Connectivity in the Middle East and North Africa:

A Fact-Finding Study

Internet Society

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Outline

III. Network Resilience

IV. COVID-19 crisis: Regional impact and responses

Executive Summary

This report explored the status of the development of broadband infrastructure as a foundation for digital transformation and a prerequisite to the socioeconomic development of the Middle East and North Africa as part of an effort to explore Internet connectivity in the region. The study follows up on Internet Society's report Middle East and North Africa Internet Infrastructure that was published in 2020, by investigating the developments of broadband infrastructure across the Arab region until 2021 while examining the ramifications of the digital divide and the impact of COVID-19 pandemic on the network performance and the Internet development plans. The report provides an analysis of recent statistics and findings on connectivity to identify potential routes to address related challenges, and underlines policy recommendations, business models, and potential technologies to further improve network connectivity in the Arab countries.

In terms of accessibility and digital inclusion, the report concluded that the situation in the Arab region is not far off from the global trend, with improvement in the inclusive Internet Index over most of the countries, reaching up to 80% in countries Kuwait, and close to 55% in Algeria. This indicates that there is a gap in broadband availability and digital inclusion that needs to be addressed. The recommendation is to bridge the infrastructure gap through a paradigm shift from providing infrastructure and access to encouraging usage of the existing infrastructure to add or create value vis-à-vis the allocation of resources and policy decisions.

In the effort toward ubiquitous access, governments of the region need to clarify their role in infrastructure rollout depending on the economic setup of the market. Community networks and other complementary access solutions need to be codified and made possible for communities to establish last-mile connectivity complementing existing networks in a gesture towards the importance of upgrading regulations across MENA. Revisiting national broadband plans is also needed through establishing a transparent collaborative process between pertinent stakeholders.

New technologies must also be leveraged to support inclusion efforts, including low Earth orbit satellites (LEO) with a focus on coordination and collaboration in the development of harmonized laws and regulations to reap the benefits of LEO and IXPs.

Reliable access is another aspect of the study, where there is a need for more international peering and connectivity reaching Arab countries, through IXPs as close as possible to users. This contributes to overall network performance and resilience, in particular with Data Infrastructure and service delivery.

The COVID-19 pandemic showed the need for long-term policies that make use of available technologies and connectivity to empower societies to carry on even through unpredictable hindrances. It offered an opportunity to accelerate adoption. This can be done through regional initiatives focusing on accelerating access to digital content while addressing the digital divide, which hampers the capacity of individuals and societies, as well as focusing on affordability and availability as part of economic recovery strategies.

The report includes four main sections, Understanding the Connectivity Gap in the Arab Region, Access Infrastructure, Network Resilience, Network Resilience, and the COVID-19 crisis. Each section includes relevant recommendations that can be implemented by governments and different stakeholders in the region.

Introduction

The Internet has a significant impact on promoting sustainable development and hence on the economic growth of countries. This is because the progress of the market economy is closely linked to the Internet in the digital age. A study by the World Bank found that a 10% increase in fixed broadband penetration improves the gross domestic product (GDP) growth by 1.21% in developed economies and 1.38% in developing ones.[1] Notwithstanding that, for countries to be able to reap the benefits of the Internet, it should be deployed in a way that improves the accessibility of individuals to the myriad of social, political, and economic opportunities provided.

This was further demonstrated to be the case in the Arab region in a study by the International Telecommunication Union (ITU) on the economic contribution of broadband and digitization. The study found that fixed and mobile broadband and economic growth were connected through two-directional causality in the Arab countries. The ITU research suggested that "the impact of fixed broadband in the Arab region is expected to fall between the contribution of low-income and high-income countries in the global sample."[2]

Against this backdrop, this report explores Internet connectivity in Arab countries with a special focus on the status of the development of broadband infrastructure as a foundation for digital transformation and a prerequisite to the socioeconomic development of the region. It aims at following up on the Internet Society's report Middle East and North Africa Internet Infrastructure that was published in 2020 by investigating the

[1] Michael Minges, "Exploring the Relationship between Broadband and Economic Growth," World Bank, 2015, https://openknowledge.worldbank.org/handle/10986/23638.

[2] International Telecommunication Union (ITU), "Economic contribution of broadband, digitization and ICT regulation: Econometric modelling for Arab States," January 2020, https://www.itu.int/hub/publication/d-pref-ef-bdt_ars-2019/.

developments of broadband infrastructure across the Arab region until 2021 while examining the ramifications of the digital divide and the impact of COVID-19 crisis on the network performance and the Internet development plans. In this vein, the report provides an analysis of recent statistics and findings on connectivity, identifies potential ways to address the network connectivity challenges, and underlines some policy recommendations, business models, and potential technologies to further improve network connectivity in the Arab countries.

Within this context, the report seeks to provide an analytic resource that enables the articulation of the aspired comprehensive vision, by methodologically mapping the recent developments of network connectivity in the MENA region. The report uses a mixed methodology that hinges on in-depth primary and secondary research and looks at a raft of resources. It examines further reports developed by the International Telecommunication Union (ITU), GSMA, World Bank, and International Monetary Fund (IMF) as well as reports by the wider Internet community including technology and service providers. This is also supported by interviews with global and regional industry actors alongside Internet Society chapters in some Arab countries, whenever possible.

To this aim, the report is divided into four main sections. The first section examines the digital divide and the ICT performance within Arab countries. The second section analyzes the state of Internet infrastructure and the main challenges that hinder connectivity. The third section investigates the resilience of networks in Arab countries, using the newly released Internet Society Internet Resilience Index to measure the robustness of the Internet ecosystem in Arab States. It also elaborates on the recent development vis-à-vis interconnectivity and Internet resource utilization. The fourth chapter tackles the impact of the COVID-19 crisis on network performance whether in terms of the quality, availability, or affordability of the network. It also looks at the responses of the Arab countries to the COVID-19 crisis and the main government and industry-led initiatives that were designed to address connectivity issues during the pandemic.

At the end of each section, the report pinpoints key recommendations of policy and technological solutions to improve connectivity, develop business models, and address the major challenges which could serve as a foundation for a dialogue among the pertinent stakeholders.

I.

Understanding the Connectivity Gap in the Arab Region

1. Understanding the Connectivity Gap in the Arab Region

According to the OECD, the digital divide signifies "the gap between individuals, households, businesses, and geographic areas at different socioeconomic levels with regard to both their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities." In that sense, the digital divide refers to socioeconomic inequalities that confine the opportunities of individuals, mostly in rural and low-income communities, who do not have access to the Internet. Such divide was further exposed and exacerbated by the COVID-19 crisis due to the social distancing measures and the reliance on the Internet by governments to provide education and health services among other public services and by individuals to secure their means of living.

1.1 Measuring the Connectivity Gap

Within this context, measuring the digital divide is important to understand the connectivity gaps and to design proper policy and technical solutions to address the gaps between the digital haves and have-nots. It encompasses an array of criteria pertinent to infrastructure, network access, human capabilities, knowledge and education, and information technology (IT) expertise. To this aim, several indices to measure the digital divide have been proposed. Such indices include but are not limited to the Information

Telecommunication Union (ITU) ICT Development Index (IDI)[3] which measures information society using 11 ICT indicators clustered into three groups of access, use, and skills. The GSMA Mobile Connectivity Index[4] focuses on the key enablers of mobile Internet adoption: infrastructure, affordability, consumer readiness, and content and services. The Economist Intelligence Unit's (EIU) Inclusive Internet Index (3i)[5] is designed around four key categories of indicators: accessibility, affordability, relevance, and readiness. Within each one, there are further sub-indicators of Internet inclusion. Additionally, the Digital Future Society developed a digital inclusion framework to examine nine international indices which hinge on four key dimensions including access, skills, use, and supportive environment with a set of indicators for each dimension (Figure 1).[6]

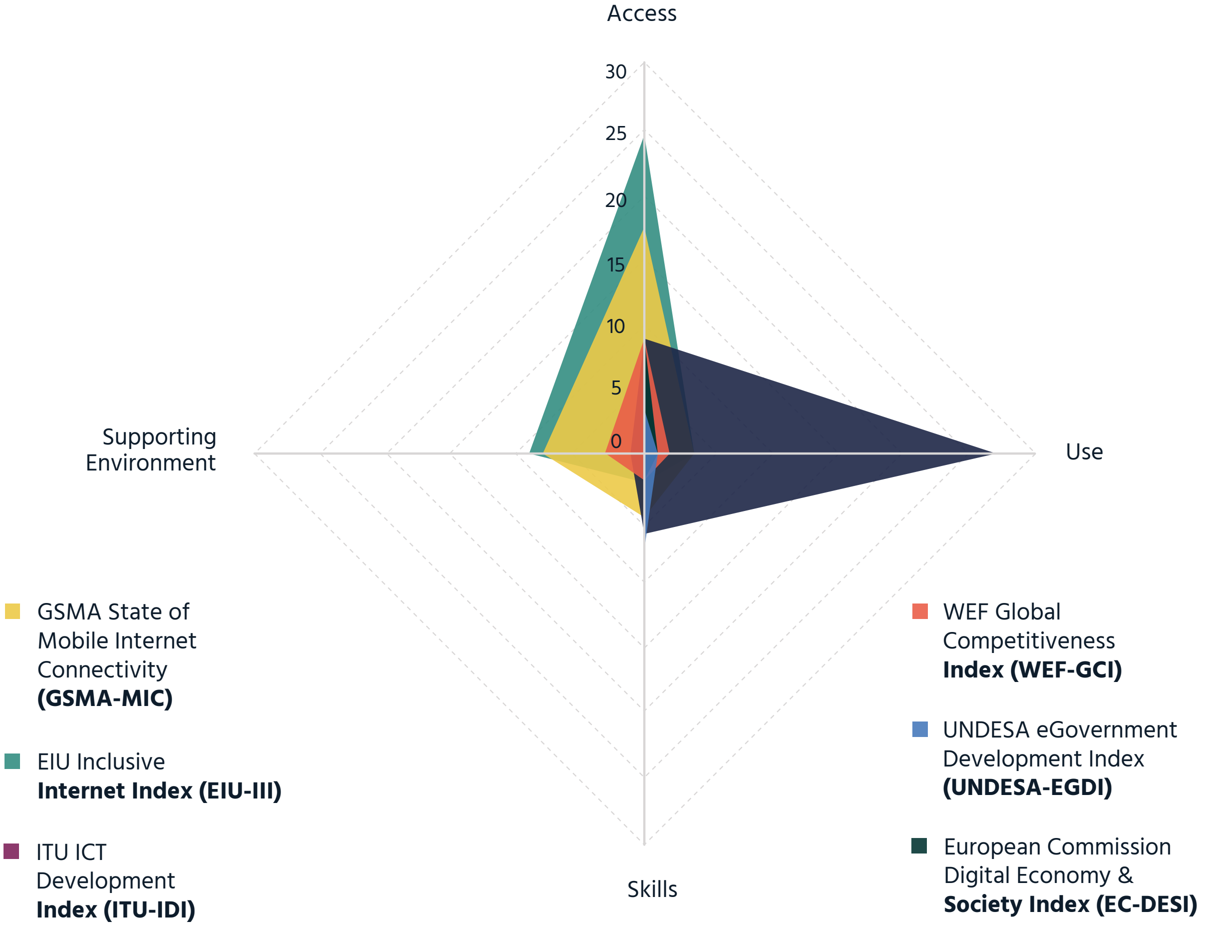


Figure 1: Digital Future Society, Digital Comparative coverage of analyzed indexes by indicator dimension, showing focus and overlaps.

[3] See https://www.itu.int/en/ITU-D/Statistics/Documents/events/egti2020/IDI2020_BackgroundDocument_20200903.pdf

[4] See https://www.mobileconnectivityindex.com/

[5] See https://theinclusiveinternet.eiu.com/

[6] "Measuring the Margins: A Global Framework for Digital Inclusion." Digital Future Society, December 2019. https://collections.unu.edu/eserv/UNU:7584/n201219_Report-7_A_global_framework_for_digital_inclusion-2.pdf

To examine the state of broadband in the MENA countries, this study adopts the EIU's index since it is the most comprehensive framework that covers 57 different elements and hence provides more factors compared to the other indices. It encompasses a mix of quantitative measures (i.e., network coverage and pricing) and qualitative measures (i.e., the presence of e-inclusion policies and the availability of local-language content). It, moreover, provides different weights for each indicator: availability (usage, quality, infrastructure, electricity) 40%, affordability 30%, relevance 20%, and readiness 10% which provides a better understanding of the impediments to digital inclusion in the region.

1.2 Closing the Connectivity Gap at the Global Level

An analysis of the previous releases of the Inclusive Internet Index between the years 2016 – 2020 shows that despite the progress made by many countries, the gap is still broadening between high-income and low-middle-income countries (Figure 2).

