunik Marz and Yerevan City lagging behind. However, only 6 respondents (all in Yerevan City) provided data on quality of their connection. Moreover, in many cases respondents could not say what type of connection they actually have and what technology is used (this is particularly evident in the responses provided by Tavush Marz). Thus, it is impossible to state unequivocally that schools that reported broadband connectivity are meaningfully connected.

Mapping school connectivity is done (see Figure 9) using a combination of school addresses found on the Marzes' websites[57] and Open Street Map data.[58] School locations are overlayed with the available information in ITU databases on mobile coverage and fibre nodes locations. Based on this information, as well as on data on population density and terrain, recommendations can be provided on the technology solutions and business models for providing sustainable meaningful connectivity to schools.[59] The map on the Figure 9 visualizes the locations of only 1,147 schools found during the desk research. Mapping shows that at least 84 schools (those coloured in red) are more than 10 km from a fibre node and thus are less likely to be connected to optical fibre. Schools coloured in blue are located within a 10 km distance to a fibre node.

[56] This is recommendation of the ITU-UNICEF Giga initiative, a global initiative aimed at connecting every school in the world to broadband. *See* Giga initiative's website (available at: https://gigaconnect.org)

[57] *See* Կազմակերպություններ կրթական (available at: http://aragatsotn.mtad.am/educational/, http://ararat.mtad.am/educational/, etc. where first part of the address is the Marz' name)

[58] See Information on Armenian school locations (available at https://public.tableau.com/app/profile/oguzhan.er/viz/ArmeniaSchool/ArmeniaSchools).

[59] *See* Giga initiative website.

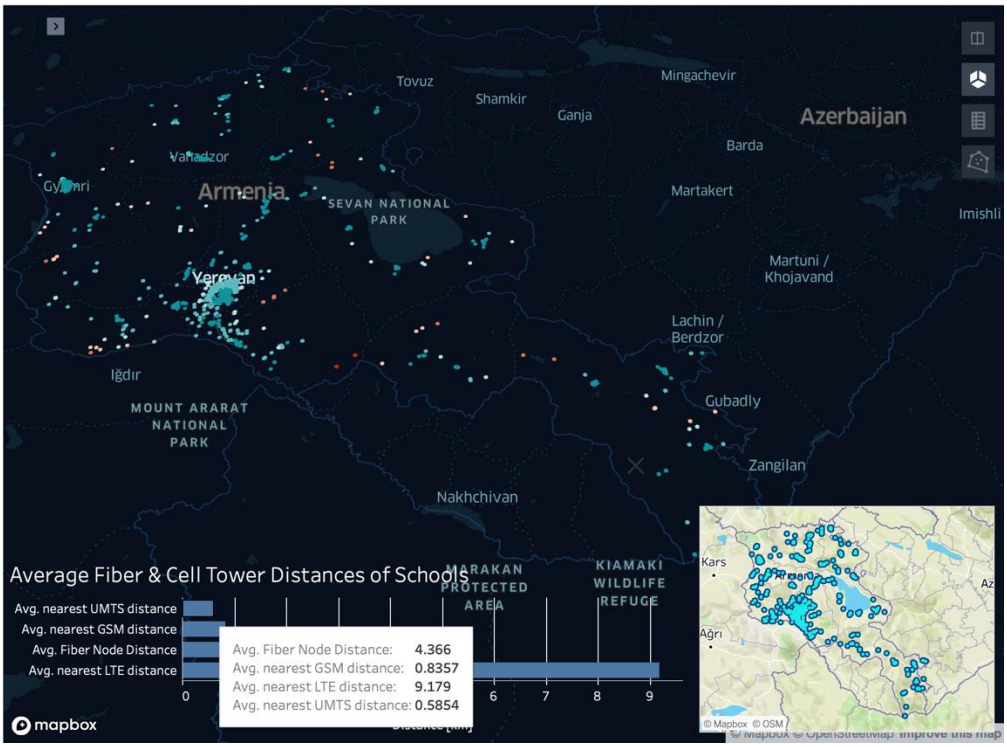

Figure 9: Schools mapping - Average fiber & cell tower distances of schools

Data on connectivity at health facilities has been provided by the Ministry of Health through MHTI. From the survey response, no hospitals have 1 Gbps links, the fastest link available was 300 Mbps and many healthcare facilities still have links under 10 Mbps, which is not enough for meaningful connectivity. At least two medical facilities in Armavir Marz reported no Internet connection. For a hospital to adequately service its data needs (with low-latency, high-capacity connections required for real time diagnostics), a minimum of 100 Mbps might be the target broadband connection with an ultimate target of 1 Gbps. The current status of broadband availability to medical facilities is shown in Figure 10.[60] Medical facilities coloured in blue on the map are located within a 10 km distance to a fibre node and thus might be connected by a fibre optic cable to ensure their meaningful connectivity.

[60] Broadband availability for medical facilities in Armenia (available at https://public.tableau.com/app/profile/oguzhan.er/viz/ArmeniaHospitals/ArmeniaSchools).

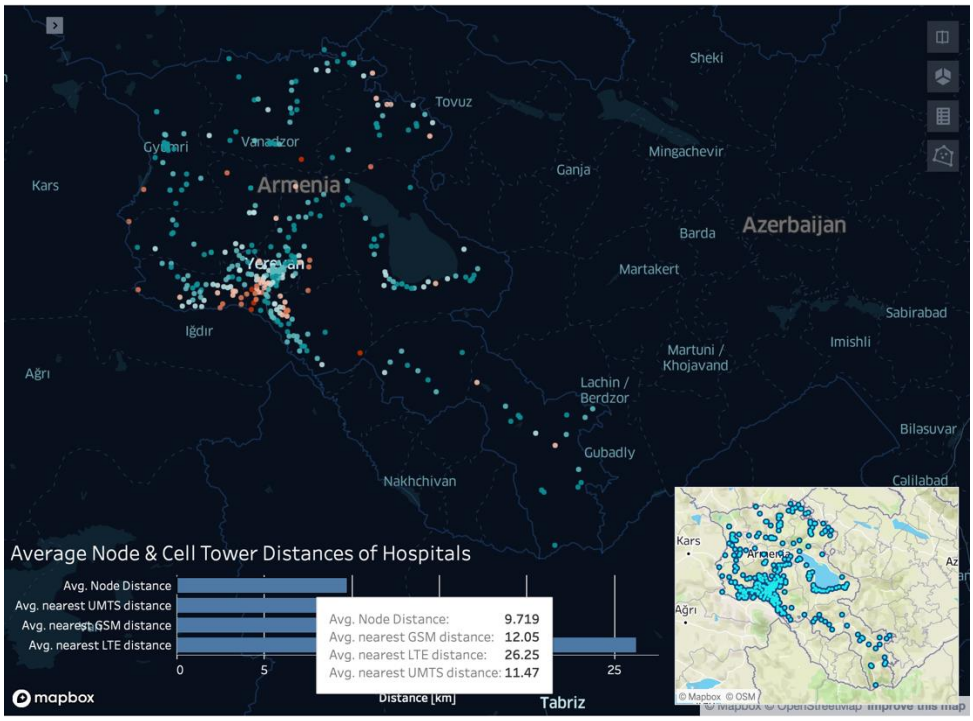

Figure 10: Broadband availability for medical facilities in Armenia

Based on information provided by the Internet Society of Armenia, most libraries don't have Internet connections, but there is a process underway to connect them with the help of the Armenian Union of Operators.

E. Historically Vulnerable Groups

Certain groups can become disenfranchised when connectivity is expanded. This section studies rates of access, adoption, and usage in rural areas and by women and girls, older persons, persons with disabilities, and other potentially vulnerable groups. The status of broadband data on vulnerable communities is shown in Table 11.

Table 11: Data on vulnerable communities

Data sub areas	Comments on data	ITU	Year	Armenia	Year	3rd party	Year
Rural areas	Data available on: proportion of households with ICT access at home; types of Internet connections used at home; speed of fixed broadband Internet access; affordability of high-speed Internet services	ITU access[61]				World Bank's representative survey[62]	2019
Vulnerable groups, such as persons with a disability, the older persons, and woman and girls	Data available on: Internet users per age group and sex, per sex, per vulnerable groups and sex; frequency of Internet usage by gender, in the last 3 months by gender, per income groups; computer and mobile phone ownership per sex, age groups and vulnerable groups	ITU access[63]	2018-2019	ARMSTAT's household survey	2019		

According to the "ITU Access to and use of ICTs by households and individuals survey", the proportion of households with ICT access at home (2018) in rural settlements is 75% and in urban settlements is 77%. Data on Internet access in rural areas is not specifically captured by the Government in Armenia but the World Bank carried out a representative survey in 2019 to check the type of connections that are used at home in both rural and urban areas. The World Bank found that 46% of users were using 3G mobile broadband connections and 10.5% were using 2G+/GPRS connections in rural areas. 60.4% were using

[61] See ITU Digital Development Dashboard (ICT access at home). Captured in Appendix D.

[62] See World Bank ICT Usage in Households, by Individuals and in SMEs in Armenia, issued May 2020 (not publicly available).

[63] See ITU Digital Development Dashboard (Percentage of the population using the Internet and Mobile phone ownership). Captured in Appendix D.

fixed broadband connections compared to 75.8% in urban areas (these could be ADSL, VDSL, fibre, Wi-Fi or satellite connections).

Users were also asked to report the speed of their fixed broadband Internet connection. In rural areas, 81.36% of rural users did not know and 62.5% of urban users did not know the speed tier of their internet connection. 7.97% of rural users said they had a link of up to 10 Mbps compared to 10.26% in urban areas. 4.7% of users in rural areas said they had a link of more than 10 and up to 30 Mbps compared to 13.46% in urban areas. The lack of knowledge about the speed of the link provided to households exposes the need for other mechanisms to obtain this data, such as directly asking the network operators for speed tiers of subscriptions. A combination of operator statistics on different speed tier packages of their subscribers broken down into small census areas (labelled as rural or urban) combined with crowd-sourced data to check if these speeds are being achieved will likely be more valuable.

The ARMSTAT 2019 household survey provides a breakdown of device ownership and Internet access by gender and age. Access to computers was generally equitable; 60.94% of males and 58.60% of females had used a computer in the 12 months prior to the study. However, there were some gender divides for different age groups (see Figure 11). The most notable gender difference for computer usage was for pensioners; 30.16% of male pensioners (65+) and 21.88% of female pensioners (63+) used a computer in the 12 months prior to the study.

Access to the Internet was also fairly similar; 71.97% of males and 70.78% of females had used the Internet in the 12 months prior to the study and there were only slight gender differences for Internet usage for different age groups (see Figure 12).

There were slightly more female than male mobile phone owners across the population surveyed; 77.72% of males and 79.81% of females owned mobile phone in the 12 months prior to the study and there were marginal gender differences for mobile phone ownership for different age groups (see Figure 13).

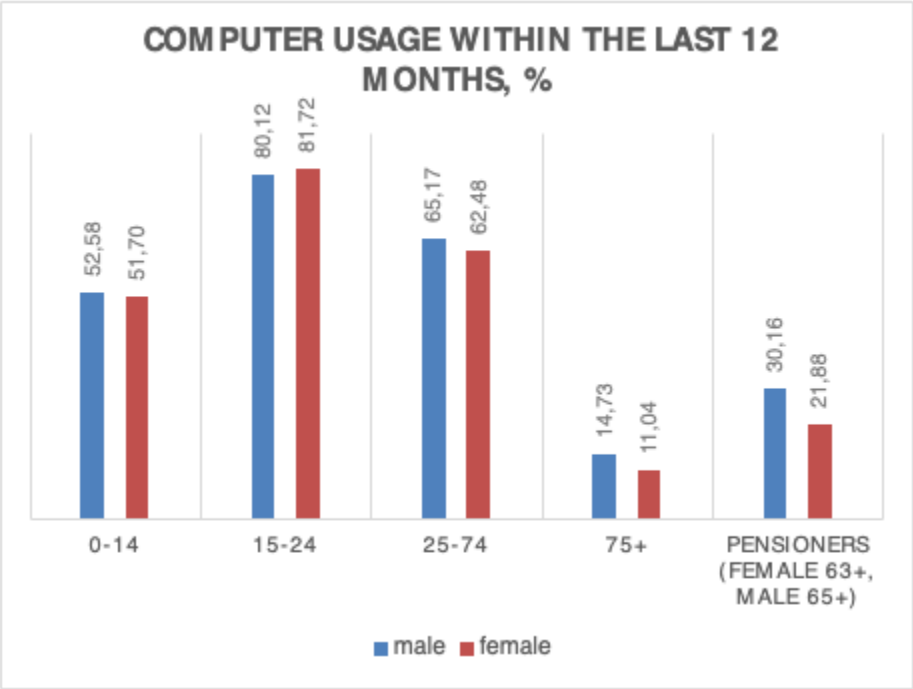

Figure 11: Computer usage breakdown by age and gender (source: ARMSTAT's 2019 household survey)

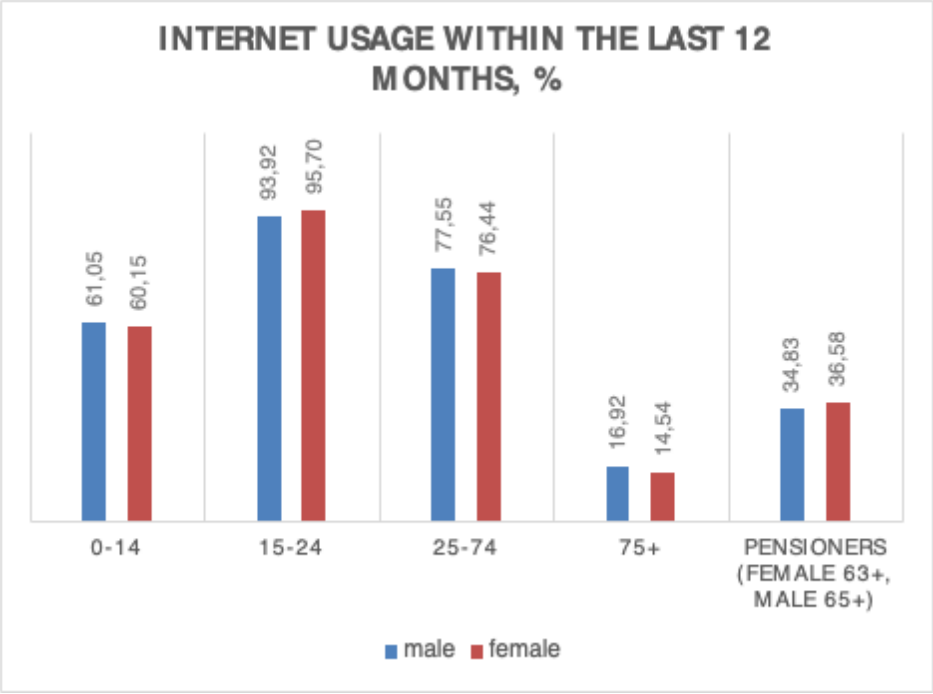

Figure 12: Internet usage breakdown by age and gender (source: ARMSTAT's 2019 household survey)

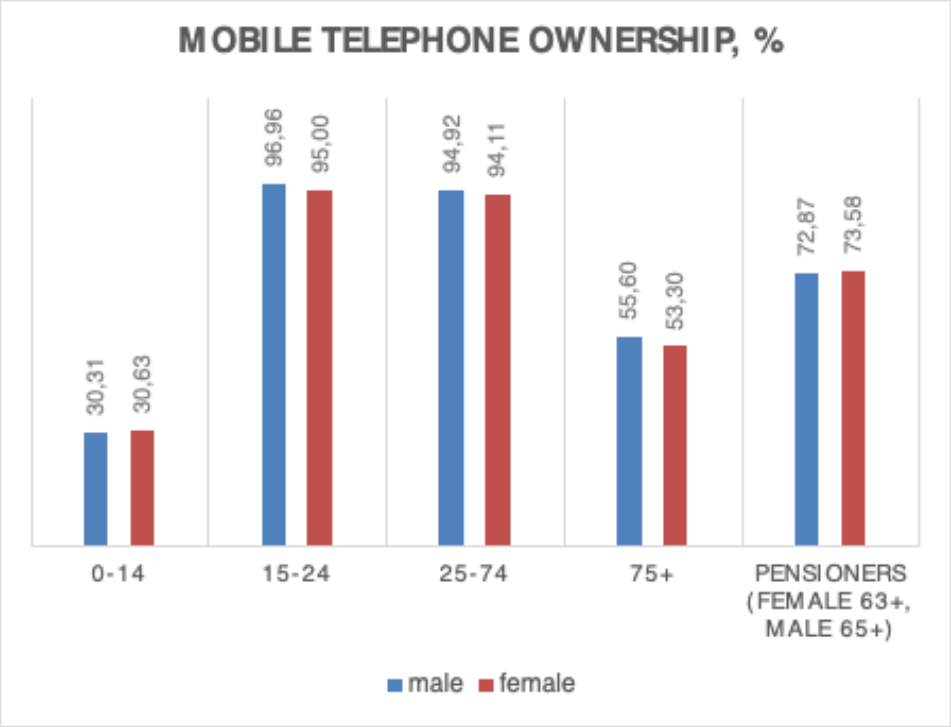

Figure 13: Mobile telephone ownership breakdown by age and gender (source: ARMSTAT's 2019 household survey)

Access to the Internet and a computer for persons with a disability was less than for the general Armenian population; 40.54% of persons with a disability versus 59.85% of Armenians had used a computer in the 12 months prior to the study and 49.43% of persons with a disability versus 71.32% of Armenians used the Internet in the 12 months prior to the study. However, mobile phone ownership for persons with a disability was slightly higher than that of the general Armenian population; 81.08% of persons with a disability versus 78.86% of Armenians owned a mobile phone in the 12 months prior to the study. In addition, there were gender divides in terms of computer usage (see Figure 14) and internet usage (see Figure 15) amongst persons with a disability.

