ICTs, LDCs and the SDGs

Achieving universal and affordable Internet in the least developed countries

Executive Summary

In Partnership with

UN-OHRLLS

ITU

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Executive Summary

LDCs

The least developed countries (LDCs) comprise the 47 nations that suffer from severe structural impediments to sustainable development. They are highly vulnerable to economic and environmental shocks and endure low life expectancy, poor education, and meagre per capita incomes. LDCs have a combined population of 979 million people, representing 13 per cent of the world's inhabitants in 2016.

Although the 47 LDCs share many similarities and face related development challenges, there are major differences within the LDC group, in particular in terms of their population, geography, and level of economic development (Table 1). Seventeen LDCs are landlocked developing countries (LLDCs) and nine are small island developing states (SIDS). While LLDCs lack direct access to the sea, which often makes international connectivity more expensive, many SIDS have numerous islands and some are very small, with few inhabitants. Some LDCs are very rural, and others have large, sparsely populated land areas, which makes the roll-out of terrestrial communication infrastructure more difficult.

Table 1: LDCs by region and income grouping

	Africa		Americas	Arab States	Asia & Pacific
Non-LLDC or SIDS	Angola† Benin Dem. Rep. of the Congo Eritrea Gambia Guinea Liberia	Madagascar Mozambique Senegal Sierra Leone Togo Tanzania		Djibouti† Mauritania† Somalia Sudan† Yemen†	Bangladesh† Cambodia† Myanmar†
LLDCs	Burkina Faso Burundi Central African Rep. Chad Ethiopia Lesotho Malawi	Mali Niger Rwanda South Sudan Uganda Zambia†			Afghanistan Bhutan† Lao PDR† Nepal
SIDS	Guinea-Bissau S. Tomé and Principe†		Haiti	Comoros	Kiribati† Solomon Is.† Timor-Leste† Tuvalu‡ Vanuatu†

Note: All low-income except: † Lower-middle income ‡ Upper-middle income.
Source: Adapted from UN-OHRLLS and World Bank and based on ITU regions.

ICTs

Information and communication technologies (ICTs) enable LDCs to tackle key development challenges, including in areas such as financial inclusion, poverty reduction and health. The international community is keen to promote greater availability of ICT infrastructure in LDCs. The *Istanbul Programme of Action*[1] 2011-2020, adopted by the Fourth UN Conference on the LDCs in 2011, recognizes ICT as an infrastructure priority on a par with water, electricity, and transport.

Great progress has been made in terms of ICT developments in the LDCs. Greater access to mobile cellular networks and falling prices have opened up new opportunities for development in areas such as farming, health, and financial services.

What the most successful mobile services and applications have in common is that they are basic, often using voice or text, affordable, easy to use, require little bandwidth, work with plain cellphones and over second-generation (2G) networks. While *narrowband* digital technologies have helped to improve lives in the LDCs, *broadband* applications and services delivered through access to the Internet could do even more. For example, telemedicine can help to compensate for a shortage of doctors, and online learning for a shortage of teachers. Indeed, it can be argued that those facing the greatest development challenges require the latest and best technologies to provide them with services that are otherwise not available.

> While the world's most vulnerable countries have witnessed impressive growth in terms of expanding ICTs, especially mobile network coverage, more efforts must be made to move from low-speed networks and basic applications to broadband services and use.

SDGs

In September 2015, the *2030 Agenda for Sustainable Development*[2] was agreed at the United Nations Sustainable Development Summit. This new framework is composed of 17 new Sustainable Development Goals (SDGs), 169 targets, and over 200 indicators. Several targets refer to digital technology, and the *2030 Agenda* recognizes that "the spread of information and communication technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies". SDG 9 on industry, innovation and infrastructure establishes Target 9.c, which commits the international community to "significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020".

> SDG Target 9.c is a commitment to "significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020".

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[1]   United Nations (UN). 2011. "Programme of Action for the Least Developed Countries for the Decade 2011-2020." In *Fourth United Nations Conference on the Least Developed Countries*. Istanbul, Turkey.

[2]   United Nations (UN). 2015. *Transforming Our World: The 2030 Agenda for Sustainable Development*.

