Sustainable Last Mile Connectivity Solutions

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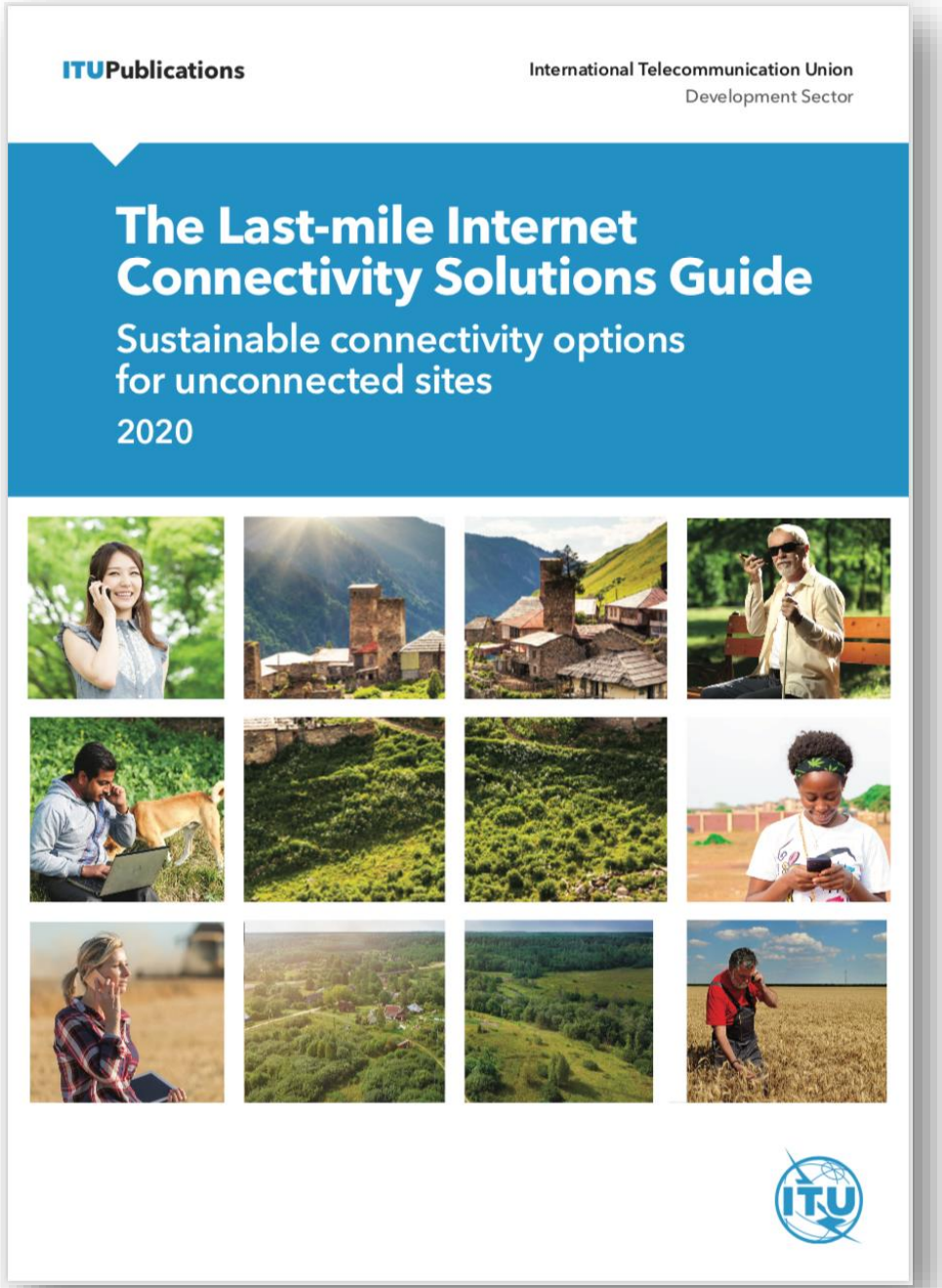
ITU Regional Forum for Europe on Meaningful Connectivity, March 8, 2021