The high levels of mobile phone ownership (81.08%) compared to the low amount of internet usage (49.43%) amongst Armenians with a disability suggests that there may be a lack of affordable access or relevant content for persons with a disability in Armenia. In its Digitalisation Strategy, the GoRA has set targets for making its online content more accessible for persons with disabilities.

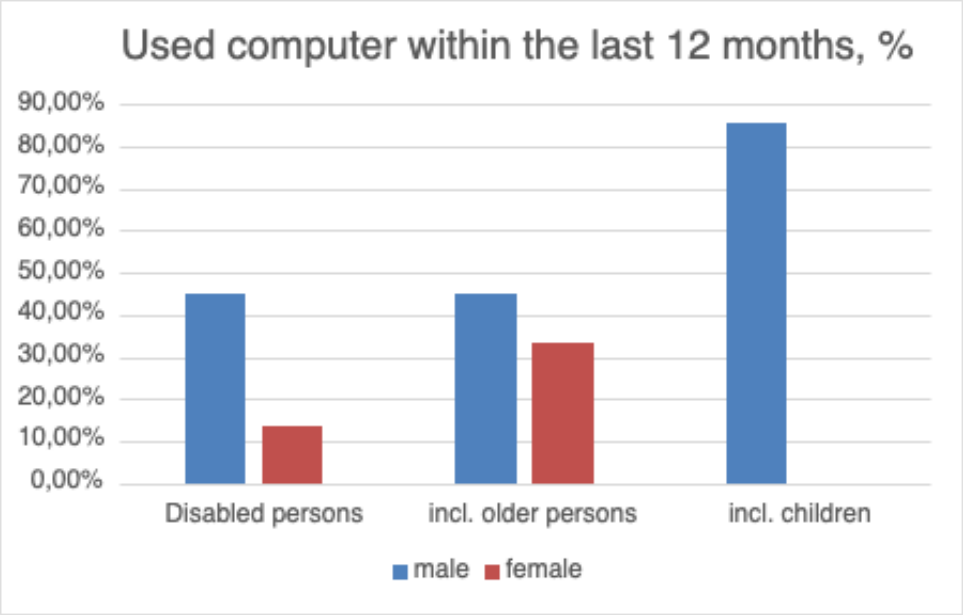

Figure 14: Computer usage by persons with disability breakdown by age and gender (source: ARMSTAT's 2019 household survey)

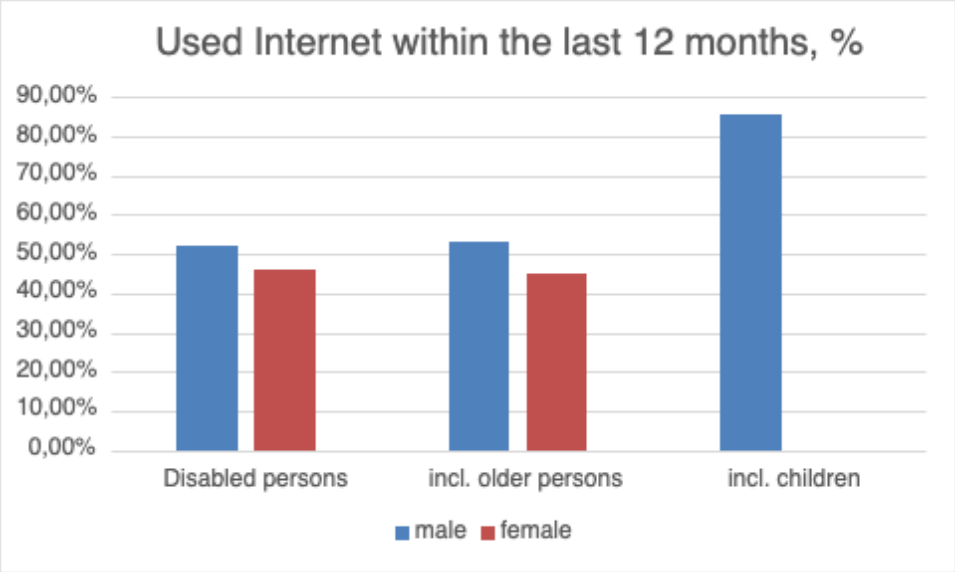

Figure 15: Internet usage persons with disability breakdown by age and gender (source: ARMSTAT's 2019 household survey)

ARMSTAT is commended for collecting this level of detail to understand age, gender divides, and levels of access for persons with disabilities.

F. Connect2Recover Phase Two Observations for Data Collection and Validation

Based on the data available, Connect2Recover phase two observations are provided as follows:

- **Outdated information on ICT infrastructure**: The current backhaul and middle mile fibre maps provided to the ITU are between 8 and 10 years old and cannot be used to understand the current fixed broadband population coverage. Providing up to date online maps with backhaul, middle mile, and last mile links to visualize real fixed coverage, using regularly updated data from operators, can be used to identify gaps, improve planning, and provide information to investors.
- **Lack of data on speed tiers**: There is currently no data for fixed network speed tiers available to potential customers. Publishing data on the speed tiers available (at the smallest census level) as well as subscriber data with speed tiers will greatly improve calculations on availability to target groups and help with planning future coverage and capacity.
- **No publicly available and reliable information on total number of international gateways:** Neither MHTI nor PSRC collect this data from operators. Information differs depending on the source, but network operators do not provide this information as they regard it as sensitive data, though some information is available on their websites.
- **Statistical data on ICT sector development requires more granularity:** Statistics on Internet adoption and usage, and device ownership are available at a country-level only (in ARMSTAT's statistical yearbooks). It would be good to have similar statistics for regions and main cities in the regions, which could be aggregated to check urban and rural population coverage.
- **Quarterly reports published by fixed and mobile operators are incomplete:** Quarterly reports provide a good source of knowledge on the state of the ICT market; however, they need to provide more detail. For example, multi-technology operators, such as Beeline, should provide additional information on the number of subscribers per technology. No information on the percentage of population covered at settlement level could be extracted from these quarterly reports.
- **Incomplete data on anchor locations:** Broadband data on anchor locations is incomplete and isn't updated regularly. Many respondents to surveys did not fully comprehend the questions on type and speed of their connections. For example, some users measured and reported the broadband speed available at the facility and others reported what they thought was the speed tier provided to the facility.
- **Commendable level of detail in annual household surveys:** ARMSTAT is commended for collecting detailed Internet access and device availability across age, gender divides, and persons with disabilities. This data will assist Armenia in understanding and addressing divides between vulnerable population groups. Additional information on the type of locality (urban/rural) of the respondents will be helpful to further identify the urban/rural digital divide.

G. Connect2Recover Phase Three Recommendations for Data Collection and Validation

Based on the data available, Connect2Recover phase three recommendations are provided as follows:

- **Create up-to-date fibre maps for all operators**: Network fibre maps for all operators, that include currently rolled out fibre and future build-out plans, should ideally be updated annually and provided to the ITU. Providing up to date online maps with backhaul, middle mile, and last

mile links to visualize real fixed coverage, using regularly updated data from operators, can be used to identify gaps, improve planning, and provide information to potential investors.[64]

- **Improve quarterly reports published by operators**: To carry out analysis required to detect coverage gaps and areas where network upgrades are required, finer grain data is required from operators. This can be achieved by reporting the population coverage (as a percentage) at the smallest census level and reporting speed tiers available with total number of subscribers in each tier at the smallest census level. Downloadable coverage maps will also facilitate the ability of third parties or consultants to carry out broadband gap analysis.
- **Improve data on anchor locations**: Yearly surveys on education and health care and other government facility broadband availability and adoption are recommended. This data could at least include the type of data connection, connection technology (such as 3G or 4G in the case of mobile access or fibre, ADSL, fixed wireless, or satellite in the case of fixed access), and the speed of the connection in the case of fixed access as advertised by the service provider. Creating a system where speed and latency for both fixed and mobile networks is measured by a network monitoring tool on a regular basis would be ideal. As an example, the Giga project will be implementing real-time school connectivity monitoring in the beneficiary countries.

V. Review of Internet Resilience

This section analyses how the Internet in Armenia performed during the pandemic, assesses the current level of network resilience, comparing Armenia to three of its peers – Georgia, Kazakhstan, and Kyrgyzstan – and considers steps Armenia can take to increase resilience during future pandemics.

A. 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 shifting patterns of work and education bandwidth needs. Workers needed to continue to collaborate with co-workers over bandwidth intensive applications like video conferencing and likewise school learners and university students were required to continue their education from home over media-rich bandwidth intensive resources.

To assess how Armenia's Internet performed during the COVID-19 pandemic, an open public dataset on Internet access performance from Ookla is used. The service measures the data throughput (speed) and latency (connection delay) of an Internet connection against any of around 10,000 geographically dispersed servers.[65] Tests are performed from users' mobile devices or computers. Ookla labels a speed test as mobile if a user connected to a cellular network and fixed if a user connects to a WiFi network or

[64] See Examples of National Broadband Systems: Цифровая карта покрытия связью РК (available at https://rfs.gov.kz/map.html); Broadband Internet Coverage. Canada (available at: https://crtc.gc.ca/cartovista/internetcanada-en/).

[65] 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/).

ethernet connection. These tests are typically performed by users who are either curious to know if their network is meeting the advertised speed from their network service provider or at times when they are frustrated by the poor performance of the network.

Quarterly reports are available from Ookla and were extracted between the fourth quarter of 2019 (pre-COVID-19) and the last quarter available from the Ookla dataset – the third quarter in 2020. Network performance data was extracted for all 600mx600m tiles across the country and an average was calculated across all these tiles (not factoring in the number of readings in each of these tiles). This provides a slightly worse performance than the average of all measurements across the whole country and therefore cannot be compared directly with the country average on Ookla's speedtest dashboard but still reveals relative speed performance trends.

The performance of fixed networks is shown in Figure 16.

A few immediate trends are clear:

- Both mobile and fixed performance dipped slightly in Q1 2020 (this aggregated dataset likely caught the tail end of the nationwide lockdown in Armenia from March 24-31, 2020).
- There was a noticeable drop in fixed performance in Q4 2020 – a 8.5% decrease in performance from Q3 2020. This is likely due to the confluence of two events: (a) There was a large surge in COVID-19 cases forcing many Armenians to work and study from home where access to high quality fibre was lacking; and (b) There were a series of cyberattacks in the second half of 2020 – mostly focused on government digital infrastructure in Armenia.[66]
- Fixed network performance was generally poor in 2019/2020 - Mobile download performance was about 80% faster than fixed network performance in this period but fixed network performance has rapidly increased in 2021 as more fibre is replacing copper. Average fixed network downlink performance is now on par with mobile performance.
- Overall, Armenia's network has been resilient during COVID-19 with only small reductions in fixed and mobile performance in Q1 and Q4 2020.

[66] *The Cyber Battlefield is Just as Important: Armenia's Cybersecurity*, January 2021 (available at https://www.evnreport.com/magazine-issues/the-cyber-battlefield-is-just-as-important-armenia-s-cybersecurity).

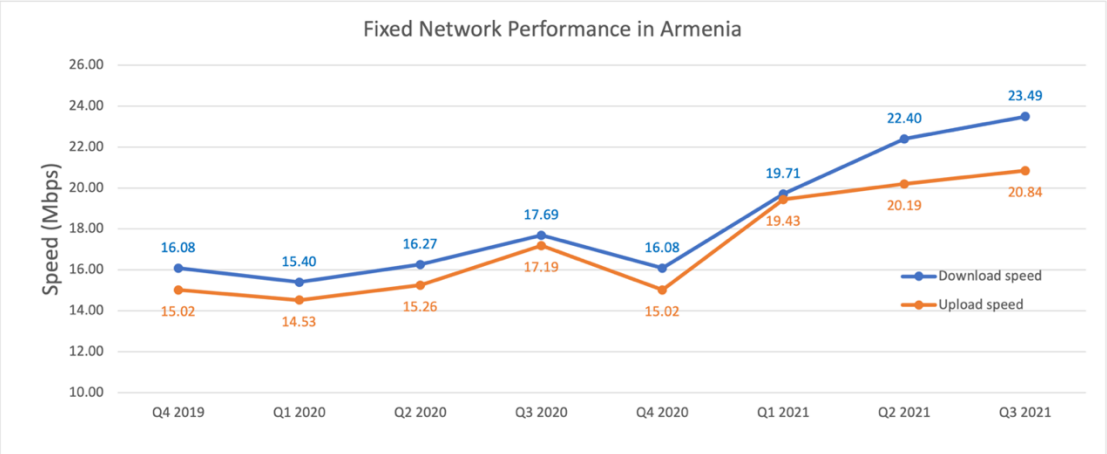

Figure 16: Fixed network performance in Armenia between Q4 2019 and Q3 2021

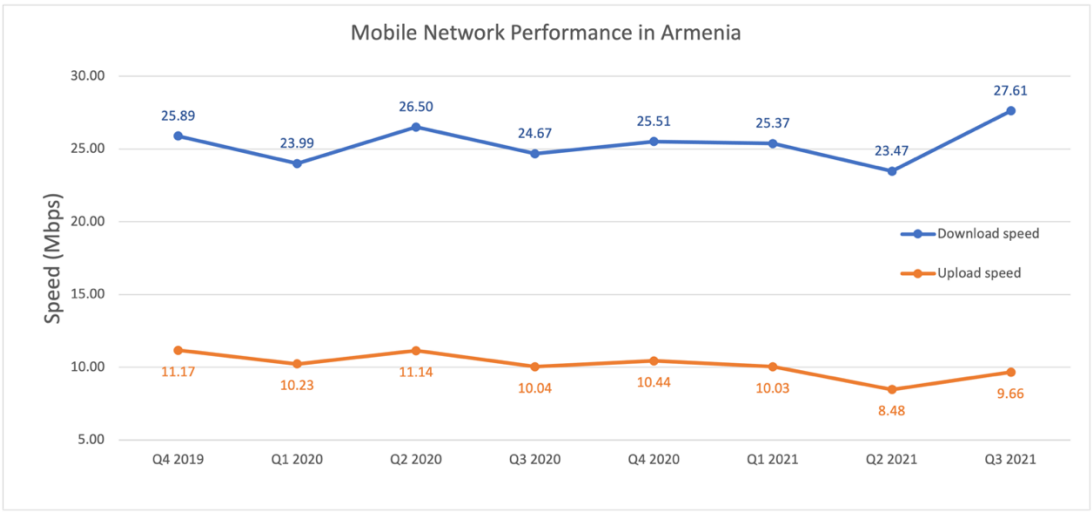

Figure 17: Mobile network performance in Armenia between Q4 2019 and Q3 2021

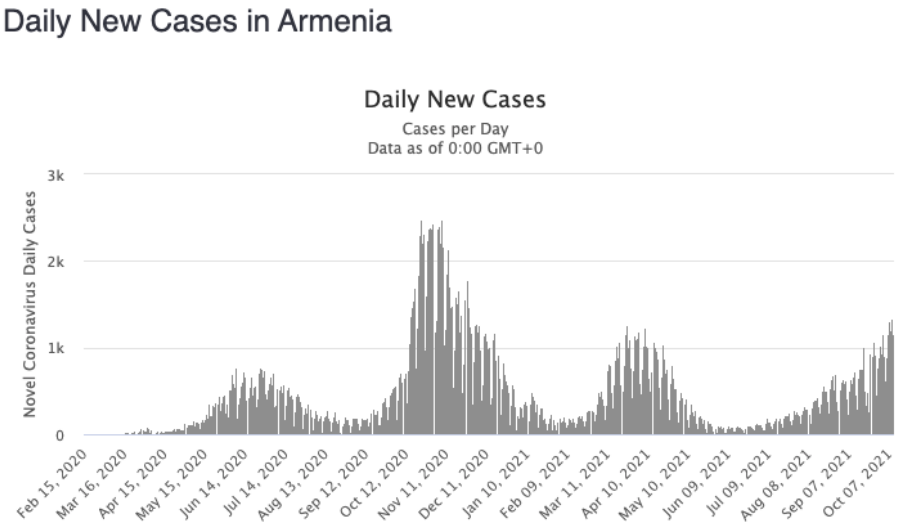

Figure 18: Daily new COVID-19 infections in Armenia67

B. Assessing Armenia's Country-Level Resilience

Key recommendations

- Critical infrastructure resilience
  - Make more spectrum available in **high-capacity bands** and **digital dividend bands**
  - Enable mobile operators to roll out **5G mobile networks**
  - Create more content and applications in the **local Armenian language**
- Network/ISP resilience
  - Increasing level of cyber security in Armenia by:
    - Using the **ITU CyberDrills** initiative for capacity building
    - Increasing the number of **secure internet servers**
    - Continuing to adopt **Domain Name System Security Extensions (DNSSEC)** across Internet infrastructure in Armenia
- Market resilience
  - Look for opportunities to **increase competition in the mobile market**.
    - There is an opportunity to open the market to **new competition** when allocating and assigning new **5G spectrum** (building on license obligations for 4G licenses)
  - Create opportunities for network operators to **expand high-speed fixed access** to more Armenians, especially in rural areas, using a combination of fixed wireless

[67] See worldometers information on the coronavirus in Armenia (available at: https://www.worldometers.info/coronavirus/country/armenia/).

access, last mile fibre access and satellite technology; selecting the appropriate technology based on population density and availability of fibre backhaul.
- Ensure that last mile providers have access to **affordable wholesale backhaul.**

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. In addition, resilience is the ability to anticipate, withstand, recover from, and adapt to adverse conditions, stresses, attacks, or compromises.[68]

This section uses the framework shown in Figure 19 to evaluate the resilience of the Internet in Armenia. Resilience of a network is defined as the ability of a country to provide Internet services to its citizens at an acceptable level of service in the face of faults and challenges to normal operations. Three critical pillars on country-level resilience are evaluated:

1. **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 top-level domains reserved for the country.
2. **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 secure domain name servers (DNS) and intrusion detection systems against threats such as denial-of-service attacks.
3. **Market resilience:** The ability of the market to self-regulate and provide affordable prices to end-users while remaining diverse and competitive.

