Working Group on Broadband for the most vulnerable countries

Broadband for national development in four LDCs: Cambodia, Rwanda, Senegal and Vanuatu

July 2018

BROADBAND COMMISSION
FOR SUSTAINABLE DEVELOPMENT

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UN-OHRLLS

Foreword

Connectivity for all now and in the years ahead is a key driver for sustainable and inclusive development as recognized in Agenda 2030. Ours is the challenge to ensure that nobody will be left behind.

Many of the world's vulnerable countries are engaging in significant efforts to improve the well-being of their citizens and do so by making every effort to become more competitive in our global economy. Challenges remain in many sectors but we get encouragement from the noticeable progress in access to broadband services. A growing number of people in the most vulnerable countries are beginning to be connected to high-speed internet.

As a voice for the least developed countries (LDCs), landlocked developing countries (LLDCs) and small island developing States (SIDSs), we at UN-OHRLLS work for and with 91 vulnerable countries representing nearly 1.2 billion people. In these countries, people are confronted with structural challenges that require our collective support, effort and partnerships to be overcome with one goal in mind: leaving no one behind.

This report shows that overcoming challenges is possible, how it was and is done and what we need to look at for scaling up action.

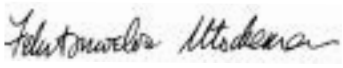
The report outlines challenges and successes encountered by four countries and is a summary of the four reports prepared by the Broadband Commission's Working Group on Broadband for the most vulnerable countries.

Lessons learnt are presented from four evidence-based country studies in Cambodia, Rwanda, Senegal and Vanuatu. This summary report also incorporates lessons learnt from related recent reports.

We can indeed be encouraged by the notable advances and gains in broadband coverage and its affordability all four countries realized. These achievements materialized in substantially differing contexts and market environments. A shared and key concern remains that the demand for and productive use of broadband has not matched the growing supply.

This finding calls for action. The report therefore presents 11 recommendations aimed at expanding access and unlocking the full development potentials associated with the use of high-speed internet. Principal among these recommendations are strengthening digital literacy, making broadband and smartphones more affordable and delivering relevant local content and applications.

It is my sincere hope that this report inspires action and is a useful guide in policy design and implementation of the SDGs in the most vulnerable countries.



Fekitamoeloa Katoa 'Utoikamanu,
Under-Secretary-General, and High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States

Acknowledgements

The present report has been produced collaboratively, drawing on contributions and insights from the participants of the Broadband Commission Working Group on Broadband for the most vulnerable countries , under the auspices of the Broadband Commission for Sustainable Development.

The Broadband Commission Working Group on Broadband for the most vulnerable countries was chaired by Ms. Fekitamoeloa Katoa 'Utoikamanu, Under-Secretary-General and High Representative of the UN Office for Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (OHRLLS).

The report was prepared based on comprehensive case studies conducted in Cambodia, Rwanda, Senegal and Vanuatu. In addition, the report drew upon the recently released report prepared between OHRLLS and ITU, entitled *ICTs, LDCs and the SDGs: Achieving universal and affordable Internet in the LDCs*. It also reflects substantive inputs from the members of the Broadband Commission Working Group and from other Commissioners.

OHRLLS coordinated the production of the document, under the guidance of Ms. 'Utoikamanu. The report benefitted from the general supervision of Heidi Schroderus-Fox, Director of the Office of the High Representative and Sandagdorj Erdenebileg, Chief, Policy Coordination, Monitoring and Reporting Service, OHRLLS.

Michael Minges provided the overall drafting support, with contributions from Miniva Chibuye, Oumar Diallo, Suella Hansen and Susanna Wolf. The process of completing the report was facilitated by Anna Polomska of the Broadband Commission Secretariat at ITU. Support for processing of the report and its media outreach was received from Hans Damien Sass, Louise Stoddard and ITU staff. Oksana Yarashuk provided general assistance.

The Broadband Commissioners, the Commissioners' focal points, and in particular, the members of the Working Group provided invaluable contributions (listed in alphabetical order of institution or individual Commissioners):

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Abbreviations and Acronyms

2G	Second Generation
3G	Third Generation
4G	Fourth Generation
CCTV	Closed Circuit Television
FCFA	West African CFA franc
GB	Gigabyte
GPT	General Purpose Technology
ICT	Information and Communication Technology
ISP	Internet Service Provider
ITU	International Telecommunication Union
LDC	Least Developed Country
LLDC	Landlocked Developing Country
LTE	Long Term Evolution
MB	Megabyte
Mbps	Megabits per second
MSMEs	Micro, Small and Medium Enterprises
PPP	Public Private Partnership
RURA	Rwanda Utilities Regulatory Authority
SDG	Sustainable Development Goal
SIDS	Small Island Developing State
TRC	Telecommunication Regulator of Cambodia
UN-OHRLLS	United Nations Office of High Representative for Least Developed Countries, Landlocked Developing Countries and Small Island Developing States
US$	United States dollars. Currency conversions made using annual average exchange rates.
VSAT	Very Small Aperture Terminal

Executive Summary

Broadband Internet offers significant benefits for Least Developed Countries (LDCs), as a transformational tool to help overcome their vulnerabilities, grow their economies and enhance the livelihoods of their citizens. As the 2030 Sustainable Development Agenda notes: "The spread of information and communications technology and global interconnectedness has great potential to accelerate human progress…". This report reviews experiences leveraging broadband infrastructure for development in four LDCs: Cambodia, Rwanda, Senegal and Vanuatu. The quartet reflects the range of different types and locations of LDCs: landlocked developing countries, LDCs with access to the sea and small island developing states, located in Africa, Asia and the Pacific. The report is based on case studies prepared for each of the countries that have been compiled from field discussions with key stakeholders, as well as extensive research including literature reviews and data analysis. It draws on research carried out for a joint OHRLLS/ITU report on information and communication technology in the LDCs (ITU and UN-OHRLLS, 2018). This report introduces new material as well as updated and comparable data.

The report finds that the four LDCs have made considerable progress in expanding broadband infrastructure and making it affordable. Broadband investment has been predominantly private sector-driven, operating in competitive market environments. Important nuances among the four are apparent in approaches to broadband deployment. For example, Cambodia has one of the most competitive broadband markets in the world with attractive features for investors such as 100% foreign ownership and limited regulatory fees. This has resulted in the cheapest mobile broadband prices in the world. Broadband is a top priority in Rwanda and the government has partnered with the private sector to build the world's first and only single wholesale fourth generation (4G) wireless broadband network that will cover 95% of the population by 2018. Similarly, Vanuatu has targeted 2018 to achieve 98% broadband coverage, supported by its innovative universal access policy. In Senegal, the incumbent telecommunications operator has made significant investments in backbone and local access network infrastructure to expand broadband coverage. In addition, satellite broadband has been used as a way to provide connectivity in rural and remote regions that have yet to be connected and is also supporting mobile broadband by providing backhaul.

Narrowband services, predominantly revolving around text-based mobile phone applications, have had impacts in health, agriculture and finance in the four countries. These range from text alerts with diet reminders for diabetics, mobile platforms for farmers to check agricultural prices, and increasing mobile money services. These services have been successful because narrowband mobile coverage is widespread, the applications operate on widely available basic handsets and they require modest user skills to operate. Evidence from Senegal indicates that mobile cellular services have had a notable impact on the economy. Mobile operators in all four countries are among the top taxpayers and have generated significant downstream employment.

However, broadband could have a much larger impact for LDCs. Econometric analysis finds that the economic contribution of broadband is highest among different digital technologies. Yet demand for and productive use of broadband in LDCs has not matched the growing supply. Causes include weak digital literacy, unaffordability of smartphones, lack of relevant local content and applications, patchy mobile broadband coverage and limited capacity among policy makers to apply broadband across different sectors of economy. Productive use of broadband also relates to the development of local e-Business, which is hindered by shortcomings with the promotion of local entrepreneurship,

access to capital and facilitating laws and business services. Broadband is a general purpose technology (GPT), whose adoption and impact take time to grasp and diffuse. Broadband technology is relatively recent in these study countries and has not quite reached a tipping point.

There is some evidence of leveraging broadband in different sectors. All four study countries have progressed in connecting government institutions and digitizing back office administrative processes. However, with the exception of Rwanda, online public services aimed at businesses and citizens are not well developed. There are also examples of innovative broadband interventions in health such as the online exchange of medical images and use of drones for dispatching blood and vaccines to hard to reach areas. In education, multimedia teaching material has been developed and online learning is available at tertiary institutions. CCTV and drones are being utilized in Vanuatu for disaster monitoring. Most of these interventions are pilots, driven by development partners and yet to reach widespread scale.

There are lessons from the four case studies informing steps needed to accelerate broadband impacts. One is that digital training and awareness needs to be magnified among both citizens and governments. Governments need a better understanding of the cross cutting nature and potential benefits of broadband. Too often, high speed Internet is seen as an infrastructure issue. Consequently, there is a narrow focus on broadband as infrastructure rather than the services it enables. A holistic vision is required that identifies how broadband can be applied across different sectors in an integrated manner. This should include a prioritization of broadband services that are likely to achieve sustainability. Quick-win public e-services such as online tax payment, business registration and vital records should be rapidly deployed to build momentum, acceptance and awareness of broadband applications.

Second, governments need to ensure the existence of enabling legislation that builds trust in the digital economy. These include laws governing electronic transactions, consumer protection, data privacy and information security. This will result in consumers and businesses having greater confidence in using and developing online services.

Third, there needs to be better coordination among the government, private sector, educational institutions and development partners to enhance broadband use. Dialogue among the government, the private sector and academic institutions is essential for understanding skills requirements in order to plan necessary training. Governments should also make greater use of the private sector to help develop public broadband applications including the leveraging of emerging startup communities. Micro, small and medium sized enterprises should be provided with the necessary assistance to adopt broadband technology for their businesses. This would help accelerate economic impacts of broadband. Interventions for development of broadband applications and services should be coordinated between governments and development partners to maximize widespread impact and sustainability.

Fourth, better systems are needed to monitor and evaluate broadband impacts. The ability of national statistical systems in the four countries to collect, compile and disseminate statistics about the evolution of the digital economy is weak. There is scarce economic and employment data about the key industries that comprise the digital sector and there are no ongoing surveys about broadband Internet use by the public and business. This makes it difficult to construct meaningful strategies or adapt them to changing market conditions. Improving this situation will require resources for carrying out business and household surveys, and training officials to interpret the data and make the necessary policy adjustments.

1 Introduction

The Least Developed Countries (LDCs) comprise 47 nations suffering from severe barriers to sustainable development. They are highly vulnerable to economic and environmental shocks and have low levels of human development. LDCs have a combined population of 979 million people representing 13% 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. Seventeen LDCs are landlocked developing countries (LLDCs) and nine are small island developing states (SIDS).

The global community has a strong commitment to using Information and Communication Technology (ICT) for development in LDCs. The *2030 Agenda for Sustainable Development*, adopted in 2015 at the United Nations Sustainable Development Summit 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".[1] Sustainable Development Goal (SDG) 9 on industry, innovation and infrastructure establishes Target 9C, specifically aimed at LDCs:

"...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".

The Fourth United Nations Conference on the Least Developed Countries adopted the *Programme of Action for the Least Developed Countries for the Decade 2011-2020*, calling for these actions by LDCs in the area of broadband infrastructure:

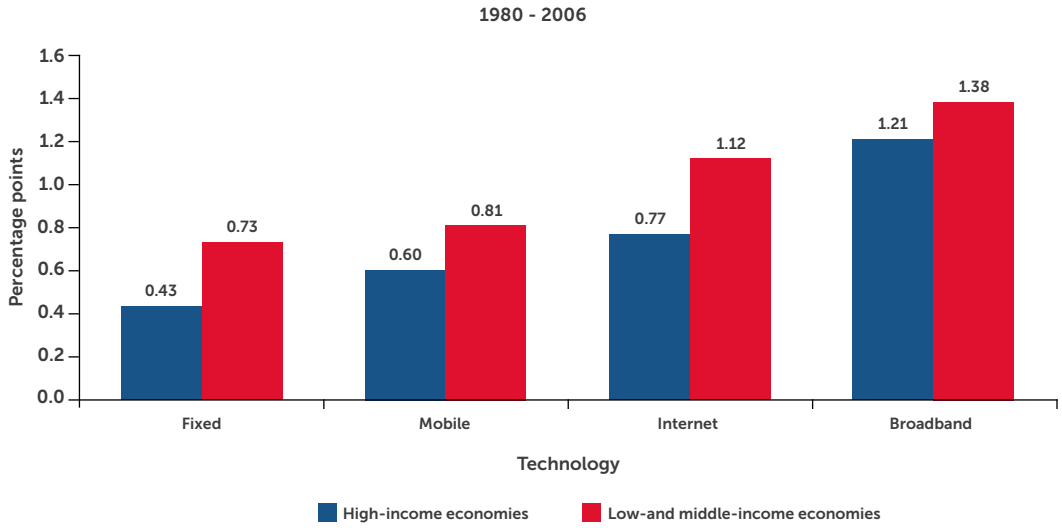
"(c) Develop modern ICT infrastructure and Internet access, including expansion into rural and remote areas, including through mobile broadband and satellite connections;

(d) Build and expand broadband connectivity, e-networking and e-connectivity in relevant areas, including education, banking, health and governance."[2]

LDCs have made progress towards increasing access to ICTs, particularly mobile services. Mobile cellular subscriptions in LDCs rose from 33 per hundred people in 2010, to 70 per hundred in 2017.[3] Basic mobile telephony services have served as a platform for various applications to improve health, increase financial inclusion and advance livelihoods in LDCs.

Broadband Internet could potentially have a greater impact than mobile-based narrowband in LDCs. Both the Internet and broadband have a larger indirect impact on the economy than plain fixed or mobile telephony (Figure 1.1).

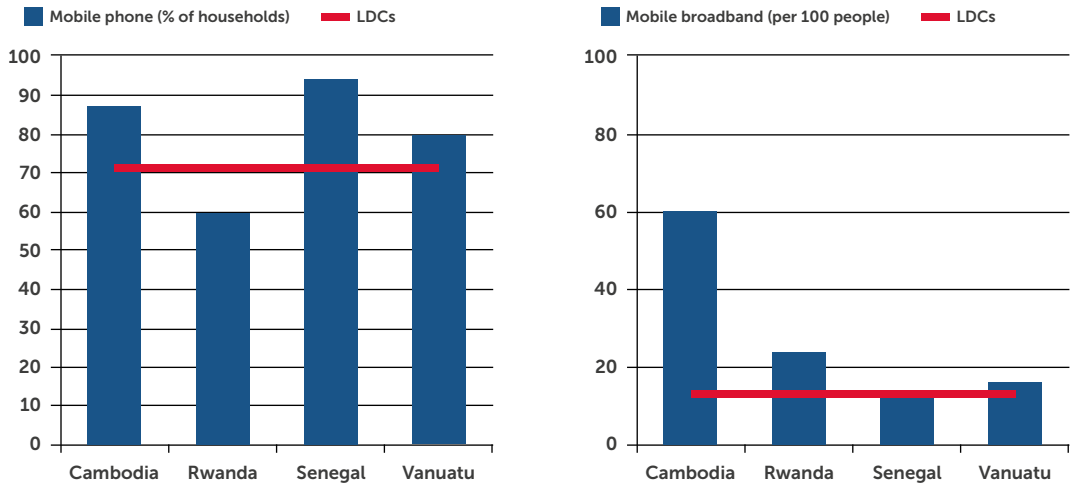
Figure 1.1: Contribution of a ten-percentage point increase in penetration in different ICTs on GDP growth



Source: Qiang et al. 2009.