The Last-mile Internet Connectivity Solutions Guide:

https://www.itu.int/en/ITU-D/Technology/Pages/LMC/LMC-Home.aspx

Introduction: Background, Motivation and Objectives

The global focus on universal connectivity is driven in part by the fact that, despite the meteoric growth of Internet use and broadband connectivity, 49 per cent of the world's population, or 3.7 billion people, were still offline and excluded from the benefits of the global digital economy at the end 2019. Offline populations are particularly concentrated in least developed countries, where only 19 per cent of individuals were online in 2019. Regionally, less than half the populations of Africa and Asia-Pacific are online (29 and 45 per cent, respectively) while 83% are connected in Europe.

Figure: Individuals using the Internet, 2005-2019*

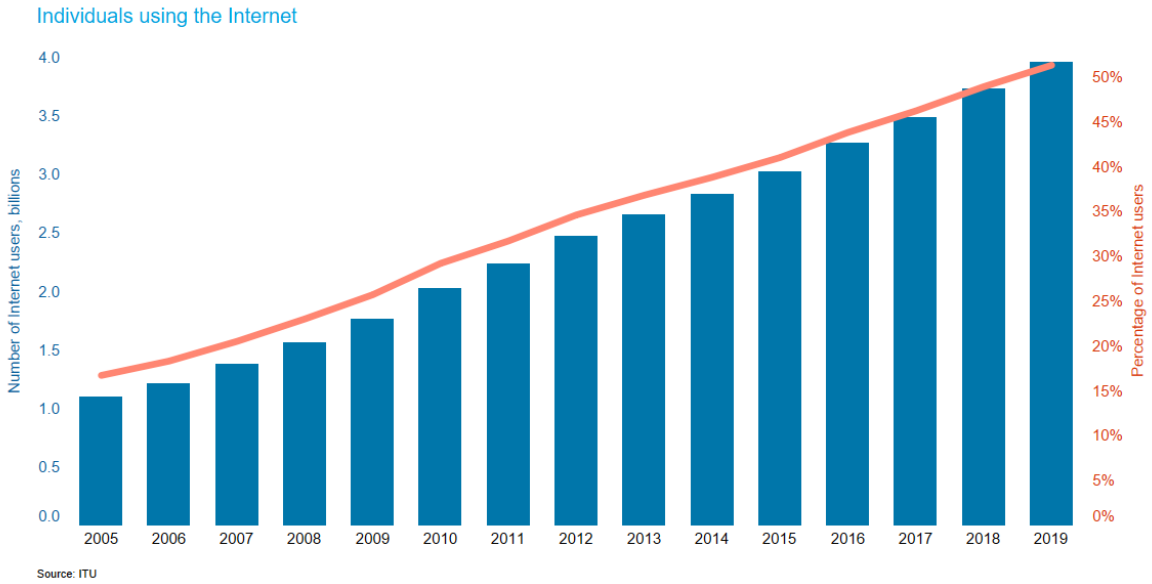
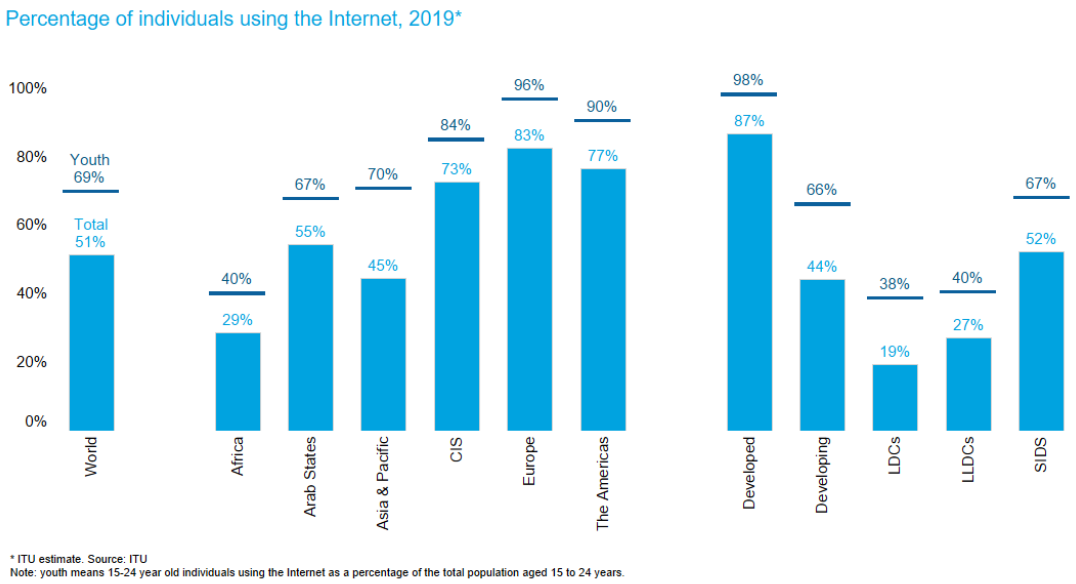