[68] See NIST SP 800-16: Information Technology Security Training Requirements: a Role- and Performance-Based Model (available at: https://csrc.nist.gov/publications/detail/sp/800-16/final)

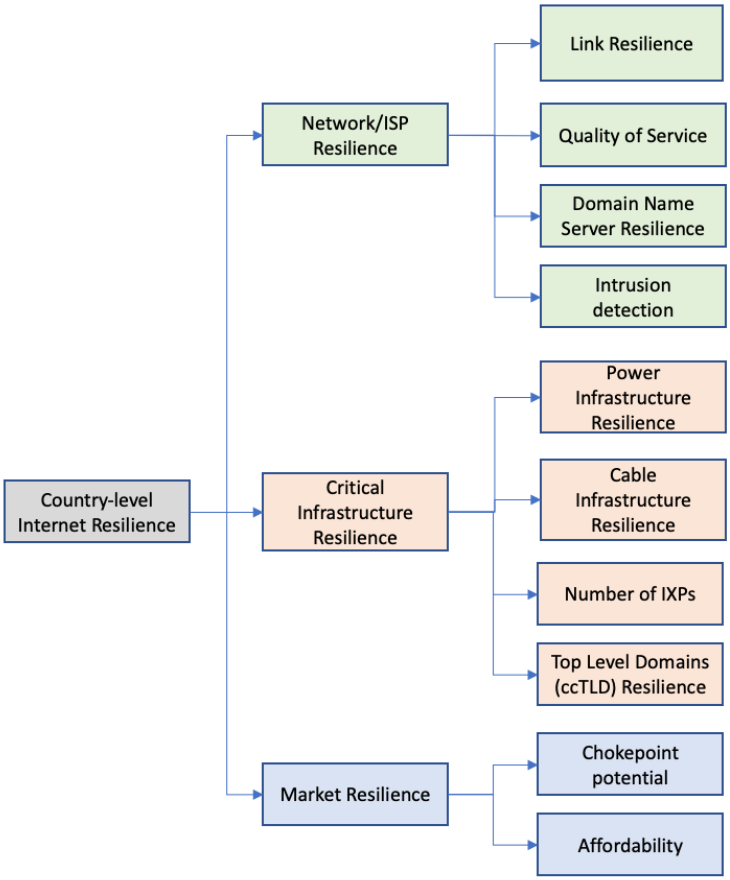

Figure 19: Hierarchical representation of resilience[69]

A summary of the Internet resilience indicators is provided in Table 12 for Armenia and three peer countries were compared – Georgia, Kazakhstan and Kyrgyzstan. Table 12 provides a more detailed description of the indicators used, the year the data was last updated, and the data source. Each of the three pillars of Internet resilience and their respective indicators will be discussed in the following sections. Some of the data for peer countries, Georgia, Kazakhstan and Kyrgyzstan, was not available. However, two of these countries, Kazakhstan and Kyrgyzstan, are part of the next round of Connect2Recover countries and a more complete comparison can be made once the data from these countries is collected.

[69] Based on work done by Afrinic/ ISOC project: MIRA. (available at: https://www.Internetsociety.org/blog/2020/11/measuring-Internet-resilience-in-africa/)

Table 12: Internet resilience indicators for Armenia, Georgia, Kazakhstan, Kyrgyzstan

Pillar	Dimension	Indicator	Armenia	Rank	Kazakhstan	Rank	Kyrgyzstan	Rank	Georgia	Rank
Critical Infrastructure	Power infrastructure resilience	Power availability[70]	100%		100%		99.90%		100.00%	
	Cable infrastructure resilience	10-km Fibre reach (percent)[71]	88%		31%		42,2%		53,1%	
		Exit points (Gateways)	Not clear							
	Mobile	Network Coverage[72]	90.0%		78.1%		77.9%		80.0%	
		Spectrum allocation[73]	21.43		31.05		39.52		37.83	
	Number of IXPs	Number of IXPs[74]	1		3		2		1	
		IXPs per 10 million	3.37		1.60		3.03		2.69	
	Top Level Domains	Number of ccTLDs[75]	14,831 (38763)		51,544		5,359		16,971	
		Number of people per ccTLD	199 (76)		364		1,230		219	
		% of apps in local language[76]	12.54%		48.64%		19.09%		15.13%	
Network/ISP Resilience	Link resilience[77]	Peering efficiency (percent ISP peering)	5.46%		N/A		N/A		N/A	

[70] See Access to electricity (% of population) (available at: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS).

[71] Calculated by the ITU using fibre maps provided to the ITU from between 2011 and 2013.

[72] See GSMA Mobile Connectivity Index Dimension Scores (available at: https://www.mobileconnectivityindex.com/#year=2019&dataSet=dimension).

[73] See GSMA Mobile Connectivity Index Dimension Scores.

[74] See IXPDB (available at: https://ixpdb.euro-ix.net/en/ixpdb/ixp/372/).

[75] See Zonefiles country code domain lists (available at https://zonefiles.io/cctld-domains/). Data in brackets provided by the Union of Operators in Armenia.

[76] See GSMA Mobile Connectivity Index Indicator Scores (available at: https://www.mobileconnectivityindex.com/#year=2019&dataSet=indicator).

[77] Data for Armenia received from the president of the Armix Foundation.

Pillar	Dimension	Indicator	Armenia	Rank	Kazakhstan	Rank	Kyrgyzstan	Rank	Georgia	Rank
		Peering efficiency (percent IPs peering)	80.00%		N/A		N/A		N/A	
	Quality of service[78]	**Fixed networks**		100		70		85		115
		Fixed Latency (ms)	12		20		13		16	
		Fixed Upload (Mbps)	33.2		57.9		46.62		28.04	
		Fixed Download (Mbps)	36.25		61.05		47.91		26.73	
		Mobile networks		74		83		101		68
		Mobile Latency (ms)	26		36		28		31	
		Mobile Upload (Mbps)	19.83		12.23		11.85		13.67	
		Mobile Download (Mbps)	33.13		31.81		24.95		36.53	
	Domain Name Server resilience	% of DNSSEC validation by country[79]	58.05%		30.82%		4.34%		37.53%	
		DNSSEC adoption for TLDs[80]	yes		no		yes		no	
	Cybersecurity	Secure Internet Servers[81]	587	104	3,307	72	420	116	3,305	71
		Global Cybersecurity Index[82]	50.47	90	93.15	31	49.64	92	81.06	55

[78] See Ookla country summary (available at https://www.speedtest.net/global-index).

[79] See DNSSEC validation by country (available at: https://stats.labs.apnic.net/dnssec/).

[80] See Internet Society Pulse data on DNSSEC adoption for Top Level Domains (available at https://pulse.Internetsociety.org).

[81] See World Bank Secure Internet Servers (available at: https://data.worldbank.org/indicator/IT.NET.SECR.P6).

[82] See ITU Global Cybersecurity Index Table 3 (available at: https://www.itu.int/epublications/publication/global-cybersecurity-index-2020/en/).

Pillar	Dimension	Indicator	Armenia	Rank	Kazakhstan	Rank	Kyrgyzstan	Rank	Georgia	Rank
		DDOS risk[83]	1	117	17	39	1	127	2	106
		Spam infections[84]	0.28%	26	0.33	23	0.34	22	0.18	40
Market Resilience	Chokepoint potential[85]	Market concentration mobile operators	4,784		3,386	N/A	N/A	N/A	3,391	
		Market concentration fixed operators	1,416		N/A	N/A	N/A	N/A	N/A	
		Spectrum concentration	3,514		N/A	N/A	N/A	N/A	N/A	
		OP2 coverage concentration mobile operators	92%		N/A	N/A	N/A	N/A	N/A	
		OP2 coverage concentration fixed operators	N/A		N/A	N/A	N/A	N/A	N/A	
		OP3 coverage concentration mobile operators	84.81%		N/A	N/A	N/A	N/A	N/A	
		OP3 coverage concentration fixed operators	N/A		N/A	N/A	N/A	N/A	N/A	
	Affordability[86]	1.5 GB mobile BB % GNI p.c.	0.96%		0.36%		2.83%		0.56%	
		1.5 GB mobile BB % GNI p.c. bottom 20%	2.13%		0.73%		5.90%		1.65%	
		1.5GB mobile BB % GNI p.c. bottom 40%	1.25%		0.45%		3.68%		0.77%	
		5 GB fixed BB % GNI p.c.	3.19%		0.85%		8.20%		2.79%	

[83] See CyberGreen Stats (available at: https://stats.cybergreen.net/download/).

[84] See Composite Blocking List: Breakdown by country infections (available at: https://www.abuseat.org/public/countryinfections.html).

[85] Calculated using data supplied by PSRC and the Herfindahl-Hirschman Index (HHI).

[86] Calculated using data from World Telecommunications/ICT Indicators Database and World Bank data on income share held by lowest 20% (available at https://data.worldbank.org/indicator/SI.DST.FRST.20) and World Bank data on income share held by fourth 20% (available at: https://data.worldbank.org/indicator/SI.DST.04TH.20).

Pillar	Dimension	Indicator	Armenia	Rank	Kazakhstan	Rank	Kyrgyzstan	Rank	Georgia	Rank
		5 GB fixed BB % GNI p.c. bottom 20%	7.09%		1.73%		17.08%		8.21%	
		5 GB fixed BB % GNI p.c. bottom 40%	4.16%		1.07%		10.65%		3.82%	

1. Critical Infrastructure

Key recommendations

- Make more spectrum available in **high-capacity bands** and **digital dividend bands**
- Enable mobile operators to roll out **5G mobile networks**
- Create more content and applications in the **local Armenian language**

From the ITU transmission maps, it can be seen that Armenia has international Internet gateways via Georgia and the Islamic Republic (IR) of Iran. However, the ITU fibre data is old (maps were obtained between 2011 and 2013) and the exact up-to-date number of international Internet gateways is still not known. The situation has improved since 2011, when 90% of the Internet was supplied through one exit via Georgia. To demonstrate how vulnerable the Internet resilience was in 2011, a Georgian scavenging for copper to sell as scrap, dug up the fibre line to Georgia and caused 90% of Armenia's Internet capacity to go down.[87] 88% of the country is within 10km of fibre; an indication that backhaul infrastructure in Armenia is widespread. This is also considerably better than Armenia's peer countries, with the percentage of the country within 10km of fibre ranging from 31% in Kazakhstan to 51.3% in Georgia. However, last mile access for fixed networks still often relies on copper lines; this is shown by the poor fixed network speed performance.

Armenia only has one IXP, which is probably sufficient for its small population. This equates to 3.37 IXPs per 10 million people. This places Armenia above a country like Germany with 2.66 IXPs per 10 million people and just below the United States with 3.56 IXPs per 10 million people according to data from the Economist Intelligence Unit's (EIU's) 'Inclusive Internet Index 2019.'[88] Adding an additional IXP would move Armenia into the top 15 countries in terms of the number of IXPs serving the population in the EIU's 120 country index. Compared to Armenia's peers, Armenia's IXPs per 10 million people index is better than Georgia, Kazakhstan, and Kyrgyzstan.

According to the World Bank, electricity is available and reliable for 100% of the population and critical infrastructure that depends on electricity in Armenia. This greatly reduces the cost of ensuring close to 100% uptime for existing telecommunications infrastructure and the cost to deploy new infrastructure across the country.

[87] See Georgian woman cuts off web access to whole of Armenia (available at: https://www.theguardian.com/world/2011/apr/06/georgian-woman-cuts-web-access).

[88] See 2021 Inclusive Internet Index (available at https://theinclusiveInternet.eiu.com/).

Mobile coverage is excellent in Armenia. According to the ITU ICT Access Survey data from 2020, there is 100% 3G and 4G population coverage. The Armenian government confirmed that 2G, 3G, and 4G networks provide coverage to 100% of the population in 2021 when all three mobile operators are combined. Armenia scores better than all three peer countries on this measure. However, there are no 5G deployments in Armenia yet and this reduces Armenia's GSMA Mobile Connectivity Index coverage score to 90%. The GSMA Mobile Connectivity Index (MCI) is a weighted sum that consists of 10% for 2G coverage, 40% for 3G coverage, 40% for 4G coverage, and 10% for 5G coverage. In 2019, Armenia's GSMA MCI coverage score was 87.6 and was placed 59 out of 170 countries; on par with countries like South Africa and Turkey.

According to information received from the Armenian government, mobile spectrum has been allocated according to Table 13. The GSMA MCI checks the balance of spectrum allocated in low, mid, and high bands to calculate a composite spectrum allocation score (see Table 14). This places Armenia in position 140 out of 170 countries indexed by the GSMA in terms of spectrum allocation and Armenia performed the worst in this aspect compared to all three peer countries.

Table 13: Mobile operator spectrum allocation

Operator	Band	Frequency range (MHz)	Total
Telecom Armenia			**105 MHz**
	900 MHz	890-902.5 / 935-947.5	12.5x2
	1800 MHz	1735-1760 / 1830-1855	25x2
	2100 MHz	1965-1980 / 2155-2170	15x2
MTS Armenia			**165 MHz**
	800MHz	811-821 / 852-862	10x2
	900 MHz	902.5-915 / 947.5-960	12.5x2
	1800 MHz	1710-1735 / 1805-1830	25x2
	2100 MHz	1935-1950 / 2125-2140	15x2
	2600 MHz	2500-2520 / 2620-2640	20x2
Ucom			**190 MHz**
	800MHz	801-811 / 842-852	10x2
	900 MHz	880-890 / 925-935	10x2
	1800 MHz	1760-1780 / 1855-1875	20x2
	2100 MHz	1950-1965 / 2140-2155	15x2
	2600 MHz	2520-2560 / 2640-2680	40x2

Table 14: Spectrum allocation used for GSMA Mobile Connectivity Index composite spectrum indicator

Spectrum range	Allocation	Allocation per operator	MCI ranking score	Weight
Digital dividend	40 MHz	13.33 MHz	16.67	40%
Other spectrum below 1GHz	70 MHz	23.33 MHz	19.05	20%
Spectrum in the bands 1-3GHz	310 MHz	103.33 MHz	36.50	30%
Spectrum in bands above 3 GHz	0 MHz	0 MHz	0.00	10%
MCI composite indicator			**21.43**	

Armenia has 37,629 .am and 1134 .հայ country code top level domains (total of 38,763 ccTLDs) registered as of October 2021 according to the director of the Union of Operators of Armenia. The .հայ country code is intended for domain names in the Armenian language. This amounts to 76 Armenians per ccTLD. In 2019, the MCI index looking at ccTLDs per capita placed Armenia at position 71 out of 177 countries; better than some neighbours such as Georgia at position 85. The Netherlands, which was placed in fourth position had 5.3 people per ccTLD. In terms of the number of apps in local languages, with only 12.54% of apps in Armenian, Armenia was placed in position 167 out of 177 on the MCI index for local language apps in 2019.

Overall, Armenia's fixed and mobile telecommunications infrastructure, as well as the reliability of grid power, is resilient and well diversified. However, Armenia can improve in terms of making more spectrum available in high-capacity bands above 3 GHz, rolling out 5G networks, and creating more content in the local Armenian language.

2. Network/ISP Resilience

Key recommendations

- Increase level of cyber security in Armenia by:
  - Using the **ITU CyberDrills** initiative for capacity building
  - Increasing the number of **secure internet servers**
  - Continuing to adopt **Domain Name System Security Extensions (DNSSEC)** across Internet infrastructure in Armenia

Peering efficiency, measured as either the number ISPs or IP addresses peering at IXPs, provides insight into the how the country is maximizing the use of its internal network infrastructure. Local Peering helps to reduce reliance on Internet exit points that often serve as choke points and decrease throughput when overused or result in services not being available should an exit point fail.

Armenia has 36 registered Autonomous System Numbers (ASNs), with many belonging to small ISPs with a small number of users. There are 186 ISPs in Armenia. Ten ISPs out of these are connected to the Armix IXP (only 5.46%). However, due to the main ISPs (with large user bases) connecting to the IXP,

80% of IP addresses are peering with the Armix IXP. This provides good in-country resilience for traffic routed within Armenia, should an Internet exit gateway fail.

To measure the quality of service offered in Armenia for fixed and mobile networks, Ookla speedtest dataset is used. The latest data from Ookla, August 2021, shows that fixed downloads averaged 36.25 Mbps and mobile downloads averaged 33.13 Mbps. Fixed upload speeds averaged 33.2 Mbps (almost symmetrical with download speed) and mobile uploads were 19.83 Mbps (close to half the download speed and typical for mobile networks). Latency for both fixed and mobile networks was well within the levels required to have a high-quality video conferencing call. Armenia's mobile performance is ranked 74th in the world and fixed performance is ranked 100th. Compared to Armenia's peers, mobile performance is better than Kazakhstan and Kyrgyzstan, ranked at 83 and 101, respectively and worse than Georgia, ranked at 68. Compared to Armenia's peers, fixed performance is better than Georgia, ranked at 115 and worse than Kazakhstan and Kyrgyzstan ranked 70 and 85 respectively. Armenia's fixed performance is increasing steadily, having increased from 30.49 to 36.25 Mbps over one year between August 2020 and August 2021 (18.9% increase).

Domain Name Servers (DNSs) are prone to DNS cache poisoning when corrupted Domain Name System data is introduced into the DNS resolver's cache, causing the name server to return an incorrect record that results in traffic being diverted to the attacker's computer. Domain Name System Security Extensions (DNSSEC) were designed to protect applications using DNS from accepting forged or manipulated DNS data and use cryptographic techniques to validate the authenticity of DNS information. DNSSEC is now widely available and being enabled by many service providers.