To better understand the development potential of broadband in LDCs, four countries were selected for closer assessment. Cambodia, Rwanda, Senegal and Vanuatu were chosen as they are performing above average in digital infrastructure deployment compared to other LDCs. Three of the four either have a higher level of mobile phone ownership or mobile broadband penetration than the average of all LDCs (Figure 1.2).

Figure 1.2: Mobile phones (% of households), 2016 or latest available data; and mobile broadband per 100 people, 2015



Source: Demographic and Health Surveys and GSMA Intelligence.

The four countries also reflect the range of regions and geographies in LDCs. Rwanda and Senegal are African nations, Cambodia is in Southeast Asia and Vanuatu is located in the Pacific. Rwanda is an LLDC while Vanuatu is a SIDS with a small population. Three of the four have either experienced devastating conflicts (Cambodia and Rwanda), or frequent natural disasters (Vanuatu). The countries are also quite diverse in income and population density while—with the exception of Senegal—the majority of the population live in rural areas (Table 1.1). These factors affect the economics of broadband network deployment. For example, Vanuatu's small population spread out over a number of islands in the South Pacific limits the scope for competition and access to international bandwidth. Rwanda's landlockedness precludes the possibility of a submarine cable landing station while its high population density suggests that networks will be more commercially viable. Senegal's coastal position in the heart of West Africa is ideally suited for undersea cable access and its relatively high level of urbanization are advantages for network deployment. However, this must be contrasted with its large land area and under populated eastern zones of the country.

Table 1.1: Key indicators, 2016

Country	Population (000s)	GDP per capita (US$)	Land area (km2)	Pop. density (persons per km2)	Rural population (% of total)
Cambodia	15,762	$1,270	176,520	89	79
Rwanda	11,918	$703	24,670	483	70
Senegal	15,412	$958	192,530	80	56
Vanuatu	270	$2,861	12,190	22	74

Source: World Bank DataBank.

Endnotes

1 United Nations, 2015, *Transforming Our World: The 2030 Agenda for Sustainable Development*, https://sustainabledevelopment.un.org/post2015/transformingourworld.

2 United Nations, 2011, *Programme of Action for the Least Developed Countries for the Decade 2011–2020*, A/CONF.219/3/Rev.1 United Nations. New York http://unohrlls.org/UserFiles/File/IPoA.pdf

3 ITU Statistics at: https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

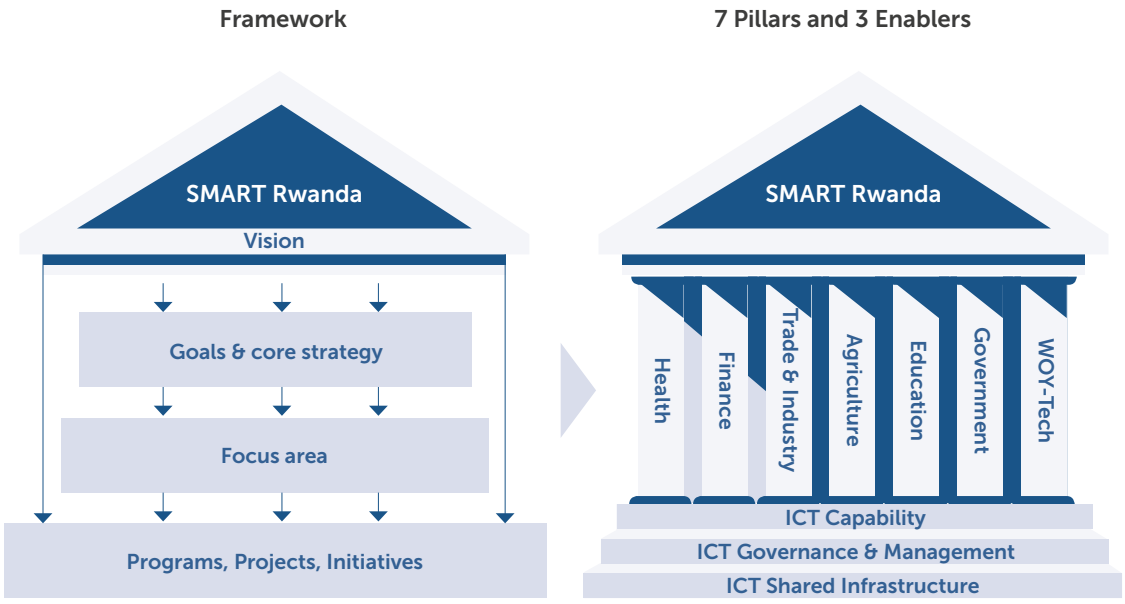

2
Commitment
to broadband

High-level political commitment accompanied by supportive policies is crucial for leveraging broadband. Governments of all four countries acknowledge the importance of ICT for the economy. However, the scope and implementation of enabling policies varies, as does the role of ICTs in national development plans. The level of commitment to ICT and recognition of its crosscutting impact on all sectors of the economy is crucial. This commitment influences the degree to which governments act impartially in reaching decisions that maximize economy wide benefits of ICT. Too often, LDCs view broadband as simply an infrastructure deployment challenge rather than a transformative technology.

Rwanda has the most holistic ICT vision of the four. The country's *Vision 2020* calls for becoming a middle-income knowledge economy with ICT considered one of the three crosscutting areas for achieving the vision (GoR 2012). Although there is a *National Broadband Policy* (and the only broadband specific policy among the four countries), it is a one-off document. More important are the quinquennial sector plans that have guided policy and strategy since 2000. These National Information Communication Infrastructure (NICI) plans outline the direction and goals and each has had a specific focus. The first fostered an enabling environment through appropriate legislation and institutions, the second focused on infrastructure development and the third on service development. The latest is the SMART Rwanda Master Plan (SRMP), covering the period 2015-2020 (MYIT, 2015). SRMP builds on the previous plans, with a focus on innovation in order to use ICTs as a transformational enabler to digitize the economy, generating growth and job creation. The plan emphasizes three key enablers and seven strategic pillars (Figure 2.1). The country's president, Paul Kagame has also been instrumental in promoting ICT.

The other countries have strategies and policies but there is a wide gap between them and Rwanda's world leading commitment embracing and promoting ICT (Table 2.1). Senegal's digital strategy comes closest to Rwanda's holistic vision. The 2016 *Digital Senegal Strategy* (MPT, 2016) calls for making broadband a priority by supporting

Figure 2.1: Smart Rwanda Master Plan Framework



Note: WOY-Tech refers to Women & Youth Empowerment in Technology (WOY-Tech).
Source: MYICT, 2015.

Table 2.1: Government commitment to ICTs

	GOVERNMENT SUCCESS IN ICT PROMOTION		IMPORTANCE OF ICTS TO GOVERNMENT VISION OF THE FUTURE	
	Score	World rank	Score	World rank
Rwanda	6.0	2	5.8	4
Senegal	4.4	41	4.1	58
Cambodia	3.6	102	3.5	95

Note: Vanuatu not included in rankings. Rankings based on an opinion survey with the following questions: How successful is the government in promoting the use of Information and Communication Technologies (ICTs) in your country? [1 = not successful at all; 7 = very successful] To what extent does the government have a clear implementation plan for utilizing ICTs to improve your country's overall competitiveness? [1 = no plan; 7 = clear plan]. For more on the methodology see: World Economic Forum. 2017. "Appendix C. The Executive Opinion Survey: The Voice of the Business Community." In The Global Competitiveness Report 2017–2018. http://www3.weforum.org/docs/GCR2017-2018/04Backmatter/TheGlobalCompetitivenessReport2017–2018AppendixC.pdf
Source: World Economic Forum, Network Readiness Index. http://reports.weforum.org/global-information-technology-report-2016/networked-readiness-index/

public private partnerships (PPPs) for infrastructure sharing and deploying networks in un-served areas with a vision of "...digital for all..." by 2025. The strategy is an all-encompassing document covering infrastructure, the legal environment, human capacity development and application of ICT across different sectors. It seeks wider connectivity and application of broadband services across different areas such as connecting schools, putting government services online and wider use of electronic commerce. The plan is budgeted at FCFA 1,361 (US$ 2.3 billion), of which 17 per cent would be financed by the government with the remainder supported by both private investment and PPPs. Cambodia views ICT as a physical infrastructure for supporting its *National Strategic Development Plan* (RGC, 2014). The country's *ICT Masterplan 2020* (KOICA, 2014), aims to use ICT to create an "intelligent and comfortable" nation and outlines detailed steps to achieve this. In Vanuatu, the *National Information and Communication Technology Policy* (RoV, 2013), was published to support the country's *Priorities and Action Agenda* (PAA) 2006 – 2015 (RoV, 2006), with its vision of a just, educated, healthy and wealthy nation. The objective of the policy is to 'maximise the contribution, efficiency and effectiveness of ICTs in achieving the National Vision, thereby empowering and benefiting every citizen and resident of Vanuatu (RoV, 2013). The policy identifies the importance of access to broadband Internet given the evidence that this service may promote greater economic impacts than other telecommunications services.

The scope of regulation and degree of competition varies among the countries with implications for network coverage and affordability. All four case study countries have liberalized the telecommunications sector in the sense of having created a regulatory agency and allowing competition. Cambodia, which until recently did not have an independent regulatory agency, has the most open and vibrant telecommunications market with more active Internet Service Providers (ISPs) than the other three combined (Table 2.2). The result is the cheapest mobile Internet prices in the world. At the other extreme is Senegal, with the most regulated market of the four and until recently, only four ISPs even though it has roughly the same population as Cambodia. The limited competition influences Senegal's high mobile Internet prices and lower coverage compared to the other three countries. In addition, the market influence of the historical telecommunications operator remains strong in Senegal, in contrast to the other three countries.

Table 2.2: Broadband market environment, 2016

Country	Telecommunications regulator (year created)	Number of active ISPs/ ASNs	Comment
Cambodia	Telecommunications Regulator of Cambodia (2012)	36 / 90	Includes mobile, fixed wireless and wired
Rwanda	Rwanda Utilities Regulatory Authority (RURA) (2001)	16 / 20	Includes mobile, fixed wireless and wired
Senegal	Autorité de Régulation des Télécommunications et des Postes (ARTP) (2001)	3-4 / 10	A fourth operator offers internet in one province
Vanuatu	Telecommunications and Radiocommunications Regulator (TRR) (2008)	7 / 12	Mobile & fixed / satellite

Note: ISP = Internet Service Provider. ASN = Autonomous System Number, uniquely identifying networks connected to the Internet. Note that Senegal awarded three ISP licenses in 2017.
Source: National regulator information and Hurricane Electric (https://bgp.he.net/report/world).

3 Infrastructure

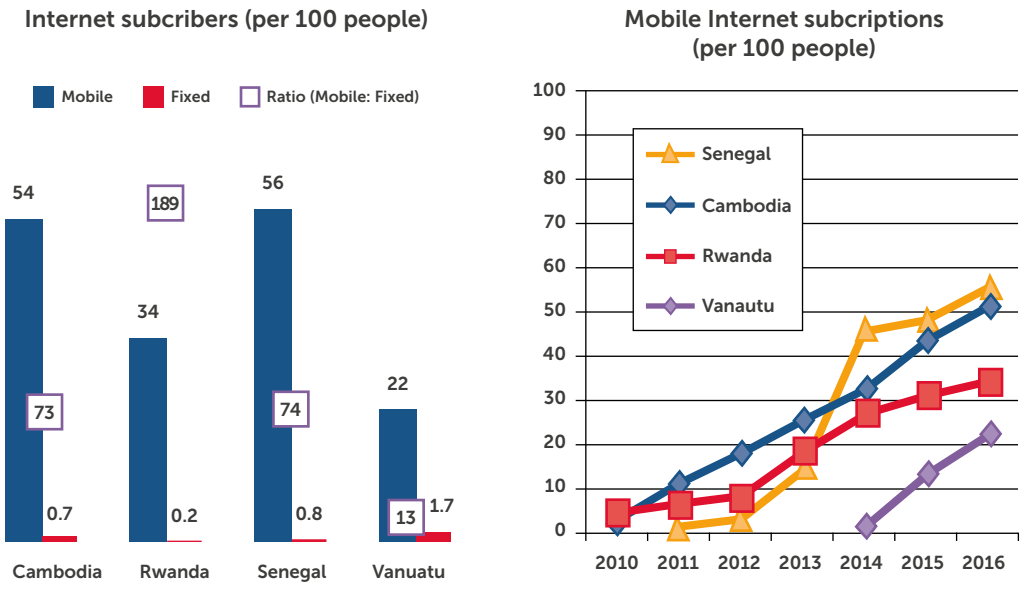
This chapter examines broadband infrastructure in the four countries. It considers local access technologies, national and international transmission networks, core Internet elements and enabling factors such as electricity and spectrum.

The main transmission technologies for broadband services are: (i) fiber optic cables, (ii) telecommunications satellites, and (iii) terrestrial microwave systems, such as cellular phone systems and broadband wireless access technology. Each of these technologies has strengths and limitations. It is important to understand the strengths and limitations of each broadband medium because lack of broadband access is a challenge to many countries. This is especially true in developing countries, landlocked countries, islands, and developed countries with low population densities.[4]

3.1 Local access networks

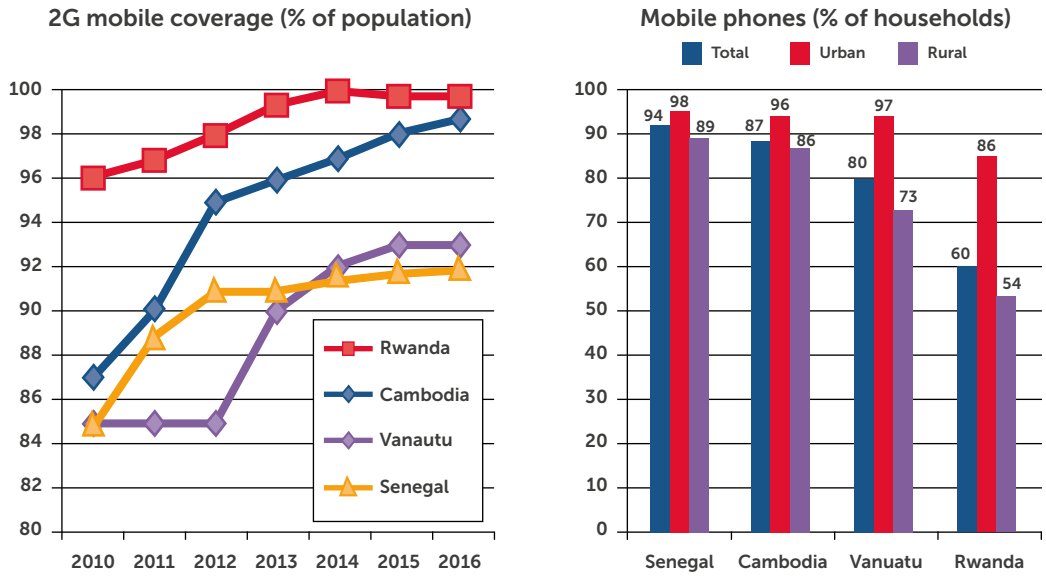
Mobile is by far the predominant technology for accessing the Internet among the four countries (Figure 3.1, left). This is due to the lower costs of deploying wireless networks and consumer preferences for prepaid solutions and mobility. Mobile Internet subscriptions have grown impressively since 2010 (Figure 3.1, right). By 2016, penetration had reached over half of the population in Cambodia and Senegal, a third in Rwanda and over a fifth in Vanuatu. The latter country is the only one among the four where fixed broadband penetration reaches single digits and the ratio between mobile and fixed Internet subscriptions is the lowest. At the other extreme is Rwanda, where mobile Internet outnumbers fixed Internet by a factor of 189. Underdeveloped fixed broadband markets constrain access options and scope for high-speed applications such as online learning and telemedicine. Mobile Internet usage has reached a tipping point of over half the population in Cambodia and Senegal, in 2016. This level of diffusion is when economic impacts start to become apparent (Koutroumpis, 2009). However not all of the reported mobile Internet users are using broadband, nor are they all using the Internet or using it productively.