Figure: Percentage of individuals using the Internet, by region and development status, 2019



Source: https://itu.foleon.com/itu/measuring-digital-development/internet-use/

Steps in Providing Sustainable Last Mile Connectivity Solutions

Step 1:

Identify digitally unconnected (and underserved) geographies

Step 2:

Review options from existing solutions

Step 3:

Select sustainable solutions by matching viability subject to constraints

Step 4:

Implement interventions to extend sustainable connectivity service

Top-Down vs Bottoms-Up mapping approach

There are two main approaches to begin geographically mapping network infrastructure and access, depending on the geographic scope of the exercise.

Figure: Differentiating between two different approaches to mapping unconnected and underserved populations

Top-down approach:

Large geographic areas (national or sub-national) are mapped by accessing secondary mapping data in order to identify infrastructure coverage gaps.
Additional characteristics:

- Data gathered from secondary sources such as national government agencies or third-party aggregators (e.g. satellite data, operator infrastructure, etc.)
- Tends to cover large geographic areas
- May develop a multipronged approach to connectivity interventions beyond a single site/location

Bottom-up approach:

Starts with the specific, targeted locality, mapping local data and testing for different aspects of network infrastructure availability.
Additional characteristics:

- Local mapping (testing network infrastructure available in the vicinity)
- Adding socio-demographic attributes at the local level collected via census
- Includes relevant geographic and environmental conditions

Top-Down Infrastructure Mapping Examples

Table: Top-down infrastructure mapping: examples

Map name	Geographic coverage	Network type	Publicly available or commercial service	Data downloadable to the public	URL
ITU Broadband Maps	Global	Terrestrial fibre, microwave and undersea fibre	Public	Limited access	https://itu.int/go/Maps
Telegeography Submarine Cable Map	Global	Undersea fibre	Public	Yes	https://www.submarinecablemap.com/ and https://github.com/telegeography/www.submarinecablemap.com
African Terrestrial Fibre Optic Cable Mapping Project (AfTerFibre)	Africa	Terrestrial fibre and undersea fibre	Public	Yes	https://afterfibre.nsrc.org/
The Connected Pacific	East Asia and the Pacific	Undersea fibre	Public	Yes	https://connectedpacific.org
Satbeams	Global	Satellite	Public	Some	https://www.satbeams.com/
GSMA Mobile Coverage Maps	Africa (8 countries)	Terrestrial cellular	Public	No	http://www.mobilecoveragemaps.com/
Masae Analytics	Global	Terrestrial networks and undersea	Commercial	No	https://www.masae-analytics.com/
InfraNav	Global	Terrestrial networks and undersea	Commercial	No	https://www.infranav.com/
Fraym	Africa	Terrestrial networks and undersea	Commercial	No	https://fraym.io/
Towersource (infrastructure)	Global	Terrestrial networks	Commercial	No	https://www.towersource.com/
mapELEMENTS (coverage)	Global	Terrestrial mobile coverage	Commercial	No	https://www.mapelements.com/
OpenSignal	Global	Terrestrial cellular coverage	Commercial	No	https://www.opensignal.com/