To check the resilience of the Internet in Armenia against these types of DNS attacks, the percentage of DNSSEC validation requests in the country was checked. According to data from Arpnic, 58.05% of DNS requests are validated using DNSSEC. The current world average is 27.37%, and Armenia is ranked 37 out of 235 countries and collective territories tracked by Arpnic. This puts Armenia's DNS security far ahead of the curve and ahead of its peers Kazakhstan, Kyrgyzstan, and Georgia with DNSSEC validations of 30.82%, 4.32%, and 37.53%, respectively. Armenia's Top Level Domain DNS is also DNSSEC enabled; out of three peers that were analysed, only Kyrgyzstan also had DNSSEC enabled for its ccTLD.

Armenia's ITU global cybersecurity index was 50.47[89] which placed it 90th in the world. Focusing on components of Armenia's cybersecurity, there are only 587 secure Internet servers per 1 million people[90] (ranked 104th in the world) and there is a Distributed Denial of Service (DDOS) attack rate of 1 Tbit/sec[91] (ranked 117th in the world). Compared to Armenia's peers, Kyrgyzstan's cybersecurity index is slightly lower at 49.64 (92nd position) and Georgia and Kazakhstan have better cybersecurity indexes of 81.06 (55th position) and 93.15 (31st position), respectively. In terms of secure Internet servers, Armenia is slightly better than Kyrgyzstan with 420 secure Internet servers per million people and not as many as Georgia and Kazakhstan with 3,305 (71st position) and 3,307 (72nd position), respectively.

[89] See ITU Global Cybersecurity Index Table 3.

[90] See World Bank Secure Internet Servers.

[91] See CyberGreen Stats.

Armenia is ranked 26th in the world in terms of originating spam;[92] 0.28% of all the IP addresses listed for Armenia are flagged for originating spam. The region appears to have a common issue with being flagged for spam; Kazakhstan and Kyrgyzstan are ranked more poorly than Armenia, in terms of spam, with rankings of 23 and 22 respectively. Georgia is marginally better and ranked 40th with 0.18% of IPs flagged for spam.

Overall, in terms of Network and ISP resilience, Armenia's mobile network performed above its peers and its fixed network is improving steadily, but lags behind global leaders in the European Union, North America, and Asia. Armenia was repeatedly targeted by cyber-attacks in 2020, often defacing Armenian government websites or obtaining citizens' private data.[93] Increasing the level of security of Armenian Internet infrastructure could prevent these attacks by, for example, using the ITU CyberDrills[94] for Armenia's CERT capacity building and ensuring that more of its Internet servers are secure. Armenia, however, did perform well in adoption secure DNS (DNSSEC) to prevent DNS cache poisoning.

3. Market Resilience

Key recommendations

- Look for opportunities to **increase competition in the mobile market**.
  - There is an opportunity to open the market to **new competition** when allocating and assigning new **5G spectrum** (building on license obligations for 4G licenses)
- Create opportunities for network operators to **expand high-speed fixed access** to more Armenians, especially in rural areas, using a combination of fixed wireless access, last mile fibre access and satellite technology; selecting the appropriate technology based on population density and availability of fibre backhaul.
- Ensure that last mile providers have access to **affordable wholesale backhaul.**

Chokepoint potential is measured across three areas: (1) The level of market concentration (ensuring that there is diversity in the market share of operators); (2) The level of spectrum concentration (ensuring that no operator is too dominant in terms of spectrum allocation); and (3) The level of coverage diversity (ensuring that users have a diversity of access options from multiple operators).

Market concentration and spectrum concentration are measured using the Herfindahl-Hirschman Index (HHI) which is a common measure of market concentration used to determine market competitiveness but can be used to check the level of concentration in other domains. The equation used to calculate HHI is provided in Appendix B.

A market with an HHI of less than 1,500 is considered a competitive marketplace, an HHI of 1,500 to 2,500 is moderately concentrated, and an HHI of 2,500 or greater is highly concentrated.

[92] See Composite Blocking List: Breakdown by country infections.

[93] See The Cyber Battlefield is Just as Important: Armenia's Cybersecurity.

[94] See ITU CyberDrills (available at: https://www.itu.int/en/ITU-D/Cybersecurity/Pages/cyberdrills.aspx).

The market share for fixed operators in Armenia is shown in Table 15. The HHI index is 1,416 which shows that the fixed market in Armenia is considered competitive.

Table 15: Market share for fixed broadband and HHI index

Fixed Operator	Fixed broadband subscribers	Market share (%)
UCOM	108,966	25.3%
Beeline	103,557	24.1%
Rostelecom	59,277	13.7%
Other ISPs (181 ISPs)	158,607	36.9%
Total	430,407	
HHI Index	1,416	

The market share for mobile operators in Armenia is shown in Table 16. The HHI index is 4,784 which shows that there are not many players in the market and the mobile broadband market in Armenia is highly concentrated with Viva-MTS having 64.3% market share.

Table 16: Market share for mobile broadband and HHI index

Mobile Operator	Mobile broadband subscribers	Market share (%)
Viva-MTS	1,592,598	64.3%
UCOM	382,728	15.4%
Beeline	502,435	20.3%
Total	2,477,761	
HHI Index	4,784	

The spectrum share for mobile operators in Armenia is shown in Table 17. The HHI index is 3,514 which shows that there are not many players in the market and the spectrum allocation is highly concentrated with UCOM having 41.3% of the spectrum. UCOM's high spectrum allocation despite only having 15.4% market share is due to it only recently being assigned 4G spectrum with aggressive coverage obligations.

Table 17: Spectrum share for mobile operators and HHI index

Operator	Spectrum Share	Spectrum Share (%)
Viva-MTS	165 MHz	35.9%
UCOM	190 MHz	41.3%
Beeline	105 MHz	22.8%
Total	469 MHz	

HHI Index	3,514	

Coverage diversity is used to check the options consumers have to choose from multiple operators. Two metrics are used to measure coverage diversity:

- OP2: measures the probability of coverage from at least 2 mobile operators for the top 3 operators
- OP3: measures the probability of coverage from the top 3 operators

The equations used to calculate these metrics are provided in Appendix B.

The population coverage for mobile operators is given in Table 18.

Table 18: Mobile operator population coverage

Operator	Population coverage
Viva-MTS	100%
UCOM	92%
Beeline	89%
OP2	99.12%
OP3	81.88%

The probability of coverage from at least two mobile operators is 99.12% and the probability of coverage from at least three mobile operators is 81.88%. Overall coverage diversity for mobile is good, although certain remote rural areas may only have coverage from one or two operators.

Without more detailed fixed broadband availability data at the last mile level, the true population coverage as well as coverage concentration levels for fixed operators is difficult to calculate and a process to collect more detailed fixed broadband availability data that goes beyond middle mile at settlement level is suggested.

Affordability is another critical aspect of market resilience; for this a combination of ITU price basket survey data as well as World Bank data on GNI p.c. for the bottom 20% of income earners and the bottom 40% of income earners is used. The ITU has set a target for the prices of entry-level fixed and mobile broadband services to be kept below 2% of monthly gross national income (GNI) per capita. For mobile services, mobile broadband is affordable if 1.5 GB of data are available below that level.[95] Fixed

[95] 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/).

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.[96]

Some have questioned whether a 2% affordability threshold is too high. The World Bank states, "it is only when the cost per gigabyte of data drops below 0.5 per cent of gross national income (GNI) per capita that data consumption reaches and eventually exceeds the 1 gigabyte threshold."[97] The World Bank further points out that data consumption is very sensitive to market prices and service affordability.[98]

By the ITU's measures, mobile connectivity is affordable for most Armenians with a 1.5GB mobile package costing 0.96% of GNI per capita, and 1.25% for the bottom 40% of income earners. However, a 1.5GB mobile package is marginally unaffordable for the bottom 20% of income earners, costing 2.13% of GNI per capita.

Fixed connectivity is not yet affordable for many Armenians. A 5GB fixed broadband package costs 3.19% of GNI per capita and as much as 7.9% of GNI per capita for the bottom 20% of income earners.

In terms of market resilience, Armenia could take steps to create more competition in the mobile operator market. There is an opportunity to open up the market to new competition by opening up more spectrum for mobile and fixed broadband services. Fixed broadband access is not affordable for many Armenians. As we discuss below, the GoRA could implement policies that would give network operators more flexibility in how they deploy fixed broadband services, including fibre, fixed wireless, and satellite technologies. In addition, costs can be reduced by ensuring that more last mile fixed and mobile network operators have access to affordable wholesale fibre backhaul.

VI. Policy and Regulation

A. Connect2Recover Initiative

As per the Connect2Recover phase one report, 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. Nonetheless, 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

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

[97] See The World Bank Group, "World Development Report 2021: Data for Better Lives", 166 (available at https://openknowledge.worldbank.org/bitstream/handle/10986/35218/9781464816000.pdf) (World Development Report 2021: Data for Better Lives).

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

implement policy changes based on those reviews.[99] This approach aligns with the ITU Global Symposium for Regulators (GSR) Best Practice Guidelines of 2019.[100]

The Connect2Recover phase one report describes 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. The table below lists and describes these six key elements:

Table 19: Key Elements of Successful National Broadband Plan

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. • Creating 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 allowing countrywide. • Processes and methodologies to collect and present availability, usage and adoption data should be open and transparent.[101]
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.

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

[100] See Global Symposium for Regulators (GSR) 2019 Best Practice Guidelines (available at https://www.itu.int/en/ITU-D/Conferences/GSR/2019/Documents/GSR19BestPracticeGuidelines_E.pdf).

[101] 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.

	• Fixed and mobile broadband data should be collected at least on an annual basis with more frequent reporting to track specific interventions.

Supply-side interventions	• Implement clear and enforceable competition policy.
	  ○ Policies should maximize competition throughout the supply chain.
	  ○ Policies should both promote competition and protect against abuse of market power.
	• Open up more spectrum for fixed and mobile connectivity.
	• Invest in infrastructure.
	  ○ 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.
	  ▪ 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.
	  ▪ 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. • Consider policies promoting community-based network operators, especially in rural areas. • Consider social-purpose spectrum licenses 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, older persons, children, youth, ethnic minorities, and women and girls, have equitable access to fixed and mobile broadband, as well as other digital services.
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, health-care centres, government offices, police and fire stations, and community centres) and vulnerable or marginalized groups (such as persons with disabilities, older persons, 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. • 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, national emergency telecommunication plans should be in place that include contingency plans for a full range of disasters from natural hazards or man-made causes. The ITU's Digital Regulation Platform provides regulators with guidance on many of these points.[102]

[102] See International Telecommunication Union Digital Regulation Platform (available at https://digitalregulation.org/).

While respecting each country's unique political and economic characteristics, as well as legal constraints, the Connect2Recover phase one report also describes a process for developing 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).
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.

B. Connect2Recover Phase Two Policy and Regulatory Assessment

To assess the situation in Armenia in relation to fixed and mobile broadband policy and regulation, desk research was conducted, which was accompanied and verified with in-person interviews with relevant experts at the MHTI, the PSRC, and other government bodies. Desktop research included a review of relevant Armenian statutes, policies, and regulations, as well as a review of three sets of ITU data – Armenia's response to the ITU's latest biennial Telecommunication/ ICT Regulatory Survey, the ITU's 2020 ICT Regulatory Tracker, and 2021 ITU G5 Benchmark Report. This was further informed by the World Bank, EU4Digital, and other reports provided by the GoRA.

Armenia received an overall score of 88.5 on the ITU's 2020 ICT Regulatory Tracker, placing it in the fourth generation (G4) of regulation characterized as integrated regulation led by economic social policy goals.[103] The ITU's ICT Regulatory Tracker is an evidence-based tool to help decision-makers and regulators make sense of the rapid evaluation of ICT regulation. The Tracker does not measure the

[103] See https://app.gen5.digital/tracker/country-cards/Armenia.

quality, the level of implementation, or the performance of regulatory frameworks in place, but records their existence and features. It helps track progress and identify gaps in regulatory frameworks, making the case for further regulatory reform towards achieving a vibrant and inclusive ICT sector. The ICT Regulatory Tracker is composed of 50 indicators grouped into four clusters: (1) Regulatory authority (focusing on the functioning of the separate regulator), (2) Regulatory mandates (who regulates what), (3) Regulatory regime (what regulation exists in major areas), and (4) Competition framework for the ICT sector (level of competition in the main market segments). Armenia scores highest on regulatory authority (20 out of 20), its regulatory mandates (19.5 out of 22), and its competition framework (27 out of 28) and scores lowest on its regulatory regime (20 out of 30).

Armenia received an overall score of 61.83 on its 2021 ITU G5 Benchmark Report, scoring highest on national collaborative governance.[104] The ITU's G5 Benchmark is a measure of collaborative regulation excellence and inclusive digital transformation across all sectors of a country's economy. The G5 Benchmark takes data from 157 countries and covers four pillars, with 66 indicators taken into account. The pillars are national collaborative governance, policy design principles, digital development, and digital economic policy agenda. The ITU is currently conducting a G5 collaborative regulation country review for the GoRA, which will complement this Connect2Recover phase two and three report.

The Ministry and the PSRC demonstrate many of the characteristics of good governance with an independent regulatory authority, ethics rules in place, open and transparent policy and regulatory proceedings, and extensive intra-government collaboration. Collaboration is stipulated by the laws on administrative proceedings, electronic communications, and the PSRC. The GoRA has progressive competition policies. All fixed and mobile network operators are privately owned and there are no limits on foreign investment. The Government reports that there is no dominant provider of fixed or mobile broadband services.[105]

The GoRA has a Digitalisation Strategy in place and a National Strategy for Broadband Communication is under consideration. However, there is no National Broadband Plan or Strategy currently in place. Therefore, the Ministry and PSRC lack a blueprint for addressing digital inequality. Beyond the obligation of all facilities-based operators to provide emergency services, the Ministry and PSRC has not adopted universal service policies and does not have a formal rural telecommunications development policy. Universal service obligations are achieved through internal cross-subsidization, which leads to marketplace distortions and may undermine efforts to boost availability and adoption of fixed and mobile broadband services.

The table below summarizes and compares Armenian laws and regulations, as well as the Government's Digitalisation Strategy to the Connect2Recover initiative's suggested national broadband plan framework.

[104] See https://app.gen5.digital/benchmark/country-cards/Armenia.

[105] See our comments above on mobile market and spectrum concentration.

Table 20: Comparison of Armenia Laws and Regulations to Connect2Recover Framework

Connect2Recover Initiative National Broadband Plan Framework		Armenia Current Laws and Regulations	Government of Republic of Armenia Digitalisation Strategy (11 Feb 2021)
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. • Creating 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 allowing countrywide. • Processes and methodologies to collect and present availability, usage and adoption data should be open and transparent.	• There is no current National Broadband Plan and coverage, quality and affordability targets are not defined. • The Ministry of High-Tech Industry of the Republic of Armenia would lead development of a NBP, in consultation with Public Service Regulatory Commission (PSRC), which would be charged with implementation. • No sandboxes identified, but nothing in electronic communications law precluding this. • According to the ITU desk research, Armenia doesn't have national ICT mapping systems (infrastructure, services or investment) in place. Neither Ministry nor the PSRC have broadband maps publicly available on their websites. Operators provide free access to mobile coverage maps (not downloadable, different format) and tables on broadband backbone and middle mile availability in urban/rural settlements.	On 11 February 2021, the Digitalisation Strategy of Armenia was approved by the Prime Minister of the Republic of Armenia (GoRA).[106] • The Digitalisation Strategy was developed in accordance with the laws of the Republic of Armenia. • The Strategy was discussed and developed within the framework of the Eastern Partnership (EaP) with the participation of the Public Services Regulatory Commission and the Ministry of High-Tech Industry of the Republic of Armenia. • By December 2021, the Strategy calls for the Ministry and PSRC to take an inventory of and map the existing optical-wired transmission networks that are being operated in the public and private sector, their capacities and the relevant network topologies; to analyse the demand according to marz (regional) distributions; and to reveal technical issues and propose

[106] The Digitalisation Strategy of the Republic of Armenia may be found at https://www.arlis.am/DocumentView.aspx?docID=149957 or https://www.arlis.am/.