LDCs have made great progress in expanding mobile services and networks

The official SDG indicator identified to track Target 9.c is the "proportion of population covered by a mobile network, by technology". The indicator, which is defined as "the percentage of inhabitants living within range of a mobile-cellular signal, irrespective of whether or not they are mobile phone subscribers or users", reflects the infrastructure availability aspect of the target, since it measures the possibility of subscribing to and using mobile cellular services. By including the breakdown "by technology", the indicator is flexible in terms of technological development. It can apply to basic narrowband mobile networks (2G) as well as third- and fourth- generation (3G and LTE-Advanced (4G)) mobile broadband networks and emerging fifth-generation (5G) networks.
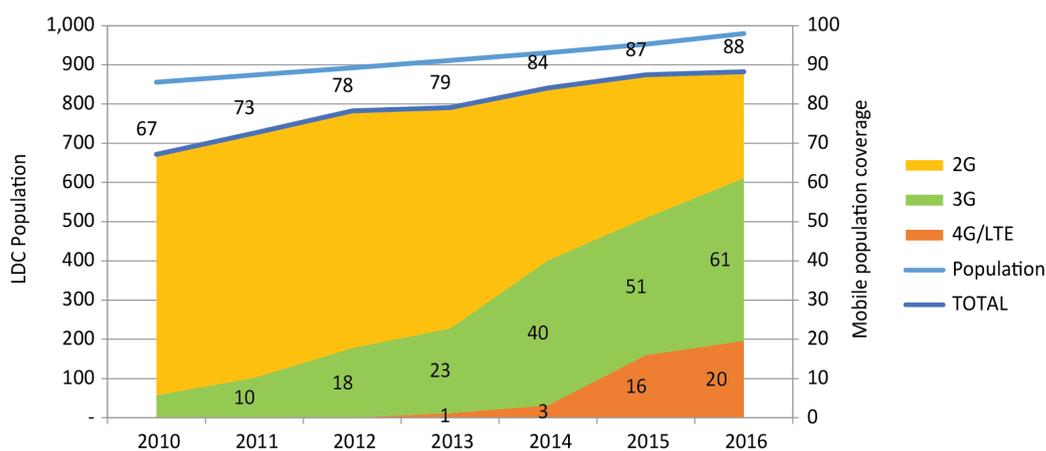
> By the end of 2016, 61 per cent of the population in LDCs had access to a mobile broadband network.

As regards the tracking indicator for SDG Target 9.c, the proportion of the population in LDCs able to receive a 2G signal rose from 67 per cent in 2010 to 88 per cent in 2016.

By 2016, all LDCs had launched 3G mobile broadband networks and 61 per cent of the population had access to 3G mobile broadband services (Figure 1).

By the end of 2016, a total of 26 LDCs had commercially deployed 4G Long-Term Evolution (LTE) networks. Although coverage is limited mainly to urban areas in most LDCs, it is growing rapidly and some countries have established concrete coverage targets. LTE-Advanced (4G) provides theoretical download speeds of 1 Gbps, some 12 times faster than the most advanced 3G+ network. Given the widespread penetration of wireless technologies throughout the LDCs, LTE is the logical next step and provides a solid platform for the data-intensive applications that could hugely affect social and economic development.

Figure 1: Mobile population coverage in LDCs

Source: ITU.

Overall, LDCs are on track to achieve SDG Target 9.c to make the Internet accessible and affordable by 2020

By early 2017, 61 per cent of the population in LDCs was covered by a mobile broadband signal and the price of mobile broadband services continues to fall rapidly. If recent growth rates hold, the LDCs will be on track to reach averages of 97 per cent mobile broadband population coverage (Figure 2, left) and Internet prices of less than 5 per cent of monthly gross national income (GNI) per capita (Figure 2, right) by the target date of 2020. This masks important differences between the LDCs but reflects the fact that some LDCs will have largely achieved the universality and affordability criteria by 2020.

Figure 2: Projections for mobile 3G coverage and mobile broadband prices in LDCs

3G coverage (% of population)

Mobile broadband 500 MB (% GNI)
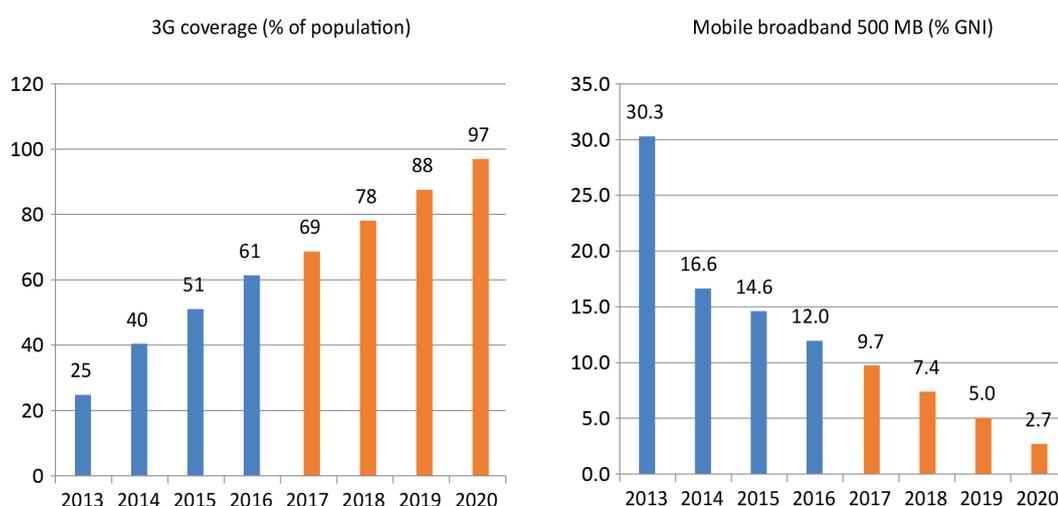
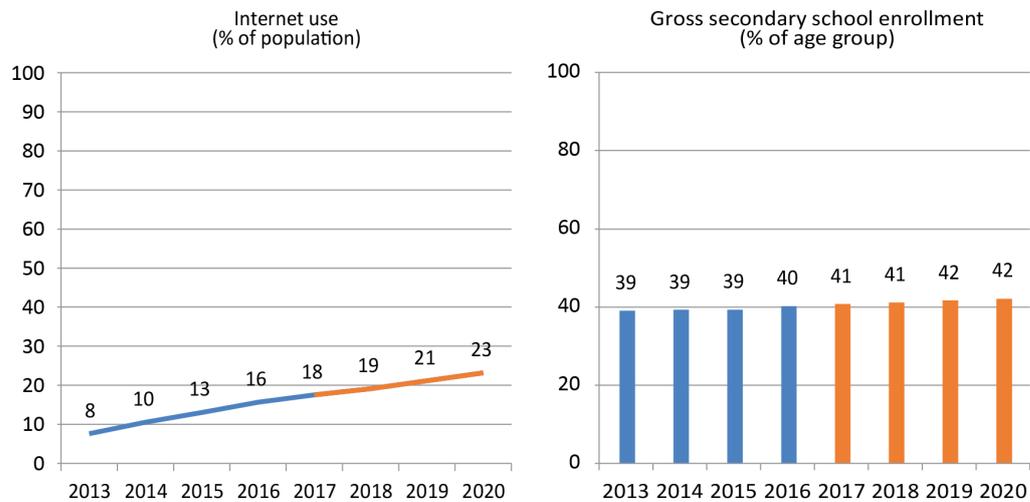Note: Projections (in orange) are not official ITU projections but based on least square regression.
Source: ITU.