Figure 3.1: Internet subscribers (per 100 people)



Source: National regulatory agencies.

Figure 3.2: 2G Mobile coverage and mobile phones (%of households), 2016 or latest available



Source: National regulatory authorities, operators and estimates (left chart) and Demographic and Health Surveys (right chart).

Given the overwhelming domination of mobile technology for accessing the Internet, the most important indicator for tracking potential access is population coverage. Indeed this is the only indicator adopted for tracking SDG Target 9c. There are several generations of mobile technology that can be used for accessing the Internet at progressively faster speeds. Second generation (2G) technologies do not provide broadband speeds, in contrast to third (3G) and fourth generation (4G) Long Term Evolution (LTE)[5] technologies. 4G/LTE offers theoretical speeds equivalent to or even faster than many wired broadband technologies used in LDCs.

The four countries have achieved a high level of narrowband 2G population coverage. Coverage is almost ubiquitous in Cambodia and Rwanda where it reaches over 99% of the population. Yet, ironically, household penetration of mobile phones is lowest in Rwanda. The case of Rwanda highlights how mobile access in rural areas remains a challenge with a notable gap between ownership of mobile phones in urban and rural households.

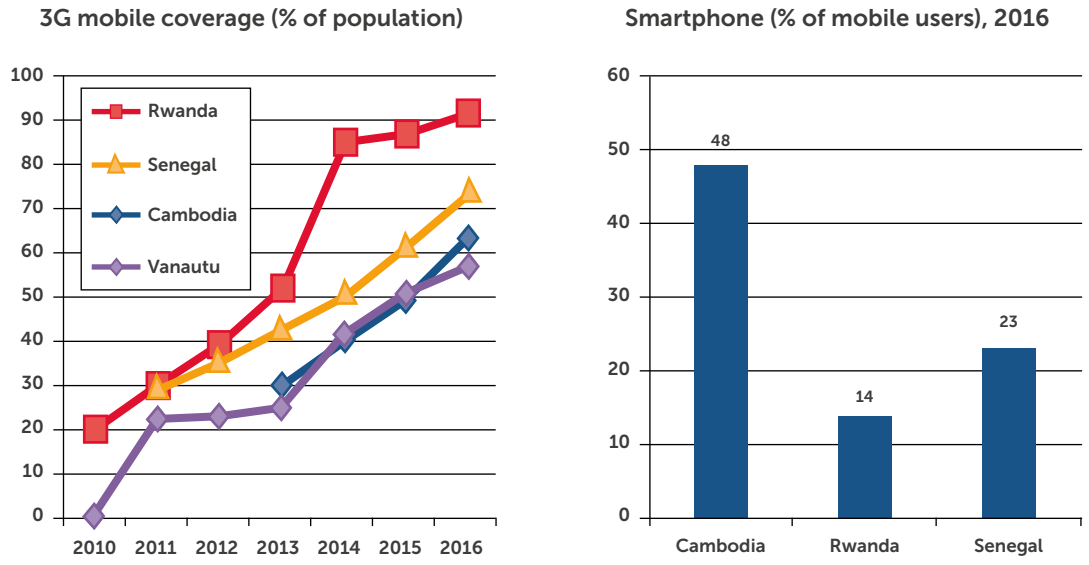
Rwanda is the leader among the four countries in mobile broadband coverage. Over 90% of the Rwandan population was covered by a 3G signal in 2016 compared to 75% in Senegal and around 60% in Cambodia and Vanuatu (Figure 3.3, left). Therefore, apart from Rwanda, the scope for most citizens to exploit broadband applications remains limited, particularly in many rural areas where 3G coverage is non-existent. Despite the increase in mobile broadband coverage, except for Cambodia, broadband use is still nascent due to limited smartphone penetration. While smartphones are used by almost half of mobile users in Cambodia, the figures are far lower in Senegal (23% in 2015) and 14% in Rwanda (no data is available for Vanuatu). This suggests that most mobile Internet use is coming from less powerful feature phones that do not have the broadband capabilities of smartphones. It also implies that while Cambodia may not have the widest 3G coverage among the four, many more people in Cambodia are using mobile broadband than in the other three countries

All of the countries have launched 4G/LTE networks using different market models. Rwanda deployed the first wholesale 4G/LTE network in the world. Launched in 2014, the network is a PPP between the government and Korea Telecom with the goal of reaching 95% of the population by 2018. 4G/LTE was first launched in Cambodia in 2014 and by mid-2017, five operators had deployed their own networks. With this number of operators, Cambodia represents one of the most competitive infrastructure-based 4G/LTE markets, not only among LDCs but also in the world. In Vanuatu, ISP Wantok launched a fixed wireless 4G/LTE network in 2014 followed by mobile operators Digicel and TVL in 2016 and 2017, respectively. Senegal opted for a spectrum auction in 2015 but there were no bidders, as the reserve price was considered too high. In July 2016, historical operator Sonatel was awarded the right to provide 4G/LTE services including the necessary frequency spectrum for which it paid FCFA 32 billion (US$54 million), more than the original reserve price.[6] License obligations require Sonatel to cover 90% of the population with 4G/LTE by 2025.

3.2 National and international backbones

Backbone transmission infrastructure is needed for transporting broadband data throughout the country and overseas. The cost of backbone networks is influenced by geography, population density and the degree of infrastructure sharing. For example, costs will be lower in Rwanda, which has the second smallest land area among the four and the highest population density; there is also an open access, cost-based backbone operated by a PPP. While Vanuatu has the smallest land area, deployment of a fiber optic backbone is costly due to the numerous dispersed islands. Cambodia has the third largest land area of the four with an incentive to build out its backbone to neighboring countries in order to access international bandwidth. With three national backbone operators, Cambodia has by far the most backbone fiber optic deployed than any of the other three (Figure 3.4, right). In Senegal, both the incumbent operator Sonatel and the government have been building fiber optic backbones. Ideally,

Figure 3.3: 3G mobile coverage and smartphone penetration, 2016 or latest available



Note: Smartphone ownership for Vanuatu not available and data for Senegal refer to 2015.
Source: National regulatory authorities, operators and estimates (left chart) and Phong et al., 2016, MTN and Pew 2016 (right chart).

Table 3.1: Status of 4G/LTE networks

Country	First commercial launch	Coverage (% of population) 2017	Number of perators (mobile/ fixed)	Remarks
Cambodia	Jan. 2014	58%	4/1	Launched by operators using a variety of frequencies (850 MHz, 1800 MHz, 2100 MHz, 2600 MHz).
Rwanda	Nov. 2014	64%	3/6	PPP building wholesale network with 95% population coverage by 2018. Using 800/1800 MHz frequencies.
Senegal	July 2016	32%	1	No bidders in Dec. 2015 auction. Sonatel awarded 800 and 1800 MHz frequency as part of license renewal.
Vanuatu	April 2014	34%	2/1	First launched by fixed wireless operator Wantok (using 2300 MHz) and later joined by mobile operator Digicel (700 MHz) in early 2016 and TVL in late 2017.

Source: TRC, RURA, Digicel and Sonatel.

the population should be as close as possible to fiber optic backbone, to ensure high quality of broadband transmission. Rwanda, the most densely populated of the three countries has the highest proportion of its population (50 per cent) living within 10 kilometers of a fiber backbone while all of the population resides within 50 kilometers (Figure 3.4). The government deployed a fiber optic backbone beginning in 2008 funded by the sale of the incumbent operator. Fiber optic backbones in Vanuatu are limited and just 19 per cent of the population is within a 10 kilometer range. In some regions of these four countries that are rural or have low population densities, satellite technology can complement terrestrial networks by providing broadband access in any geographic location, including underserved areas.[7]

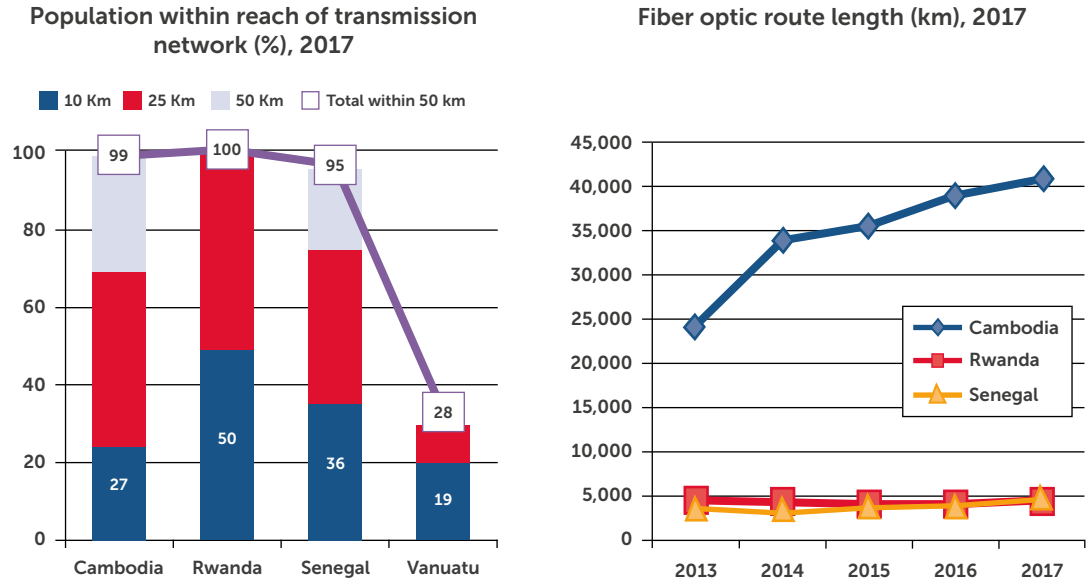
Senegal is the only one of the four countries that has had direct access to fiber optic submarine cable for several years. Leveraging its favorable geography on the west coast of Africa, Senegal was one of the first countries in the region to connect to an undersea fiber optic network through the Atlantis-2 cable in 2000. Since then, two other cables along the west coast of Africa have landed in Dakar. Senegal has been an important transit point for providing international connectivity to its neighbors. The national backbone extends to border crossings in Mauritania, Gambia, Mali and Guinea. Despite the relative abundant connectivity provided by the submarine cable, the consortium structure of the cables poses a challenge for open and cost-based access. Instead, international Internet bandwidth is accessed over cross border terrestrial fiber optic routes to Thailand and Vietnam at very reasonable prices. Despite a coastline of over 400 kilometers, Cambodia only recently connected to submarine cable. In 2017, connections to two undersea submarine cables were established, both landing in Sihanoukville on the Gulf of Thailand. With no bordering nations, Vanuatu has historically relied on satellite connectivity, which may have been considered expensive in the past. However, satellite technologies have seen dramatic improvements in capacity, cost and reach over the last decade.[8] The construction of the Interchange Cable Network (ICN1) to Fiji was completed in January 2014. ICN1 was financed through a PPP involving private local investors with the National Provident Fund as majority shareholder. Despite being landlocked, Rwanda has managed to procure sufficient international bandwidth at reasonable

prices. Its national backbone extends to the borders of Uganda and Tanzania for onward transmission to undersea fiber optic cables. The World Bank provided a grant for the Rwandan government to purchase bulk capacity in order to achieve scale and lower international bandwidth costs. This was followed by a 10-year agreement in 2012 with the Tanzania Telecommunications Company Limited, to procure international bandwidth at an attractive price. For more effective coverage, this option could have been extended to cover the cost of satellite capacity in bulk.

3.3 Internet infrastructure

Key Internet infrastructure components including Internet Exchange Points (IXPs), country top-level domain names and data centers are vital for a resilient broadband environment.[9] The four countries have these elements in place, with Senegal finally launching an IXP in August 2017, after years of discussion (Table 3.2).

Figure 3.4: Population within range of a backbone network and backbone route length



Note: Data on length of fiber optic route length not available for Vanuatu.
Source: ITU, Interactive Transmission Map, https://www.itu.int/en/ITU-D/Technology/Pages/InteractiveTransmissionMaps.aspx.

Table 3.2: Key Internet resources

Country	ccTLD / Administrator	IXP (year launched)
Cambodia	KH / TRC	Cambodian Network Exchange (CNX) (2008)
Rwanda	RW / RICTA	Rwanda Internet Exchange (RINEX) (2004)
Senegal	SN / NIC	Senegal Internet Exchange Point (SENIX) (2017)
Vanuatu	VU / VUNIC	Vanuatu Internet Exchange Point (VIX) (2013)

Note: ccTLD = country code Top Level Domain.
Source: Author research.

3.4 Other infrastructure issues

Factors such as spectrum, electricity, and universal service policies affect broadband infrastructure deployment. Wireless networks are dependent on radio spectrum for their operation. Insufficient radio spectrum at the appropriate frequency is a bottleneck for the expansion of wireless networks. The rapid growth of mobile data requires adequate spectrum to ensure quality. Low frequency spectrum has a wider coverage area, reducing network investment requirements. The lack of low frequency spectrum hinders the deployment of mobile broadband, particularly in rural areas. This is a challenge in Cambodia where there is no low frequency available to advance wireless broadband expansion in rural areas. There has been a delay in the transition to digital broadcasting, which would free up considerable low frequency spectrum. On the other hand, Rwanda was one of the first African countries to move to digital broadcasting, freeing up 700 MHz frequency. Hence, it has the highest level of mobile broadband population coverage among the four countries and one of the highest among all LDCs. While Cambodia and Rwanda have provided spectrum to operators at low costs, this is not the case in Senegal. A December 2015 auction of 4G spectrum in Senegal had no bidders due to the high cost. The historical operator eventually acquired the spectrum the following year when renewing its global license and actually paid more than the initial reserve price, establishing a price precedent that the other operators do not find economical.