Connect2Recover Initiative National Broadband Plan Framework		Armenia Current Laws and Regulations	Government of Republic of Armenia Digitalisation Strategy (11 Feb 2021)
			relevant solutions. See Digitalisation Strategy 7.
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.	• No current National Broadband Plan.	• Development of the National Broadband Communication Strategy is envisaged in the Digitalisation Strategy. The Digitalisation Strategy does contain several goals relevant to broadband, including in relation to broadband availability, website and e-systems accessibility, and digital skills. See generally Digitalisation Strategy.
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.	• The GoRA has commendably detailed ICT access statistics on age, gender, and persons with disabilities, but lacks timely granular operator data on speed tier availability and adoption. • Fixed and mobile broadband adoption data is provided quarterly by the operators to the PSRC. However, this data lacks sufficient details on actual population coverage, adoption and usage per technology, level of last mile broadband penetration to households.	• By December 2021, the Digitalisation Strategy calls for the Ministry and PSRC to take an inventory of and map the existing optical-wired transmission networks that are being operated in the public and private sector, their capacities and the relevant network topologies; to analyse the demand according to marz (regional) distributions; and to reveal technical issues and propose relevant solutions. See Digitalisation Strategy 7.
Supply-side interventions	• Implement clear and enforceable competition policy.	• Competition Policies: Under the shared jurisdiction of the PSRC and the Commission for	• The Digitalisation Strategy notes that "ensuring access to broadband connections

Connect2Recover Initiative National Broadband Plan Framework		Armenia Current Laws and Regulations	Government of Republic of Armenia Digitalisation Strategy (11 Feb 2021)
	○ Policies should maximize competition throughout the supply chain. ○ Policies should both promote competition and protect against abuse of market power. • Open up more spectrum for fixed and mobile connectivity. • Invest in infrastructure. ○ 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. ▪ Separate programmes should be created for fixed and mobile services. ▪ Fund recipients should be required to deploy broadband throughout the concession area.	the Protection of Economic Competition (CPEC). The Law on Protection of Economic Competition (2000) is under the competency of the CPEC. The Electronic Communications law, which is under the competency of the MHTI and PSRC, includes a variety of competition provisions specific to the ICT sector. All private companies. No dominant providers reported. No foreign investment limits. Full competition across relevant market segments. ITU Reg. Survey at 90-91, 22-23. • Spectrum: 3G and 4G licensing. Only 800 MHz under the digital dividend licensed (Band 20). Have transitioned from beauty contests to auctions for 4G licenses. ITU Reg. Survey at 62. 2.4 and 5 GHz are license-exempt (unlicensed) bands, with licensing required for outdoor 5 GHz deployments. No spectrum sharing in place. ITU Reg. Survey at 57-63. • Investment in Infrastructure: The policy pursued by the Ministry of High-Tech Industry of the Republic of Armenia is based on equal and non-discriminatory approaches for investors within the framework of free market	throughout the Republic of Armenia, targeting access in remote areas, is a fundamental condition for the implementation of the Digital Agenda." At 42 • The Digitalisation Strategy further notes that a National Strategy for Broadband Communication is currently being developed with a view to supporting this goal. Digitalisaton Strategy at 42. • The Digitalisation Strategy further states that in the field of development of broadband connections, key attention shall be paid to the models of co-operation with the private sector and the actions aimed at promoting private investment in the sector in general. Digitalisaton Strategy at 42. • The Digitalisation Strategy does include goals for making websites and e-services accessible for persons with disabilities. Digitalisaton Strategy at 37-39.

Connect2Recover Initiative National Broadband Plan Framework		Armenia Current Laws and Regulations	Government of Republic of Armenia Digitalisation Strategy (11 Feb 2021)
	▪ 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. ▪ 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. • Consider policies promoting community-based network operators, especially in rural areas. • Consider social-purpose spectrum licenses to support community networks in	relations.[107] The government has not invested in core telecommunications network infrastructure. The network infrastructure in Armenia is under the control of the private sector. • Universal service obligations and programmes: No universal service funding programmes. Universal service obligations do exist. Universal service has been defined as emergency services and universal service obligations are funded through cross subsidies. ITU Reg. Survey at 68-69. • Community-based network operators: No specific policy, but also nothing preventing formation of community-based network operators. • Social-purpose spectrum licenses: No social-purpose spectrum licenses, but all mobile licenses have buildout obligations. Have 100% 4G coverage to all settlements. • Equitable access to disenfranchised groups: No. Television broadcasters are required to provide disability access to content through	

[107] See The Armenian Parliament Decision 26.08.2021 N ԱԺՈ-002Ն https://www.arlis.am/.

Connect2Recover Initiative National Broadband Plan Framework		Armenia Current Laws and Regulations	Government of Republic of Armenia Digitalisation Strategy (11 Feb 2021)
	locations where licensed spectrum is not being used. • Ensure that citizens from vulnerable or traditionally disenfranchised groups, such as persons with disabilities, older persons, children, youth, ethnic minorities, and women and girls, have equitable access to fixed and mobile broadband, as well as other digital services.	captioning. ITU Reg. Survey at 91-92.	
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, health-care centres, government offices, police and fire stations, and community centres) and vulnerable or marginalized groups (such as persons with disabilities, older persons, children, youth, women and girls, and indigenous populations). • Implement both basic and advanced digital skills programming. • Support programmes developing locally relevant applications and content.	• Generally: The www.e-gov.am platform promotes demand for digitalized services, where state-provided digital services are brought together in a single platform. Development and approval of the state digital complex system design is envisaged, which will clarify the state as a joint services e-gov platform for providing digital services and the state internal government system (government agencies as subsystems) as a common design. • Low-Income Programmes: No programmes to discount fixed and mobile broadband services and devices for low-income individuals and households. • Discounted Services: With encouragement of Ministry and PSRC, network operators implemented programmes	• Generally: One of the measures envisaged by the Digitalisation Strategy is the availability of digital services for people with disabilities, within the framework of which it is envisaged: - to hold discussions with NGOs dealing with issues of persons with disabilities; - to study the requirements for persons with disabilities, including persons with visual, hearing and intellectual impairment, and to provide opportunities for equal access to the common platform of public services; - to develop and implement affordable solutions (Text to Speech and Speech to Text conversions, etc.). It is planned to develop and implement at least 5 functional solutions.

Connect2Recover Initiative National Broadband Plan Framework		Armenia Current Laws and Regulations	Government of Republic of Armenia Digitalisation Strategy (11 Feb 2021)
		to maintain services for customers unable to pay bills during the COVID-19 forced shutdowns. Network operators also provided free calls to the hotline of the Ministry of Health. • Also the programme "University-Private Sector Cooperation" implemented by the Ministry is aimed at the development of digital skills.[108] The main goal of the project is to support the establishment of a knowledge-based progressive society in Armenia, a developed and world-renowned high-tech sector. • Locally relevant applications and content: Out of the competency of the MHTI.[109]	• Basic Digital Skills: The Digitalisation Strategy includes recommendation on digital skills including digital skills programmes in general education (including programmes targeted to persons with special needs), programmes for the older persons, and in the general public. See Digitalisation Strategy at 37-39, 42-43. • Advanced Digital Skills: The Digitalisation Strategy includes recommendations on digital technology service training programmes, implementation of educational programmes for the creation of digital technologies, and establishment of technology transfer centres. See Digitalisation Strategy at 42-43.
Monitoring and evaluation programmes	• Include a monitoring and evaluation programme from the outset.	• Nothing in place, but in the context of the Eastern Partnership, a working group is looking into	• By December 2021, the Digitalisation Strategy calls for the Ministry and PSRC to take an inventory of and map

[108] See https://edu.hti.am/en/about; see also 16 point action plan available at https://www.arlis.am/DocumentView.aspx?docID=149957.

[109] More information about this program can be found in the action plan to the strategy of the Digitalisation Strategy of Republic of Armenia.

Connect2Recover Initiative National Broadband Plan Framework		Armenia Current Laws and Regulations	Government of Republic of Armenia Digitalisation Strategy (11 Feb 2021)
	• 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.	developing a monitoring and evaluation framework. • Nonetheless, network operators are required to publish advertised speeds and speed ranges of Internet access services. Financial penalties (and even license revocation) can be imposed for publication of incorrect information.	the existing optical-wired transmission networks that are being operated in the public and private sector, their capacities and the relevant network topologies; to analyse the demand according to marz (regional) distributions; and to reveal technical issues and propose relevant solutions. See Digitalisation Strategy 7.

The Armenian Ministry of Emergency Situations is responsible for emergency communications.[110] The GoRA has ratified the Tampere Convention but does not have a National Emergency Telecommunications Plan. The PSRC has regulation on the provision of universal emergency (911 and 112) calling free of charge.[111]

C. Connect2Recover Phase Three Policy Recommendations

The Connect2Recover phase one report observed that 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. This begins with developing national broadband plans and strategies. Governments should implement definitions and targets for broadband availability, adoption overall, and adoption by traditionally vulnerable or disenfranchised groups, such as women and girls and persons with disabilities. As data is the basis for good policymaking, governments can improve 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, to prepare for other disasters – whether the result of natural hazards or man-made causes – that will strike in the future, every national authority is encouraged to have a national emergency telecommunication plan in place. These recommendations align with the checklist of recommended government and national regulatory authority actions included

[110] *See* Armenia 2020 ITU Regulatory Survey Response at 93-94.

[111] See Armenia 2020 ITU Regulatory Survey Response.

in the ITU's recent report entitled, "Pandemic in the Internet age: From second wave to new normal, recovery, adaptation and resilience."[112]

Below, we apply and summarize key elements common to successful national broadband plans to the Armenian context.

Table 21: Application of Connect2Recover national broadband framework to Armenian context

Good governance	• It is recommended that Armenia's **National Strategy for Broadband Communications** be **developed through an open and transparent process** and with significant **inter-governmental coordination** • The MHTI and PSRC might consider **creating a space for limited trials of new regulatory models and technologies** prior to permanently allowing countrywide. • The GoRA might take **additional steps to collect and present** availability, usage, and adoption **data** at the highest feasible level of granularity available and in an open and transparent manner.
Clear goals	• The GoRA is encouraged to **include broadband definitions and policies based on connectivity goals** the GoRA wants to achieve for all of its citizens. • **Affordability targets** could initially be set at **2% of income for the lowest 40 of income earners** and the lowest 20% of income earners at some point in the future.
Regular assessment of availability and adoption	• It is recommended that the GoRA **combine data from network operators and household surveys**, along with third-party data on availability, adoption, and usage. • It is recommended that **detailed fixed and mobile broadband data** (population coverage in each settlement, speed tiers and technology available as well as subscriber data) **be collected at least on an annual basis** with more frequent reporting on subscribers to track specific interventions.

[112] See International Telecommunication Union, Pandemic in the Internet age: From second wave to new normal, recovery, adaptation and resilience, May 2021, at 3-4 (available at https://www.itu.int/en/myitu/Publications/2021/05/11/08/52/Pandemic-in-the-Internet-age).

Supply-side interventions	• In addition to clear and enforceable competition policies and regulations already in place, the GoRA might consider **additional steps to promote market entry and competition**, especially in underserved communities. This might include:
	  ○ **Non-discriminatory and low-cost access to rights-of-way** (for example, roads, railways, pipelines, or electricity transmission lines); and
	  ○ **Dig-once policies**, ensuring that all construction projects include the installation of fibre.
	• Spectrum policy can also be utilized to promote private investment. While the GoRA has licensed spectrum for 4G, it could **open up more spectrum** for fixed and mobile connectivity
	• Given lack of ubiquitous middle mile and last mile fibre infrastructure, the GoRA also might consider the following measures:
	  ○ Consider pursuing **public-private partnerships;**
	  ○ In the absence of viable private-sector investment, **consider investing in core network infrastructure**, with access sold on a non-discriminatory (wholesale open access) basis; and
	  ○ In instances of market failure (such as in high-cost rural areas), the GoRA might consider **subsidizing deployment of fixed and mobile last-mile networks.**
	• The GoRA might also consider policies **promoting community-based network operators**, especially in rural areas, taking into due account the existing competitive environment and with the aim at avoiding affecting the competition in the future.
	• In addition, GoRA might consider **social-purpose spectrum licens**es to support community networks in locations where licensed spectrum is not being used.
	• The Digitalisation Strategy sets forth goals meant to ensure that citizens from traditionally disenfranchised

	groups have equitable access to fixed and mobile broadband, as well as digital services. The GoRA might consider **elaborating on such provisions in its National Strategy for Broadband Communications**.
Demand stimulation activities	• The GoRA is encouraged to consider programmes ensuring that low-cost fixed and mobile broadband **services and devices are affordable to low-income** individuals and households. • In addition to other steps the GoRA is already taking, it might consider enabling **discounted services for anchor institutions and vulnerable groups.** • We encourage the GoRA to implement targets and plans for both basic and advanced **digital skills programming**, as well as to develop **locally relevant** applications and content.
Monitoring and evaluation programmes	• The GoRA is encouraged to: o Include a **monitoring and evaluation** programme from the outset. o Collect fixed and mobile broadband **data at least once a year** at the highest feasible level of granularity, with more frequent reporting to track specific interventions. o 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.

Each of these recommendations is discussed in more detail below.

1. Adopting a National Broadband Plan

The Broadband Commission for Sustainable Development (Broadband Commission) has observed that digital inequality persists around the world, even in countries with high-speed connectivity infrastructure.[113] The Connect2Recover phase one report documented how digital inequality disproportionately impacts following groups: (1) low-income populations; (2) those located in rural areas, in small island developing nations, and in landlocked developing countries; (3) those lacking literacy and digital skills; and (4) those from traditionally vulnerable or disenfranchised groups, such as

[113] See 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").

women and girls, persons with disabilities, and ethnic minorities. Based on a review of available data, some of the same patterns are evident in Armenia. A national broadband plan or strategy can be the GoRA's blueprint for overcoming such gaps.

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.[114] As noted in the Connect2Recover phase one report, numerous resources are available to governments developing national broadband strategies, including from the ITU, the Broadband Commission, the World Bank, and from the Alliance for Affordable Internet.[115] The Alliance for Affordable Internet has detailed the linkage between high-quality national broadband plans and progress on affordability and describes key components of successful national broadband plans.[116] And, the World Bank has observed that "countries with high rates of broadband penetration have comprehensive broadband policies that coordinate both supply- and demand-side actions."[117]

The GoRA is encouraged to build upon its Digitalisation Strategy and adopt and implement a National Strategy for Broadband Communications aligned with the Connect2Recover framework. A national broadband strategy can help the GoRA further goals spelled out in the Digitalisation Strategy, namely: (1) Ensuring a high quality of public service delivery; (2) Efficiency and transparency of the public administration system; (3) Development of broadband and telecommunication infrastructure; (4) Increasing the competitiveness of the private sector; (5) Decision-making necessary for economic growth; and (6) Development of digital skills for the workforce. Specifically, the Digitalisation Strategy states that "[e]nsuring access to broadband throughout the Republic of Armenia, targeting access in remote areas, is a fundamental condition for the implementation of the Digital Agenda. A National Strategy for Broadband Communications is currently being developed with a view to supporting this goal. In the field of development of broadband connection, key attention shall be paid to models of co-operation with the private sector and the actions aimed at promoting private investment in the sector in general."[118]

To help inform the GoRA's development of its National Strategy for Broadband Communications, recommendations have been developed on the 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.

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[114] See Broadband Commission for Sustainable Development Targets available at https://broadbandcommission.org/broadband-targets/.

[115] See Connect2Recover Phase One Report at 47.

[116] See A4AI Affordability Report 2020 at 18.

[117] See The World Bank Group, Broadband Strategy Toolkit (available at https://ddtoolkits.worldbankgroup.org/broadband-strategies/node/26#section-76).

[118] See Digitalisation Strategy of Armenia at Section IV.9. pages 42-43.

2. Practising Good Governance

Key recommendations

- It is recommended that Armenia's **National Strategy for Broadband Communications** be **developed through an open and transparent process** and with significant **inter-governmental coordination.**
- The MHTI and PSRC might consider **creating a space for limited trials of new regulatory models and technologies** prior to permanently allowing countrywide.
- The GoRA might take **additional steps to collect and present** availability, usage, and adoption **data** at the highest feasible level of granularity available and in an open and transparent manner.

A prerequisite for good policymaking includes a stable, transparent, and impartial (and ideally independent) regulator, not subject to undue influence by particular market actors.[119] 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 digital strategies; and takes a collaborative approach to regulation.[120] 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 policymaker 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.

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[119] 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).

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

As discussed in more detail above, the Ministry and the PSRC demonstrate many of the characteristics of good governance. The GoRA can build upon the attributes of good governance it has already implemented to develop its National Strategy for Broadband Communications through an open and transparent process and with significant inter-governmental coordination. In doing so, the MHTI and PSRC might consider creating a space for limited trials – or regulatory sandboxes – of new regulatory models and technologies prior to permanently allowing countrywide. Such projects can help to demonstrate the viability of a new technology, service, or approach. A discussed in more detail in the data recommendations, the GoRA might take additional steps to collect and present availability, usage, and adoption data at the highest feasible level of granularity available and in an open and transparent manner.

3. Developing Clear Definitions and Targets

Key recommendations

- The GoRA is encouraged to **include broadband definitions and policies based on connectivity goals** the GoRA wants to achieve for all of its citizens.
- **Affordability targets** could initially be set at **2% of income for the lowest 40 of income earners** and the lowest 20% of income earners at some point in the future.

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.

Based on the data and resiliency assessment conducted for this report, the GoRA could focus policy and regulatory efforts on: (1) Ensuring that all Armenian citizens have meaningful access to the Internet; (2) On closing the urban-rural divide, extending high-speed fixed and mobile broadband to all of Armenia's citizens; (3) Ensuring the community anchor institutions, such as hospitals, schools, libraries, government offices, police stations, and other community centres, have access to high-speed fibre broadband connections; and (4) Addressing adoption gaps among certain categories of users, such as low-income consumers, persons with disabilities, and older persons. Broadband definitions and targets should reflect these goals.

The Digitalisation Strategy Action Plan includes a target that 80% of urban and rural areas of the Republic of Armenia will be provided with broadband and high-quality Internet connections and access to public digital services.[121] As suggested in the ITU's Connect2Recover phase one report, fixed and mobile broadband definitions and policies should be aggressive but achievable and based on the connectivity goals the GoRA wants to achieve for all of its citizens. In addition to referencing fixed and mobile broadband definitions and policies developed by the ITU, the GoRA could look to other upper middle-income countries for guidance on broadband definitions and policies. The World Bank's suggestions, as well as definitions developed by other development finance institutions, might also be a

[121] See Digitalisation Strategy of Armenia Action Plan at 13.

helpful starting point. For example, the European Union (EU) has heavily promoted broadband in its member states. Its strategy for broadband (i.e., towards a Gigabit Society) aims for: 100 Mbps access for all households (urban and rural), 1 Gbps access for all socioeconomic drivers (e.g., schools, businesses, government offices), and 5G connectivity.[122] Moreover, the Inter-American Development Bank recently published a paper detailing five-year targets that governments in Latin America and the Caribbean could adopt.[123]

To address adoption gaps, governments could adopt targets for affordability that are more nuanced than those currently in use globally. To ensure that fixed and mobile broadband are affordable for the lowest income earners in a country, a government could set affordability 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.[124] 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. To minimize these risks, the GoRA could set affordability targets for the average Armenian income earner, as well as for the lowest 20 per cent or 40 per cent of income earners.