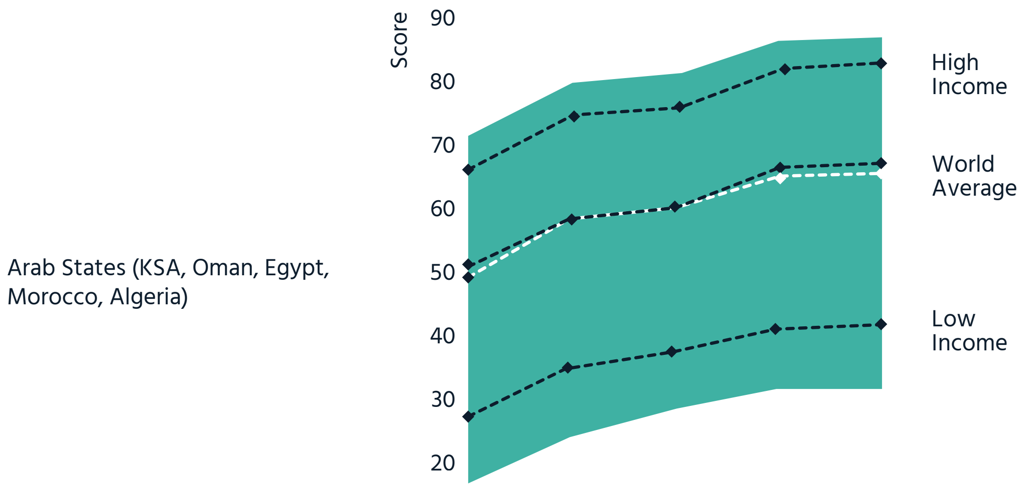
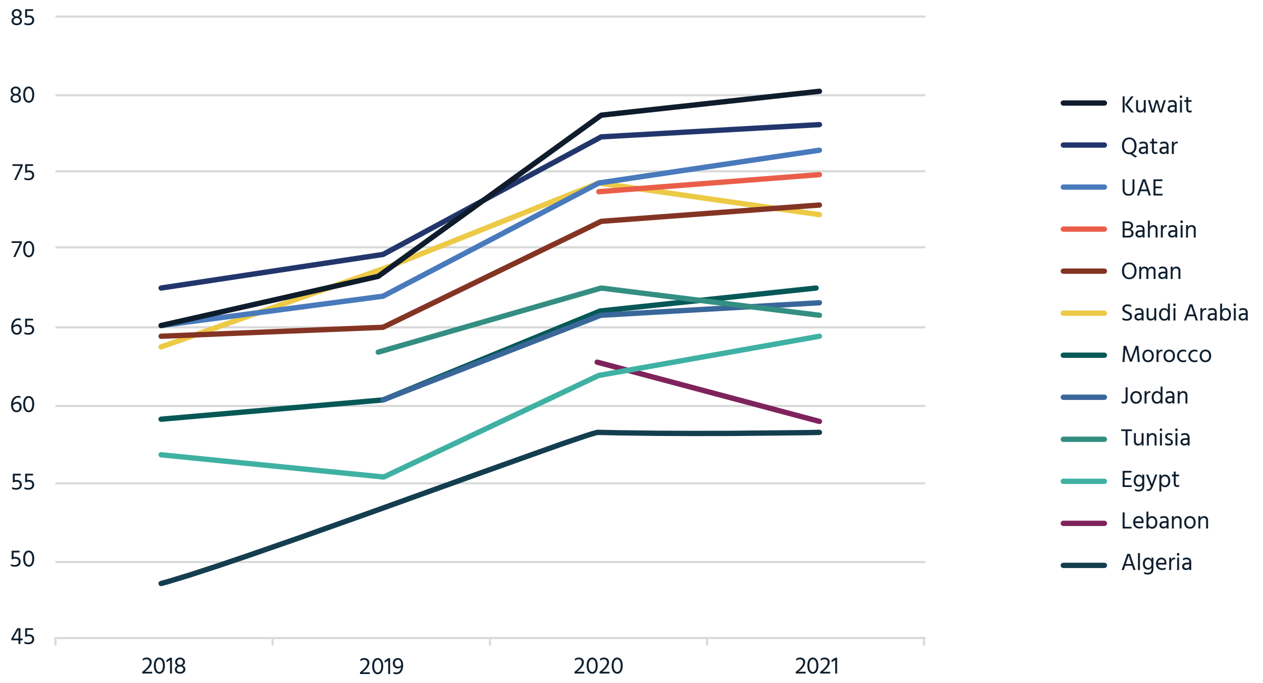


Figure 2: EIU's Inclusive Internet Index, an illustrative graph of the digital divide in some Arab countries versus high-income and low-income countries

This was further validated by the Inclusive Internet Index 2021 which focused mostly on the extent to which the Internet has enabled social and economic outcomes during the COVID-19 crisis. The 2021 index reported improvements in Internet inclusion propelled mostly by the availability of Internet in developed and developing countries which could be attributed to government and private sector-led initiatives to improve broadband connectivity. Yet, the digital divide between high-income and low-middle-income countries proved to be persistent which was manifested by the pandemic and the wide-ranging consequences ascribed to the gap between those who were connected and not connected to the Internet. The ramifications were particularly demonstrated in the access to information about Covid-19, online education, and applications for remote work to name a few.[7]

1.3 Internet Inclusion in the Arab Region

The situation in the Arab region is not far from the global one. A detailed analysis of the performance of the Arab countries from 2018 – 2021 exemplifies an improvement in the status of Internet inclusion buttressed by the economic development in different countries, except for countries going through political or economic turbulence (i.e., Tunisia and Lebanon) (Figure 3). The 2021 index, which examines 120 countries, marked the top achievers in the Arab region to be Kuwait (28th) followed by the United Arab Emirates (UAE) (40th) and Egypt (73rd).



[7] The Economist Intelligence Unit. "The Inclusive Internet Index 2021 Executive summary." Accessed December 6, 2021, https://theinclusiveinternet.eiu.com/assets/external/downloads/3i-executive-summary.pdf

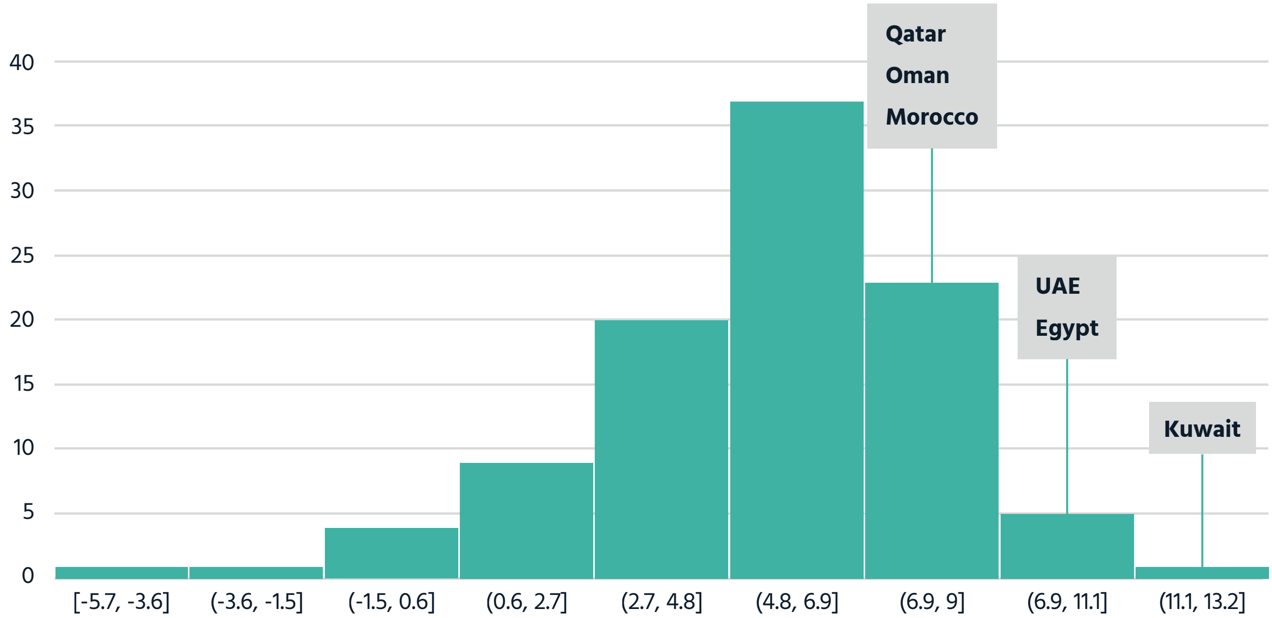


Figure 3: The performance of Arab countries on the Inclusive Internet Index between 2019 and 2021

Kuwait which is the best performer in the MENA region has scored high in availability and readiness. The availability of the infrastructure required to improve access was advanced with the deployment of fiber-optic networks to promote smart cities[8] which enhanced the average fixed broadband download and upload speed. The UAE has ranked the 4th highest in the MENA region and scored high in the relevance and availability pillars due to the development of the infrastructure which promoted the average mobile download and upload speed. Egypt, which climbed five ranks, has scored high in three pillars out of four including relevance, affordability, and availability because of the investment in the ICT infrastructure and the deployment of fiber optics which improved Internet speed from 6.5 Mbps to 34.8 Mbps.[9]

On the other hand, Tunisia (72nd) and Lebanon (85th) which are going through political and economic crises have reported a decline in Internet inclusion specifically in the content relevance pillar. While the value of e-health and e-commerce content dwindled in Tunisia, the availability of e-government services in the local language and e-finance content dropped in Lebanon. A decline in e-entertainment usage and e-health content was also reported in both countries.

[8] Al-Methin, Salem "Fiber optics essential part of Kuwait's smart cities' projects, 2035 vision." Kuwait News Agency, January 7, 2019. https://www.kuna.net.kw/ArticleDetails.aspx?id=2768711&language=en

[9] Arab Republic of Egypt Ministry of Communications and Information Technology. "Egypt Moves Up Five Places at EIU Inclusive Internet Index 2021." April 22, 2021. https://mcit.gov.eg/en/Media_Center/Press_Room/Press_Releases/63329

Broadband Availability in the Arab States

On the question of Internet availability, the performance of the Arab high-income countries has improved between 2019-2021 from 77.34 to 79.37 compared to the world average (62.3) and the global high-income countries average (77.34) and the upper-middle-income countries average (64.7). A closer look into the drivers for such improvement illustrates that the high-income Gulf Cooperation Council (GCC) countries[10] are progressing on the availability pillar due to the launch of 5G networks and its impact on network quality (Figure 4).

	AVAILABILTY	
UAE	81.3	
Qatar	79	
Kuwait	76.7	High income Average
Oman	73.4	
Saudi arabia	73.1	Arab States Average
Bahrain	72.8	High income Average
Morocco	68.5	
Jordan	66.3	
Tunisia	63.2	Upper Middle-income Average
Lebanon	62.6	
Egypt	62.4	
Algeria	58	World Average
Sudan	32.2	

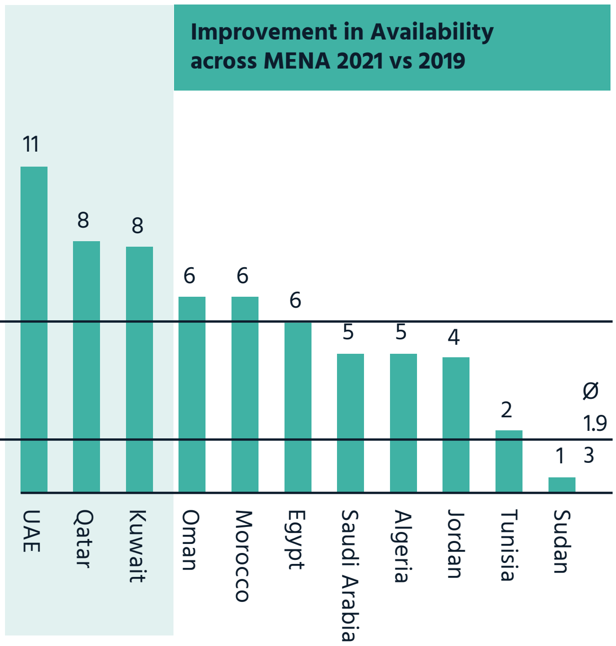


Figure 4: Broadband availability in the Arab countries between 2019 and 2021

[10] The only exception is Kingdom of Saudi Arabia (KSA) which could be attributed to the inaccuracy of data provided.

For example, UAE currently has the fastest 5G network demonstrating high performance in average mobile download speed, average mobile upload speed, average fixed broadband download speed, and average fixed broadband upload speed. Low middle-income countries in the region have also climbed from 29.97 to 31.32 reflecting a 1.35 improvement between 2019-2021. That said, while almost all countries of the region are progressing ahead of their income group, challenges to availability were manifested between low-middle-income and high-income countries in the Arab region which indicates that the digital divide is widening within the region. For example, Tunisia is lagging on average in quality and infrastructure because of the domestic political crisis.

Turning now to the sub-indicators of the EIU's Availability pillar, the average score of the Arab countries in the availability of electricity is 99.3 which is close to the global average score of high-income countries (99.5). The regional scores are also in line with the high-income countries regarding Internet quality (45.5 average) and infrastructure (66.4). However, the Internet usage in the region (69.5 average) demonstrates a lag to the world average (Figure 5), except for UAE which is slightly ahead of the high-income countries group, and Morocco which is ahead of the upper-middle-income countries group.