Electricity has been a constraint for broadband though the countries have found ways to adapt. Electricity is needed to power wireless base stations as well as by users to recharge their devices. Reliable electricity is also needed for data centers to ensure uninterrupted operation of web sites and cloud applications and services. In Cambodia, access to electricity has grown significantly, particularly since 2010. However in 2015, while all households had some form of lighting, one third, mostly in rural areas, did not have grid-based electricity. In 2014, average per capita monthly electricity consumption was 23 kWh costing around US$4 per month, which was twice the average rate of monthly communications consumption. Despite a low level of household access to electricity in Rwanda, mobile coverage is widespread. Less than a quarter of households reported having electricity in 2015 (DHS), yet virtually the entire population was covered by 2G mobile technology and 60% of households had a mobile phone. There is nationwide grid coverage and only around 10% of mobile base stations use batteries or diesel generators. The discrepancy between household electricity and mobile phone

availability and coverage is explained by dispersed settlements that may not be electrified but are situated close to locations that are, and where mobile phones can be recharged. In Senegal, universal service contributions are used to expand electricity coverage. Vanuatu's urban centers have access through local electricity grids but outside these urban areas there is no or only very limited access to electricity. Of the 75% of rural dwellers, only 17% have access to any form of electricity other than battery powered mobile lamps or radios. [10] The lack of grid electricity in some rural and remote areas represents a challenge for telecommunications operators, since they must often rely on diesel generators to power base stations, which results in higher costs. Renewable energy technologies such as solar photovoltaic (PV) and wind power are well suited for telecom applications in rural and remote areas with non-existing or poorly functioning commercial electric power. They have been utilized effectively with several ground terminals that provide for satellite connectivity. These technologies can be operated in hybrid arrangements. Each option is best suited for a specific geographic location. It is crucial to have a good understanding of the local power needs and site conditions.[11]

All of the countries have created universal access funds to support connectivity to rural and underserved communities with mixed results. Monitoring, evaluation and transparency of these funds is often weak. Cambodia just recently established a universal service fund to collect 2% of annual revenue from operators, while another fund collects 1% for R&D and training. In Rwanda, the Universal Access Fund (UAF) has been used for a variety of purposes. The UAF is funded by an annual contribution by telecommunications operators of 2% of revenues. It has been used to provide funding for schools to connect to fiber optic cable and deployment of VSAT satellite terminals in rural areas where other connectivity options are non-existent. In Senegal, operators contribute 5% of revenues to the Contribution au Développement du service universel des Télécommunications et du secteur de l'Energie (CODETE). CODETE aims ot primarily expand electricity access and subsequentlybenefits the telecom sector. In 2017, CODETE was replaced by another program with operators contributing 3% of revenues for economic development. Universal service funds have not been widely used for directly improving access to telecommunication networks in underserved areas. There was a request for bids issued in 2009 to provide telecommunication services in underserved parts of Senegal. The winning criteria provided special considerationfor lower amounts of requested subsidies. The Consortium du Service Universel (CSU) won the bid and did not request any subsidy. Operating under the brand HALO, it launched operations in the Matam region in 2013 but has struggled with high wholesale access charges for which it gets no relief. In Vanuatu, the Universal Access Policy (UAP) calls for 98% of the population to have access to broadband speeds (i.e., 2 Mbps download) by 2018. A so-called "play or pay" model has been implemented to accomplish this. Three "players" provided plans for deploying new infrastructure while four licensees have been identified as "payers", contributing 4% of annual revenue to the UAP Fund. The Fund is also used for educational connectivity.

Endnotes

4 ITSO-IADB. 2016. *The Provision of Satellite Broadband Services in Latin America and the Caribbean*. https://publications.iadb.org/bitstream/handle/11319/7843/The-Provision-of-Satellite-Broadband-Services-in-Latin-America-and-the-Caribbean.pdf?sequence=1&isAllowed=y

5 This report uses the term 4G/LTE as some operators market higher speed versions of 3G as a 4G technology. See "What exactly is 4G Technology?" at: https://www.regulator.gov.ws/images/Notices/Press-Release-What-exactly-is-4G-Technology-2012.pdf

6 "Décret n° 2016-1081 du 03 août 2016 portant approbation de la convention de concession et du cahier des charges de la SONATEL." *Journal Officiel Du Senegal*. http://www.jo.gouv.sn/spip.php?page=imprimer&id_article=10896

7 ITSO-IADB. 2016. *The Provision of Satellite Broadband Services in Latin America and the Caribbean*. https://publications.iadb.org/bitstream/handle/11319/7843/The-Provision-of-Satellite-Broadband-Services-in-Latin-America-and-the-Caribbean.pdf?sequence=1&isAllowed=y

8 Broadband Commission. Working Group on Technologies in Space and the Upper Atmosphere. 2017. http://www.broadbandcommission.org/workinggroups/Pages/spacetechnology.aspx

9 For an extensive analysis of these key foundational Internet elements, see ITU, 2017 Chapter 3.

10 United Nations Development Programme. 2015. Rural electrification in Vanuatu. http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/MDG%20Carbon%20Facility/NAMA%20Final%20Vanuatu.pdf.

11 ITSO-IADB. 2016. *The Provision of Satellite Broadband Services in Latin America and the Caribbean*. https://publications.iadb.org/bitstream/handle/11319/7843/The-Provision-of-Satellite-Broadband-Services-in-Latin-America-and-the-Caribbean.pdf?sequence=1&isAllowed=y

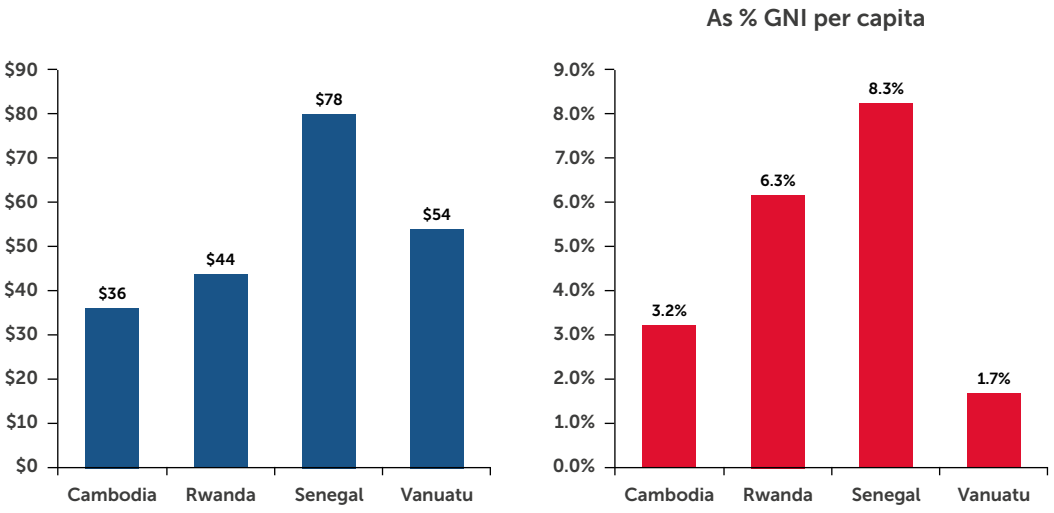
4 Affordability

Limited affordability, along with other factors such as lack of awareness, skills and local content are important barriers to take-up and Internet usage. Affordability has two dimensions: i) getting people online for the first time, and ii) the extent of usage. Device costs remain the key obstacle to affordability for non-users whereas the price of Internet services affects the amount of data existing users consume.

An Internet-device is a prerequisite to using the service. The cheapest smartphone offered by the largest operator in each of the four countries ranges from US$36 in Cambodia to US$78 in Senegal. In relative terms, smartphone prices represent the largest portion of GDP per capita in Rwanda and Senegal, at over five percent. This is likely to be a barrier to Internet take-up in rural areas, where incomes are far lower than the average country GDP.

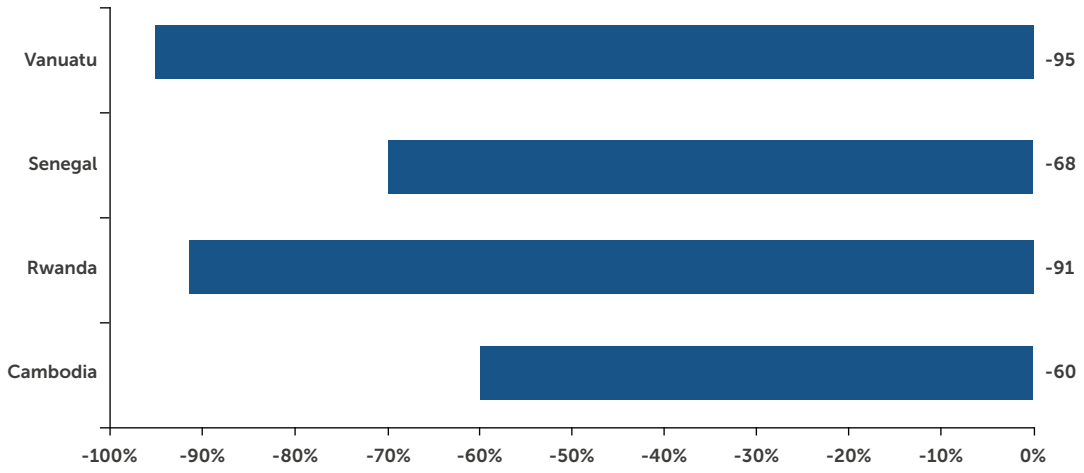
Mobile Internet prices have dropped more than fifty per cent in all of the study countries over the last few years because of expanding infrastructure, growing markets and competition (Figure 4.2). Vanuatu had the biggest drop, largely due to the arrival in January 2014 of the Interchange Cable Network 1, connecting the country to Fiji via fiber optic cable, which dramatically reduced wholesale Internet prices and resulted in a huge increase in capacity. This led to an 80 per cent drop in retail Internet prices (ITU, 2018).

Figure 4.1: Smartphone prices, 2017



Source: Web site of the largest mobile operator in each country (i.e., Axiata, MTN, Sonatel and Digicel).

Figure 4.2: Change in mobile Internet prices, 2011-2017

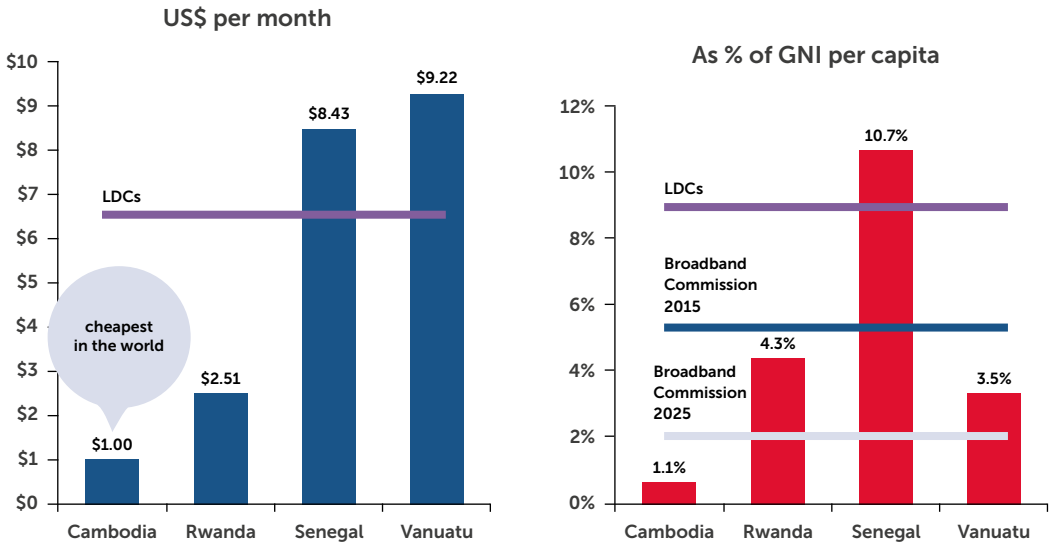


Note: Except for Vanuatu, the change is based on the price per GB for the cheapest plan offering at least 500 MB per month. In the case of Vanuatu, the change is based on the on demand price (i.e., access not using a plan). Rwanda refers to 2010-2017.
Source: Web site of the largest mobile operator in each country (i.e., Axiata, MTN, Sonatel and Digicel).

Baskets are typically used to gauge the affordability of Internet use. For example, the ITU publishes monthly mobile Internet baskets for 500 MB of data.[12] This is calculated in US$ and as a proportion of per capita Gross National Income (GNI). To put this in context, the Broadband Commission established a target that the price of entry-level broadband access should be less than five per cent of per capita income by 2015.[13] The Broadband Commission recently revised the affordability target, lowering it to two per cent of per capita income to be reached by 2025.[14] While three of the study countries have achieved the 2015 target, only Cambodia has reached the 2025 target (Figure 4.3, right).This might imply that use of the Internet is not affordable. However, the basket does not take into account smaller denominations and daily and weekly plans that are available for low-income groups.

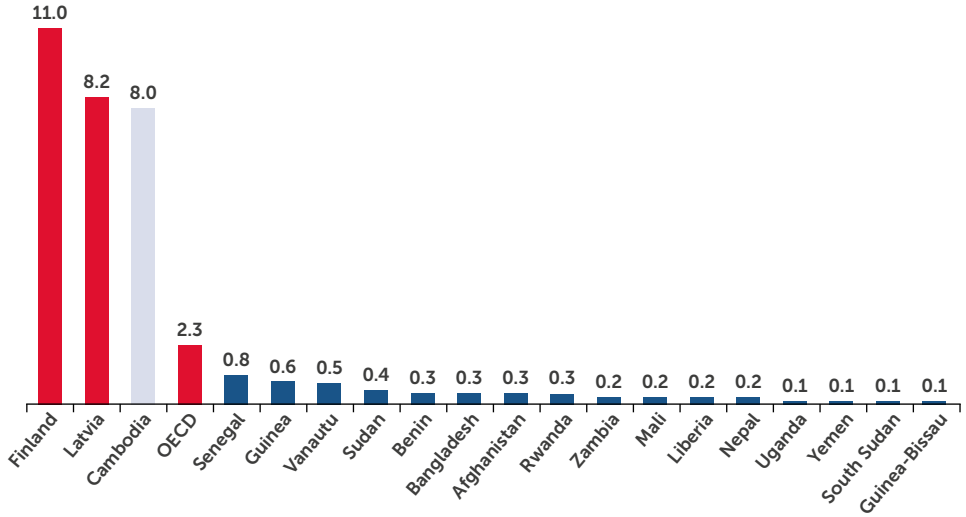
Higher prices in Senegal and Vanuatu—above the LDC median—reflect more limited competition compared to Cambodia and Rwanda (Figure 4.3, left). Leading operators in those countries have a larger market share than in Cambodia or Rwanda and there are more operators providing Internet access in the latter two.15 In addition, a high level of regulatory fees as well as relatively high license costs contribute to higher tariffs in Senegal than in the other three LDCs. The extremely low prices in Cambodia, which are considered the cheapest in the world, result in an extraordinary amount of usage. According to one operator, mobile Internet use is 8 GB of data per month, which is the third highest in the world and far higher than any LDC for which data is available (Figure 4.4).

Figure 4.3: Mobile Internet price (500 MB per month), 2017



Note: Published prices not including discounts or promotions. Converted to US$ using 2016 annual average exchange rate. Converted to GNI per capita using 2016 GNI per capita. LDCs reflect 2016 median.
Source: Website of leading operator by subscription market share in the four countries (i.e., Axiata, MTN, Sonatel and Digicel), ITU for LDC average and World Bank for annual average exchange rate and GNI.

Figure 4.4: Mobile data usage per month per subscriber (GB), 2016



Source: OECD, Sonatel, MTN, TRR and Axiata.