Affordability is not the only issue impacting adoption of fixed and mobile broadband and digital services. Lack of basic digital skills and lack of relevant content in local language are also barriers to adoption of digital services. As discussed below, the GoRA's Digitalisation Strategy includes several provisions relevant to digital skills and these could be further quantified. In addition, Armenia scores low on the percentage of applications in a local language (12.5%) overall and when compared to its regional peer markets. The GoRA might want to set targets for development of local content.

4. A Multistakeholder Approach to Assessing Availability and Adoption

Key recommendations

- It is recommended that the GoRA **combine data from network operators and household surveys**, along with third-party data on availability, adoption, and usage.
- It is recommended that **detailed fixed and mobile broadband data** (population coverage in each settlement, speed tiers and technology available as well as subscriber data) **be**

[122] See European Commission (2013). The broadband State aid rules explained. https://ec.europa.eu/regional_policy/sources/conferences/state-aid/broadband_rulesexplained.pdf

[123] See Garcia Zaballos, Antonio; Garnett, Paul; Johnson, David; Urrea Ayala, Hector; Puig Gabarro, Pau; Iglesias Rodriquez, Enrique , Development of National Broadband Plans in Latin America and the Caribbean, Inter-American Development Bank, September 2021, at 17 (available at https://publications.iadb.org/en/development-national-broadband-plans-latin-america-and-caribbean).

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

collected at least on an annual basis with more frequent reporting on subscribers to track specific interventions.

As discussed above, while the GoRA has commendably detailed ICT access statistics on age, gender, and persons with disabilities, the GoRA lacks timely granular operator data on speed tier availability and adoption. While the GoRA is encouraged to continue customer surveys, it is encouraged to collect more data from network operators. Quarterly reports published by fixed and mobile network operators could be improved by including population coverage or availability, as well as subscription numbers, by speed tiers at the smallest feasible geographic level. In addition, data on anchor locations, such as healthcare facilities, schools, and libraries, could be improved and include access technology available at location and the speed tier subscribed to.

We suggest annual reporting as a minimum requirement. When specific interventions are put in place, such as connecting a certain percentage of schools by a target date, quarterly reporting may be warranted. 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.

In addition, we encourage the GoRA to supplement data from network operators and household surveys with third-party data on availability, adoption, and usage. As discussed in this report, data from companies such as Ookla, OpenSignal, Facebook, and others can help provide highly valuable insights into Internet usage trends in a country.

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,[125] there remain significant gaps in fixed and mobile broadband availability and network capacity (or throughput available to each user), especially as between high population density urban and low population density rural areas. 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 declines. This undermines the commercial viability of deploying networks in small markets and rural areas.

The data show that this same phenomenon is present in Armenia. While fibre middle mile and last mile connectivity is available in Yerevan and other population centres, fibre middle mile and last mile connectivity is not present in many small markets and rural areas. Lack of fibre backhaul negatively impacts the ability of service providers to extend high-speed fixed broadband into underserved and unserved communities and deploy next generation 5G mobile broadband to these communities. To address this shortcoming, the GoRA might decide to support efforts to deploy middle mile and last mile fibre infrastructure to all settlements and to all premises. Middle mile fibre optic infrastructure could be extended to all settlements and fibre optic last mile infrastructure could be extended to all anchor institutions, such as schools, hospitals, police stations, and government offices.

[125] See World Development Report 2021: Data for Better Lives at 163.

As we explain in more detail below, the GoRA 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. Each of these approaches is discussed below.

a. Clear and enforceable competition policies

Key recommendations

- In addition to clear and enforceable competition policies and regulations already in place, the GoRA might consider **additional steps to promote market entry and competition**, especially in underserved communities. This might include:
  - **Non-discriminatory and low-cost access to rights-of-way** (for example, roads, railways, pipelines, or electricity transmission lines); and
  - **Dig-once policies**, ensuring that all construction projects include the installation of fibre.

Markets with high rates of fixed and mobile broadband availability and adoption also tend to be markets with high rates of competition throughout the broadband network value chain and within and between technology platforms – in the first mile, middle mile, last mile and even with respect to the invisible mile.[126] 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.

The GoRA has already taken steps to promote market entry and competition among mobile and fixed broadband providers. The GoRA's competition policies are aimed at maximizing competition throughout the value chain. According to its response to the 2020 ITU Regulatory Survey, the GoRA reports that all mobile and fixed network operators are private companies, there are no dominant providers in the market, there are no foreign investment limits, and there is full competition across relevant market segments.[127] In addition, the PSRC has mandated interconnection, infrastructure

[126] For an explanation of the broadband network value chain, please see the Connect2Recover Phase One Report at 38-41.

[127] See 2020 ITU Regulatory Survey responses.

sharing (towers, base stations, posts, and ducts, etc.), and colocation/site sharing.[128] In addition to clear and enforceable competition policies and regulations already in place, the GoRA might consider additional steps to promote investment, market entry and competition, especially in underserved communities. This might include non-discriminatory and low-cost access to rights-of-way (for example, roads, railways, pipelines, or electricity transmission lines) and dig-once policies, ensuring that all construction projects include the installation of fibre.

Effective competition also needs effective protection, particularly in nascent markets at the early stages of opening.[129] 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.[130] In Armenia, competition policies are shared by the Ministry of High-Tech Industry and the State Commission for the Protection of Economic Competition. Both entities have jurisdiction over competition issues relative to the telecommunications/ICT sector. Collaboration on these matters is stipulated by the laws on administrative proceedings, electronic communications, protection of economic competition and regulatory body for public services.

The Law on Protection of Economic Competition (2000) specifies competition policy across all sectors, including telecommunications. However, competition is defined by both this law and the Law on Electronic Communications. While issues like interconnection are governed by the Law on Electronic Communications, the general competition law governs mergers.

b. Opening up spectrum

Key recommendations

- Spectrum policy can be utilized to promote private investment. While the GoRA has licensed spectrum for 4G, it could **open up more spectrum** for fixed and mobile connectivity.

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, expanding access to underserved and previously unserved

[128] See 2020 ITU Regulatory Survey responses.

[129] See *Broadband Commission Working Group on Financing and Investment Report* at 21-22.

[130] See *Broadband Commission Working Group on Financing and Investment Report* at 21-22.

communities, increasing competition, and reducing costs for consumers.[131] To support network operator deployments, regulators can 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. In addition to some examples outlined in the Connect2Recover phase one report, sample COVID-19 spectrum-related policy responses are detailed in the ITU's recent report entitled, "Pandemic in the Internet age: From second wave to new normal, recovery, adaptation and resilience."[132]

Around the world, 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).[133] Spectrum below 2 GHz and between 6 GHz and 24 GHz is less attractive for 5G because these bands are heavily utilized by other licensed users.[134] At the same time, as detailed in the Connect2Recover phase one report, 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).[135] The Connect2Recover phase one report also describes how 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.[136] In addition, 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).[137]

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[131] See 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] See, e.g. Pandemic in the Internet age: From second wave to new normal, recovery, adaptation and resilience at 4, 8-9.

[133] 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).

[134] 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.

[135] See Connect2Recover phase one report at 56-57.

[136] See Connect2Recover phase one report at 57.

[137] See Connect2Recover phase one report at 58.

Thanks to aggressive 4G license buildout obligations, most Armenians are covered by 4G networks. However, there is limited 4G competition, especially in small markets and rural areas, and 4G adoption rates remain low. In addition, while 4G licenses include build out requirements, they do not include speed requirements associated with coverage requirements. As is currently being considered, the GoRA could allocate more spectrum for fixed and mobile services. This includes allocation and licensing of more spectrum for International Mobile Telecommunications (IMT) services, as well as more unlicensed or license-exempt spectrum allocations, across a variety of complementary low-, mid-, and high-band frequencies. By opening up more large swaths of spectrum across complementary low, mid, and high band spectrum, the GoRA will enable a fixed or mobile 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. The GoRA might also consider other policies to promote fixed and mobile network deployment in underserved and unserved areas, such as various forms of spectrum sharing, as well as licensing next generation satellite communications, HAPS, and HIBS providers.

c. Investment in infrastructure

Key recommendations

- Given lack of ubiquitous middle mile and last mile fibre infrastructure, the GoRA might consider the following measures:
  - Consider pursuing **public-private partnerships;**
  - In the absence of viable private-sector investment, **consider investing in core network infrastructure**, with access sold on a non-discriminatory (wholesale open access) basis; and
  - In instances of market failure (such as in high-cost rural areas), the GoRA might consider **subsidizing deployment of fixed and mobile last-mile networks**.

According to the ITU's recent report entitled *Connecting humanity: Assessing investment needs of connecting humanity to the Internet by 2030*, making fixed and mobile broadband available to all of the world's population is, above all, an infrastructure investment challenge.[138] The ITU provides an ICT Infrastructure Business Planning Toolkit that can be useful in assessing the long-term sustainability of network expansion.[139]

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). A recent ITU report shows that both fixed and mobile broadband return significant economic benefit, but at different stages of

[138] 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).

[139] 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/).

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.[140] For example, a 10% increase in fixed broadband penetration would deliver a 2.94% increase in GDP in Europe's high-income countries, but a negligible benefit in Africa.[141] Conversely, a 10% increase in mobile broadband penetration would deliver 2.46%. In the CIS region, each 10% rise in fixed and mobile broadband penetration would result in a 0.63% and a 1.25% rise Gross Domestic Product (GDP), respectively.[142]

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. The ITU has published an ICT Infrastructure Business Planning Toolkit, which provides helpful guidance to network operators looking to invest in ICT infrastructure.[143] It is worth highlighting 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 Broadband Commission 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.[144] Policy and regulation play 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 permits, access to rights-of-way and placement of conduit can also help reduce costs. As discussed above, the GoRA already has regulations in place mandating interconnection, infrastructure sharing (towers, base stations, posts, and ducts, etc.), and colocation/site sharing, and might also consider additional steps, such as easing rights-of-way permits and implementing dig once policies, to promote market entry and competition, especially in underserved communities.

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[140] 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).

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

[142] See Economic contribution of broadband, digitization and ICT regulation: Econometric modelling for the ITU Commonwealth of Independent States Region at 9.

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

[144] See Broadband Commission for Sustainable Development, "Connecting Africa Through Broadband: A strategy for doubling connectivity by 2021 and reaching universal access by 2030" at 110 (available at https://www.broadbandcommission.org/Documents/working-groups/DigitalMoonshotforAfrica_Report.pdf).

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.[145]

The ITU recently published a comprehensive report on financing universal access to digital technologies and services, which might serve as a guide for the GoRA as it considers the development of universal service programs.[146] The report notes that regulators are shifting to a more principle and outcome-based approach to regulation which facilitates investment and innovation and creates an enabling regulatory environment important for digitalization and supporting digital investment.[147] This report notes significant shifts in the approach to funding universal access:

1. Using a combination of monetary and non-monetary, or in-kind, contributions, based on project needs and the various strengths of collaborative financiers;
2. Making smarter investments and thus a move away from "funding" (out of a moral imperative) to "financing," which is more commercially grounded and relates to making good investments, while contributing to socio-economic development; and
3. Collaboration between governments, commercial banks, development finance institutions (DFIs), the private sector and bilateral and multilateral donor organizations to meet funding gaps is increasing, including through blended finance or the strategic use of development finance to mobilize additional finance for sustainable development in developing countries.[148]

Another recent ITU report describes a range of ICT infrastructure financing models, including traditional project financing, municipal financing models, pooled financing models as co-investment mechanisms, public-private partnerships, policies and regulations to reduce the cost of network development, and auctions for subsidies.[149] The GoRA might consider pursuing some of these ideas.

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[145] 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.

[146] See International Telecommunication Union, Financing universal access to digital technologies and services, (2021) (available at https://www.itu.int/en/myitu/Publications/2021/09/28/11/09/Financing-universal-access-to-digital-technologies-and-services).

[147] See Financing universal access to digital technologies and services at 55.

[148] See Financing universal access to digital technologies and services at 1.

[149] See International Telecommunication Union, Telecommunications industry in the post-COVID-19 world: Report of the 7th Economic Experts Roundtable (2021) (available at https://www.itu.int/en/myitu/Publications/2021/05/11/08/10/The-telecommunication-industry-in-the-post-COVID-19-world).

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. The ITU's recent report on financing universal access to digital technologies and services advises that "public money should only be used where private capital does not intend to go, or where the injection of public money will bring about a significant step change without distorting competition."[150]

A wide range of universal service funds have been created in different countries, focused on extending services to high-cost rural areas, reducing the cost of services for low-income consumers and other vulnerable or disenfranchised groups such as ethnic minorities and persons with disabilities, and ensuring that schools, libraries, health care providers, and other community anchor institutions have high-speed connectivity. The GoRA might consider targeted evidence-based universal service funding interventions; for example, to increase access to fibre connections in rural settlements and to anchor institutions, such as healthcare facilities, schools, libraries, and other community anchors.

In recent years, there has been 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.[151] 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.[152] 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.[153]

One note of caution is that many governments' universal service funds have proven unsuccessful.[154] 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 US FCC's reverse auctions mechanism (discussed above). Fund recipients should be held accountable for meeting quantifiable targets and should be rewarded for surpassing buildout deadlines. Mechanisms for funding universal service subsidies should minimize marketplace distortions and ensure that funds are not diverted to other government programmes.

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[150] See Financing universal access to digital technologies and services at 2.

[151] 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.

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

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

[154] See World Development Report 2021: Data for Better Lives at 163.

Finally, universal service funds should be administered independently, with appropriate fiscal oversight. ITU's Digital Regulation Platform provides additional guidance on the development of universal service funds.[155]

d. Explore community-based network operators

Key recommendations

- The GoRA might consider policies **promoting community-based network operators**, especially in rural areas.
- The GoRA might consider **social-purpose spectrum licenses** to support community networks in locations where licensed spectrum is not being used.

To further stimulate supply of fixed and mobile broadband connectivity, especially in underserved small markets and rural areas, the GoRA might consider regulatory approaches supporting innovative business models with proven success in some other markets. For example, the GoRA might consider policies promoting community-based network operators, especially in rural areas. In addition, GoRA might consider social-purpose spectrum licenses 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 is 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; and
- Locally relevant content: development and promotion of local content is done in local languages.

Community networks can be operationalized, wholly or partly, through individuals and local stakeholders, non-governmental organizations (NGOs), private sector entities, and/or public administrations.[156] 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

[155] 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/).

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

independent, community-based telecommunication company members leading innovation in rural and small-town America.[157]

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 policymakers, 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 to be the case – some of these rural markets can only be served by community-based network operators. There is a growing body of evidence (see for example the GISWatch report 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.[158]

e. Digital inclusion

Key recommendation

- The Digitalisation Strategy for Armenia sets forth goals meant to ensure that citizens from traditionally disenfranchised groups have equitable access to fixed and mobile broadband, as well as digital services. The GoRA might consider **elaborating on such provisions in its National Strategy for Broadband Communications**.

The 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.[159] 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.

Fortunately, the GoRA's action plan for its Digitalisation Strategy includes provision directing the MHTI and the Ministry of Labour and Social Affairs to ensure access to digital services for persons with

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

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

[159] 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).

disabilities, namely: (1) Discussions with NGOs dealing with issue of persons with disabilities; (2) Study of the requirements for and providing opportunities to people with disabilities, including people with vision, hearing and mental impairments, to enjoy equal rights in the unified platform of public services; and (3) Elaboration and implementation of easily accessible solutions (Text to Speech and Speech to Text conversations, etc.).[160] By December 2022, the Action Plan requires elaboration and introduction of at least five functional solutions. In addition, by 2025, all public websites and e-systems will have unified criteria and architecture and will be fully adapted for people with disabilities.[161] The GoRA might consider elaborating on such provisions in its National Strategy for Broadband Communications. The GoRA might consider targeted universal service funding interventions when the data shows that vulnerable or disenfranchised groups, such as persons with disabilities, older persons or low-income communities, lack equitable access to fixed and mobile broadband, as well as other digital services.

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.[162] 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.[163] 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.[164] The same supply and demand gaps exist in Armenia. Addressing these barriers is critical to further reducing the usage gap and driving digital inclusion.[165] Below, we discuss how the GoRA can stimulate demand for fixed and mobile broadband services.

a. Addressing affordability

Key recommendation

- The GoRA is encouraged to consider programmes ensuring that low-cost fixed and mobile broadband **services and devices are affordable to low-income** individuals and households.

[160] See Digitalisation Strategy of Armenia.

[161] See Digitalisation Strategy of Armenia.

[162] 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) (State of Mobile Internet Connectivity 2019).

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

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

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

- In addition to other steps the GoRA is already taking, it might consider enabling **discounted services for anchor institutions and vulnerable groups.**

Affordable Services. As discussed above, the 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 broadband is affordable if 1.5 GB of data are available below that level.[166] 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.[167]

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.[168] 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 0.5 per cent of gross national income (GNI) per capita that data consumption reaches and eventually exceeds the 1 gigabyte threshold."[169] The World Bank further points out that data consumption is very sensitive to market prices and service affordability.[170]

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. The same is true in Armenia. As discussed above, while basic mobile Internet access is affordable for most Armenians, it is unaffordable for the bottom 20% of income earners. Basic fixed Internet access is not yet affordable for many Armenians amounting to 7.9% of GNI per capita for the bottom 20% of income earners.

In addition to implementing the supply-side efforts discussed above, which will reduce the cost of network inputs and enable operators to deliver 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

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[166] 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/).