Electricity - 99.3

UAE	100	
Kuwait	100	
Bahrain	100	
Jordan	100	
Tunisia	100	
Lebanon	100	
Morocco	99.8	
Egypt	99.7	High Income
Qatar	99.1	
Saudi Arabia	98.6	Arab States
Algeria	98.3	
Oman	95.8	Upper Mid.
Sudan	50.9	Income

High income	**99.5**
Upper middle income	**93.8**
Lower middle income	**80.1**
Low income	**38.7**

Usage - 69.5

UAE	87.4	High Income
Oman	79.3	
Saudi Arabia	79.3	
Qatar	76.2	
Bahrain	74.3	
Kuwait	73.8	Arab States
Morocco	65.7	
Algeria	63.6	Upper Mid.
Tunisia	63.2	Income
Lebanon	58	
Egypt	51.6	
Jordan	50.9	
Sudan	39.3	

High income	**81.7**
Upper middle income	**64.1**
Lower middle income	**48.5**
Low income	**30.2**

Quality - Av. 45.5

UAE	67.5	
Qatar	61.8	High Income
Saudi Arabia	51.6	
Kuwait	50.4	
Jordan	46.4	
Bahrain	44.8	Arab States
Oman	43.7	
Lebanon	41.3	Upper Mid.
Morocco	38.7	Income
Tunisia	37.4	
Egypt	35.5	
Algeria	28.4	
Sudan	22.2	

High income	**53.1**
Upper middle income	**39.7**
Lower middle income	**35.4**
Low income	**29.7**

Infrastructure - 66.4

Kuwait	82.7	
Qatar	79.1	High Income
Oman	74.9	
Bahrain	72.1	
UAE	70.3	
Morocco	69.9	
Jordan	68.2	Arab States
Saudi Arabia	63	
Egypt	62.9	
Tunisia	52.2	
Lebanon	51.1	Upper Mid.
Algeria	41.6	Income
Sudan	16.3	

High income	**77.9**
Upper middle income	**61.2**
Lower middle income	**48.4**
Low income	**24.8**

Figure 5: Performance of Arab countries in the EIU's availability pillar (electricity, usage, quality, and infrastructure)

II.

Internet Infrastructure

The digital divide entails an infrastructure divide which consequently necessitates an approach to close the gaps in the Internet infrastructure. However, while the Internet infrastructure is not the only element of the digital divide, providing adequate digital infrastructure remains a fundamental prerequisite that paves the way for the other elements to be addressed. In this vein, bridging the infrastructure gap requires a paradigm shift from "providing infrastructure and access" to "encouraging usage of the existing infrastructure to add or create value" vis-à-vis the allocation of resources and policy decisions. Such added value could include substantial social, economic, and political alongside a wide range of life improvements.[11]

In Arab countries, Internet access became an integral part of the life of citizens with the growth of ICT uptake and the rise of digital natives. In response, the Arab countries have developed digital strategies to promote digital transformation including national broadband policies and infrastructure deployment. Many of these countries have, moreover, demonstrated a steady increase in broadband adoption between the years 2015 – 2021, where wireless Internet access via mobile networks prevailed in most Arab countries due to the high availability and affordability of mobile devices in lower-middle-income economies. The unique mobile Internet users has in turn increased from 130M to more than 180M in total (Figure 6) with a Compound Annual Growth Rate (CAGR) of 7.7% over the period 2016 – 2021. Fixed broadband has also been on the rise from 17M to 29M in total (Figure 7) with a CAGR of 9% between 2015 – 2021. In both mobile and fixed broadband connections, Egypt reported the highest increase (9.93% and 17%) followed by Tunisia (8.36% and 16.76%)

[11] Ben Shenglin, Felice Simonelli, Zhang Ruidong, Romain Bosc, and Li Wenwei, 'Digital infrastructure: Overcoming Digital Divide in Emerging Economies, G20, December 10, 2020,' https://www.g20-insights.org/policy_briefs/digital-infrastructure-overcoming-digital-divide-emerging-economies/.

and Morocco (11.59% and 11.89%). Despite the political and economic challenges that Syria is currently undergoing, mobile and fixed connections reported 13.3% and 15.62% growth respectively.

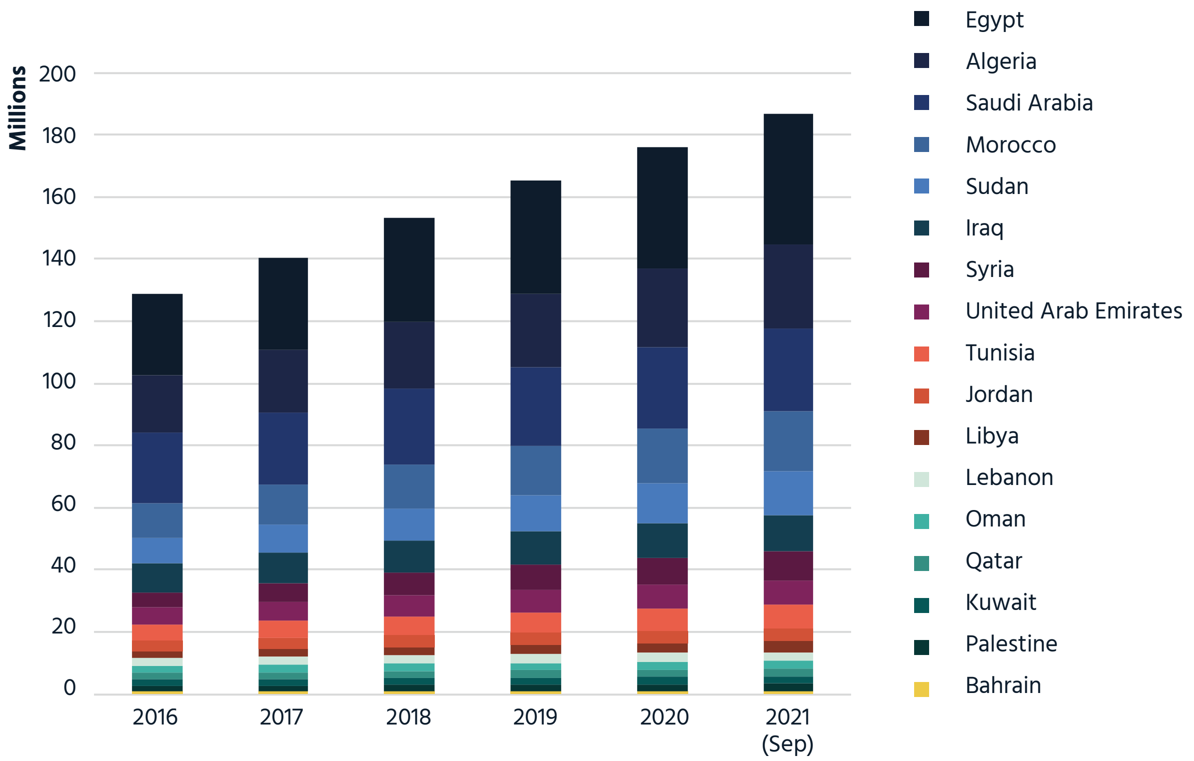


Figure 6. Mobile unique Internet users. Source: GSMAi, Market Metrics.

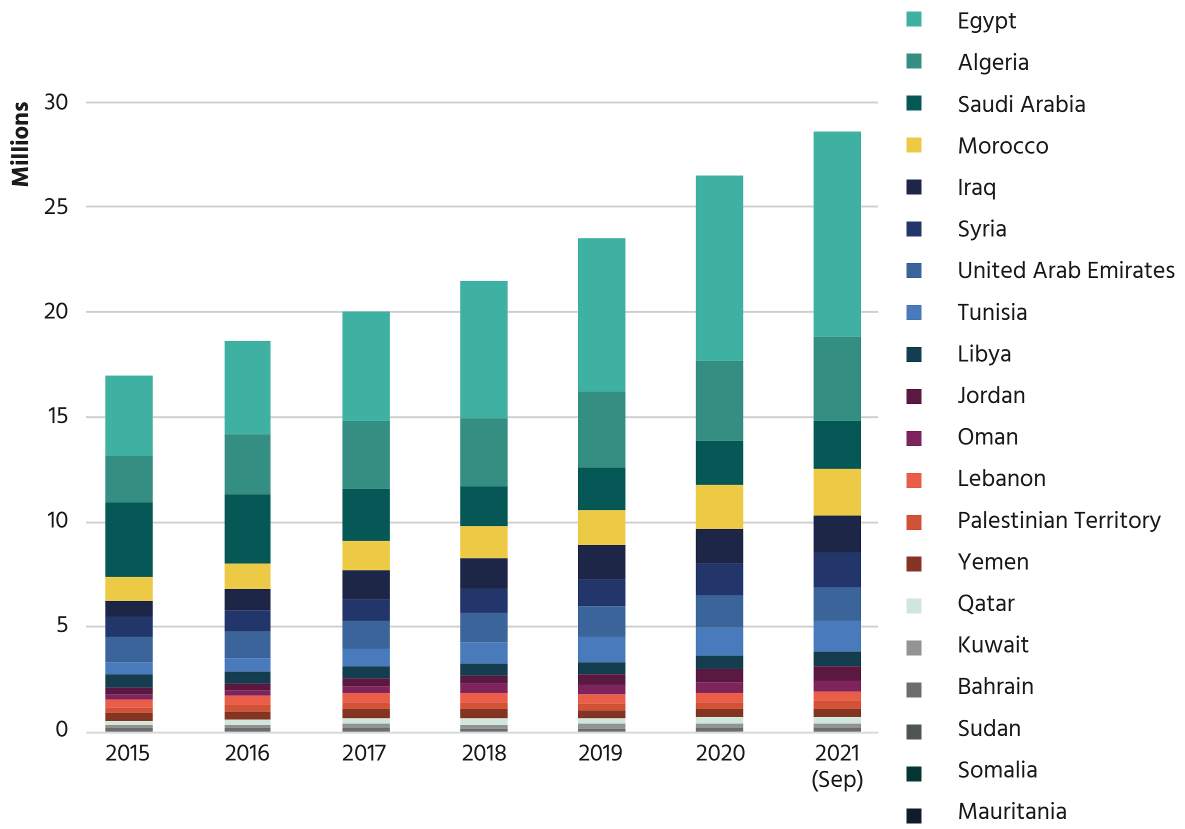


Figure 7. Fixed Broadband Connections. Source: Telegeography, GlobalComms, Country Fixed Broadband.

According to Speedtest Global Index,[12] which provides a global ranking to mobile and fixed broadband speeds across the world, the download speeds were improved from 2014 onwards due to the wide-scale deployment of 4G services in the GCC countries. In 2017, significant progress was further introduced with the upgrade to 5G services and the rapid deployment of Fiber to the home (FTTH) in the GCC countries, and the launch of 4G services in Egypt. Despite this, little progress has been made in the rest of the Arab countries on account of the deferred deployment of both services. With respect to the fixed download speed, UAE (101.8 Mbps), Kuwait (85.92 Mbps), Saudi Arabia (79.39 Mbps), and Qatar (60.73 Mbps) are above the global average (56.09 Mbps). The four countries alongside Oman and Bahrain are also above the global mobile download speed average (28.56 Mbps) (Table 1).

	#	Mobile Download	Mbps
1	-	United Arab Emirates	130.2
4	-1	Qatar	92.83
6	1	Saudi Arabia	87.66
12	2	Kuwait	77.06
32	-2	Oman	46.54
34	1	Bahrain	44.52
47	-1	Iraq	36.56
Global Average			
63	4	Morocco	28.35
72	-3	Tunisia	25.22
82	-9	Lebanon	21.45
85	-2	Jordan	19.7
91	-	Egypt	18.3
121	3	Libya	12.51
124	-10	Syria	12.17
126	-	Algeria	11.5
133	-3	Somalia	9.01
135	-	Sudan	8.74
138	-2	Palestine	5.78

	#	Fixed Download	Mbps
15	-2	United Arab Emirates	101.8
30	-	Kuwait	85.92
36	-	Saudi Arabia	79.39
48	-4	Qatar	60.73
Global Average			
55	3	Jordan	51.8
65	-1	Bahrain	47.13
75	-3	Oman	42.71
85	16	Egypt	33.07
151	1	Iraq	18.98
128	-2	Palestine	13.8
131	2	Morocco	12.79
135	5	Libya	10.82
141	-4	Algeria	9.85
159	-4	Tunisia	7.61
160	-	Lebanon	7.55
163	-	Mauritania	5.91
166	-4	Somalia	5.47
167	-1	Djibouti	5.27
174	-	Sudan	3.61
176	-1	Syria	2.87

Table 1. Global Median Speeds November 2021. Source: Ookla, Speedtest Global Index.