By 2020, fewer than one out of four people in the LDCs will be using the Internet since most will lack the necessary skills

The prospects for widespread use of the Internet by 2020, however, remain poor. At current growth, less than a quarter of the population of the LDCs will be online (Figure 3, left). A key reason is that growth in the ability to use the Internet will not match that of coverage and affordability. While Internet use is dependent on infrastructure and affordability, it also requires the development of human skills. This report identifies gross secondary education enrolment[3] as an important proxy for ability to use the Internet. The reason for this is that LDCs have youthful populations; in many of these countries, most Internet users are young, and secondary school students or recent school leavers account for most of the Internet users among the young. It is forecast that secondary school enrolment will be only two percentage points higher in 2020 than it was in 2016 (Figure 3, right). Imbalances among these three factors of access, affordability and skills strongly influence take up of the Internet.

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3   Gross secondary education enrolment refers to the total number of students enrolled in secondary education as a percentage of the official secondary education school age population; see: http://uis.unesco.org/en/glossary-term/gross-enrolment-ratio.

**Internet use
(% of population)**

**Gross secondary school enrollment
(% of age group)**

Note: Projections are not official ITU/UIS projections but based on least square regression.

Source: ITU and UIS.

A three-dimensional framework to identify challenges and accelerate growth

To identify bottlenecks and challenges, LDCs have been classified into three categories based on their overall performance across the areas of access, affordability and skills (Figure 4). This includes those on track to achieve SDG Target 9.c by 2020 (high); those that might achieve at least one or more of the indicator thresholds particularly with the right policies to induce rapid growth (medium); and those unlikely to reach the target by 2020 owing to vulnerability challenges and structural barriers, and where change is likely to be incremental (low).

This framework for gauging performance across each of the three dimensions makes it easier to identify the areas that are most pressing and hence where to direct policy and scarce financial and human resources.

Figure 4: Performance across three dimensions of Internet use: Access, affordability and skills
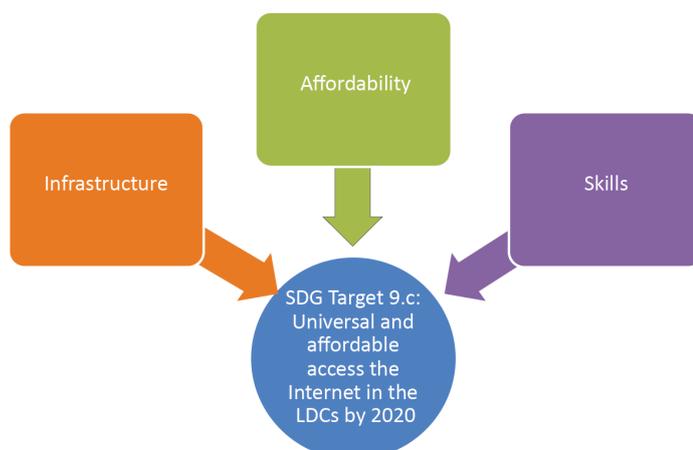
High	Medium	Low
S. Tomé & Principe	Tuvalu	Mali
Bhutan	Yemen	Haiti
Timor-Leste	Solomon Islands	Burkina Faso
Myanmar	Ethiopia	Sierra Leone
Bangladesh	Angola	Burundi
Nepal	Sudan	Chad
Vanuatu	Comoros	Niger
Lesotho	Zambia	Mauritania
Kiribati	Benin	Central African Republic
Rwanda	Senegal	South Sudan
Lao PDR	Afghanistan	Somalia
Cambodia	Uganda	Dem. Rep. of the Congo.
Tanzania	Djibouti	Eritrea
Gambia	Mozambique	Guinea-Bissau
	Guinea	
	Liberia	
	Togo	
	Madagascar	
	Malawi	

Note: Based on average of rank across three indicators. The three indicators are: 3G coverage (% of population), 500 MB monthly mobile Internet package (% of GNI p.c.) and gross secondary school enrolment.
Source: ITU.

For each of these three dimensions, the report analyses progress, identifies major bottlenecks based on developments in the LDCs, and makes specific recommendations.

Making the Internet accessible and sustainable

ICT infrastructure, which includes international connectivity, national backbone and local access networks, is the key building block for providing Internet access.