Endnotes

12 ITU. 2016. *Measuring the Information Society*. https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2016.aspx

13 See "Broadband Targets for 2015" at: http://www.broadbandcommission.org/Documents/publications/Broadband_Targets.pdf

14 See "2025 Targets: "Connecting the Other Half" at: http://www.broadbandcommission.org/Documents/publications/wef2018.pdf

15 In the case of Vanuatu, the small population size limits the potential for a large number of ISPs.

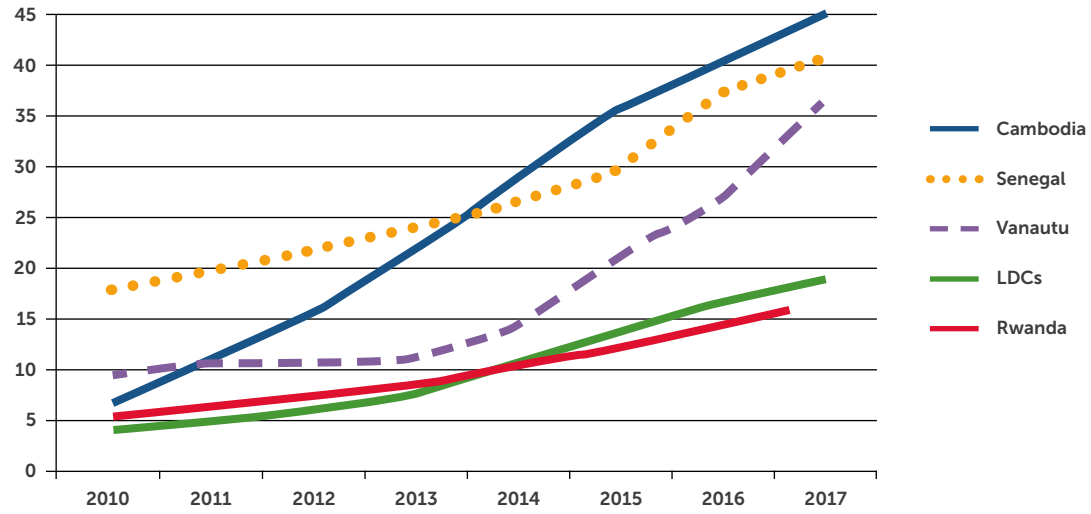
5 Demand and use

SDG 9C calls for universal and affordable access to the Internet in LDCs, implying that infrastructure and high costs are the main obstacles to getting online. As broadband coverage expands and prices drop, the ability and aspiration to use the Internet are emerging as significant barriers. This chapter provides an overview of Internet usage looking at factors that influence uptake such as digital literacy, local content and digital businesses.

5.1 Internet use

Driven by expanding coverage and falling prices, Internet usage has increased rapidly in Cambodia, Senegal and Vanuatu. Growth has been slower in Rwanda due to challenges with computer literacy and limited content in the local language.

Figure 5.1: Internet use (% of surveyed population)



Note:
***LDCs average** based on ITU data;*
***Cambodia data** from 2010-2013: Author estimate based on Internet subscriptions, 2013-2016: Phong et al. 2016, 2017: Author estimate based on Internet subscriptions; Rwanda data from 2010: NISR 2016, 2011-2013: Based on growth between 2010 and 2014 surveys (NISR 2016), 2014: NISR 2016, 2015-17: Author estimate based on Internet subscriptions;*
***Senegal data** from 2010-2012: Based on growth between 2009 survey (ARTP 2010) and 2013 survey (Pew 2016), 2013-2015: Pew 2016, 2015-2017: Author estimate based on Internet subscriptions;*
***Vanuatu data** from 2010-2015: Based on growth between 2009 census (VNSO 2009) and 2016 mini-census (VNSO 2017), 2016: VNSO 2017, 2017: Author estimate based on Internet subscriptions.*
Sources: ITU, Phong et al. 2016, ARTP 2010, NISR 2016, Pew 2016, VNSO 2009, VNSO 2017, and author estimates.

Table 5.1: School connectivity

Country	Provision of ICT for schools
Cambodia	In Cambodia, corporate social responsibility has been the major source of funding for Internet in schools. In 2009, a Memorandum of Understanding (MoU) between the Ministry of Education, Youth and Sport (MoEYS) and telecommunications operator Metfone was signed to provide Internet access in all schools with electricity resulting in some 500 schools being connected. However, this is only twelve per cent of the some 4,000 schools in the country. Metfone stated that its contribution for connecting schools was US$ five million. The agreement was renewed in 2015 that would extend free broadband access to all public schools in the Kingdom over the next five years as part of the operator's corporate social responsibility initiatives.[16] Once again, Metfone cites a figure of US$5 million for this second phase of the initiative. Electricity has been a major barrier in connecting schools to the Internet. The first MoU with Metfone only covered schools with electricity, which according to a 2012 survey, amounted to just 24% of secondary schools and 7% of primary schools.[17] Even though the Metfone MoU included free Internet access, some electrified schools could not take advantage because they could not afford the cost of electricity.[18] Some schools with electricity restricted access to computers to reduce electrical costs.
Rwanda	There are 2,753 primary and 1,543 secondary schools serving 2.5 million primary and 543,000 secondary students.[19] Current levels of computerization are low: around 150,000 computers in primary schools for a computer ratio of 16:1, and just over 19,000 in secondary schools for a ratio of 28:1. One reason for the lower ratio in secondary schools is that a One Laptop per Child (OLPC) program was launched for primary students whereas the focus for secondary schools has been on deploying computer labs.[20] Around 250,000 laptops were deployed to 764 schools reaching around 10% of primary school students. Only around 5% of secondary schools have computer labs. One challenge is that less than half of public schools have electricity and hence, Internet access is limited to 6% of primary and 18% of secondary schools.
Senegal	There is no official data on the number of schools connected to the Internet but the figure is believed to be low. The Digital Resources for All ("Ressources numériques pour tous", (RNPT)) initiative is providing tablet computers to the country's 308 secondary schools ("Lycées").[21] The Sankoré project has installed some 700 digital blackboards for accessing educational content in primary schools.[22] There have also been initiatives to provide computers to schools through corporate social responsibility or bi-lateral development assistance. The Digital Senegal Strategy calls for all students to have access to a device and half of schools to be connected by 2025.
Vanuatu	Nine per cent of primary schools and 35% of secondary schools had access to the Internet in 2015.[23] Thirty per cent of primary schools had computers with the figure rising to 74% for secondary schools. One study indicated that 5% of students had access to ICT and 4% of students were computer literate. 24 However, in the small number of schools where computer lab facilities were available to students, 71% were computer literate. Some schools have privately funded computer and Internet facilities. The Computer Lab and Internet Community Centre (CLICC) is an initiative of the universal service fund for school connectivity. An initial 19 schools were selected for CLICC with one key criteria being the availability of electricity. Other factors included capacity for local support and the potential impact on teachers, students and members of the community. Operators using fixed wireless and VSAT provide Internet access. The labs are also open to the community during and after school hours, to promote ICT literacy, enhance the development of local content and potentially to provide a hub for the delivery of e-Government services. Another universal service fund initiative is then rollout of tablets to schools. Still at its beginnings, 50 tablets have been delivered and its impact is being evaluated.

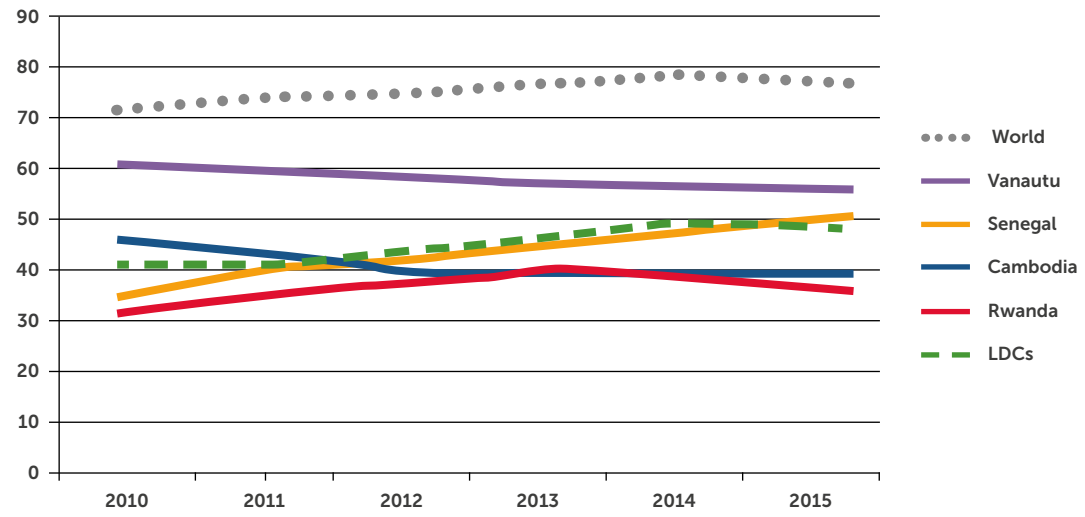
Note: Not be considered comprehensive, as there may be other interventions that have yet to achieve scale.
Source: UN-OHRLLS country case studies.

5.2 Digital literacy

The inability to use the Internet is a major obstacle in LDCs. Though no Internet specific survey has been recently carried out in the four study countries, evidence from other LDCs finds that a lack of ability and awareness of the Internet is a major reason it is not used (ITU and UN-OHRLLS, 2018). In this regard, two different groups need to be addressed. The first are youth, where school is the logical place for them to obtain the necessary skills to use the Internet. The second are those who have a low level of educational attainment, such as the elderly and people in rural and remote areas.

Schools need to have Internet access and computers in order to teach students computer skills. School connectivity is far from ubiquitous across the four countries (Table 5.1). Governments in the countries have generally not directly funded school connectivity through education sector budgets. Instead, support has mainly come from corporate social responsibility programs, universal access initiatives, development assistance and parents. Lack of electricity in schools remains a major challenge. True broadband speeds that would fully enable e-learning are also lacking. Rwanda and Senegal have recently taken a more coordinated approach by explicitly earmarking funding for school connectivity in national ICT sector plans. There is also a need to improve teacher acquisition of digital skills, which is key to support student's ability to embrace computers and the Internet, and later be in a position to make productive use of the Internet.

Figure 5.2: (%) Gross enrolment ratio, secondary, both sexes



Note: Missing data estimated using inter-year growth rates.
Source: UNESCO Institute of Statistics (http://data.uis.unesco.org) and Cambodia Ministry of Education, Youth and Sport.

Enrolment, particularly at the secondary level, has a strong bearing on Internet usage. There is a close link between education and Internet use with a notable jump in online use occurring with secondary education, particularly upper secondary (ITU and UN-OHRLLS, 2018). High school enrolment in the four countries is low with only Vanuatu exceeding the LDC average and Senegal slightly above. Worryingly, enrollment is dropping in Vanuatu and Rwanda and remains flat in Cambodia. The only country where enrollment has grown is Senegal. The situation will likely improve in all of the study countries, given SDG 4.1 target which states that "*by 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes*".[25]

Table 5.2: Literacy by language

	Census year	Age	Literacy by language	Literate	% of total	% of literate	Language of government portal
Cambodia	2013	7+	Any language	10,173,741	80%	100%	
			Khmer only	8,985,346	70%	88%	✓
			English	610,424	5%	6%	
Senegal	2013	10+	Any language	4,238,375	45%	100%	
			6 national languages & Arabic	3,687,386	40%	87%	
			French	1,568,199	37%	37%	
			Arabic	470,460	11%	11%	✓
Rwanda	2012	15+	Any language	4,369,268	71%	100%	
			Kinyarwanda only	3,022,420	49%	69%	
			English	769,194	12%	18%	✓
			French	557,039	9%	13%	
Vanuatu	2009	5+	Any language	166,045	85%	100%	
			Bislama	143,977	74%	87%	✓
			English	125,313	64%	75%	✓
			French	72,245	37%	44%	✓

Note: URL of government portal source from United Nations (https://publicadministration.un.org/egovkb/en-us/Resources/Country-URLs).
Source: Latest national census

Table 5.3: Top local / regional content sites

Cambodia	Rwanda	Senegal	Vanuatu
② Khmerload.com News Digital Ads Khmer US hosting	③ Igihe.com News Digital Ads Kinyarwanda US hosting	④ Seneweb.com News Digital Ads French US hosting	④ Usp.ac.fj University of South Pacific English Fiji hosting
④ Sabay.com.kh News Digital Ads Khmer Cambodian hosting	⑦ Inyarwanda.com Social website Digital Ads Kinyarwanda US hosting	⑤ Senego.com News Digital Ads French US hosting	⑦ Gov.vu Government English Vanuatu hosting
⑦ Freshnewsasia.com News Digital Ads Khmer / English Cambodian hosting	⑧ Eachamps.rw Entertainment Digital Ads Kinyarwanda US hosting	⑥ Sunubuzzsn.com News Digital Ads French US hosting	⑧ Telsatbb.vu ISP English Vanuatu hosting
⑨ Todaysharing.com News Digital Ads Khmer US hosting	⑨ Ukwezi.com News Digital Ads Kinyarwanda US hosting	⑧ Sanslimitesn.com News Digital Ads French French hosting	⑨ Dailypost.vu News Digital Ads US hosting
⑩ Khmer24.com Online shopping Digital Ads Khmer / English US hosting	⑩ Bwiza.com News Digital Ads Kinyarwanda/English/ French US hosting	⑩ Galsen221.com News Digital Ads French US hosting	

Note: Numbers before web site indicate the popularity rank. A site's ranking is based on a combined measure of Unique Visitors and Pageviews (see: https://support.alexa.com/hc/en-us/articles/200449744-How-are-Alexa-s-traffic-rankings-determined-).
Source: Alexa, the sites listed and Ping.eu.

Citizens that never went to school or that dropped out before secondary school form a significant share of the population in all of the countries. Efforts are therefore needed to provide training on how to use the Internet for this group. The Government of Rwanda recognizes digital literacy is a major obstacle to its aspirations of the country becoming a Smart Nation. In early 2017, it launched the Digital Ambassador Program (DAP), where 5,000 youth will be trained and then posted to all 30 districts in the country, to provide digital skills training to five million Rwandans over a four-year period.[26] The DAP is a partnership between the Ministry of ICT, the Canadian NGO Digital Opportunity Trust and the World Economic Forum's Internet for All initiative.[27] DAP would require each trainer to teach 250 people a year, which seems realistic based on

current experience.[28] If successful, it would dramatically boost Rwanda's digital literacy to 85% of the population and provide a strong boost for Internet penetration nationwide.

5.3 Local content

Cambodia has the highest Internet penetration among the four countries despite the uniqueness of its non-Latin character set for its alphabet. The unique characters of its alphabet may appear to inhibit Cambodia from developing local content in comparison to the other three case study countries. However, there are more literate people (9 million) in Cambodia's national language of Khmer than in any of the other countries (Table 5.2) can be used on popular global web sites thanks to computer standardization of the language, and there is a growing amount of local content in the national language. This helps drive the public to use the Internet, contributing to their having the highest penetration among the four.

Global social networking, search and video exchange sites dominate popular Internet content in all of the countries. These global platforms are local in the sense of users uploading and posting information. Local and regional sites are making inroads, ranking among the top ten in the four nations. They are almost all news and entertainment sites, sponsored by online advertising. This illustrates the synergy between local content and local advertising. There is generally a noticeable absence of government sites. One exception is Vanuatu where the government's portal is ranked seventh; in Rwanda the public e-services portal Irembo ranks 11th. Vanuatu is also distinguished in that the regional University of the South Pacific, with many online courses, is ranked fourth and an ISP's site is ranked 8th. Few of the sites use the national country code in their domain name or are hosted locally, thus not contributing to national infrastructure such as data centers or Internet Exchange Points.

5.4 Digital business

Despite the increase in broadband infrastructure and a growing number of mobile Internet users with smartphones, the computer software and information services sector is underdeveloped in the four countries. The lack of statistics is in itself a reflection of this. Data on the number of establishments and employment in the computer software and information services sector is scarce. Despite the absence of data, there is evidence of tech hubs and communities with the potential of creating contextually relevant broadband applications for the conditions of LDCs. Ecosystem support facilities are starting to develop such as co-working spaces, incubators/accelerators, events and funding.