[12] See https://www.speedtest.net/global-index

Thus far, while 93% of the MENA population was covered by a 3G mobile broadband network, only 5% enjoyed 5G coverage by 2020 (Figure 8).[13]

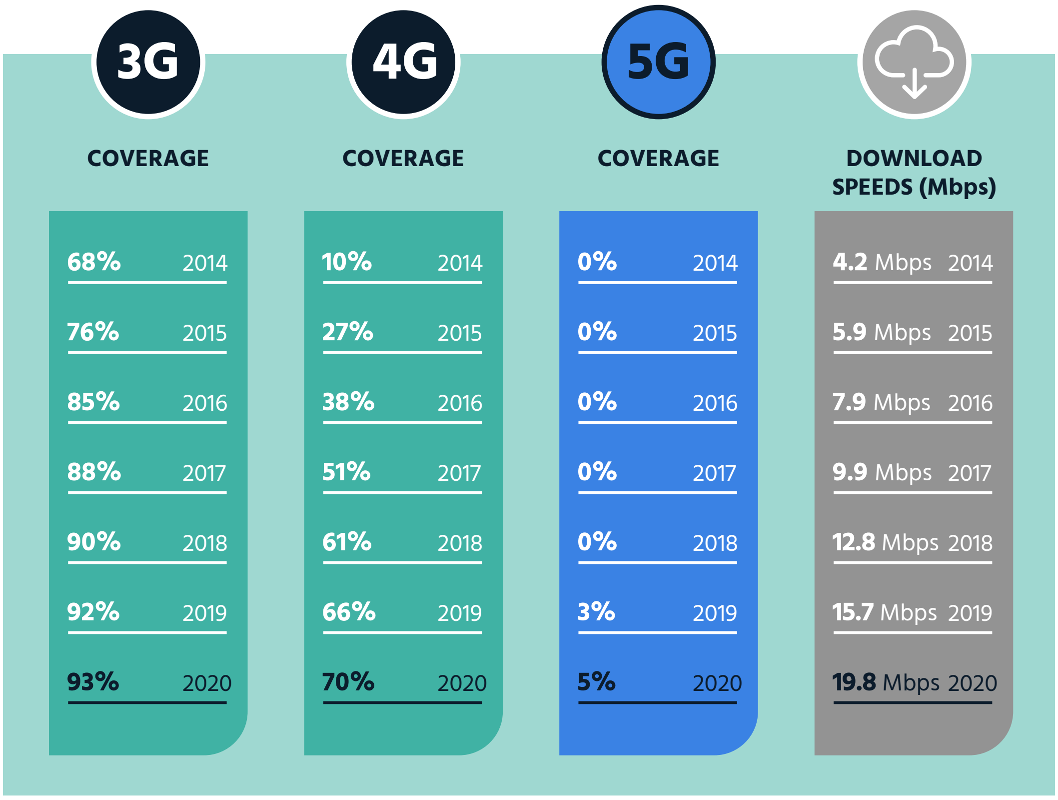


Figure 8. Coverage and download speed statistics. Source: GSMA, Mobile Internet Connectivity 2021 Middle East and North Africa Key Trends.

As far as Internet speed is concerned, the mobile and fixed speeds were meliorated in the region as well. On one hand, the mobile average speed was upgraded from 42 Mbps in 2020 to 74 Mbps in 2021. The Speedtest Global Index 2021 reports a growth in mobile speed between 76-94% throughout most of the GCC markets with the 5G adoption. Oman and Kuwait have outperformed the rest of the countries with a staggering 150-180% growth. Additionally, the rollout of 4G has improved the average download speed between 47-55% in Libya, Sudan, and Algeria and between 3-12% in most Arab countries (Figure 9).

[13] GSMA. "Mobile Internet Connectivity 2021 Middle East and North Africa Key Trend." September 2021. https://www.gsma.com/r/wp-content/uploads/2021/09/The-State-of-Mobile-Internet-Connectivity-2021-Middle-East-and-North-Africa.pdf

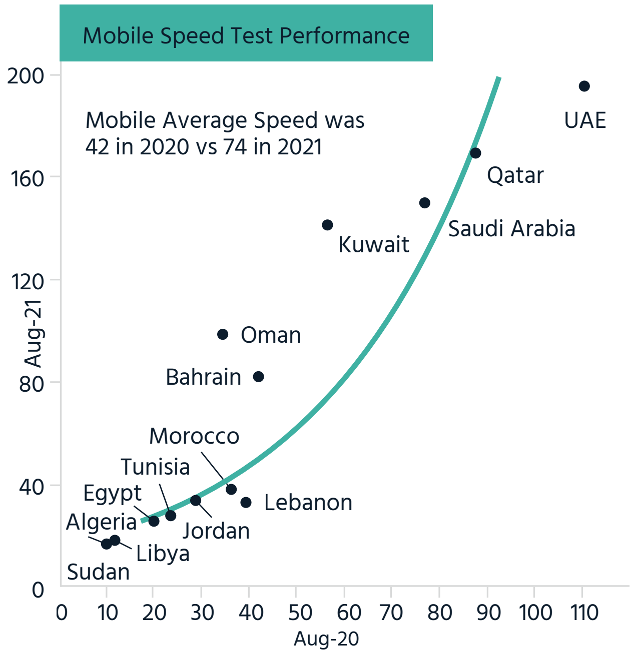


Figure 9. Mobile speed test performance. Source: Ookla Speed Test.

On the other hand, the fixed Internet speed was improved from 45 Mbps in 2020 to 64 Mbps in 2021. While the fixed download speed was developed in most of the GCC countries between 21-44%, Oman and UAE have achieved 78% and 65% progress, respectively. The rapid deployment of Fiber and moving it as close as possible to the home, the cabinet, or even the curb (FTTX) has further increased the download speed between 37-41% in Morocco, Jordan, and Egypt. Additionally, Algeria, Tunisia, and Lebanon have managed to achieve a 44-65% growth to reach 11 Mbps, and Sudan's 154% growth to almost 10 Mbps (Figure 10).

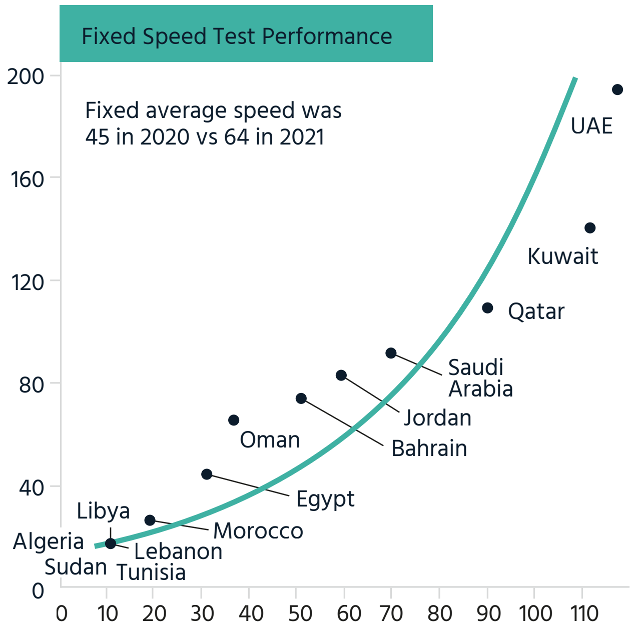


Figure 10. Fixed speed test performance. Source: Ookla Speed Test.

Fast and ubiquitous Internet connectivity is quintessential to the information society. In this vein, this section of the report explores the Internet infrastructure required to secure meaningful connectivity to citizens in the Arab region. To this aim, it analyzes four key elements required for ubiquitous Internet connectivity. First, the international Internet bandwidth includes submarine cables, international gateways, and Internet exchange points (IXPs). Second, the national backbone focuses on the reach of fiber to the closest point possible to end-users and the satellite services required to bridge national backbone gaps. Third, last-mile access technologies include fixed technologies (DSL and Fiber) and wireless technologies (4G and 5G). Fourth, the special access networks elaborate on the national research and education network (NREN) and the community networks (Figure 11).

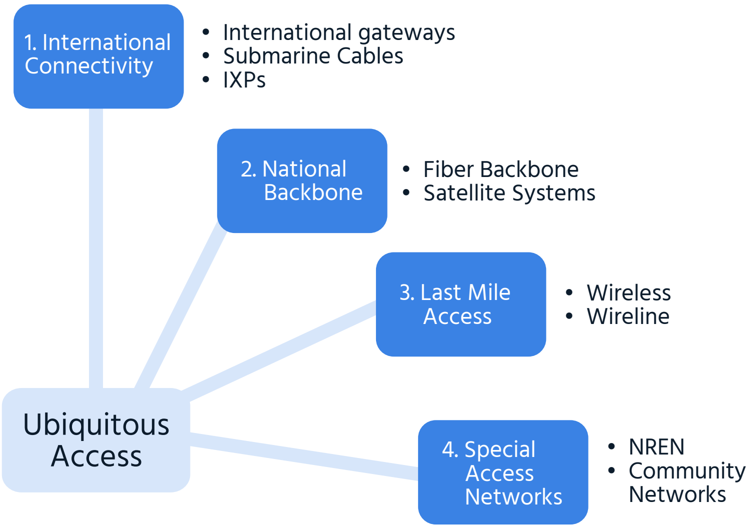


Figure 11. Key elements of ubiquitous Internet access.

2. International Connectivity

2.1. International Gateways

The international Internet traffic in the Arab region has grown between the years 2016 – 2020 compared to the global peak traffic (ca. 200,000 Gbps) which had a 30% CAGR during the same period.[14] Saudi Arabia marked the highest growth rate reflecting the scale and the scope of the efforts invested to fulfill Saudi Vision 2030 which hinges on the ICT sector as a key enabler (Figure 12). The wide-scale deployment of 4G services in the GCC countries in 2015 and in Egypt in 2017 has resulted in rapid growth in international traffic (Figure 13). Further exponential growth in Internet traffic occurred with the launch of 5G and the wide adoption of FTTH in the GCC countries.

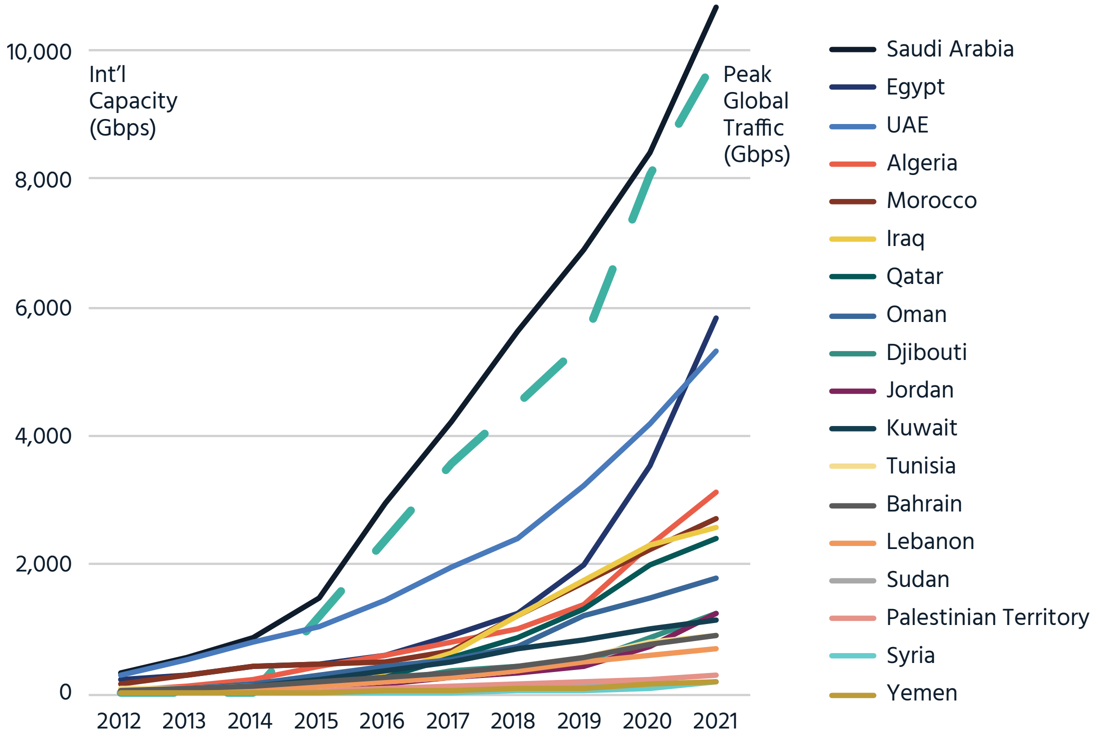


Figure 12. International Traffic in the Arab countries. Source: Telegeography, Global Internet Geography

[14] Jayne Miller, "2021 Global Internet Map Tracks Global Capacity, Traffic, and Cloud Infrastructure," Telegeography, February 16, 2021, https://blog.telegeography.com/2021-global-internet-map-tracks-global-capacity-traffic-and-cloud-infrastructure.