International connectivity has grown for LDCs, particularly those in Africa, and has brought down prices. A key factor is the fact that the deployment of submarine cables has intensified over the last few years, dramatically increasing international Internet capacity. While only three of the 20 sea-facing African LDCs had direct access to a submarine cable prior to 2009, by 2016 all but two had such access. Almost all sea-facing LDCs in other regions are connected to submarine cables. Four unconnected small island states are planning to connect in the near future. Land-locked LDCs are dependent on cross-border connections to neighbours and transit through those countries in order to access international capacity at submarine cable landing stations. Cross-border interconnection is considered important for regional economic integration, and several regional initiatives are driving progress in this area.

Greater access to international connectivity has also created strong incentives for expansion of regional and national backbones. In addition to regional inter-governmental efforts, several mobile network operators have linked their national backbones where they share common borders, and a growing number of wholesale operators are developing regional backbone infrastructure.

> By 2016, almost all sea-facing LDCs had direct access to a submarine cable. LLDCs are increasingly benefiting from cross-border interconnection and regional connectivity projects.

There is no standard model for LDCs to boost connectivity, but progress to date points to the importance of competition, public interventions when needed, open access, infrastructure sharing and private investment. Market dominance, troubled privatization, excessive taxation, and monopoly control over international gateways, remain key obstacles. Competition is often highly concentrated and other ingredients, such as infrastructure sharing, are underdeveloped.

Access to spectrum is a key factor influencing wireless broadband development in the LDCs. The demand for spectrum is growing with the increasing adoption of mobile services, the expansion to new market segments, and continuous technological innovation. The allocation of spectrum in the 700/800 MHz bands freed up by analogue to digital migration (the so-called "digital dividend") has emerged as an important tool for promoting the deployment of 4G, and its high propagation is ideally suited to rural areas. While some LDCs have developed policies that support proactive spectrum use, others remain in traditional "command and control" mode of spectrum allocation. A challenge for many LDCs is the difficulty of elaborating price models for the use of radio-frequency spectrum. The different economic and market conditions and diverse technical factors underlying spectrum fees make capacity building, including on the job training and experience sharing, crucial.

Other important tools to drive broadband infrastructure deployment are regulation on rights of way, access to network facilities, infrastructure sharing, and universal service funds. A number of LDCs have created special funds generally financed by obligatory contributions from telecommunication operators. The first was created in 1999, and by 2016, a total of 20 LDCs had a universal service fund. In principle, universal service funds have the mandate of developing ICTs in underserved and remote communities. This ranges from infrastructure provision and deployment of ICTs in schools to subsidizing network expansion and training. In practice, however, their performance has been mixed, and some have yet to disburse any money despite having substantial balances.

Sustaining the Internet ecosystem

Core Internet infrastructure (Internet Exchange Points (IXPs), country top-level domain names (ccTLDs), web hosting and data centres) plays a fundamental role for LDCs in developing a vibrant and sustainable digital economy. Three strategic components need to be present domestically to ensure that the Internet continues to operate in the event of a disruption to international connectivity: a root name server, a ccTLD name server, and an IXP. This core infrastructure enables all other parts of the Internet to function. While largely invisible to most people, it is indispensable for enabling Internet applications, services, and online content for citizens, businesses and governments.

Core national Internet infrastructure has significant economic implications. If the ccTLD is not managed locally, money accrues to overseas registrars and web hosting companies. If there is no IXP, all data will be exchanged overseas, requiring additional and often costly Internet bandwidth. If the capacity of national data centres is limited, storage and cloud computing applications will be located abroad, adding to the need for and cost of international bandwidth, increasing dependency on external networks over which there is no local control, and inhibiting the development of a local digital economy.

LDCs are making steady progress towards developing their key national Internet infrastructure. Almost half of all LDCs have an active IXP (Figure 5), and almost one third of LDCs have all three key components: a root name server, a ccTLD name server, and an IXP. These 14 nations are on the path towards a high level of Internet resiliency and sustainability. Another 11 have two components, and eleven others have at least one in place, while a dozen do not have any of the key components in operation.

Figure 5: IXPs in LDCs

Percent of LDCs with active IXP, 2017

Number of IXPs in LDCs
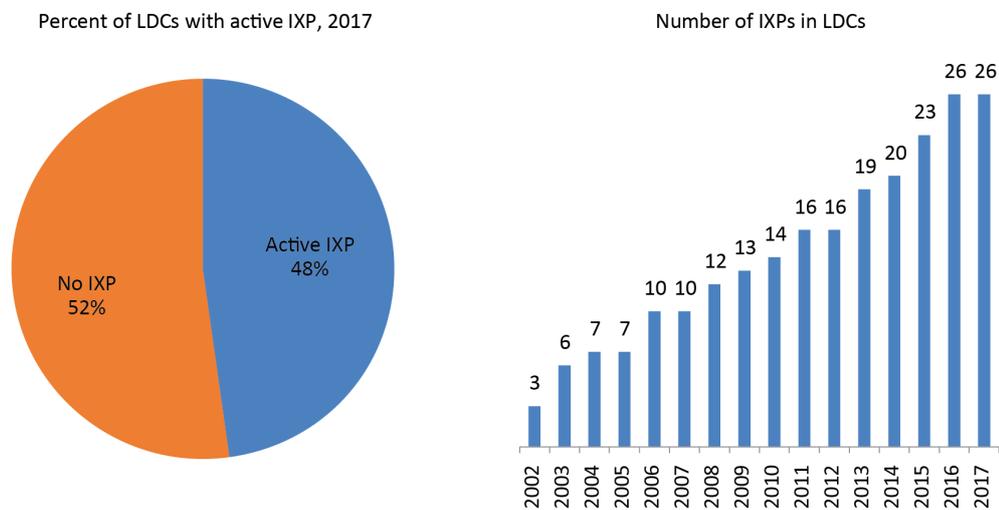
Note: Some LDCs have more than one IXP (i.e. Angola, Cambodia and Tanzania).
Source: Adapted from Packet Clearing House (www.pch.net).