Characteristics & Trade-offs – Common Access Network Technologies (Wireless)

Table : Comparison of common wireless access network technologies

Access network technology	Potential throughput / QoS	Range	Capital expenditure to deploy new network	Operating expenses	Infrastructure required	Suitability for rural deployments	Spectrum licensing requirement	Access device type
Wi-Fi: 802.11	2 Mbit/s (a) to 10 Gbit/s (ax)	100s of m	Low	Low	Wi-Fi routers	Yes, but backhaul required (satellite, microwave or fibre)	No specific licence but compliance with technical specifications via “blanket licence" under non-interference/non- protection regime	Wi-Fi enabled smartphones, tablets, computers
Mobile cellular (2G, 3G, 4G, 5G)	0.1 – 1000 Mbit/s	5 to 15 km	Medium to high	Medium to high	Towers and radio equipment	Yes, but backhaul required (satellite, microwave or fibre)	Yes	Cellular mobile phones, laptops, personal computers (via dongles)
Fixed wireless access (4G/ 5G)	20 – 1 000 Mbit/s	Up to 10 km	Low to medium	Low	Towers and radio equipment	Maybe, depending on financial viability and demand	Depends on country regulations	Consumer premises modems to Ethernet or Wi-Fi
Satellite (HTS GEO and MEO)	5 – 150 Mbit/s	1 000s of km	High (for new satellite deployment); low (for end-user terminals)	Low	Earth station, satellite, very-small-aperture terminal	Yes	Yes	Very-small-aperture terminal, consumer premises modems to Ethernet or Wi-Fi

Note with the evolution of 4G and 5G, throughput can reach up to 1 Gbps

Sources: adapted from various sources, including the European Union, Cisco, Huawei, ITU, the Inter-American Development Bank, the World Bank and the EMEA Satellite Operators Association

Characteristics & Trade-offs – Common Access Network Technologies

Table: Comparison of common wired access network technologies

Access network technology	Potential throughput / QoS	Range	Capital expenditure to deploy new network	Operating expenses	Infrastructure required	Suitability for rural deployments	Additional regulatory issues	Access device type
Fibre	100 – 1 000 Mbit/s	100s of km	Overhead cabling: low to medium	Medium	Tower, poles, cabinets, active network equipment	In some cases, with sufficient purchasing power and population densities	Pole attachment	Fibre modem to Ethernet-enabled devices or to Wi-Fi
			Below ground: medium to high (new excavation)	Low to medium	Subterranean duct work, cabinets, active network equipment	No	Right of way	
Coax (cable)	Up to 200 Mbit/s	Up to 100 km	Low to medium	Low to medium	Tower, poles, cabinets, active network equipment	In some cases, with sufficient purchasing power and population densities	Pole attachment	Cable modem to Ethernet-enabled devices or to Wi-Fi
Copper	0 to 24 Mbit/s (for ADSL, ADSL 2, ADSL 2+); 100 Mbit/s (for VDSL, VDSL2, Vectoring); 1 Gbit/s (G.Fast)	0.1 to 5 km	Low to medium	Low to medium	Tower, poles, cabinets, active network equipment	In some cases, with sufficient purchasing power and population densities	Pole attachment	Modem to Ethernet-enabled devices or to Wi-Fi