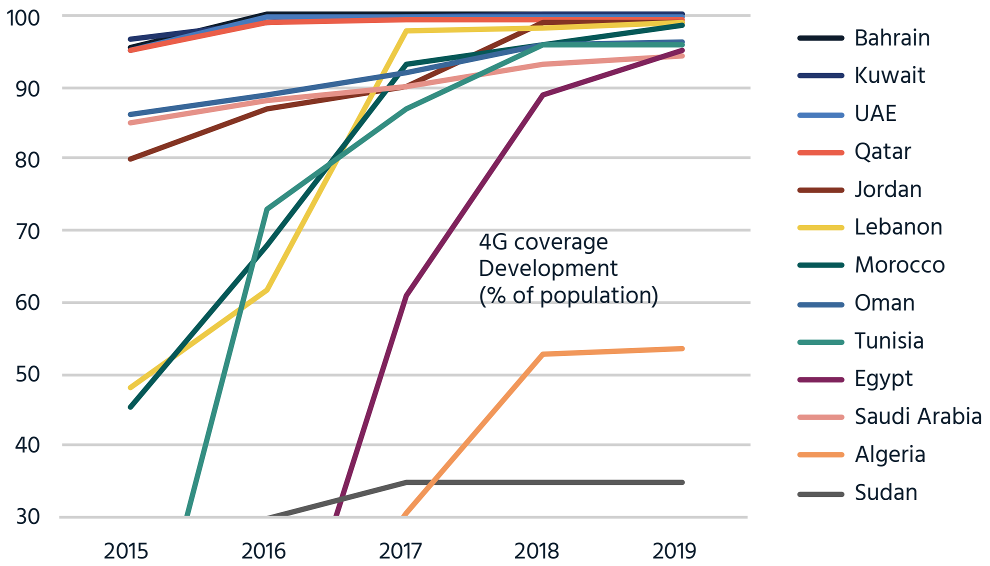


Figure 13. 4G coverage deployment in the Arab countries. Source: ITU Telecom Indicators 2019.

That said, although the bandwidth has witnessed growth in the region, international traffic still connects the region to mostly Europe with minimal regional connectivity which adversely impacts Internet speed and adds hops while the data is transferred between the source and the destination. For example, major peering partners to the region are in Europe where many ISPs in MENA countries pay for transit to either an IXP in Marseilles or one of the other large IXPs in Europe (Figure 14).[15]

[15] Kende, Michael. "Middle East and North Africa Internet Infrastructure." Internet Society, May 2020. https://www.internetsociety.org/resources/doc/2020/middle-east-north-africa-internet-infrastructure-report/

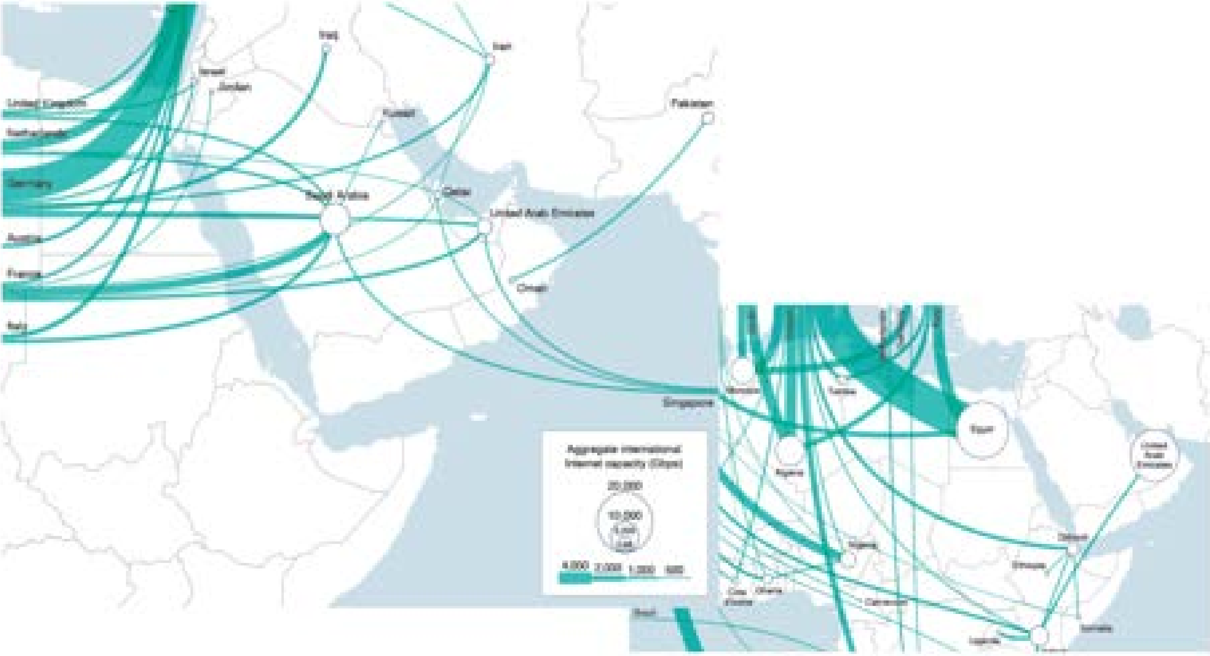


Figure 14. Major International Internet Routes in North Africa and the Middle East.
Source: Telegeography.

The limited competition in international gateways is yet another challenge that constrains the development of a competitive market for broadband services and quality submarine fiber optic cables. A competitive submarine cable market would provide local ISPs with open access to the international capacity while encouraging global technology companies to invest in the submarine capacity and hence promote international traffic.[16] For example, KSA has a competitive market with four international gateways and international bandwidth of 10,650 Gbps compared to UAE which has a concentrated market with only two gateways and international bandwidth of 5,310 Gbps (Table 2).

[16] ibid.

Competitive Markets

Country	No. of Intl Gateways	Intl B/W (Gbps)	CAGR 2019-21 (%)	Major Destination
KSA	4	10,650	24%	France
Morocco	2	2,724	26%	France
Jordan	3	1,239	72%	
Bahrain		912	28%	
Oman		1,798	22%	Pakistan

Concentrated Markets

Country	No. of Intl Gateways	Intl B/W (Gbps)	CAGR 2019-21 (%)	Major Destination
UAE	2	5,310	28%	France
Egypt	1	5,816	70%	France
Lebanon		700	21%	
Palestine		272	20%	
Sudan		282	54%	

Table 2. Competitive and concentrated markets in the Arab region. Source: TeleGeography, Team Analysis

2.2. Submarine Cables

All MENA countries have access to the sea which allows them to have a Submarine Cable System (MENA-SCS) with an 8800km submarine communications cable that connects Italy, Egypt, Saudi Arabia, Oman, and India (Figure 15). The MENA-SCS, which is now a private cable owned by Telecom Egypt, has been further developed in partnership with Gulf Bridge International (GBI) to provide connectivity from Oman to India and Western Europe across Egypt.[17] Alongside, MENA-SCS, the Arab countries have a web of sea cables that run across their seabed which are important to improve Internet connectivity and can further boost download speed across the region. For this reason, international connectivity across the MENA region could be ameliorated by installing more cable systems like 2AFRICA,[18] which is the largest sea cable project and the first cable system developed to connect east and west seaboards of Africa.[19] Existing cable systems should also be frequently maintained and upgraded, i.e. the submarine cable BERYTAR developed in 1997 to connect Syria and Lebanon.

[17] https://www.submarinenetworks.com/systems/asia-europe-africa/mena

[18] https://www.2africacable.com/

[19] Engineering at Meta. "Building a transformative subsea cable to better connect Africa." Meta. May 13, 2020. https://engineering.fb.com/2020/05/13/connectivity/2africa/

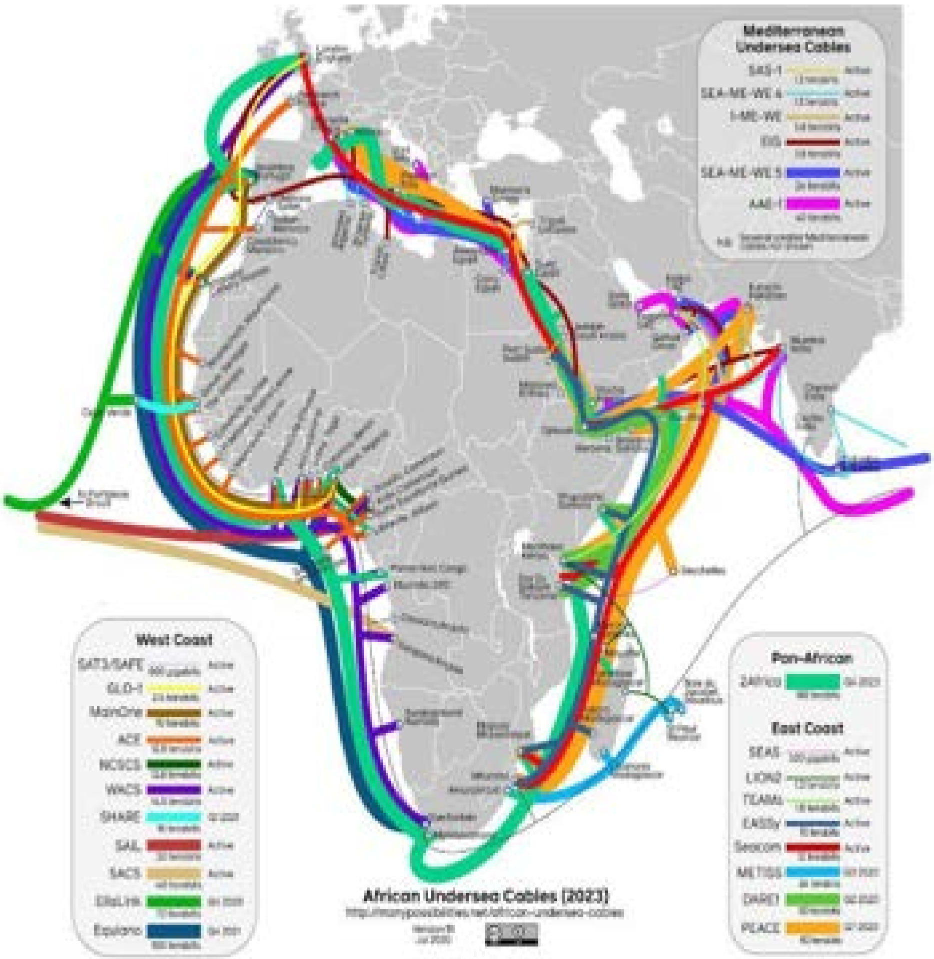


Figure 15. Map of subsea cables in Africa. Source: Steve Song.[20]

International cross-connect pricing is yet another challenge in the Arab region since it is treated as commercially sensitive data and is not published on the websites of international gateway service providers. That said, most of the MENA countries are members of the Basic Telecom Agreement of the World Trade Organization (WTO) and signatories of the Telecommunications Reference Paper; a blueprint of the telecom regulatory principles that are legally binding for the governments of these countries. On top of these principles is the transparency of interconnection arrangements which mandates incumbent operators to make publicly available their interconnection agreements or a reference interconnection offer (RIO) for providers of bottleneck facilities.[21]

[20] https://manypossibilities.net/african-undersea-cables/

[21] World Trade Organization. TELECOMMUNICATIONS SERVICES: REFERENCE PAPER." 24 April 1996. https://www.wto.org/english/tratop_e/serv_e/telecom_e/tel23_e.htm

Popular Arabic websites with high regional traffic are still hosted outside the region due to some regulatory and infrastructural challenges. For example, youm7.com, which has 70% of its traffic from Egypt, is hosted by CLOUDFLARENET in the United States (Figure 16).[22] Another example is shahid.net, which has 51% traffic from Jordan and is also hosted in the United States by AMAZON-AES (Figure 17).[23]

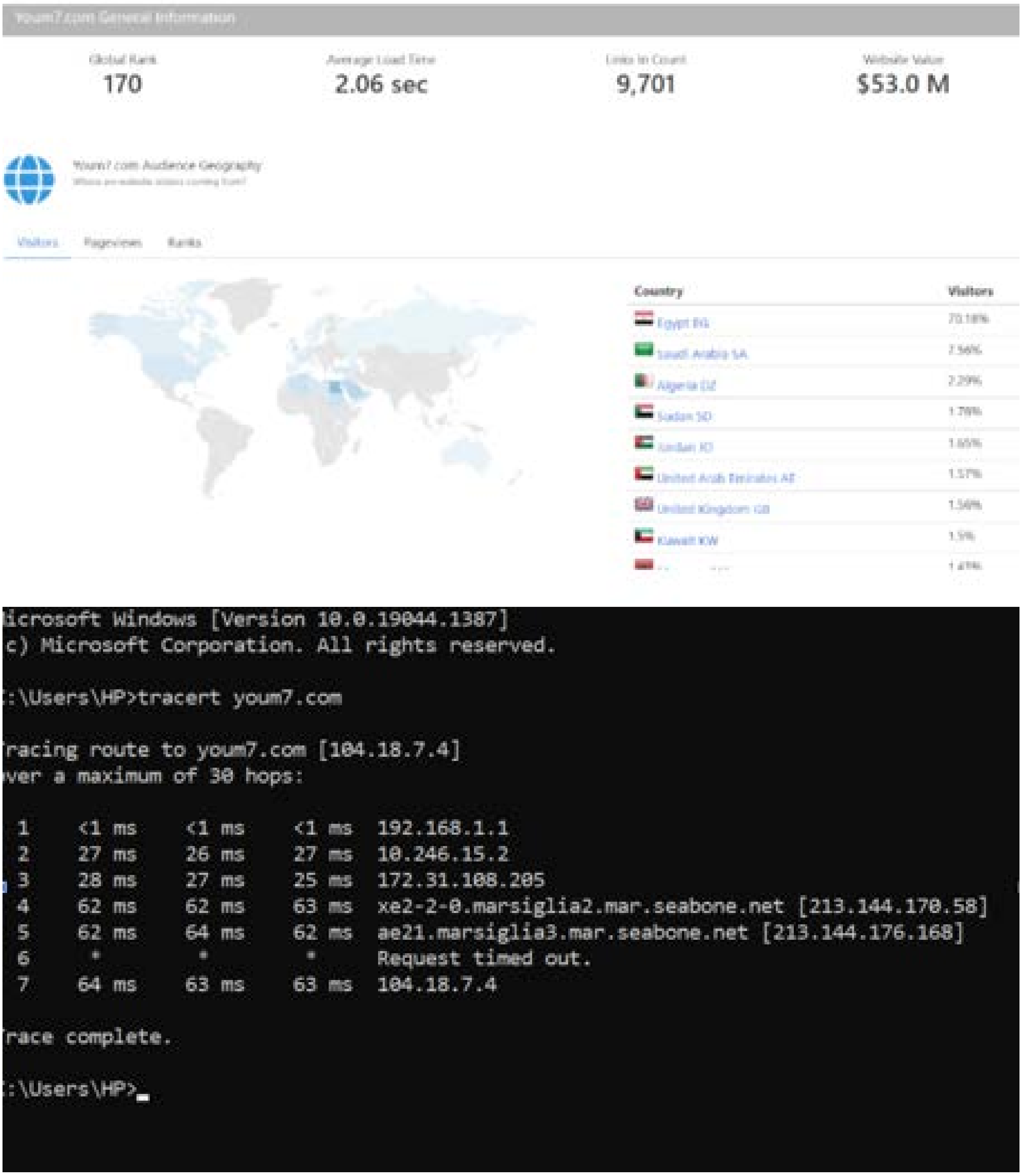


Figure 16. Youm7.com. Source: Rank Chart.