With the right policy push, there is no reason why most LDCs cannot achieve the three requirements for Internet sustainability. Some LDCs have recognized their ccTLD as an essential resource and understand the important link between domain names and domestic web hosting. There are various resources for LDCs to master the skills for managing their ccTLD, and free open source software is available for ccTLD operations. Prefabrication, modularization and scaling are making data centres more affordable. This provides an opportunity for LDCs to leap-frog to energy efficient and ecologically friendly data centres. This is essential for driving government services and cloud computing

applications. For those LDCs still lacking pieces of critical national Internet infrastructure, support is available. Many IXPs in the LDCs have been created with the support of different development partners.

Making the Internet affordable

Surveys for some LDCs suggest that affordability is not necessarily the main obstacle to getting people online for the first time; other challenges, such as lack of awareness, skills and local content, are also important barriers. When analysing affordability constraints, it is essential to distinguish between *getting people online for the first time* and *the extent to which those already online can use the Internet*. Device prices remain the key affordability obstacle for non-users, whereas the price of Internet services impacts on the amount of data consumed by existing users.

An Internet device is a prerequisite for using the service. The price of smartphones has been falling but can still be a barrier in some LDCs, particularly when import duties and other taxes are added. According to GSMA, handset taxes as a proportion of the handset price averaged 23 per cent around the world, about the same average as in the LDCs.[4] Taxes are more onerous in LDCs, where they account for a larger share of per capita income. Data for LDCs show that handset taxes range from 0 to 40 per cent of the total cost. The device affordability barrier is being circumvented in some LDCs through "hand-me-downs" from family and friends and access at public Internet locations such as schools and community centres.

Baskets are typically used to gauge the affordability of Internet usage. In 2016, according to the ITU monthly mobile Internet basket, there was a wide range of prices for a 500 MB data package across the LDCs, ranging from USD 1 to USD 50, with a median of USD 10. As a proportion of monthly per capita GNI, values range from less than 1 to over 100 per cent, with the median of 10 per cent. To put this in context, the Broadband Commission established a target to bring the price of Internet access below 5 per cent of average per capita income by 2015. In 2017, the great majority of LDCs (36) still exceeded that target price. This might imply that use of the Internet is not affordable for many in the LDCs, although the basket does not take into account the flexible packages that are available for low-income groups.

Operators in LDCs have adapted to low-income users and offer a wide variety of different low-denomination plans that range from a one-hour plan featuring 5 MB of usage to weekly bundles offering unlimited access to popular social media applications.

4   GSMA. 2015. Digital Inclusion and Mobile Sector Taxation.

Figure 6: ITU prepaid mobile broadband price basket (at least 500 MB per month) 2016
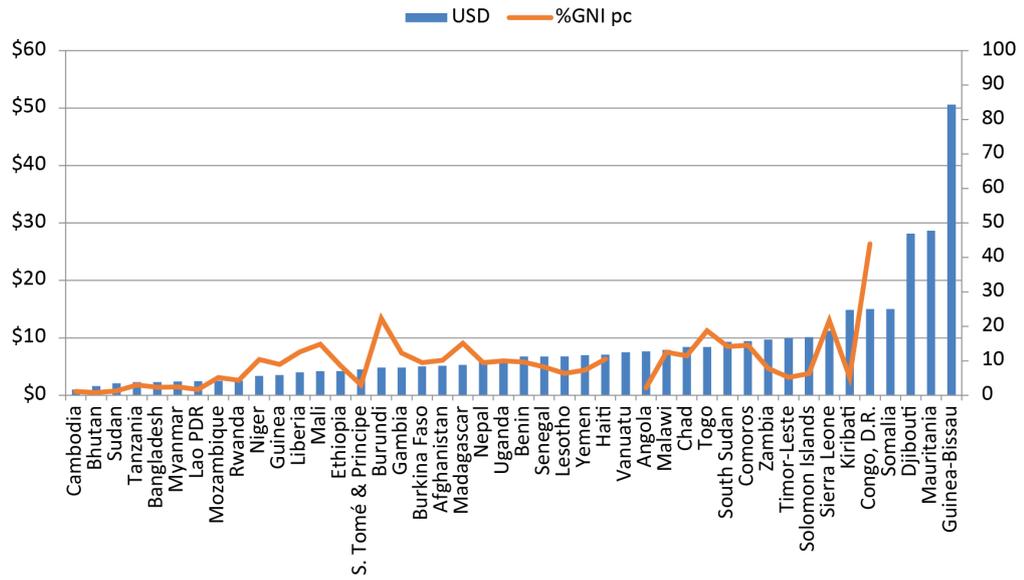
Note: Refers to plan of largest mobile operator (by subscriptions). LDCs for which tariff data were not available are not included.
Source: ITU.