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

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

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

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

discounted fixed and mobile broadband services.[171] 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.[172]

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.[173] 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.[174]

The GoRA might also take steps to promote demand from households and other groups facing adoption gaps. Similar to what has been done in other markets, the GoRA might consider establishing programs that enable network operators to discount fixed and mobile broadband services to households and individuals in the bottom 20% of income earners. In addition, the GoRA might consider programs enabling fixed network operators to discount the cost of broadband services for persons with disabilities and for anchor institutions, such as schools and libraries.

Affordable Devices. 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.[175] 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

[171] 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).

[172] See https://www.fcc.gov/emergency-broadband-benefit-program#:~:text=The%20Act%20directed%20the%20Federal%20Communications%20Commission%20to,providers%20can%20receive%20a%20reimbursement%20for%20such%20discounts.

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

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

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

devices over time.[176] 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."[177]

Several types of taxes impact the cost of devices, including value-added taxes, sales taxes, customs duties, and technology-specific taxes.[178] 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. 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.[179] The GoRA might consider reviewing its taxes impacting the cost of mobile and fixed connectivity devices in Armenia and determine whether any could be reduced or eliminated in order to increase demand.

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. The Connect2Recover phase one report provides examples from Malaysia, Spain, Costa Rica, and the United States.[180]

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. A GSMA report highlights programmes in India, Kenya, Rwanda, and other markets, and provides recommendations on how to implement rent-to-own programmes.[181] 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.

The GoRA might consider programs discounting the cost of computing devices for certain user groups. For example, the data show low utilization of computing devices by older persons. This low utilization might reflect a digital skills gap and so a closer look at the causes for this gap might be warranted prior to implementing a discount program.

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

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

[178] 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).

[179] 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).

[180] See Connect2Recover phase one report at 68-69.

[181] 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).

b. Digital skills

Key recommendation

- We encourage the GoRA to implement targets and plans for both basic and advanced **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.[182] 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.[183] One can expect the same to be true for fixed broadband. Lack of digital skills impacts both youth and adults (especially older adults).

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 in sustainable digital skills by 2025.[184] The European Commission's goal is for 70 per cent of adults to have basic digital skills by 2025.[185]

The GoRA is to be commended for including several provisions relevant to digital skills in its Digitalisation Strategy. The Digitalisation Strategy notes that "[t]he real digitalisation of Armenia is possible exclusively through the development of essential digital skills among all groups of the society, which is interconnected with the modernisation of the public sector and the economy."[186] To that end, comprehensive educational programmes for all ages and social groups are envisaged to be implemented as a result of cooperation with all agencies and the business sector.[187] This includes "[p]aying special attention to educational programmes aimed at developing digital and technical skills and knowledge among women and girls throughout the country." The Digitalisation Strategy also includes plans for inclusion of a course on digital skills in the general education systems and training teachers on educational technologies.[188] Further, "[t]he development of digital skills will be implemented among people with special needs in a targeted manner as a significant means of social inclusion and

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

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

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

[185] 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/).

[186] See Digitalisation Strategy of Armenia at Section IV.10 pages 43-44.

[187] See Digitalisation Strategy of Armenia at Section IV.10 page 43.

[188] See Digitalisation Strategy of Armenia at Section III.4.1 pages 37-38.

development of working skills."[189] In addition, interactive courses on digital skills will be made available at e-service centres (such as Hayposts) for older persons and those who do not possess advanced digital skills.[190] The Strategy also includes a provision for increasing cyber literacy among the general public.[191]

The Digitalisation Strategy Action Plan directs the MHTI, the Ministry of Education, Science, Culture and Sport, and the Ministry of Economy to: (1) Implement education programmes for using digital skills; (2) Implement education programmes for operating digital technologies; (3) Implement education programmes for creating digital technologies; and (4) Establish digital technology use and transfer centres. By December 2025, among persons aged 16-65, at least 60% should be able to apply electronic tools.

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."[192] Such partnerships will be critical for governments to ensure that more of their citizens have the digital skills they need to participate online. The GoRA might also consider pursuing such partnerships.

c. Local content

Key recommendations

- We encourage the GoRA to set targets and implement programming to develop **locally relevant** applications and content.

Finally, it is important that consumers have access to content that is relevant to them and available in their first language. 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.[193] In Armenia, the percentage of apps in a local language is only 12.5%, compared to 48.64% in Kazakhstan.

[189] See Digitalisation Strategy of Armenia at Section III.4.1 page 38.

[190] See Digitalisation Strategy of Armenia at Section III.4.2 page 38.

[191] See Digitalisation Strategy of Armenia at Section III.4.3 page 38-39.

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

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

While the English language continues to dominate the Internet,[194] numerous efforts are under way, such as one led by the Internet Society, to encourage the development of relevant content in more local languages.[195]

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).[196] Technology companies have various efforts underway to enable consumers to translate content into their local languages.[197] 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. The GoRA already has set goals for the digitization of government content, which will increase local language content on the Internet.[198] The GoRA might pursue further efforts, as well as work with the private sector, to develop more local content.[199]

7. Effective Monitoring and Evaluation Programmes

Key recommendations

- The GoRA is encouraged to:
  - Include a **monitoring and evaluation** programme from the outset.
  - 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.

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

[195] 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/). The Internet Society has a chapter in Armenia.

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

[197] 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/).

[198] See generally Digitalisation Strategy for Armenia.

[199] The Digitalisation Strategy includes, for example, provisions raising awareness and use of digital technologies among the private sector. See Digitalisation Strategy of Armenia at 34-37.

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. The most effective national broadband plans have regular reviews and iterations.[200] 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.[201]

The GoRA's action plan for its Digitalisation Strategy includes a provision directing the MHTI and the PSRC to: (1) Take inventory of and mapping the optical-wired transmission networks existing and being operated in the public and private sector, their capacities and the relevant network topologies; (2) To analyse the demand according to marz distributions; and (3) To reveal technical solutions and propose relevant solutions.[202]

Consistent with international best practices, the GoRA is encouraged to include a monitoring and evaluation programme from the outset. The GoRA could collect fixed and mobile broadband data at least once a year at the highest feasible level of granularity, with more frequent reporting to track specific interventions. Aligned with recommendations from Alliance for Affordable Internet, the GoRA is encouraged to hold an open and transparent assessment and review of progress at least every two years. The GoRA should be prepared to course-correct and update the plan in response to changed conditions.

8. Emergency Preparedness

Key recommendation

- The GoRA 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.[203] Ratification of the Tampere Convention and waiving

[200] See Trends in Telecommunications Reform 2015 Getting Ready for the Digital Economy at 192-211.

[201] See A4AI Affordability Report 2020 at 36.

[202] See Digitalisation Strategy for Armenia.

[203] 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).

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 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."[204]

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.

[204] 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).

VII. Conclusion

The ITU welcomes the opportunity to work the Government of the Republic of Armenia on a Connect2Recover initiative phase two assessment and phase three recommendations. The ITU thanks the Ministry of High-Tech Industry of the Republic of Armenia, the Public Service Regulatory Commission of the Republic of Armenia, and the Union of Operators of Armenia for their extensive cooperation and support for this effort. The Government of the Republic of Armenia is to be commended for its efforts to develop its ICT sector. This assessment has further reinforced and, in some cases, provided new insights on fixed and mobile connectivity data, resilience, and policy and regulation. This report has highlighted areas where more timely, accurate, complete, and granular data on fixed and mobile broadband availability and adoption would help inform the Government's assessment of country-level resilience and any needed policy interventions. This report also suggested ways in which the Government could further increase the resiliency of the ICT sector, so that Armenia is better prepared for future events. As detailed in this report, it is recommended that the Government develop and implement a national broadband plan or strategy, with a particular focus on addressing rural-urban divides, stimulating demand for fixed and mobile broadband services, and incorporating 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; (5) demand stimulation activities; and (6) monitoring and evaluation programmes. The GoRA can use this report to develop, update, and effectively implement comprehensive information and communications technology (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 the ITU and other relevant organizations.

Appendix A: Data sources

Table 22: Description of resilience data indicators, year obtained and data source

Pillar	Dimension	Indicator	Description	Year obtained (Armenia)	Data source
Critical Infrastructure	Power infrastructure resilience	Power availability	Power availability for entire population	2021	World Bank
	Cable infrastructure resilience	10-km Fibre reach (percent)	% of the population within 10km of a fibre network	2013	ITU transmission map
		Exit points (Gateways)	Number of international gateways	2021	ISPs websites Invest in Armenia website
	Mobile	Network Coverage	Network coverage MCI composite indicator (3G,4G,5G)	2021	GSMA
		Spectrum allocation	Spectrum allocation MCI composite indicator	2019	GSMA
	Number of IXPs	Number of IXPs	Total IXPs in the country	2021	Armix Armenia
		IXPs per 10 million	IXPs per 10 million people	2021	Calculated
	Top Level Domains	Number of ccTLDs	Number of Country Code Top Level Domains registered	2021	Zonefiles.io
		Number of people per ccTLD	Number of people per Country Code Top Level Domain	2021	Calculated
		% of apps in local language	Percentage of mobile apps in main local language	2021	GSMA
Network/ISP Resilience	Link resilience	Peering efficiency (percent ISP peering)	% of ISPs peering at local IXPs	2021	Armix Armenia
		Peering efficiency (percent IPs peering)	% of IPs peering at local IXPs	2021	Armix Armenia
	Quality of service	**Fixed networks**			
		Fixed Latency (ms)	Latency measured to the nearest speed test server	2021	Ookla
		Fixed Upload (Mbps)	Upload throughput measured to the nearest server	2021	Ookla
		Fixed Download (Mbps)	Download throughput measured to the nearest server	2021	Ookla
		Mobile networks			
		Mobile Latency (ms)	Latency measured to the nearest speed test server	2021	Ookla
		Mobile Upload (Mbps)	Upload throughput measured to the nearest server	2021	Ookla
		Mobile Download (Mbps)	Download throughput measured to the nearest server	2021	Ookla
	Domain Name Server resilience	% of DNSSEC validation by country	% of DNSSEC validation by country	2021	APNIC
		DNSSEC adoption for TLDs	DNSSEC adoption for TLDs	2021	ISOC Pulse
	Cybersecurity	Secure Internet Servers	Secure Internet Servers per 1 million people	2020	World Bank
		Global Cybersecurity Index	Global Cybersecurity Index	2020	World Bank
		DDOS Full	Country overview of DDOS Potential in Tbit/sec	2021	Cybergreen
		Spam infections	% of IP addresses in the spam list	2021	Spamhaus
Market Resilience	Chokepoint potential	Market concentration mobile operators	HHI Index for mobile market	2021	PSRC Armenia (calculated)
		Market concentration fixed operators	HHI Index for fixed market	2021	PSRC Armenia (calculated)

Pillar	Dimension	Indicator	Description	Year obtained (Armenia)	Data source
		Spectrum concentration	HHI Index for spectrum allocation	2019	Armenian government (calculated)
		OP2 coverage concentration mobile operators	Diversity of coverage from top 2 mobile operators	2021	Calculated
		OP2 coverage concentration fixed operators	Diversity of coverage of top 2 fixed operators	2021	Calculated
		OP3 coverage concentration mobile operators	Diversity of coverage of top 3 fixed operators	2021	Calculated
		OP3 coverage concentration fixed operators	Diversity of coverage of top 3 fixed operator	2021	Calculated
	Affordability	1.5 GB mobile BB % GNI p.c.	How affordable is mobile broadband for the country.	2020	ITU price basket data /World Bank
		1.5 GB mobile BB % GNI p.c. bottom 20%	How affordable is mobile broadband for income share held by lowest 20%	2020	ITU price basket data / World Bank
		1.5GB mobile BB % GNI p.c. bottom 40%	How affordable is mobile broadband for income share held by lowest 40%	2020	ITU price basket data / World Bank
		5 GB fixed BB % GNI p.c.	How affordable is fixed broadband for the whole country.	2020	ITU price basket data / World Bank
		5 GB fixed BB % GNI p.c. bottom 20%	How affordable is fixed broadband for income share held by lowest 20%	2020	ITU price basket data / World Bank
		5 GB fixed BB % GNI p.c. bottom 40%	How affordable is fixed broadband for income share held by lowest 40%	2020	ITU price basket data / World Bank

Table 23: Location of public data sources used in report

Description	Data source
% of allocation listed in the spam list	https://www.abuseat.org/public/countryinfections.html
% of ASN peering at local IXPs	https://www.pch.net/ixp/data
% of DNSSEC validation by country	https://stats.labs.apnic.net/dnssec/
% of HTTPS usage	https://pulse.Internetsociety.org
% of IPv6 adoption	https://pulse.Internetsociety.org
% of the population within 10km of a fibre network	https://www.itu.int/en/ITU-D/Technology/SiteAssets/Pages/InteractiveTransmissionMaps/ITU%20Broadband%20Capacity%20Indicators%202020.xlsx
Access to electricity (% of population)	https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS
age and sex distribution of rural population (marz level)	https://armstat.am/file/doc/99524733.xlsx

age and sex distribution of total population (marz level)	https://armstat.am/file/doc/99524723.xlsx
age and sex distribution of urban population (marz level)	https://armstat.am/file/doc/99524733.xlsx
ARMSTAT Household's Integrated Living Conditions Survey (Internet usage, devices ownership, incl. by sex, age, vulnerable groups)	https://armstat.am/en/?nid=206
ARMSTAT Number of anchor locations (schools, health facilities, libraries) per marz	https://armstat.am/en/?nid=111
ARMSTAT SDGs data - Internet users per age groups	http://sdg.armstat.am/17-8-1-a/
ARMSTAT: Country-level summary of ICT data	https://armstat.am/en/?nid=586&year=2020
Beeline fixed coverage table	https://www.beeline.am/file_manager/Coverage/FIx.pdf
Beeline mobile coverage table	https://www.beeline.am/en/mobile-network-coverage-areas/
Beeline: subscriptions data	https://www.beeline.am/ru/results-reporting
Core indicators on access to and use of ICT by households and individuals	https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2021/July/CoreHouseholdIndicators.xls
Country overview of DDOS Potential	https://stats.cybergreen.net/country
DDoS risk a country poses to other countries	https://stats.cybergreen.net/download/
Download throughput measured to the nearest server	https://registry.opendata.aws/speedtest-global-performance/
Download throughput measured to the nearest server	https://registry.opendata.aws/speedtest-global-performance/
DNSSEC adoption for Top Level Domains	https://pulse.Internetsociety.org
E-Government Development Index	https://publicadministration.un.org/egovkb/en-us/Data-Centre

Fixed-broadband subscriptions	https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2021/July/FixedBroadbandSubscriptions_2000-2020.xlsx
Gender ICT statistics	https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2021/July/IndividualsUsingInternetByGender.xlsx
GINI Coefficient	https://ihr.iijlab.net/ihr/api/hegemony/countries/?country=MU&af=4&timebin=2021-06-27T00:00&transitonly=True&weightagescheme=eyeball&ordering=hege
Global Cybersecurity Index	https://www.itu.int/epublications/publication/global-cybersecurity-index-2020/en/ (table 3)
GSMA mobile coverage map	https://www.gsma.com/coverage/
HHI Index	https://stats.labs.apnic.net/cgi-bin/aspopjson/c=* https://stats.labs.apnic.net/cgi-bin/aspop
How affordable is Internet services in this country.	https://a4ai.org/extra/downloads/ITU/2020/Pricing-Database-2020.csv
ICT Indicators Database 2021	https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx
ICT Price Baskets: Data-only mobile broadband basket (1.5 GB), 2020	https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2020/ITU_ICTprices_UnderlyingIndicators_2020.xlsx
ICT Price Baskets: Fixed-broadband Internet basket, 5GB, 2020	https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2020/ITU_ICTprices_UnderlyingIndicators_2020.xlsx
ICT Price Baskets: Mobile cellular - low usage basket (70 min, 20 SMS), 2020	https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2020/ITU_ICTprices_UnderlyingIndicators_2020.xlsx
ICT Price Baskets: Mobile data and voice high usage basket (140 min, 70 SMS, 1.5 GB), 2020	https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2020/ITU_ICTprices_UnderlyingIndicators_2020.xlsx
ICT Price Baskets: Mobile data and voice low usage basket (70 min, 20 SMS, 500 MB), 2020	https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2020/ITU_ICTprices_UnderlyingIndicators_2020.xlsx

International bandwidth, in Mbit/s	https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2021/July/InternationalBandwidthInMbits_2007-2020.xlsx
ITU Digital Development Dashboard	https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/Digital-Development.aspx
ITU Interactive Transmission Network Maps	https://www.itu.int/en/ITU-D/Technology/Pages/InteractiveTransmissionMaps.aspx
IXPs per 10 million	https://www.pch.net/ixp/data
Latency measured to the nearest speed test server	https://registry.opendata.aws/speedtest-global-performance/
Latency measured to the nearest speed test server	https://registry.opendata.aws/speedtest-global-performance/
MANRS score by country	Observatory.manrs.org
Mobile-broadband subscriptions	https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2021/July/MobileBroadbandSubscriptions_2007-2020.xlsx
Mobile-cellular subscriptions	https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2021/July/MobileCellularSubscriptions_2000-2020.xlsx
Network coverage composite indicator	https://www.mobileconnectivityindex.com/widgets/connectivityIndex/excel/MCI_Data_2020.xlsx
Number of datacentres	https://www.datacentremap.com/datacentres.html
Number of domain registered by ccTLD per person	https://zonefiles.io/cctld-domains/
Number of international gateways	https://docs.google.com/spreadsheets/d/1D4dIDW12_VzMI5vHQK2p48mmiOUvH0laLgnSXsUvbNw/edit#gid=0
Ookla country summary	https://www.speedtest.net/global-index
Ookla interactive map	https://www.ookla.com/ookla-for-good/open-data
Percentage of Individuals using the Internet	https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2021/July/PercentIndividualsUsingInternet.xlsx

PSRC's subscriptions summary data	https://psrc.am/uploads/files/Էլեկտրոնային%20հաղորդակցություն/Վիճակագրական%20ցուցանիշներ%20և%20դիագրամներ/Cucanshner.pdf
Quality of power supply	https://www.doingbusiness.org/en/data/exploretopics/getting-electricity
Rostelecom Armenia fixed coverage - description	https://www.rtarmenia.am/en/about-us
Rostelecom Armenia fixed coverage map	https://www.rtarmenia.am/en/service-centres
Rostelecom Armenia: subscriptions data	https://www.rtarmenia.am/en/reports
Schools location: crowdsourced data	https://data.humdata.org/dataset/hotosm_arm_education_facilities
Secure Internet Servers per 1 million people	https://data.worldbank.org/indicator/IT.NET.SECR.P6
Spam infections	https://www.abuseat.org/public/countryinfections.html
Spatial distribution of population density	https://data.humdata.org/dataset/7e6e6073-4196-4da3-87cc-4479f65acb6a
Spectrum allocation composite indicator	https://www.mobileconnectivityindex.com/widgets/connectivityIndex/excel/MCI_Data_2020.xlsx
UCOM mobile and fixed coverage map and table	https://www.ucom.am/en/footer/coverage/
UCOM: subscriptions data	https://www.ucom.am/en/footer/general/reports
Upload throughput measured to the nearest server	https://registry.opendata.aws/speedtest-global-performance/
Upload throughput measured to the nearest server	https://registry.opendata.aws/speedtest-global-performance/
Viva-MTS mobile coverage map and table	https://www.mts.am/en/individual-customers/help/service-zone/coverage-map-2020
Viva-MTS: subscriptions data	https://www.mts.am/en/about-us/financial-reports

Appendix B: Formulas for chokepoint potential

Market concentration

Market concentration and spectrum concentration are measured using the Herfindahl-Hirschman Index (HHI) which is a common measure of market concentration and used to determine market competitiveness but can be used to check the level of concentration in other domains.

$$HHI = s_1^2 + s_2^2 + s_3^2 + \cdots + s_n^2$$

where:

s_n = the market share percentage of the entity expressed as a whole number, not a decimal

A market with an HHI of less than 1,500 is considered a competitive marketplace, an HHI of 1,500 to 2,500 is moderately concentrated, and an HHI of 2,500 or greater is highly concentrated.