[22] Rank Chart. "Youm7.com." Accessed December 23, 2021. https://rankchart.org/site/youm7.com/

[23] Rank Chart."Shahid.net." Accessed December 23, 2021. https://rankchart.org/site/shahid.net/

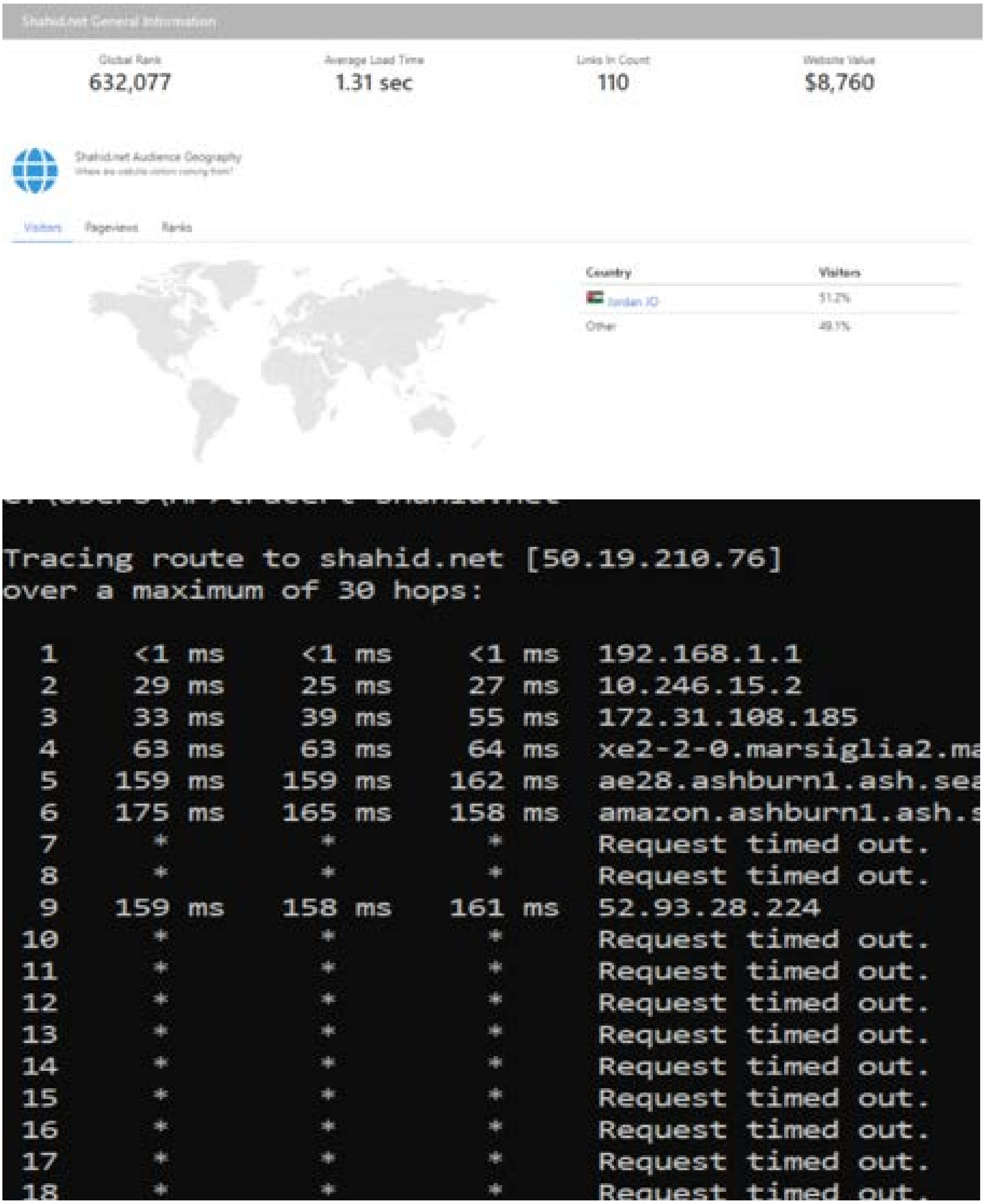


Figure 17. Shahid.net. Source: Rank Chart.

2.3. Internet Exchange Points (IXPs)

As explained earlier, most of the Internet bandwidth in the MENA region is linked to Europe where the Internet traffic transits between servers and IXPs in Europe because MENA countries still have a limited number of IXPs, let alone active ones. Currently, only eleven MENA countries own a total of eighteen IXPs (Table 3).

Country	City	IXP Name	Partici-pants	Peak	Avg	Prefixes	Established
Egypt	Cairo	Cairo Internet Exchange	7	31.5G	15.4G	2209	May-02
Egypt	Cairo	Middle East Internet eXchange	10	15K			May-07
Lebanon	Beirut	Beirut Internet Exchange	12	61.8M		760	Dec-07
Tunisia	Tunis	Tunisian Internet Exchange Point	5			1426	Jan-11
Sudan	Khartoum	Sudan Internet Exchange Point	7	16.4M		96	Oct-11
United Arab Emirates	Dubai	UAE-IX by DE-CIX	70	274G	94.2G	2438	Feb-12
Palestine	Ramallah	Palestinian Internet Exchange	10	27.3M		99	Jun-12
Tunisia	Enfidha	Enfidha Internet Exchange	2			99	Jan-13
United Arab Emirates	Fujairah	SMARTHUB Internet Exchange	13				Mar-13
Djibouti	Djibouti City	DjIX	12	4.72G	2.86G		Jan-16
Qatar	Doha	Qatar Internet Exchange Point	3				Jun-16
Saudi Arabia	Riyadh	Saudi Arabia Internet Exchange	12	47.4G	39.1G		May-17
Lebanon	Beirut	Advanced Internet Exchange	26	76.2M	26.1M	713	May-17

Kuwait	Kuwait	Kuwait Internet Exchange	17	20G			Jan-18
Saudi Arabia	Jeddah	JEDIX by Linx	4				Dec-18
Morocco	Casablanca	Casablanca Internet Exchange	3				Oct-19
Jordan	Aqaba	Aqaba IX	6				Jan-20
Palestine	Ramallah	Palestine IX	16	2G			Mar-20

Table 3. IXPs in Arab countries. Source: Internet Exchange Directory[24]

In 2002, Egypt established the first IXP in the Arab region. Cairo Internet Exchange Point (CAIX) was launched as a government initiative and regulatory mandate for licensed operators to host domestic traffic only. However, amid the COVID-19 crisis, there was an upsurge in CAIX's traffic from 6 Gbps to 26 Gbps (1-3% of total traffic) (Figure 18).[25]

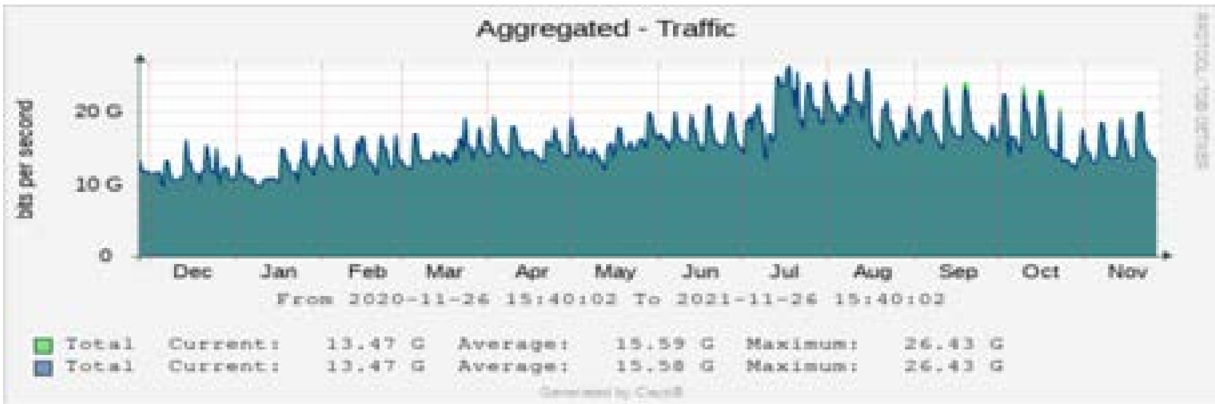


Figure 18. Traffic at CAIX from 26 November 2020 to 26 November 2021. Source: CAIX.

[24] See https://www.pch.net/ixp/dir

[25] See http://www.caix.net.eg/

In 2012, the UAE established the largest IXP in the region. UAE-IX which was commercially initiated has 70 participants from national and regional GCC countries operators (Saudi, Kuwait, Qatar, Bahrain, Oman, and GulfBridge); Asian operators (Sri Lanka, China, and India); international operators (Orange, Vodafone, Level 3, Belgacom, Reliance, and Swisscom); and cloud/content providers (Google, Microsoft, Akamai, Alibaba, and MBC) (Figure 19).[26]

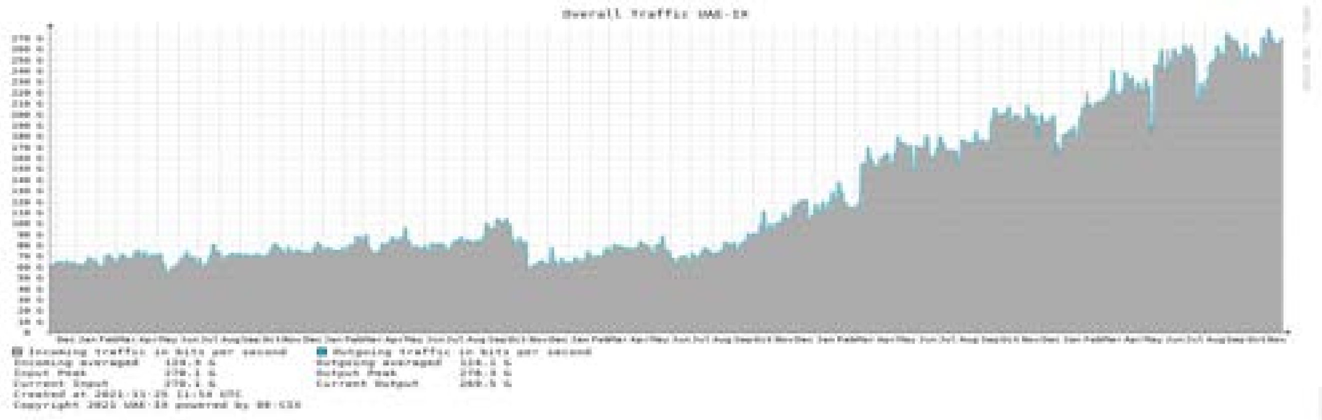


Figure 19. 2016-2021 traffic development at UAE-IC. Source: UAE-IX.

Recently several Arab countries have established for the first time IXPs, i.e., Morocco (2019), Jordan (2020), and Palestine (2020). Additionally, other countries have established commercials IXPs to attract Internet fares and traffic. For example, the KSA launched JEDIX[27] powered by London Internet Exchange (LINX). TE Data is also in the process of launching EGIX in cooperation with AMS-IX Amsterdam. The rapid uptake of digital transformation instigated by the COVID-19 crisis has further propelled some countries – Egypt, Lebanon, and Sudan – to upgrade their existing national IXPs or to plan for establishing new IXPs (Table 4).