Cambodia in particular has a vibrant startup sector that has created applications that are gaining traction and which are beginning to attract venture capital investment. Khmerload, a news aggregator and one of the most visited web sites in the country, secured funding of US$200,000 from 500 Startups, a California-based global venture capital seed fund.[29] Local mobile operator, Smart, launched a US$ 5 million Digital Innovation Fund to invest in Cambodian startups.[30] AdAsia, a major digital advertising technology company in the region recently opened an office in Phnom Penh, citing a rise in mobile broadband penetration.[31] The number of applications is particularly growing for those using smartphones. Several target the transportation sector, such

as BookMeBus, an app for reserving bus seats, which won a prize at the 2015-16 Cambodian ICT Awards. There are also some information services export activities. For example, the company Pathmazing which provides outsourcing services for eBay Motors. Activities include enhancement of digital photographs of motor vehicles and "scraping" of automotive sales information from various web sites into a database. The company employs around 80 staff. Moreover, it recently launched the Tesjor app for users to order food and drinks from different places through an integrated process of digital ordering and payment.

Startup communities and support services are also emerging in other countries. The Knowledge Lab (kLab) in Kigali, Rwanda features an open space with room for around 60 people providing free and fast Wi-Fi. It organizes various events such as workshops and hackathons and provides a unique networking opportunity for Kigali's young techies by providing mentoring to help them turn their ideas into business models. Next door to kLab is the Rwanda FabLab, which opened in 2016 as the first hardware space in Central Africa. The FabLab is supported by a number of institutions: ICT Chamber in partnership with Rwanda Development Board (RDB), Japan International Cooperation Agency (JICA), Ministry of Education, SolidWorks Corporation, MIT-CBA, and Gasabo3D. There is a range of equipment for hardware techies to experiment with, such as 3D printers, milling machine, shopbot and laser

cutter. Senegal is emerging as the digital entrepreneurship hub of West Africa.[32] A number of facilities and initiatives aim to leverage broadband connectivity, to create jobs and boost the digital economy. This includes five tech hubs such as CTIC Dakar, the first incubator launched in West Africa in 2011. Some 75 entrepreneurs have received incubation at CTIC, generating over 200 jobs.[33]

Several factors are restraining the market for digital services. One such factor is a lack of laws that would i) legitimize online transactions; ii) protect consumers; iii) safeguard privacy and data; and iv) provide penalties for computer crimes. The absence of these laws reduces confidence among developers to create applications, and among citizens to use them. A recent eTrade readiness assessment if Cambodia found that barriers included trust in online platforms and mobile payment solutions and an unclear legal

Table 5.4: Status of key online transaction laws

	Electronic Transactions	Consumer Protection	Privacy & Data Protection	Cyber Crime
Cambodia	❑	❑	☒	❑
Rwanda	☑	☑	☒	☑
Senegal	☑	☑	☑	☑
Vanuatu	☑	ND	☑	☑

Note: ☑ Legislation; ❑ Draft legislation; ☒ No legislation; ND - No data.
Source: UNCTAD (http://unctad.org/en/Pages/DTL/STI_and_ICTs/ICT4D-Legislation/eCom-Global-Legislation.aspx)

and regulatory framework (UNCTAD, 2017). Only Senegal has adopted all four laws considered conducive to e-commerce. The ability to make digital payments is also limited. While mobile money is available, its use for making online purchases is limited and digital money deployments in the countries are in a nascent stage. Cyber security commitment is low. According to the ITU Cyber Security Index, there is a wide gap between Rwanda (ranked 36th in the world) and Senegal (ranked 88th), Cambodia (ranked 91st) and Vanuatu (130th) in the development of laws, training, institutions and cooperation related to information security.[34] A firmer commitment to information security, including the creation of a Computer Emergency Response Team (CERT), awareness-raising among the public and rapid response to incidents are essential complements for the development of digital economies.

Another challenge for developing digital businesses is a lack or mismatch of information technology (IT) skills. The private sector often complains that the number of computer technicians and engineers trained in higher education and vocational training is sometimes insufficient, and hence they have trouble finding locally qualified people. The developers' community is often made up of people who offer a mixed range of skills, some being totally or partially self-trained, to those who have a computer engineer degree. The latter are often not considered appropriate to be employed by SMEs or public organizations, but rather undertake their own professional initiatives as entrepreneurs.

Rwanda and Senegal are looking towards special zones, to create a large computer and information services industry. Kigali Innovation City (KIC), aims at uniting multinational information technology firms with domestic startups alongside higher education institutions to create a tech ecosystem. The roughly US$ one billion KIC began to take shape in 2016, with the launch of the Rwanda Innovation fund, a US$100 million venture capital vehicle that will provide startup financing. Carnegie Mellon University of the United States is one of the core anchor institutions and the first phase of its campus is scheduled for completion in 2017.[35] The projected impacts of KIC include 4,500 skilled ICT jobs and export earnings of US$180 million by 2022.[36] In Senegal, the Digital Technology Park is being constructed near Diamniadio, a designated industrial zone, around 100 kilometers from Dakar. With state of the art broadband infrastructure, it aims be the leading ICT cluster in West Africa. The African Development Bank is making a €61 (US$68) million investment in the Digital Technology Park, with aims to generate 30,000 direct jobs by 2025 (AfDB, 2015).[37]

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6 Impacts

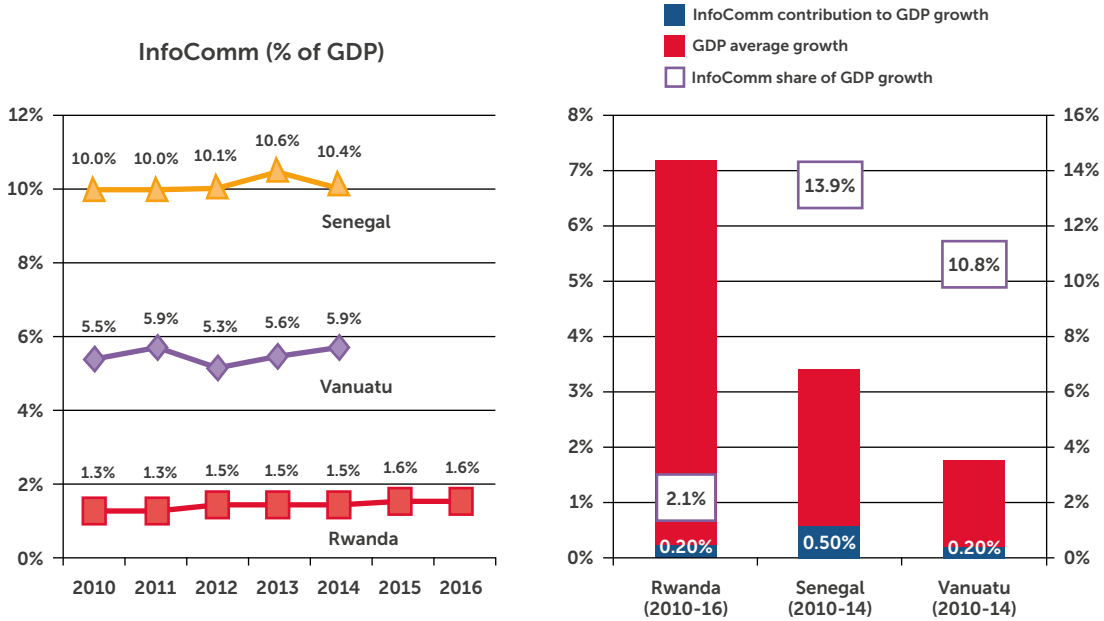
This chapter reviews broadband use and evidence of impacts in the four countries. It looks at several sectors including the overall economy as well as government, health, education, and finance.

6.1 Economics

Broadband generates both direct and indirect economic impacts. International economic classifications include broadband in the telecommunications industry, which in turn is part of the Information and Communications (InfoComm) sector in the national accounts.[38] None of the case study countries published disaggregated national account data for the telecommunications industry. Rwanda and Vanuatu provide data at the InfoComm level (where telecommunications likely comprise over 90% of the total), whereas Senegal compiles data for posts and telecommunications (of which telecommunications are estimated to comprise over 90%). Cambodia has no national accounts data for either the InfoComm industry or telecommunications sector (telecommunications are included with transport for which no disaggregation is available). Another issue is that national account data for Senegal and Vanuatu lags by several years. The inability to provide a full breakdown of the InfoComm industry limits deeper analysis of impacts and trends.

Telecommunications have the greatest direct impact in Senegal where they comprises one tenth of Gross Domestic Product. This large proportion is partly a reflection of high prices and the country being a telecommunications hub in West Africa. The share of InfoComm (or telecommunications) in GDP has been flat in the three countries with data since 2010 (Figure 6.1, left). InfoComm contributed between 0.3-0.5 percentage points to GDP growth recently. This is equivalent to 14% of GDP growth in Senegal, 11% in Vanuatu and 2% in Rwanda (Figure 6.1, right).

Figure 6.1: InfoComm sector as % of GDP and contribution to GDP growth, constant prices



Note: Data for Senegal refer to posts and telecommunications. Data are not available for Cambodia.
Source: National Institute of Statistics Rwanda, Agence Nationale de la Statistique et de la Démographie and Vanuatu National Statistics Office.

There are also direct economic benefits for the government, from regulatory fees and taxes paid by operators providing broadband services. For example, SONATEL paid US$ 360 million in 2015 to the Senegalese government for import duties, taxes and social contributions and the three main operators in the country paid almost US$ 500 million in direct license fees over the last decade (UN-OHRLLS, 2017). Cambodia's largest mobile operator, Smart, reported that its tax payments in 2016 accounted for 3.6% of national tax income.[39]

Indirect economic benefits from broadband are higher than the direct contribution of the ICT sector to the economy. Computerization and connectivity increases productivity in firms and has a positive impact on the economy.[40] While the ICT sector contributed 0.2 - 0.5 per cent to GDP growth in the study for countries since 2010, research finds that a ten percentage point increase in wired broadband penetration is estimated to increase GDP per capita between 0.9 - 3.2 per cent.[41] The World Bank finds that each ten percentage point increase in mobile broadband subscriptions results in a 0.48 - 0.68 percentage point increase in GDP.[42]

These indirect impacts are limited in the LDCs due to low levels of broadband access, particularly among SMEs. Most studies find impacts from wired broadband are only achieved once a certain penetration threshold is reached, generally over 10% of the population, which is a level that none of the countries are close to reaching.[43] A study on the economic impact of ICTs in Senegal found no statistically significant impact from broadband on the economy due to low levels of penetration.[44] On the other hand, it found that mobile had a significant contribution with each ten percentage point increase in mobile penetration, increasing GDP by 0.5 percentage points.

Table 6.1: Telecommunications, computer, and information services trade, US$ millions

	Indicator	Flow	2011	2012	2013	2014	2015	2016
Cambodia	Telecommunications, computer, and information services	Exports	45.0	45.3	43.1	49.2	56.7	49.7
		Imports	39.5	39.7	40.7	76.6	101.7	81.3
		Balance	5.5	5.6	2.4	-27.5	-45.0	-31.6
	Telecommunications services	Exports	45.0	45.0	43.0	46.0	54.7	44.4
		Imports	38.0	37.0	36.0	38.0	28.6	28.4
		Balance	7.0	8.0	7.0	8.0	26.1	16.0
	Computer services	Exports	0.0	0.3	0.1	3.2	2.0	5.3
		Imports	1.5	2.7	4.7	38.6	73.1	52.9
		Balance	-1.5	-2.4	-4.6	-35.5	-71.1	-47.6
Rwanda	Telecommunications, computer, and information services	Exports	53.2	17.4	18.1	18.8	42.3	41.5
		Imports	35.1	21.8	8.4	23.1	27.0	27.4
		Balance	18.1	-4.4	9.7	-4.3	15.3	14.1

	Indicator	Flow	2011	2012	2013	2014	2015	2016
Senegal	Telecommunications, computer, and information services	Exports	200	248	296	296	274	
		Imports	110	109	130	150	143	
		Balance	90.4	138.7	166.1	146.7	131.4	
	Telecommunications services	Exports	180.4	224.0	278.9	274.5	255.2	
		Imports	80.5	85.0	96.3	117.1	114.2	
		Balance	99.9	139.0	182.6	157.4	141.0	
	Computer services	Exports	10.6	13.0	9.6	11.3	9.9	
		Imports	16.3	12.6	15.7	16.5	14.6	
		Balance	-5.7	0.4	-6.0	-5.2	-4.8	
	Information services	Exports	9.0	10.6	7.4	10.4	9.1	
		Imports	12.8	11.5	17.9	16.0	13.9	
		Balance	-3.8	-0.8	-10.5	-5.5	-4.8	
Vanuatu	Telecommunications, computer, and information services	Exports	3.0	1.6	1.8	5.2	7.3	
		Imports	14.7	14.2	11.5	8.2	7.7	
		Balance	-11.7	-12.6	-9.7	-3.0	-0.4	
	Telecommunications services	Exports	2.8	1.4	1.6	5.0	7.1	
		Imports	11.7	11.2	7.7	5.0	6.1	
		Balance	-8.9	-9.7	-6.0	0.1	1.0	
	Computer services	Exports	0.1	0.1	0.1	0.1	0.1	
		Imports	2.9	3.0	3.9	3.2	1.6	
		Balance	-2.9	-2.9	-3.8	-3.2	-1.5	
	Information services	Exports	0.1	0.1	0.1	0.1	0.1	

Source: World Trade Organization (WTO).

Telecommunications operators generate downstream employment. Direct employment in the telecommunications services industry is relatively low compared to other sectors but telecommunications operators trigger indirect employment in areas such as selling prepaid vouchers, device recharging, equipment sales, and installation and maintenance. For example, Senegal's largest operator SONATEL, employed 1,734 people in the country in 2015 but had over 60,000 indirect distribution partners (Orange, 2016).[45] In Cambodia, the operator SMART directly employed around 1,000 people in 2016 and generated employment for an additional 40,000 persons through its operations and investments.[46]

It is problematic to gauge, compare and measure investment in broadband networks across the four LDCs for a number of reasons. First, none of the countries compile statistics at the level of broadband investment and only Rwanda publishes data on telecommunications capital expenditure. Second, a greater level of investment does not necessarily mean more broadband capital stock is being created. Investment requirements are dictated by the degree to which other alternatives are available and geographic conditions. In Cambodia, a neutral wholesale backbone provider offers access so operators do not need to invest in duplicate national transmission networks. Similarly, there is a PPP open access national backbone in Rwanda offering cost-based wholesale prices. Rwanda also has a high level of population density lowering investment requirements. On the other hand, Senegal has a large land area and sparsely populated eastern regions, infrastructure sharing is limited and wholesale backbone services are often not cost-based. The lack of sharing and cost-based access to backbones leads to higher investment requirements in Senegal. Similarly in Vanuatu, the large number of islands with small populations results in above average investment requirements. In any case, efforts are needed to strengthen data availability of ICT investment flows, both government and the private sector, domestic and foreign.

Given that investment can vary depending on several factors, it is not clear which metrics should be used for benchmarking, even if data were available. Nevertheless, ICT investment has been sizeable according to various sources. The World Bank's Private Participation in Infrastructure Database indicates that ICT has been the sector with the largest investment share in all of the countries except Senegal, where it has the second largest investment share. [47]

Foreign private companies have predominantly invested in broadband networks. All of the countries have operators that are subsidiaries of large multinational mobile groups. These private operators have made the bulk of broadband investments in the country. In Rwanda, the ICT sector accounted for the largest portion of foreign direct investment (FDI) inflows in 2014 (US$116 million or 29% of the total), and ICT foreign investment stock was highest in the country at US$613 million.[48] Governments have made some investments such as the government financed backbone in Rwanda (funded by the sale of the historical operator, the backbone has now been contributed to the PPP with Korea Telecom), or the PPP in Vanuatu for financing the undersea submarine cable.