Coverage diversity

Coverage diversity is measured using two metrics

- OP2: measures the probability of coverage from at least 2 mobile operators for the top 3 operators
- OP3: measures the probability of coverage from the top 3 operators

The probability OP2 (coverage from at least 2 mobile operators) for 3 operators with coverage,

O_1, O_2, O_3 expressed as a fraction is given by

$$OP2 = O_1.O_2.O_3 + O_1.O_2.(1 - O_3) + O_1.(1 - O_2).O_3 + (1 - O_1).O_2.O_3$$

The probability OP3 (coverage from the top 3 operators) with coverage, O_1, O_2, O_3 expressed as a fraction is given by

$$OP3 = O_1.O_2.O_3$$

Appendix C: Recent Efforts to Assist the Government of Armenia on National Broadband Strategies

A. World Bank Ultrafast Armenia Report

Supported by the European Union (EU) through the broadband component of the EU4Digital initiative, the World Bank is supporting Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova and Ukraine (EaP partner countries) in the development and early implementation of their national broadband strategies. In 2020, the World Bank issued two reports relevant to fixed and mobile broadband availability, adoption, and usage in Armenia.[205]

The World Bank found that, as of late 2019, most Armenian households (~96 percent) have access to some form of Internet service, including in rural areas, and 4G mobile broadband networks cover over 90 percent of the population.[206] In addition, about 65 percent of households have fibre broadband connections; indeed, Armenia's fixed broadband market is well developed relative to its economic status, suggesting that most of the urban areas in the country are well connected.[207] At the same time, the World Bank found a 15 percentage-point gap between urban and rural areas in terms of access to fixed broadband services.[208] In addition, only one in ten households surveyed by the World Bank reported that they subscribe to fixed broadband providing speeds over 100 Mbps.[209] This digital divide is not just limited to residential users as "only one in five small businesses surveyed by the World Bank in 2019 reported having Internet connections with speeds over 30 Mbps."[210] In summary, the World Bank found that "while most Armenian households and businesses are connected to the Internet, many of them only have basic connectivity; about a third of households and small businesses do not have fixed broadband connectivity and most do not know the speeds to which they have subscribed."[211] As discussed above, this report describes similar patterns, albeit with a smaller percentage of households with fixed broadband and a higher percentage of Armenians with 4G mobile coverage.

The World Bank recommended that the GoRA focus its efforts on closing the urban-rural divide and extending high-speed fixed broadband to all of Armenia's citizens. The World Bank stressed the importance of fixed broadband connectivity, noting that mobile networks do not offer as reliable and

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[205] See World Bank, Options to Improve Rural Broadband Connectivity in Armenia (May 2020) (point of contact Siddartha Raja); World Bank, Ultrafast Armenia, Policy options toward broadband-for-all, December 31, 2020.

[206] See Ultrafast Armenia, Policy options toward broadband-for-all at 1.

[207] See Ultrafast Armenia, Policy options toward broadband-for-all at 8. 68 percent of households with Internet access at home use fixed broadband Internet. At the same 42 percent use also mobile broadband and 10 percent mobile narrowband Internet (the total is not 100 percent, as the same HH can use different types of connections). See id. at 14.

[208] See Ultrafast Armenia, Policy options toward broadband-for-all at 15.

[209] See Ultrafast Armenia, Policy options toward broadband-for-all at 16.

[210] See Ultrafast Armenia, Policy options toward broadband-for-all at 16.

[211] See Ultrafast Armenia, Policy options toward broadband-for-all at 1.

high-speed connections as fixed networks.[212] The World Bank also stressed the importance of extending fibre connectivity outside Yerevan. According to the World Bank, about 500 settlements—almost all of them in rural areas—are not connected to a fibre optic backhaul network and many of those settlements do not have competitive markets for broadband services.[213] Lack of fibre backhaul negatively impacts the ability of service providers to extend high-speed fixed broadband and next generation 5G mobile broadband to these communities.

According to the World Bank, the resolution of the market failures identified above – impacting both fixed and mobile broadband availability and adoption, especially impacting rural areas and low-income households -- can be achieved through two parallel mechanisms:[214]

(2) Policy and regulatory reform measures—to reduce costs of network rollout and to open markets:

    a. Reduce the costs of backhaul and fixed broadband infrastructure deployment

    b. Expand radio spectrum allocations and assignments

    c. Link with existing Government programmes to boost demand and skills

    d. Remove any impediments to competition in various industry segments

    e. Create enabling environment for technology innovation

(3) Mobilization of private investment to build network infrastructure – specifically, middle mile backbone infrastructure – in locations where those measures will not take effect and private investment will not be made in any reasonable timeframe, with options including:

    a. Demand aggregation: Government identifies locations at which broadband capacity is needed (e.g., schools, hospitals, government offices) and organizes a bulk purchase tender. Service providers create open access infrastructure.

    b. Passive infrastructure development: Government builds only the passive infrastructure elements (e.g., ducts, poles, dark fibre) needed to rollout backbone networks. Service providers lease those elements to extend their networks.

    c. Viability gap financing: Government evaluates the financing gap per settlement or clusters to make business case viable, offers least-cost-subsidies to Service providers to compete and then provide services.

    d. Public backbone: Government alone invests in the development of a national backbone network, opens access to SPs to source connectivity and provide downstream services to end-users.

[212] See Ultrafast Armenia, Policy options toward broadband-for-all at 17-18.

[213] See Ultrafast Armenia, Policy options toward broadband-for-all at 2.

[214] See Options to Improve Rural Broadband Connectivity in Armenia at 8-9.

Based on its review of the Armenian broadband marketplace and policy landscape assessment, the World Bank suggests three areas of focus for a broadband development strategy:[215]

(1) Increasing the resilience of international connectivity

(2) Closing the rural-urban connectivity divide

(3) Promoting demand among households and small businesses

The World Bank suggested that the GoRA consider the following targets for 2025:[216]

Table 24: World Bank Broadband Targets for Armenia

Target	Current value (end-2020)	Goal (end-2025)
All households have access to connectivity offering 100 Mbps	~40%	100% of households
All settlements with public institutions have access to connectivity offering at least 1 Gbps	~51%	100% of settlements
5G coverage in the largest cities (population coverage)	0%	50% population covered
Average price of 30 Mbps Internet connection as a share of household income	3.4%	2%

[215] See Ultrafast Armenia, Policy options toward broadband-for-all at 33.

[216] See Ultrafast Armenia, Policy options toward broadband-for-all at 2, 34.

The World Bank proposed a high-level framework for Armenia to consider with highest priority actions underlined:[217]

Table 25: World Bank High Priority Actions for Armenia

	Enabling environment	Investment attraction	Promoting uptake
Closing the rural-urban connectivity divide	• Implement broadband cost reduction rules, including through coordination across state bodies on cost reduction measures • Ensure spectrum availability (e.g., for 5G) • Updating the legal framework to be aligned with EU, including 2018 EECC and to comply with CEPA commitments • Capacity building	• State aid programmes to close rural access gaps (a.k.a. universal access/service programmes)	• Programmes to ensure inclusion of specific user groups at risk of being digitally excluded; e.g. socially vulnerable households in rural areas, persons with disabilities
Increasing the resilience of international connectivity	• Domestic and international coordination to improve the legal and regulatory frameworks related to data flows across borders	• Coordinate domestically and internationally to secure and improve international connectivity and attract investment into regional connectivity	
Promoting demand among households and small businesses	• Implement legal framework for e-commerce, e-transactions –	• Improved coordination of state bodies on the digital agenda	• Digital inclusion programmes

[217] See Ultrafast Armenia, Policy options toward broadband-for-all at 3, 35.

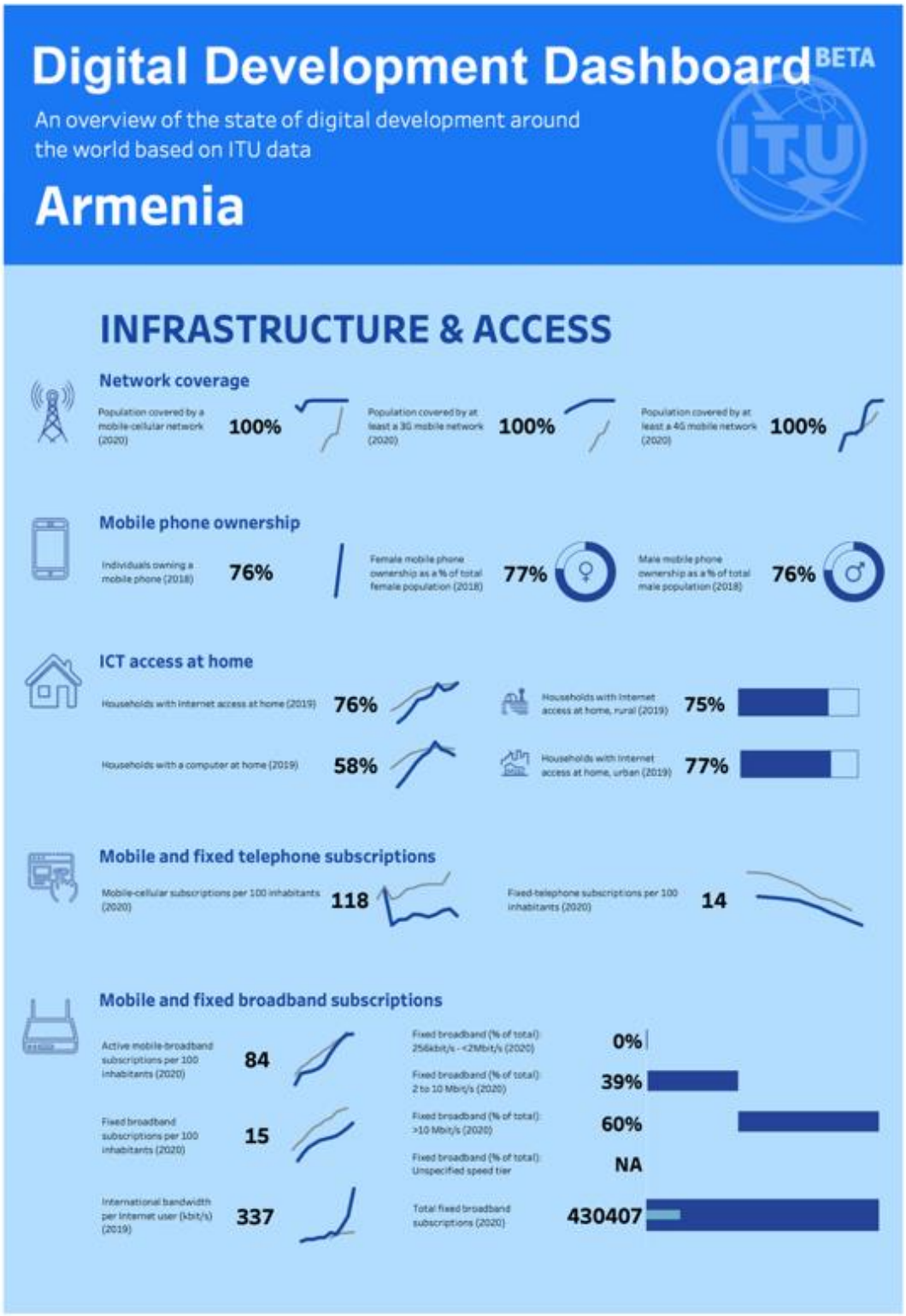
	Enabling environment	Investment attraction	Promoting uptake
	including improvement of personal data protection and introduction of online dispute resolution mechanisms	(including e.g. public services, ecommerce)	• Support to small businesses' digitization

B. EU4Digital Programme

In June 2020, a report was prepared as part of the World Bank (WB) analytical programme to support the Eastern Partnership (EaP) countries development of broadband services supported by the European Union (EU) through the EU4Digital programme, in partnership with the World Bank.[218] The goal of this report is to support Armenia in development of a national broadband strategy that aligns with EU policies and extends the EU's Digital Single Market (DSM) to Armenia. This Report studied and analysed legal and regulatory framework of Armenia and presented findings and legal recommendations to align Armenian broadband policy with the EU's DSM. Like the Connect2Recover initiative, the EU4Digital programme includes best practices for supporting broadband deployments.

[218] *See* Regional Broadband Legal and Regulatory Study between the European Union and the Eastern Partnership Countries. The EU4Digital is a regional initiative, launched in 2016, which aims to deliver the benefits of the Digital Single Market (DSM) beyond the EU Member States, extending to the EU's Eastern neighbourhood countries "the potential of the digital economy and society, to bring economic growth, generate more jobs, improve people's lives, and help businesses." See https://eufordigital.eu/discover-eu/eastern-partnership/.

Appendix D: ITU Digital Development Dashboard



Armenia

INTERNET USE

Percentage of population using the Internet

Individuals using the Internet, total (2019)	67%
Female Internet use as a % of total female population (2019)	67%
Male Internet use as a % of total male population (2019)	66%

< 15 years as a % of all < 15 years (2016)	54%
15-24 years as a % of all 15-24 years (2016)	82%
25-74 years as a % of all 25-74 years (2016)	69%
75+ years as a % of all 75+ years (2016)	26%

Broadband traffic

Average monthly fixed broadband Internet traffic per fixed broadband subscription (MB) (2020)	389167
Average monthly mobile broadband Internet traffic per mobile broadband subscription (MB) (2020)	5723

ENABLERS & BARRIERS

ICT prices

Fixed broadband basket as a % of GNI p.c. (2020)	3.2%
Mobile data and voice basket (low consumption) as a % of GNI p.c. (2020)	1.0%
Mobile data and voice basket (high consumption) as a % of GNI p.c. (2020)	1.0%
Mobile cellular basket as a % of GNI p.c. (2020)	1.0%
Mobile broadband basket as a % of GNI p.c. (2020)	1.0%

ICT skills

Individuals with basic skills	NA
Individuals with standard skills	NA
Individuals with advanced skills	NA

About this dashboard

The Digital Development Dashboard reports the latest values for selected indicators drawn from three ITU data sets.

- **Telecommunication/ICT infrastructure and access data**, collected annually through one short and one long questionnaire. These indicators are defined in the ITU Handbook for the Collection of Administrative Data on Telecommunications/ICT.
- **Price data**, collected through an annual questionnaire. Price indicators are also defined in the ITU Handbook for the Collection of Administrative Data on Telecommunications/ICT.
- **Data on access to and use of ICTs by households and individuals**, collected annually through one short and one long questionnaire. These indicators are defined in the Manual for Measuring ICT Access and Use by Households and Individuals.

This version of the Dashboard uses data collected up to November 2020.

When a value is not available, NA is reported. In some cases, it is possible that the value reported for disaggregated indicators is for a different period than the main indicator.

ICT skills

- **Basic skills:** the highest value among the following four computer-based activities: copying or moving a file or folder; using copy and paste tools to duplicate or move information within a document; sending e-mails with attached files; and transferring files between a computer and other devices.
- **Standard skills:** the highest value among the following four computer-based activities: using basic arithmetic formula in a spreadsheet; connecting and installing new devices; creating electronic presentations with presentation software; and finding, downloading, installing and configuring software.
- **Advanced skills:** the value for writing a computer programme using a specialized programming language.

This version of the Dashboard uses data collected up to November 2020. When a value is not available, NA is reported. In some cases, it is possible that the value reported for disaggregated indicators is for a different period than the main indicator. For most indicators, values are rounded to the nearest integer. As a result, it is possible that the sum of the values of disaggregated indicators does not add up to 100%.

A print-friendly, two-page version of the Dashboard for the selected economy is available by clicking the PDF icon, next to the map.

Questions and comments: indicators@itu.int

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