Country	City	CAGR
Algeria	Algiers	Algeria Internet Exchange
Bahrain	Manama	Manama-IX
Kuwait	Kuwait	Kuwait Internet Exchange
Lebanon	Beirut	LebanonIX
Mauritania	Nouakchott	Mauritania IX
Mauritania	Nouakchott	RIMIX
Syria	Damascus	Syrian Internet Exchange Point
United Arab Emirates	Abu Dhabi	Gulf Internet Exchange

Table 4. Planned IXPs in Arab countries. Source: Internet Exchange Directory

[26] Packet Clearing House. "UAE-IX by DE-CIX." Accessed December 27, 2021. https://www.pch.net/ixp/details/1341 and https://www.uae-ix.net/en/location/traffic-statistics

[27] https://www.jedix.net/

Another model of IXPs was initiated in Saudi Arabia. JEDIX, which is also the newest IXP in the region, was established by Saudi Telecom Company (STC) in collaboration with LINX in August 2020. In addition to STC, JEDIX has seven members including content providers (Microsoft, Google, and Limelight). While JEDIX has an average traffic of 2.7 Gbps, the current traffic is 138.5 Gbps and the all-time high traffic is 196.4 Gbps (Figure 20).[28]

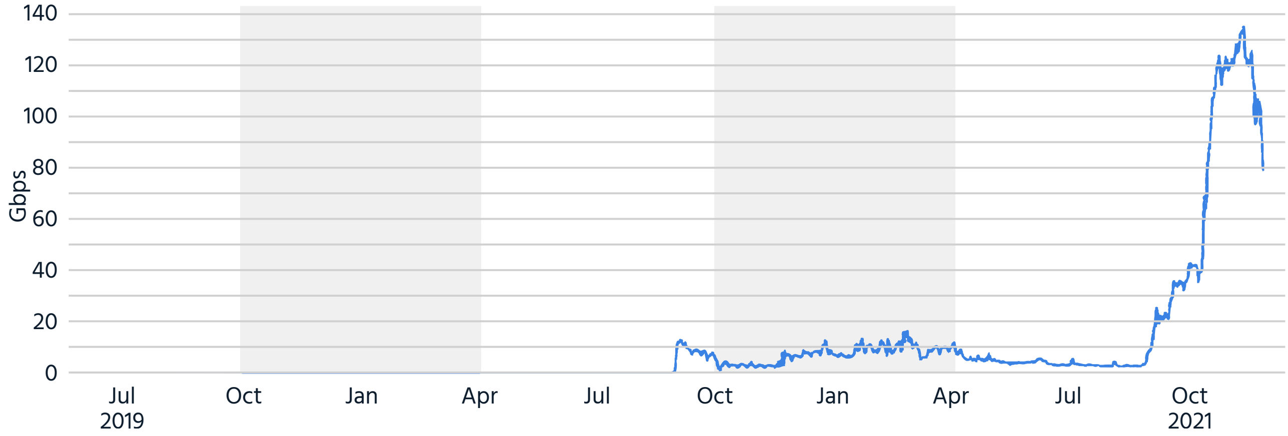


Figure 20. Traffic at JEDIX from 2020 - 2021. Source: LINX LANs[29]

Finally, a different model of a social initiative emerged in Palestine where the Internet Society chapter launched Palestinian IX in June 2012 which managed to attract thirteen members including ten ISPs and three academic institutions. It has further succeeded in attracting international content providers (Facebook and Google) to host content locally where the average daily traffic was 3Gbps resulting in considerable savings to smaller ISPs. Members have also shared the cost of international bandwidth used to update local content based on consumed bandwidth. In response, the Palestinian government developed Ps-IX in 2020 and mandated ISPs to interconnect. As a result, almost 16 ISPs connect now to Ps-IX and content providers moved their cashing to larger ISP locations instead of interconnecting at Ps-IX. However, the number of members at P-IX fell to six (five ISPs and one academic institute) alongside the three content providers.

The question of the resilience of the IXPs in the Arab region is discussed in detail in the next section which is dedicated to the topic of network resilience.

[28] https://www.jedix.net/

[29] https://portal.linx.net/services/lans-snmp

3. National Backbone

3.1. Fiber Backbone

There has been significant improvement in extending fiber core across many Arab countries which made them double their reach to fiber between the years 2016 – 2017 (Figure 21). For example, Jordan achieved the highest growth in fiberoptics between 2013 – 2014 with a CAGR of 365%. During the years 2013 – 2017, Algeria, Saudi Arabia, and Morocco ranked the highest improvement with a CAGR of 9%, 43%, and 17% respectively (Table 5).

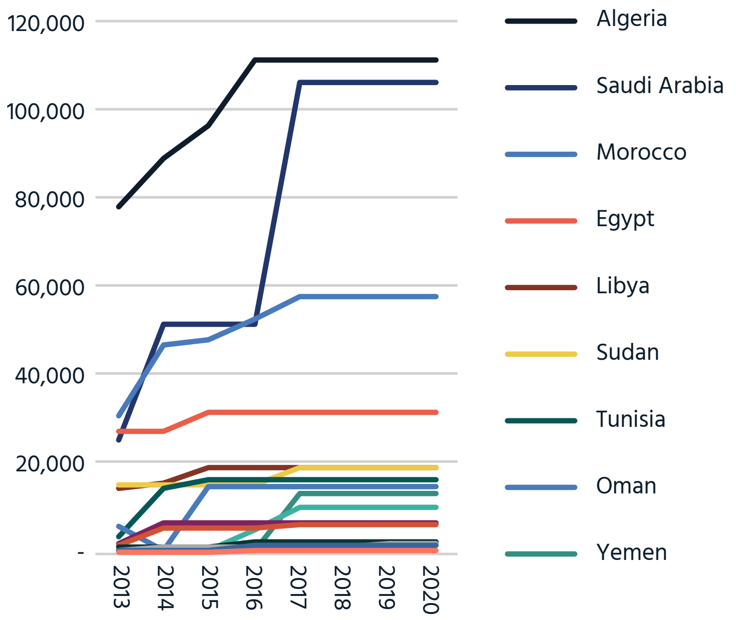


Figure 21. development in Length of national fiber backbone (km). Source: ITU Broadband Capacity Indicators 2020

	2013	2014	2015	2016	2017	2018	2019	2020	CAGR
Algeria	77,700	88,700	96,070	111,070	111,070	111,070	111,070	111,070	9%
KSA	25,257	51,105	51,105	51,105	106,105	106,105	106,105	106,105	43%
Morocco	30,410	46,625	47,684	52,484	57,484	57,484	57,484	57,484	17%
Egypt	27,000	27,000	31,187	31,187	31,187	31,187	31,187	31,187	16%
Libya	13,943	15,243	18,816	18,816	18,816	18,816	18,816	18,816	16%
Sudan	15,060	15,060	15,060	15,060	18,765	18,765	18,765	18,765	25%
Tunisia	3,312	14,095	16,094	16,094	16,094	16,094	16,094	16,094	120%
Oman	5,500	#N/A	14,347	14,347	14,347	14,347	14,347	14,347	62%
Lebanon	1,800	6,200	6,200	6,200	6,200	6,200	6,200	6,200	244%
Iraq	#N/A	#N/A	-	4,650	9,650	9,650	9,650	9,650	108%
Jordan	1,134	5,270	5,270	5,285	5,750	5,750	5,750	5,750	365%
Mauritania	704	704	704	2,152	2,152	2,152	2,152	2,152	206%
Qatar	#N/A	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0%
Syria	#N/A	679	679	679	679	679	1,779	1,779	162%
UAE	#N/A	#N/A	1,100	1,100	1,100	1,100	1,100	1,100	0%

Table 5. Fiber-optics development in Arab countries. Source: ITU Broadband Capacity Indicators 2020

Some Arab countries have also launched national broadband initiatives to improve connectivity and promote digital transformation. For example, the Jordanian Ministry of Digital Economy and Entrepreneurship has developed the National Broadband Network (NBN)[30] project which is a fiber-optic, open-access data network to connect education facilities (930), government entities (315), health facilities (116), and knowledge stations. The project was developed in partnership with the National Electric Power Company (NEPCO) utilizing its right of way (ROW) to deploy fiber (circa 3000 km) in 2014.

The Arab countries that induced investment and competition in national backbone through either licensing or public–private partnerships (PPPs) were able to achieve quantum improvement in fiber reach compared to countries that are contingent on investments by incumbent operators solely. For example, the Saudi Communications and Information Technology Commission (CITC) managed to quadruple the fiber backbone from 25,257 to 106,105 by allowing mobile carriers to deploy their own fiber networks between the years 2013-2017 (Table 5).

[30] https://www.modee.gov.jo/EN/Pages/National_Broadband_Network_Program

Notwithstanding that the Arab region is still falling behind international penetration levels. While the fiber reach was growing in Africa and Asia-Pacific (APAC) and Americas (AMS) and it doubled in Europe between 2015 - 2016, it has been stagnant in the Arab countries since 2015 (Figure 22) and major investment in fiber was almost halted since 2018. Currently, the average population density within 10 Km reach of fiber in the Arab countries is (22.90% of the population) where most GCC countries are below the EU average (59.1 % of the population), except for Bahrain (75% of the population) and Jordan (79.1% of the population). The rest of the Arab countries are below the African average (24.6% of the population), except for Oman, Qatar, Tunisia, Algeria, Lebanon, and Egypt (Figure 23).

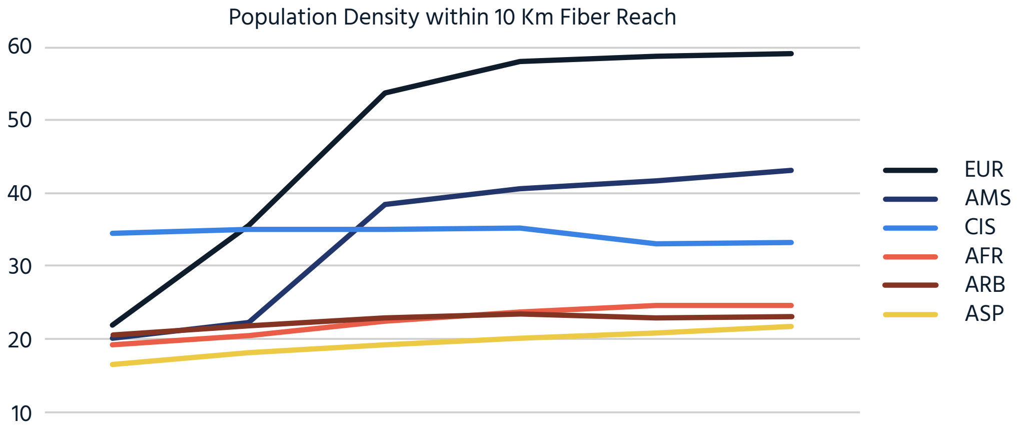


Figure 22. Regional development in 10 Km fiber reach. Source: ITU Broadband Capacity Indicators 2020.

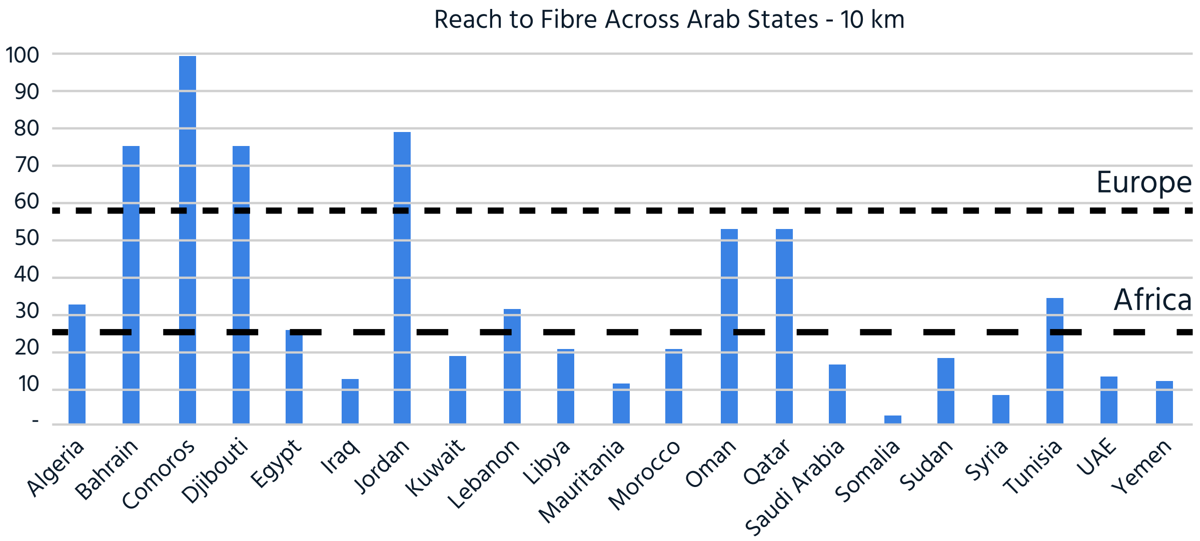


Figure 23. Reach to fiber across Arab countries. Source: ITU Broadband Capacity Indicators 2020

3.2. Satellite Systems

Satellite broadband provides an effective approach to bridging the digital divide and addressing the network and connectivity gaps, particularly in remote or rural areas in the Arab region. According to the ITU, Morocco, Iraq, Algeria, and Saudi Arabia have the highest satellite broadband subscriptions in the region. Nevertheless, during the years 2017 – 2019, while broadband satellite subscriptions were improved in Bahrain (+24%), Tunisia (+19%), Sudan (+15%), Morocco (+8%), and Oman (+2%), they dropped in Egypt, Saudi Arabia, Algeria, and UAE which resorted to the development of fiber optics rather than satellite services (Figure 24).[31]