Operators in the LDCs recognize that many users cannot afford to use the Internet every day. For low-income Internet users, they offer a variety of different low-denomination plans that range from a one-hour plan featuring 5 MB of usage, to weekly bundles offering unlimited access to popular social media applications (Figure 7). Although not providing the convenience of a monthly plan, the bundles allow lower-income users a variety of options to access the mobile Internet at low cost.

Figure 7: Mobile Internet bundles in the LDCs, 2017
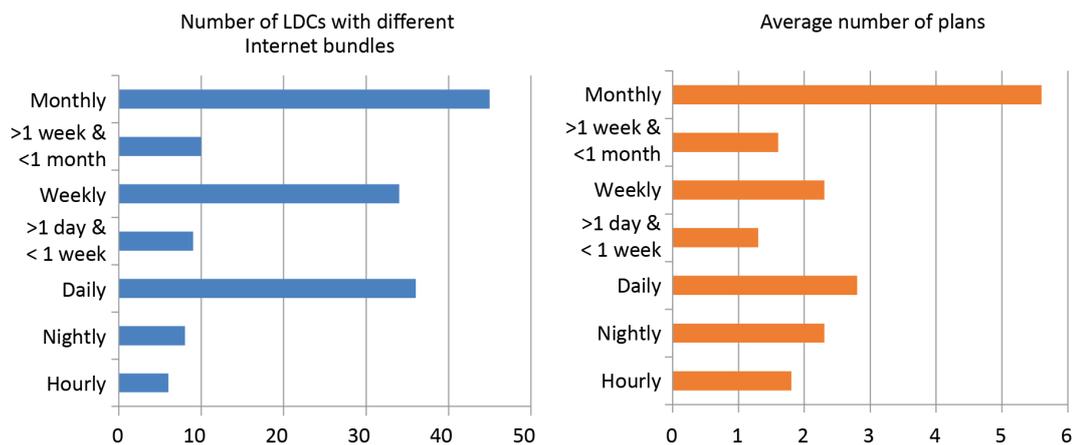
Note: Based on the largest mobile operator (by subscriptions) in the 45 LDCs for which data were available. The left-hand chart shows how many LDCs have a specific time bundle. For example, six LDCs have an hourly plan. The right-hand chart shows the average number of plans per time bundle. For example, there are 1.8 different hourly plans in LDCs that offer such a plan and 5.6 different monthly plans.
Source: ITU.

Zero-rated services aim to overcome affordability challenges by providing access to certain content without applying the user's data cap. It is not clear to what extent zero-rated services get new, previously unconnected users online. Another issue is that making only specific content available for free runs counter to the principle of net neutrality.

The strongest influence on mobile Internet prices is competition. Both the existence of a competitive mobile market and the intensity of competition are crucial. Regulatory steps to create a more competitive mobile market will align prices more closely with costs and enhance affordability. Competition in LDCs also leads to the availability of a diversity of data bundles for different data requirements and catering to the specific needs of low-income users.

Skills for using the Internet

While infrastructure and affordability are supply-side factors, knowledge of how to use the Internet is a demand-side constraint. For policy-makers, developing human capacity to use the Internet requires approaches different from the policy and regulatory tools used to spur infrastructure roll-out and influence Internet pricing. The lack of digital literacy is increasingly emerging as a leading barrier to Internet use in many LDCs. This is reflected in some available surveys for LDCs in which a significant proportion of respondents state that they do not use the Internet because they lack the skills.

> Strategic ICT sector plans need to highlight the role of, and make the link to, educational policies.

Source: UNESCO Institute of Statistics.

Lack of skills for using the Internet is closely linked to educational attainment. Data further suggest that as more women achieve higher educational levels, the gap between female and male Internet use narrows. These findings show that more efforts need to be devoted to eliminating the gender digital divide and to ensuring that the universality aspect of SDG Target 9.c is achieved.

In particular, governments need to encourage greater secondary school enrolment, which, at 48 per cent in the LDCs, remains below the world average (76 per cent) (Figure 8). Not surprisingly, those LDCs with relatively high secondary gross enrolment rates are also doing well in terms of Internet uptake.

Figure 8: Secondary school gross enrolment ratio
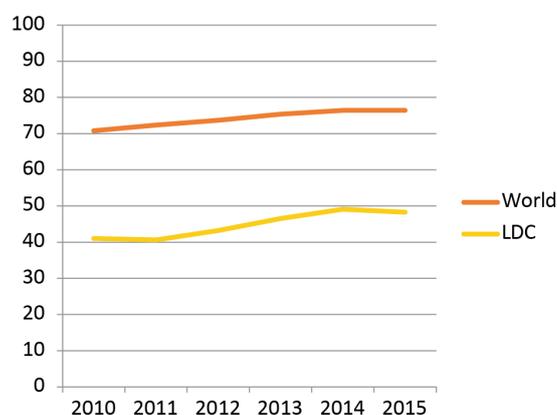
In addition, governments need to link education to ICT sector policies given the close synergies. Some LDCs have adopted ICT sector plans that recognize the importance of skills and elaborate the need for collaboration between ICT and education ministries with specific objectives. The need for this collaboration is reinforced by the link to SDG Goal 4: "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all."[5] SDG 4 has a target relevant for enhancing Internet use (ensuring free secondary education by 2030) and relevant tracking indicators such as the proportion of young people and adults with ICT skills and the proportion of schools with Internet access.