Service trade is one area where internationally comparable statistics exist for all of the study countries. Relevant indicators include telecommunications, computer and information services. In the case of telecommunications, operators' receive/pay money from/to overseas for terminating calls. Examples of computer and information services tradability include developing software or hosting websites for overseas clients. Data for the four countries is shown in the table below. Note that disaggregated data is not available for Rwanda.

All of the countries generally run a surplus in telecommunication services while also incurring a deficit in computer and information services (Figure 6.1). This means that the countries receive more telecommunications voice traffic than they produce. It also means that they have deficit spending for overseas information services (e.g., web hosting), and the development of software and applications signaling an underdeveloped computer and information services sector. Another aspect of digital trade is the export of personal information used to generate online advertising revenue in other countries.

Table 6.2: Government connectivity

Country	Remarks
Cambodia	The National ICT Development Authority (NiDA), was created in 2000 as the agency responsible for the implementation of e-government in the country. Chaired by the Prime Minister, NiDA was instrumental in efforts to connect ministries in Phnom Penh. It also developed four back end applications as part of the Government Administrative Information System (GAIS) project: 1) Electronic Approval System to support the flow of digital documents within government; 2) Real Estate registration; 3) Resident Registration; and 4) Vehicle Registration. NiDA was abolished in 2013 when it was merged into the MPTC, which is now responsible for e-government. The 2016 *ICT Policy* calls for developing an e-government strategy and a common technical framework; prioritizing software applications; establishing a Chief Information Officer across ministries; developing human resources, administrative and financial management systems as well as a single window system for trade; and establishing a national data center with a government cloud.[4950] The ICT Masterplan 2020 also has a section devoted to e-government development.
Rwanda	In Rwanda, the computerization of government back office processes has been progressing and a number of electronic public services are available for citizens and businesses. E-government deployment was supported by the World Bank eRwanda project (2006-2010), a US$ 10 million grant aimed at the deployment of local area networks in government offices, development of government applications and services and training for staff.[51] Today, most ministries are connected to the Internet via fiber optic broadband.
Senegal	The Senegalese government has been progressively automating its operations. This includes a backbone consisting of fiber optic and high-speed wireless links across the country. The backbone connects government buildings nationwide and has lowered the costs of communications. The state saved FCFA 10 billion (US$17 million) between 2014 and 2016 from having its own internal communications network.[52] Employees have been provided with computers and mobile phones resulting in a high level of connectivity and device availability in public administration. Government investment has been significant with some US$ 200 million funded through a combination of loans and grants primarily from China and the Republic of Korea (OECD, 2013). A 2015 agreement with China will see the government's fiber optic network extended some 2,500 kilometers to reach 4,000 kilometers in total, as well as construction of a new data center at a cost of FCFA 51 billion (US$ 85 million).[53] Despite extensive capacity, the government's fiber optic network is for its exclusive use and not available for sharing with the country's telecommunications operators.
Vanuatu	The first Vanuatu e-Government plan was developed in 2008. One of its main objectives was to create a Government Broadband Network (GBN). The project, which was funded by a low interest loan from China, cost approximately USD28 million. The GBN links government offices in the main provincial centers of Vanuatu through a fiber optic and fixed wireless network. The network also provides Internet access to government offices. Currently, four services are provided over the e-Government network including VoIP telephony for internal and external communications, video conferencing, website development and hosting for government agencies, and databases. Examples of databases running on OGCIO servers include the new Court Management System which was commissioned in November 2015, and the Civil Registry information management system. The latter system had a huge impact on the efficiency and coverage of the civil registry office and has already been extended to enable birth registration using mobile units.[54] For cost reasons, there is a government-wide trent to shift to open source software.[55] As a result, the OGCIO has been building a small base of programmers who are developing programming expertise. Government agencies are encouraged to develop capabilities to manage their own website development. The database used by the civil registry was developed locally. These capacity building activities can be considered a positive side effect of the GBN. However, no data exists about the number of staff trained in the process.

Note: This list should not be considered comprehensive, as there may be other interventions that have yet to achieve scale.
Source: UN-OHRLLS country case studies.

6.2 Other sectors

Broadband impacts in health, education and other sectors have been limited. Applications mainly involve computerization of backend administrative processes in government, health and education with few broadband services targeted at citizens. Initiatives are often donor driven in health and education sectors. There have been no formal impact assessments conducted but rather, outcomes are more often based on anecdotes or outputs (i.e., so many people using an intervention rather than how much it contributed to their income, learning or health).

6.2.1 Government

Broadband has the potential to make government operations more efficient as well as save citizens and businesses time and money through online service delivery. All of the countries have moved to connect government institutions and introduce computerized applications for backend processes (Table 6.2). However, with the exception of Rwanda, the availability of online applications and services for businesses and citizens are limited.

The four countries have leveraged broadband to develop their own fiber optic government backbones or in the case of Cambodia, by leasing fiber lines from operators. Senegal and Vanuatu have dedicated agencies for e-government while in Cambodia and Rwanda, responsibility rests with ICT sector ministries. Impact evidence from high-speed government connectivity is mainly anecdotal.

Rwanda is the most advanced in providing online services to citizens. In 2013, the government entered into a 25 year PPP with Rwanda Online Platform Limited (ROPL) for managing the portal for the delivery of online government services. Although moving services online has reduced costs, user fees have remained the same in order for ROPL to earn income. Services are provided over the Irembo (Kinyarwanda for gate) platform, accessible via both web and mobile.[56] Over 30 services are available ranging from birth certificates to driving tests, with plans to expand to more than 100 services. Some 90,000 transactions are processed a month.[57] ROPL has partnered with banks and mobile money providers to enable payments to be made online. Over 200 service centers are spread throughout the nation for citizens to learn how to use the system or have an intermediary carry out the transaction for them. There are anecdotal stories of how the system has reduced wait times and the number of offices that need to be visited for government services.[58] In Senegal, the procedures for carrying out some 700 administrative processes are available online as is the Official Journal, enhancing transparency and saving some steps for citizens and businesses by making them better informed about how to go about their transactions with the government.[59] Only two procedures are interactive (i.e., construction authorization and application to the National Administrative University (ENA)). The Digital Senegal Strategy calls for 40% of administrative services to be delivered electronically by 2025. To date there is only one example of an e-Government service in Vanuatu where the public can submit an online application. Launched in September 2017, this online process is available on the Ministry of Education's scholarships website.[60]

Table 6.3: ICT-based health interventions

	Initiative	Remarks
Cambodia	National Health Information System (NHIS)	NHIS launched in 1993 reaching full country coverage by 1995 with support from the United Nations Children's Fund (UNICEF). NHIS has been progressively updated and today is a web-based application allowing health facilities to enter operational data online.[61] NHIS is connected to 990 health centers, 55 referral hospitals, 24 provincial hospitals, 8 national hospitals and 2 NGO supported hospitals. The Ministry received assistance from USAID to upgrade to the web-based system.
	115	Cambodia's Communicable Disease Control (CDC) Department implemented a platform for crowd sourced reporting of disease outbreaks using mobile phones. This includes both SMS reporting and a hotline reached by dialing 115.[62] Jeff Skoll, the first president of online shopping site eBay, supports the project through his philanthropic foundation.[63]
Rwanda	Rwanda Health Management Information System (R-HMIS)	Over 500 health facilities across the country are connected to R-HMIS through the Internet (around 94% of the total). The system has been progressively updated adding new tracking features such as child death reporting, tuberculosis and HIV patients.
	RapidSMS	Community health workers in all of the country's approximately 15,000 villages are provided with cellphones to send text messages about the status of child health in order to quickly track any anomalies and provide rapid treatment.[64] By mid-2016, over 9 million text messages had been sent to 2.5 million mothers.[65]
Senegal	District Health Information System (DHIS) 2	Part of a regional effort led by the West African Health Organization (WAHO) to share medical records and achieve efficiencies through the use of common software.[66]
	m-Diabetes	This program is supported by the World Health Organization (WHO) and International Telecommunication Union (ITU) and uses a SMS platform to send text messages to diabetics with diet reminders.[67] While the front-end system consists of basic text messages, the back end features cloud-computing software. There are some 50,000 people registered to use the system out of some 123,000 with diabetes in Senegal.[68]
Vanuatu		With support from UNICEF, the Ministry of Health has piloted the use of open source software Akvo Flow to carry out supervision and data collection.[69] Tablets and smartphones are pre-loaded with checklists and other materials to assist with supervision and data collection related to child vaccination at health centres around the country. The collected data can be made immediately accessible online, over the mobile network, to data officers at the Extended Program for Immunization (EPI). According to a UNICEF report from July 2017, the system has already been piloted in 60 health facilities throughout Vanuatu.

Note: This list should not be considered comprehensive, as there may be other interventions that have yet to achieve scale.
Source: UN-OHRLLS country case studies.

6.2.2 Health

Broadband impacts in the health sector are limited and most initiatives use narrowband technology (Table 6.3). Development partners largely drive usage of ICTs in the health sector and there are scaling challenges for widespread impacts. There is some evidence of innovative and broadband interventions in the health sector though they have yet to achieve widespread deployment. This includes the use of drones and telemedicine.

- In Cambodia, Operation Village Health, a telemedicine project was introduced in 2001 at a health center in Rovieng and a referral hospital in Ban Lung. Harvard-affiliated physicians provided diagnoses to Cambodian health workers based on images received via email and recommendations were sent back to health care workers within hours. There have been around 700 consultations to date. The project won the Stockholm Challenge in the category of health and has resulted in a falling referral rate to facilities outside the village and a decrease in the duration of chronic medical problems among villagers.[70]

- Drones are being used in Rwanda to deliver blood to remote areas.[71] The service is operated by Zipline a US startup. The blood packages are dropped by parachute and then the drone returns to its base. The first phase involves 15 drones delivering the blood to hospitals in rural western Rwanda. They use GPS navigational data and the cellular network to transmit information to air traffic control and the base station, and for health workers to send text messages when blood is needed. Although the transportation costs are roughly the same as motorbike or ambulance, delivery by drones are much faster. Another innovative application is the use of drones in Vanuatu to make disaster assessments and monitor volcanic activity.[72]

- Vanuatu's first telemedicine facility was launched in the remote village of Naviso on East Maewo island in July 2016. The project is part of the Vanuatu Inter-Island Telemedicine and Learning Network pilot project.[73] The facility connects nurses with doctors at a hospital in Luganville. In the six months since its inception, more than 1,250 engagements with doctors were reported and 32 patients were assisted, including six life-threatening cases. The facility, which uses the Kacific broadband satellite, provides the only connection to the outside world. Consequently, its use extends beyond telemedicine to provide general Internet connectivity. The local community took an active role in building the infrastructure to extend connectivity, assisted by Peace Corps volunteers. The funding for the Internet use finishes at the end of 2017, at which point the Ministry of Health may assume responsibility for the ongoing charges. The project is under evaluation to determine whether the model is suitable for other parts of the country.

6.2.3 Education

Broadband services for education such as multimedia courseware and online learning have been mainly implemented at the tertiary level. Higher education institutions are generally well connected, often provide free Internet access to students and have online learning modules (Table 6.4). Services for primary and secondary schools are mainly narrowband and largely exchange of administrative data. The lack of Internet and computers in primary and secondary schools, largely due to limited budgets and absence of electricity, is the main obstacle to more widespread use of broadband educational services.

Table 6.4: Tertiary education connectivity and broadband services

Country	Initiative	Description
Cambodia	Cambodian Research and Education Network (CamREN)	Connects five higher education institutions in the capital. It offers online learning materials in both English and Khmer and courses in chemical, electrical and energy engineering and computer science, together with access to an online library. It is also connected to the international research and education community through the Trans-Eurasia Information Network (TEIN).[74] ISP Ezecom has been supporting connectivity in higher education by providing free Internet access to nine universities in Phnom Penh.[75]
Rwanda		
Senegal		All universities are interconnected and provide free Internet access to students. There is growing access to international content and university bandwidth has grown from 20 Mbps to 620 Mbps by mid-2016. There is a growing number of courses available online.[76]
	Open Digital Spaces ("Espaces numériques ouvert (ENO))"	A virtual university project supported by the African Development Bank aims to democratize access to higher education by establishing access points in all of Senegal's 45 departments.[77] They would also support access to online learning and content for the wider public. [78]
Vanuatu		Both the University of the South Pacific and the Agence Universitaire de la Francophonie offer online programs.

Note: This list should not be considered comprehensive, as there may be other interventions that have yet to achieve scale.
Source: UN-OHRLLS country case studies.

Cambodia is the only one of the four countries where there is evidence of online tools for primary and secondary education. Digital materials can be exchanged through a portal created by the education ministry. This includes interactive multimedia, posters, digital lesson plans and video clips. Since early 2017, twelfth grade students can practice for final exams using an online application. Students can use smartphones, tablets and PCs to practice tests in math, physics, chemistry, biology and history and get immediate results.[79] Khmer Academy (khmeracademy.org) provides online university and secondary school study materials in Khmer.[80] Launched in 2015 with the support of the Korea Software HRD Center, content includes video tutorials and discussion forums. The portal won the Cambodia ICT Award 2015-2016, in the category of digital content.

6.2.4 Rural livelihoods

These interventions are predominantly 2G based using text messaging, which is more accessible than mobile broadband for users in rural areas. Few have achieved widespread scale and most have been deployed in partnership with development agencies.

Table 6.5: Digital interventions for rural livelihoods

Country	Initiative	Description
Cambodia	Agricultural Market Information System (AMIS)	The Department of Agricultural Extension has developed a market-pricing project supported by the Canadian International Development Agency (CIDA) and recently the European Union.[81] AMIS collects prices of various commodities and transmits the results through radio, a web site and SMS.[82] AMIS can increase revenues for farmers by reducing information asymmetry allowing them to obtain better prices.
	Rural Farm Information Center	A web site for farmers providing a variety of relevant information including pricing and learning materials and an extensive video library.[82]
Rwanda	ESoko	Derived from the Swahili word "Soko" meaning market and 'e' representing electronic, ESoko is a mobile text and web-based service providing market price information for farmers. The platform has been introduced in several African countries. It allows farmers to make better production and selling decisions by reducing information asymmetry. Launched in Rwanda in 2011, it presently covers 50 markets across the country providing pricing info on almost 80 commodities.[8485]
	Buy from Women	The platform was launched in 2016 and is targeted at female farmers, providing weather, pricing and other information to their mobile phones. Some 700 women from two cooperatives have already registered with plans to extend the system to ten more cooperatives. The system also allows farmers to calculate production capacity based on their land size, matching it to cooperative requirements.[86]
Senegal	Manobi	Manobi was established in 2001. Its agricultural price service using text and low speed mobile Internet service has raised incomes for middlemen and farmers.[87] Manobi also launched a GPS-based service for protection of fishermen at sea. Manobi has started to exploit the features provided by broadband networks and smartphones in areas such as water management.

Note: This list should not be considered comprehensive, as there may be other interventions that have yet to achieve scale.
Source: UN-OHRLLS country case studies.