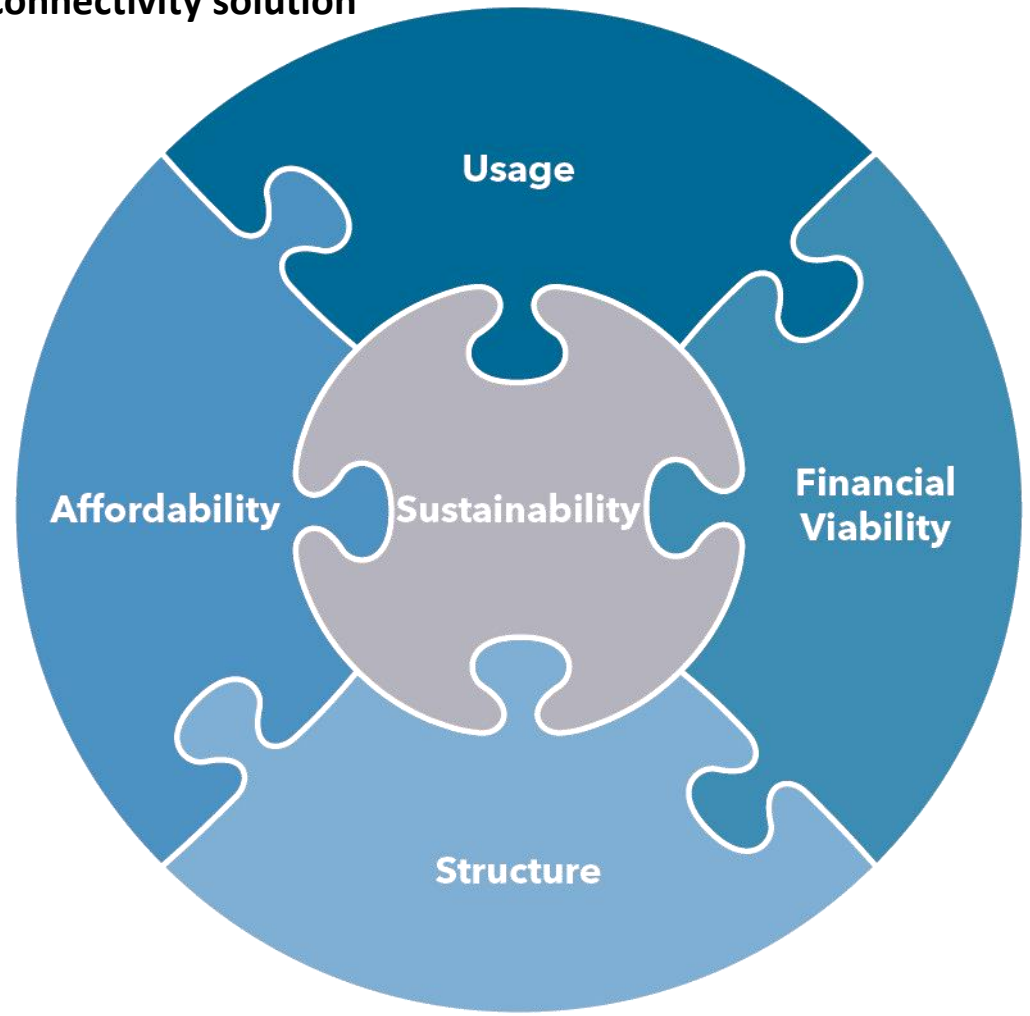
Sources: adapted from various sources, including the European Union, Cisco, Huawei, ITU, the Inter-American Development Bank, the World Bank and the European School of Antennas

Selecting a Sustainable Last-Mile Connectivity Solution

To identify suitable last-mile connectivity interventions, after a specific unconnected geography / locality has been selected, it is necessary to first determine the five main aspects of a given situation that serve as binding constraints and can provide direction for any possible solution.