Tools inherent to the ICT sector, such as universal service funds and operator corporate social responsibility (CSR) initiatives, have been successfully applied in some LDCs to provide computers and Internet access for schools. Uganda has tapped its universal service fund to provide Internet access in almost all public high schools, while Sao Tomé and Principe has leveraged CSR and receipts from the sale of a second mobile licence to provide Internet access in its secondary schools.
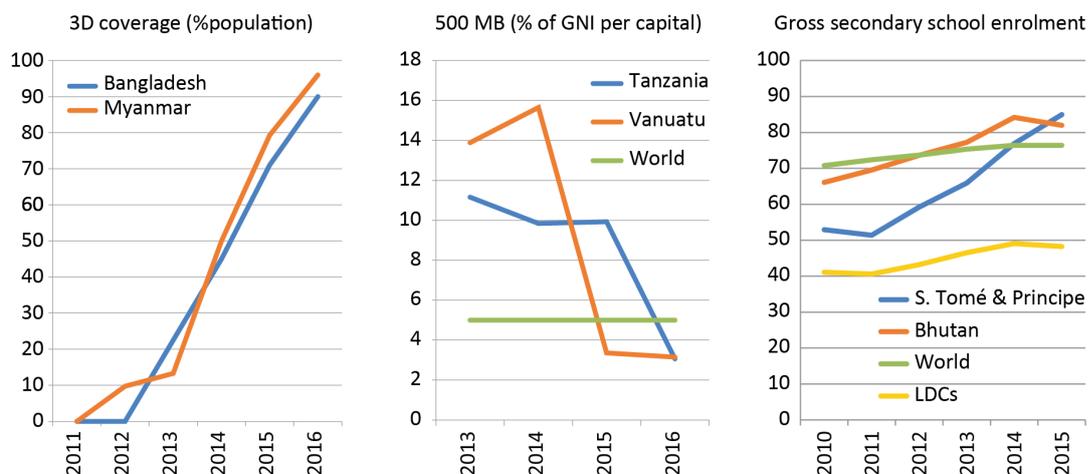
Learning from the progress made in LDCs

Driving rapid improvements in network infrastructure, affordability and skills will be essential for LDCs that want to achieve SDG Target 9.c by the target date. Several LDCs provide examples of impressive leap-frogging triggered by progressive policies (Figure 9). For example, both Bangladesh and Myanmar, the largest and fourth largest LDC, respectively, in terms of population, were able to boost mobile broadband coverage from less than 10 per cent to over 90 per cent of the population in just four years. Myanmar's new telecommunication law opened the sector to competition; in Bangladesh, spectrum for 3G was auctioned. Both nations have experienced operators with the resources needed to undertake the necessary investments. Other factors driving rapid growth were low fixed broadband penetration and strong fibre backbones; coverage obligations and tower sharing also drove investment in Myanmar.

In terms of affordability, mobile broadband prices fell by over 70 per cent between 2013 and 2016 in Tanzania and Vanuatu. Although Tanzania has long had a competitive mobile market, the entry of Viettel in October 2015 (operating under the brand Halotel) caused disruption, triggering a price war; the cost of a 500 MB mobile Internet package fell by 70 per cent between 2015 and 2016, resulting in affordability reaching the target threshold of less than 5 per cent of monthly GNI per capita. In the case of Vanuatu, the commissioning in January 2014 of the 1 259 kilometre Interchange Cable Network 1, connecting the country to Fiji via fibre-optic cable, dramatically reduced wholesale Internet prices and greatly increased capacity. This led to an 80 per cent drop in retail Internet prices, which also brought Vanuatu below the threshold of 5 per cent of GNI per capita.

Bhutan and Sao Tomé and Principe have leap-frogged in secondary school enrolment, surpassing the world average. The Government of Bhutan provides free education for all students until grade 10, and spent over a quarter of its budget on education in 2015- the highest proportion in the world. Primary school enrolment is over 100 per cent and 95 per cent of those completing primary education move on to secondary. The Government of Sao Tomé and Principe developed an education sector plan outlining strategies for the education sector with the objective of the government providing 12 years of free education for all children. It has already achieved universal primary enrolment, with a significant number of children going on to secondary. This is manifested through an increase of more than thirty percentage points in gross secondary education enrolment between 2010 and 2015. This increase was stimulated by government prioritization of the education sector, establishing the preconditions through an increase in resources: the proportion of public expenditure for education increased from 2.7 per cent of GDP in 2002 to 8.8 per cent by 2010.

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[5]   See Goal 4: "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all " at: www.un.org/sustainabledevelopment/education/

Figure 9: Leap-frogging – examples from LDCs

3D coverage (%population)

Bangladesh
Myanmar

500 MB (% of GNI per capital)

Tanzania
Vanuatu
World

Gross secondary school enrolment

S. Tomé & Principe
Bhutan
World
LDCs

Note: STP refers to Sao Tomé and Principe.