6.2.5 Finance

Using mobile phones to receive and send money makes life more convenient for users. This allows users to save time that they would otherwise need for commuting to banks—which are typically scarce in rural areas—and users feel safer by not having to carry cash.

There are also schemes for depositing wages directly into mobile money accounts. Transaction fees are often lower with mobile money compared to other alternatives. Mobile money is popular in Cambodia and Rwanda where mobile accounts exceed the number of formal bank accounts. In Vanuatu, cellphones have to be linked to a formal bank account, thus lessening demand for mobile money.

Mobile money works on a basic cellphone and does not require broadband. The ability to make online payments for shopping or government services is more relevant in the context of broadband. Online payments—using either mobile money accounts or digital money—are undeveloped and electronic transaction web sites in the countries typically require credit or debit cards. There are some initiatives promoting online payments such as Paygo in Cambodia, where a digital wallet can be used for a variety of purchases. In Senegal, the Wari digital wallet can be used to pay utility bills, transfer money and purchase airtime credit. Rwanda online e-government platform supports payments made via mobile money platforms.

Table 6.6: Financial services, 2016

Country	Adults with following financial services (%)			Remarks
	Formal bank account	Credit / Debit card	Mobile money accounts	
Cambodia	17%	0.3% / 6%	36%	First launched in 2009, there are now six mobile money providers
Rwanda	26%	0.1% / 4%	34%	All three mobile operators offer mobile money.
Senegal	17%	2%	5%	Two of the mobile operators offer mobile money.
Vanuatu	39%	0.7% / 19%	**	Mobile money accounts must be linked to a bank account.

*Note: Data for Cambodia and Senegal refer to 2015. ** Linked to bank accounts with most cellphone activity relating to mobile banking rather than mobile money.*
Source: FinScope, World Bank, Reserve Bank of Vanuatu.

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7 Conclusions

All four countries have made notable gains in broadband coverage and affordability over the last few years. This has been accomplished with different market environments including a mix of local access competition and wholesale PPP interventions in Rwanda, an unregulated and fiercely competitive market in Cambodia, a regulated market dominated by the incumbent operator in Senegal and a mobile duopoly in Vanuatu with a universal access policy calling for 98% broadband coverage in 2018. With the exception of networks for government use, the bulk of investment has largely been made by the private sector. This illustrates the range of models deployed in LDCs for building out broadband networks. The Rwanda model has resulted in the highest level of mobile broadband coverage, while the Cambodian model has resulted in the lowest prices among the four study countries.

Despite the progress, work remains to make mobile broadband universal. Only Rwanda is close to achieving universal coverage of mobile broadband. It is cheaper to deploy infrastructure in the densely packed country and other factors have contributed to high mobile broadband signal availability. Operators have obligations to extend coverage facilitated by an open access, low-cost nationwide broadband infrastructure. This latter point is critical since mobile broadband requires a high-speed backbone to get traffic across a country, as well as across the world. Rwanda's innovative wholesale 4G/LTE PPP will also see 95% of the country covered by the fastest mobile broadband technology in 2018. Cambodia also has an open access, cost-based fiber optic backbone. Cable is the preferred medium in densely populated areas because of its superior transmission capacity and cost effectiveness in these cases. In rural settings, however, cable is not cost effective, and satellite broadband is often the preferred medium. Satellite broadband can be used either as backhaul and feeder to local service provider facilities or as a direct to the end-user satellite broadband service. In extremely rural settings, direct satellite broadband can be a technically and financially reasonable solution.[88] Senegal has opted for a carefully regulated market that has not been proactive in facilitating infrastructure sharing and cost-based wholesale access. As a result, the incumbent operator controls much of the backbone infrastructure and other operators do not have the resources to make the large investment required. While the launch of the fiber optic submarine cable in Vanuatu has provided the potential for huge Internet capacity increases, pricing remains relatively high. The government has a target of 98% broadband coverage with the universal service policy used to deploy infrastructure in remote areas.

Narrowband services such as text messages in the health and agricultural sector and mobile money have achieved some traction in the study countries. Anecdotal information suggests this is improving the well-being and livelihoods of citizens. Evidence surrounding financial inclusion is more concrete where mobile money has widened the population with an account, particularly in Cambodia and Rwanda.

Broadband impacts have been more modest. One notable development is increased access by citizens to social media, entertainment and news. Governments have interconnected ministries through fiber optic cables, enhancing administrative information flows amongst them, but apart from Rwanda, have not yet leveraged this to deliver online services to the public. There are a few examples of high speed and innovative services in the education and health sectors but few have scaled to widespread use. There have been direct impacts of the ICT sector on economic growth but these are modest compared to the potentially bigger impact from economy wide absorption of broadband.

There are several reasons why broadband is not being fully leveraged by LDCs for enhancing development prospects. One is that broadband is a General Purpose Technology (GPT) — technologies that benefit a large segment of the economy and have long-lasting effect—whose effects take time to emerge.[8990] This is often associated with a diffusion rate of over 50% of the population and businesses (Koutroumpis, 2009). Although mobile Internet penetration has grown rapidly in all of the countries, it is still a relatively recent phenomenon. Another reason for the constrained exploitation of broadband is limited resources among governments to invest in both digital training for their staff and in broadband applications and services. Governments have generally lacked the expertise required for leveraging broadband for the delivery of public services, and if they have the understanding, they lack the money to develop the platforms. They have also largely not tapped expertise in the private sector to assist with broadband development. Productive use of broadband has also been hindered by a lack of development of local e-Businesses caused by limited support for local entrepreneurship, access to capital and facilitating laws and business services. As a result, broadband interventions across social sectors are often driven by development agencies, NGOs, philanthropies or corporate social responsibility initiatives. These initiatives often do not go to scale nor are they normalized into government operations. Broadband absorptive capacity of LDCs is limited and there are few models for how information technology can best be incorporated at a large scale for tackling the unique challenges of low-income nations. The supply of high-speed Internet in countries is outpacing demand and productive use, with limited impact on the economy and wellbeing, reflecting an imbalance in the broadband ecosystem (Figure 7.1).

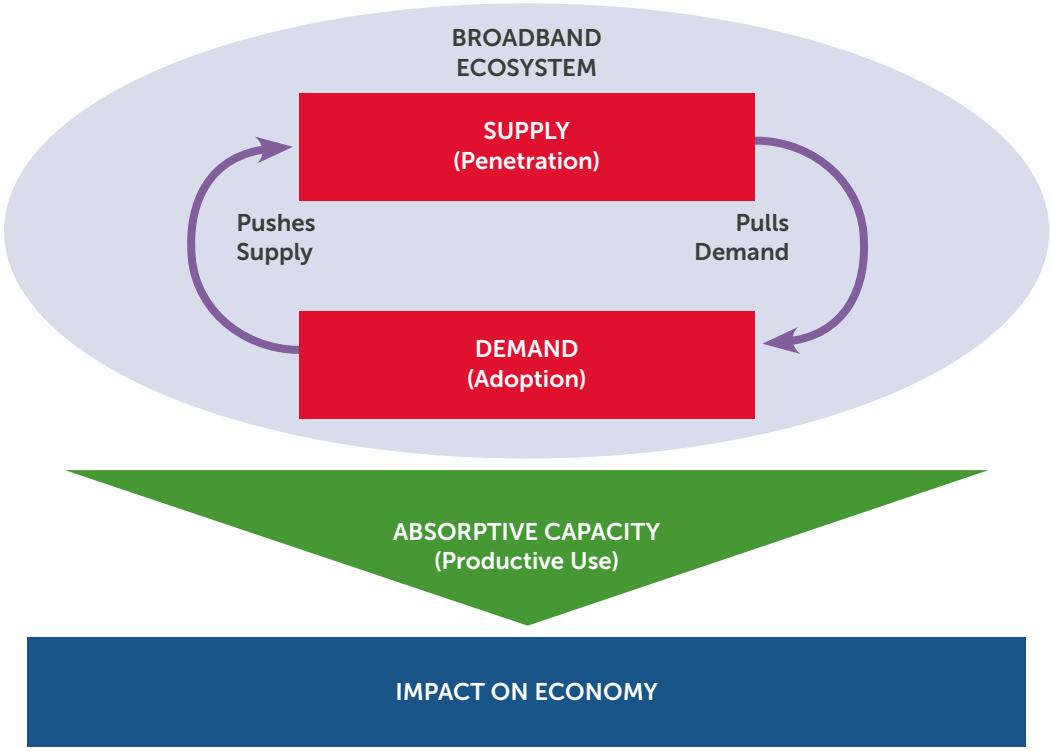
A three-dimensional framework (infrastructure, affordability, skills) developed for a recent report (ITU and UN-OHRLLS, 2018), provides a tool to identify digital technology strengths and weaknesses for LDCs. The report notes: "LDCs should strive to balance the different elements of their broadband ecosystems. Coverage, affordability and digital literacy are often lopsided. Some LDCs such as Cambodia have low tariffs but insufficient mobile broadband coverage, or as in the case of Rwanda, low tariffs and high coverage but weak digital literacy."

Recommendations for leveraging broadband at a faster rate in LDCs include:

1. A strong **commitment** envisioning broadband as a holistic cross cutting GPT, that can trigger development transformation is needed at a high political level. LDCs need to decide between broadband as a major revenue source for governments or as a driver of the economy. A high level champion in the government, such as in Rwanda, can ensure that the leveraging of broadband as transformational technology and receives the necessary political support and resources.

2. It is essential to find the **right combination of complementary technologies** to bridge the digital divide. Satellite technology, fiber optic cables, and terrestrial microwave systems are not mutually exclusive or competing technologies, but together, they form the inventory to be used for the design, implementation and operation of broadband systems, optimized on a case-by-case basis. In order to do so, it is important to have technology neutral digital strategies and national broadband plans.[91] It is also important to promote coordinated international standards for interoperability, address the availability of adequate radio frequency spectrum, and recognize that spectrum should be regarded as a resource for socio-economic development.

Figure 7.1: The broadband ecosystem and its impact on the economy



Source: Kelly et al., 2014.

3 Acknowledge the **urgent need to serve rural populations** and ensure that it is reflected in government policies and regulations. Identify rural, remote, and low-population density communities that need broadband coverage and that cannot be served by terrestrial media. Include satellite broadband as an available alternative and make it an integral part of any national broadband plan to bring broadband to rural and remote areas. [92]

4 Broadband applications that have notable economic and social impact must be made **sustainable**. Development partners have funded and often lead many ICT interventions across social sectors. Many of these projects have suffered from a lack of sustainability as they do not scale and often stop when funding runs out. While there is a tremendous requirement for donor assistance in LDCs, a more coordinated approach is required. Governments need to identify priorities for broadband support such as educational connectivity and online learning, public e-services and others that will have widespread impacts. These projects should be integrated into ICT sector strategies and showcased to development partners for funding. Governments should gradually assume responsibility for these interventions in their budgets to ensure sustainability.

5 Expanding broadband networks and making them more affordable generally has **straightforward solutions**. But choosing the best solution is often constrained by each country's governance context and risk adversity. Cambodia is a case

in point where the government has encouraged a highly competitive and deregulated broadband market that has resulted in the cheapest mobile Internet prices in the world. Another example is Rwanda where the government has been willing to intervene in wholesale markets to ensure open and cost-based access to key facilities resulting in the highest mobile broadband coverage among the four study countries and among the highest of any LDC. Vanuatu's play or pay universal access policy has been designed to help achieve 98% coverage of the population with at least 2 Mbps download speed in 2018. Universal and affordable coverage of broadband technology will be achieved more rapidly by taking bold steps.

6 **Digital literacy** needs to be strengthened to enhance productive use of broadband and increase absorptive capacity. This includes actions targeting citizens, government and Micro, Small and Medium Enterprises (MSMEs). As broadband coverage spreads and prices drop, digital literacy is rising in importance as a significant barrier to broadband uptake. At the same time, while a growing number of people are using the Internet, productive use is often limited. Effort is needed to drive users from just being able to push a couple of smartphone apps to access social media and entertainment, and should encompass the ability to search for relevant information, use and create content and for some, proficiency in office applications. Rwanda's Digital Ambassador program is a notable intervention to deal with this problem. If successful, it could serve as a model for other LDCs. Governments also need to expand digital training of their own staff, not only in computer skills but also in strategically thinking about how to best utilize broadband for economic and social transformation. This also includes initiatives to provide teachers with the necessary digital skills as well as partnerships with the private sector to fund the deployment of computers and the Internet in schools.

7 **Digital laws** need to be adopted to ensure greater confidence among suppliers and users of broadband services. Most of the four countries are lacking some element of digital laws such as recognizing electronic transactions, protecting consumers online, strengthening cyber security and ensuring privacy and safeguarding of personal data. The latter is becoming particularly important with vast amounts of personal data moving from LDCs to multinational companies, as broadband use for global platforms increases.

8 Local **e-Business** needs to be supported to make productive use of broadband. This includes facilitating local entrepreneurship, access to capital and a supportive legal and regulatory environment. [93]

9 There should be greater **coordination** between governments and the private sector to boost the broadband economy. This includes getting more MSMEs online by providing training and subsidized broadband packages where necessary. An attractive startup ecosystem should be facilitated by streamlining business registration; supporting tech hubs, incubators and accelerators; enhancing networking opportunities for mentoring; and creating a conducive environment for startup financing venture capital. Governments should also tap the startup community, particularly social enterprises to assist with the development of applications for improving livelihoods in health, agriculture and other sectors. Governments should also outsource the development of e-government applications to the private sector

when the public sector lacks the required skills. So-called quick win applications that have fast and visible impact should be considered in order to build support and interest in broadband services.

10 National **statistics systems** need to be improved to better interpret the dynamics of broadband diffusion and impacts across the economy. Limited official data on the ICT sector restricts the scope for evidence-based policy making. National accounts data on the ICT sector is published at a highly granular level, without being broken-down by sub-industries. This makes it impossible to meaningfully gauge development of the broadband sector and identify weaknesses. Similarly, improved data on the labor force and employment is required to better match the demand for ICT skills with the supply. Here, labor ministries need to work with the private sector and educational institutions to identify skills needs and how they can be provided. Targets should be continuously monitored so that bottlenecks are quickly identified and strategies modified as the economic and technical environments change. Support by development agencies, such as the Partnership on Measuring ICT for Development, could help to strengthen statistical capacity in LDCs for improved collection and monitoring of indicators of the digital economy.[94]

11 LDCs should strive to **balance** the different elements of their broadband ecosystems. Coverage, affordability and digital literacy are often lopsided. Some LDCs, such as Cambodia, have low tariffs but insufficient mobile broadband coverage or as the case of Rwanda, low tariffs and high coverage but weak digital literacy. Another example of imbalance is the growing gap between infrastructure growth and productive use of the infrastructure. The four countries have made notable progress in expanding telecommunications infrastructure, growing international bandwidth and mobile broadband coverage. However, they still have room for infrastructure growth, a more notable gap is appearing in usage and applications. This is reflected in underdeveloped computer and information service sectors characterized by trade imbalances.

Broadband Internet can have a transformative economic and social impact on LDCs. Evidence is emerging from the four study countries of broadband innovations in education, health, agricultural and disaster assessment. However, widespread broadband impacts for LDCs will not just happen on their own once infrastructure becomes available. Leveraging broadband to take LDCs to the next level of development requires strategic thinking about how best to engage the cross cutting technology across all sectors of the economy. Understanding each nation's absorptive capacity to make appropriate broadband interventions will ensure that limited resources are well deployed, enhance acceptance and create sustainable conditions.

Endnotes

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