1) **Affordability** – Ensuring that connectivity service user pricing falls within a given affordability threshold, such as the 2 per cent of monthly GNI per capita for 1GB of mobile broadband data discussed above.
2) **Usage** – Identifying the applications and services that need to be available to the locality, and the level of QoS that those applications and services require.
3) **Financial viability** – This includes measuring the economic viability for private investment of the connectivity service, based on estimates of ARPU, availability of backhaul / middle-mile connectivity, options for different local access technologies and the potential level of the service's QoS.
4) **Structure** – This involves articulating the service delivery business model and identifying any regulatory constraints on the model and technologies utilized.
5) **Sustainability** – This requires an understanding of the service's revenue model and of any potential subsidy (one-time and/or recurring).

Figure: Components in selecting a sustainable last-mile connectivity solution



A Decision Matrix for Sustainable Solutions

The range of options facing any single intervention are extensive and the process of filtering the characteristics of the constraints can be linear (e.g. a decision tree) or iterative (determines a good fit on the basis of all of the inputs and constraints unique to each situation).

Table: A decision matrix for appropriate sustainable solutions

		Commercial MNO	Commercial ISP	Not-for-profit local mobile network	Not-for-profit local ISP network
Affordability		Ex-ante measure of affordability threshold (such as 2 per cent of monthly GDP per capita for 1 GB of mobile broadband data) applied at national or local level; determination whether this will govern selection process or used just as an external measure of progress			
Usage		Ex-ante determination of usage requirement: will usage be determined by what the market (and financial viability) support, or are there specific services and applications (such as e-government, health or education) that require meeting specific QoS thresholds?			
Financial viability	**Estimating demand and financial viability**	Small population/low income Small population/higher income Larger population/low income Larger population/higher income	Small population/low income Small population/higher income Larger population/low income Larger population/higher income	Small population/low income	Small population/low income Small population/higher income Larger population/low income
	QoS options (backhaul)	High capacity and competitive pricing Low capacity and high pricing	High capacity and competitive pricing	Low capacity and high pricing	Low capacity and high pricing
	Access network characteristics	Small area/flat terrain Large geographic area/flat terrain	Small area/flat terrain Small area/mountainous terrain Large area/flat terrain Large area/mountainous terrain	Small area/flat terrain; Small area/mountainous terrain; Large area/flat terrain	Small area/flat terrain Small area/mountainous terrain Large area/flat terrain Large area/mountainous terrain
Structure		Commercial telecom operation licences required; licensed spectrum rights required	Commercial ISP licence required	Licensed spectrum rights required (except partnerships with an MNO); telecom licence may be required	ISP licence may be required
Sustainability		Commercial operation that must break even (or provide coverage as a corporate social responsibility endeavour or coverage obligation requirement)	Commercial operation that must break even (or provide coverage as a corporate social responsibility endeavour or coverage obligation requirement)	Usage fees may have to be supplemented with in-kind contributions (network installation and operation) or ongoing community or government subsidies	Usage fees may have to be supplemented with in-kind contributions (network installation and operation) or ongoing community or government subsidies

Options for interventions – Examples of Recurring financing

Limited concessional financing support can serve to de-risk private sector investment (as described as a smart subsidy).

Table : Recurring subsidy interventions and their applicability to different last-mile connectivity models

Recurring subsidy interventions	Examples	Commercial MNO	Commercial ISP	Not-for-profit local mobile network	Not-for-profit local ISP network
Collect and distribute universal service funds for recurring subsidies to de-risk deployments	Malaysia's Universal Service & Access Fund provided support for the deployment of the six main initiatives in the National Broadband Initiative; Gabon's experience using its universal service fund to finance network expansion and operations for 2 700 remote villages in areas deemed too unprofitable for private telephony operators (see LMC case study); South Africa's experience utilizing recurring subsidies from the South African Universal Services Fund to provide free Wi-Fi to rural schools and clinics (see LMC case study)	✓	✓	✓	✓
Consider more flexible and beneficial tax arrangements for non-profit local complementary networks				✓	✓