Source: ITU and UNESCO Institute of Statistics

Recommendations

Based on the experience of LDCs in terms of driving access, affordability and skills, to achieve SDG Target 9.c, the following recommendations are made:

Competition: A healthy and competitive market is key for spreading coverage and making prices affordable. All but five LDCs (Djibouti, Eritrea, Ethiopia, Kiribati, and Tuvalu) now have competition in the mobile broadband market. The challenge has moved from the simple existence of more than one operator to the intensity and quality of competition. A number of LDCs suffer from market concentration, whereby one strong operator is dominant. Unless there are effective market dominance controls, prices will tend to be higher than they should be. Examples of *ex-ante* regulation in this area include open and cost-based access to key facilities such as submarine cable landing stations, national fibre-optic backbones and towers. Another regulatory tool that has helped to reduce costs in LDCs and facilitated a more equitable playing field includes a requirement for infrastructure sharing. Wholesale costs have also been reduced in LDCs through public private partnerships for capital-intensive projects such as national backbones and access to submarine cables. Bangladesh and Myanmar demonstrate how strong operators can accelerate the building of infrastructure through their technical know-how and financial resources. Policy makers in LDCs should keep this in mind when awarding new licences or overseeing industry mergers and acquisitions.

Coverage: A competitive market is the best way to extend coverage. In addition, coverage obligations can be written into licences and spectrum award conditions. For areas that are economically unviable for commercial operators, there are a number of options. These include the use of universal service funds to subsidize the higher cost. In Bhutan, the universal service fund has subsidized the provision of mobile coverage for 649 villages. However, in a number of other LDCs, universal service funds have not been deployed effectively and their operation needs to be improved. Sufficient spectrum needs to be awarded, particularly low-frequency spectrum made available by the transition to digital broadcasting, since it lowers investment costs by allowing coverage of a wider area.

Affordability: There are several ways in which affordability can be improved. One is to enable a competitive market so that operators will compete for low-usage customers through a variety of Internet plans that cater to different income and usage levels. Another way is to rationalize taxation. Many LDCs have high import and other taxes on devices, which affect adoption by first-time Internet users as well as users wishing to move up to mobile broadband by purchasing a smartphone, tablet or laptop. Sector-specific service taxes such as special taxes on mobile usage are regressive, particularly affecting low-income users. The wide array of taxes, beyond just business income tax and including the imposition of licence fees, can reduce network investment and may result in users paying more. Governments that rationalize their ICT sector taxation and other fees can find the right balance between the need for government revenue and the development of their digital economy. A third way of enhancing affordability involves making community centres available with Internet access. Such centres can serve as low-cost or free venues for accessing the Internet and for providing training.

Skills: Secondary school enrolment has been found to have an important and statistically significant impact on Internet use in LDCs. Although education sector policies are outside the remit of the ICT sector, there are nonetheless linkages. For example, LDCs that have adopted strategic ICT sector plans typically recognize the importance of skills and elaborate the need for collaboration between ICT and education ministries with specific objectives. The need for this collaboration is politically reinforced by the strong link with SDG 4: "Ensure inclusive and equitable quality education and promote life-long learning opportunities for all". SDG 4 has a number of targets that are essential for enhancing Internet use, such as ensuring free secondary education by 2030, and relevant tracking indicators such as the proportion of young people and adults with ICT skills and the proportion of schools with Internet access. At the same time, tools inherent to the ICT sector, such as universal service funds and operator corporate social responsibility (CSR) initiatives, have been successfully applied in some LDCs to provide computers and Internet access for schools.

Gender: In a number of LDCs, there are large gender gaps in Internet usage. These must be addressed and can be reduced by increasing gender parity in schools, establishing gender-friendly public Internet access and training venues, and empowering women and girls by recognizing and promoting the image of women as an essential part of the digital economy.

Institutional strengthening: It is crucial to make available the necessary resources for the public institutions involved in the policies, strategies and plans that are crucial for promoting vibrant competition, implementing universal access and fomenting learning. This includes human capacity building in those institutions and ensuring they have the necessary tools and support to carry out their duties.

Core Internet infrastructure: A sustainable Internet ecosystem is necessary if LDCs are to successfully harness digital technology for social and economic development. Core Internet infrastructure encompasses the fundamental components that store and exchange data within a nation: Internet exchanges, data centres, and cloud computing and hosting services. This digital infrastructure is critical to keeping the Internet up and running and enabling Internet applications, services, and online content for citizens, businesses and governments. The need for relevant local content makes this infrastructure even more important in LDCs.

Data: There is a need for more and better data on Internet use and barriers to its use in LDCs. The lack of data in LDCs remains an important challenge to ICT policy-makers, investors and content producers. Data that provide in-depth information on how exactly people use the Internet and what people do online are scarce and often outdated. Household surveys are essential to provide reliable demand-side data disaggregated by socio-economic characteristics. Some LDCs, such as Malawi and Zambia, have forged a partnership between regulators and national statistical offices to carry out such surveys, which are analytically very useful. Regulators, national statistical agencies and the international community should strengthen collaboration to generate more demand-side surveys on Internet use in LDCs.

While policy prescriptions are clear, implementation often stumbles as a result of a number of factors. A key way to keep policy on track is to have strong government commitment to fostering a digital economy and to identify targets.

The experiences described in this report show that LDCs with a strong government commitment that recognizes the importance of digital technologies for national development, backed by enlightened policy and regulatory actions including steps to develop skills, can achieve universal and affordable Internet access.