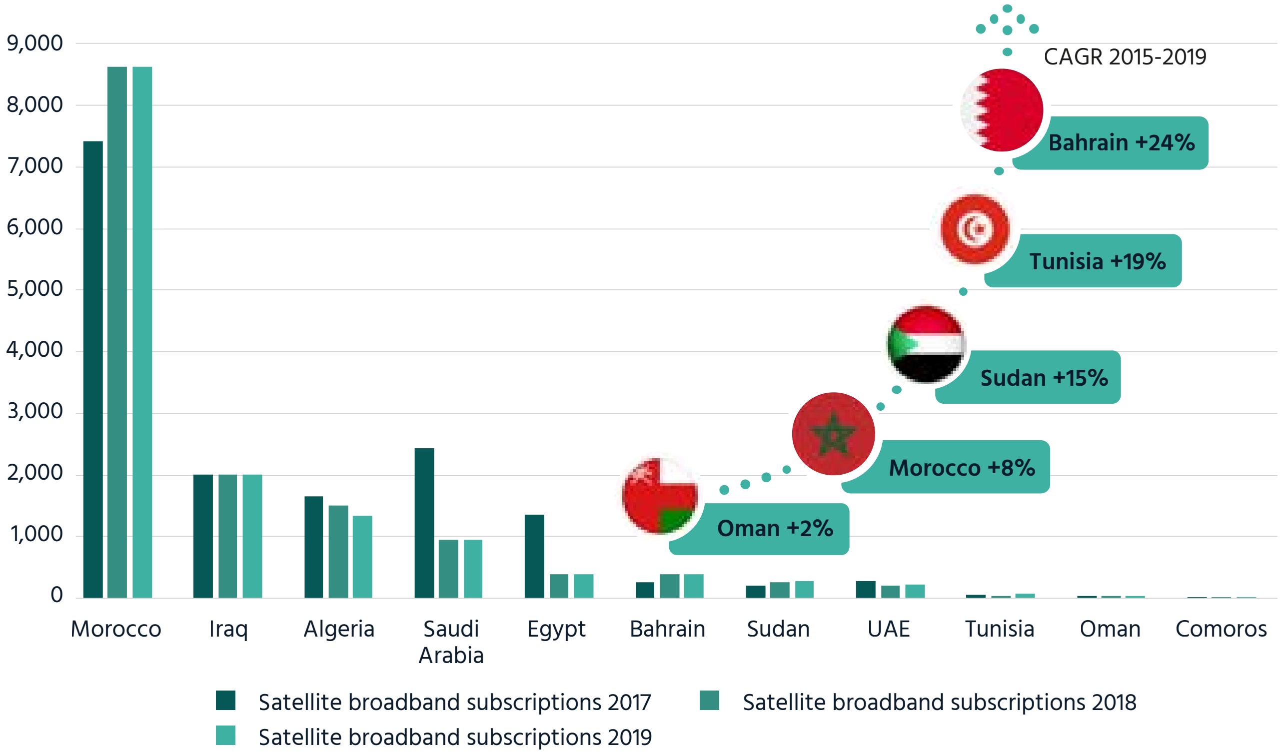


Figure 24. Abonnements au haut débit par satellite, 2018-2019 et TCAC, 2017-2019 dans certains États arabes. Source : UIT, Tendances du numérique dans le monde arabe 2021.

Afin d'améliorer la connectivité, certains gouvernements arabes ont lancé des projets et des initiatives visant à renforcer leurs capacités dans le domaine des satellites à haut débit (HTS), qui fournissent une connectivité d'une capacité allant jusqu'à 10 Gbps. Ainsi, Yah Satellite Communications Company a lancé Yahsat 1A (2011), Yahsat 1B (2012), et

[31] Regional Preparatory Meeting for WTDC-21 for Arab States (RPM-ARB). "Digital trends in the Arab States region in 2021." International Telecommunication Union, April 7, 2021. https://www.itu.int/dms_pub/itu-d/md/18/rpmarb/c/D18-RPMARB-C-0002!R1!PDF-E.pdf

Yahsat-3 (2018) aux EAU. En Égypte, Badr 7 (2015) a été lancé par ArabSat, et TibaSat (2019) a été lancé par l'entreprise Égyptienne de services de télécommunication pour améliorer les communications à haut débit et l'accès à Internet en zone rurale.[32]

En octobre 2021, NEOM Tech & Digital Hold Co et OneWeb ont signé un accord d'un montant de 200 millions de dollars américains pour créer une joint-venture (JV) visant à offrir la connectivité à haut débit par satellite à NEOM (un projet de ville en Arabie saoudite), à l'Arabie saoudite et au Moyen-Orient dans son ensemble, ainsi qu'aux pays d'Afrique de l'Est voisins. Après l'achèvement de l'infrastructure au sol en 2022, la nouvelle entité en joint-venture aura les droits exclusifs pour la prestation des services de OneWeb dans ses régions cibles pendant sept ans à partir du lancement du réseau de satellites en orbite terrestre basse (LEO), qui devrait commencer en 2023.[33]

Il reste pourtant du chemin à parcourir pour augmenter le nombre d'abonnements au haut débit par satellite et promouvoir le marché du satellite dans le monde arabe. Cela est important car le marché du satellite fait désormais partie intégrante de l'économie et de l'évolution de l'infrastructure numérique. Des technologies émergentes, comme les satellites en LEO, devraient également offrir des solutions peu onéreuses pour les communautés rurales. Selon la Banque mondiale, la connectivité dans les zones rurales avec un satellite en LEO a un coût nettement plus faible et de meilleures performances qu'avec un satellite traditionnel (Figure 25).[34] Les comparaisons de coûts du segment spatial de la Banque asiatique de développement (BAD) en sont une autre illustration : le coût des services de satellites en LEO par rapport aux satellites traditionnels (HTS) a chuté au cours des 20 dernières années, passant de plus de 7 dollars américains à 0,7 dollars américains. La BAD affirme qu'une nouvelle baisse des prix est attendue après 2020 en raison du déploiement de « nouvelles capacités à moindre coût fournies par les systèmes GEO-HTS et les constellations NGSO-HTS à l'échelle mondiale, par opposition aux impacts plus localisés des vagues précédentes de nouvelles offres HTS » (Figure 26).[35]

[32] The free encyclopedia. « High-throughput satellite. » Wikipedia. Consulté en décembre 2021. https://en.wikipedia.org/wiki/High-throughput_satellite

[33] OneWeb. « NEOM Tech & Digital Holding Company and OneWeb sign $200m JV for satellite network. » 26 octobre 2021. https://oneweb.net/media-center/neom-tech-digital-holding-company-and-oneweb-sign-200m-jv-for-satellite-network

[34] Banque mondiale. « Innovative Business Models for Expanding Fiber-Optic Networks and Closing the Access Gaps. » Décembre 2018. https://openknowledge.worldbank.org/handle/10986/31072

[35] Garrity, John et Husar, Arndt. « Digital Connectivity and Low Earth Orbit Satellite Constellations: Opportunities for Asia and the Pacific. » Banque asiatique de développement. Avril 2021. https://www.adb.org/publications/digital-connectivity-low-earth-orbit-satellite-opportunities

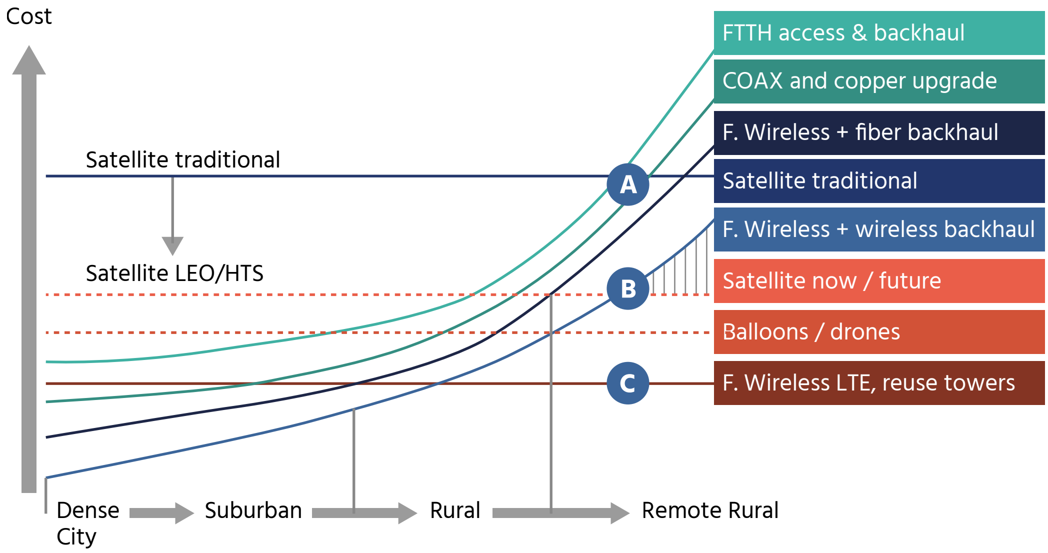


Figure 25. Coût relatif de fourniture d'accès par technologie. Source : Banque mondiale, Innovative Business Models for Expanding fiber-optic networks and closing the Access Gaps.

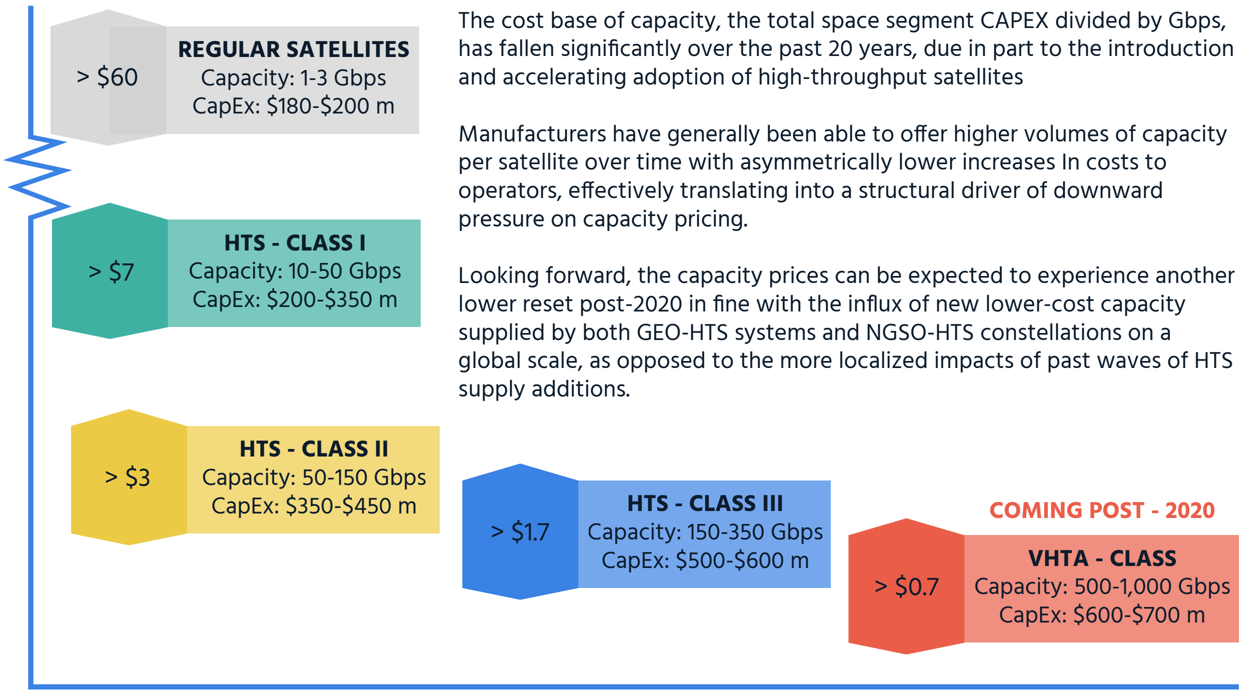


Figure 26. Comparaison des segments dans le domaine spatial (CAPEX en millions de dollars américains par Gbps). Source : Banque asiatique pour le développement, Digital Connectivity and Low Earth Orbit Satellite Constellations Opportunities for Asia and the Pacific

In addition to offering a considerable reduction in providing connectivity (compared to traditional satellite systems), the quality of service on LEO is close to fiber and fulfills the criteria for 5G backhauling. To this aim, global communications companies are investing now in the installation of LEO to secure reliable communications networks (Table 6). For example, OneWeb is targeting prices comparable with terrestrial microwave connectivity for backhauling services, enabling delivery of 4G and 5G services to users, and improving the connectivity of schools and universities in rural areas. SpaceLink is also targeting a unified tariff of US$99 for its services to end-users irrespective of their location.[36] That said, to reach the full potential of LEO, challenges vis-à-vis licensing should be addressed including the spectrum pricing required for delivery of services to end users, the international connectivity tariffs to facilitate the rollout of tbeleports, and the process for type approval for end-user equipment. Satellite operators are currently being licensed in Arab countries, but the governments may need to consider facilitating the process through a harmonized approach towards LEO to resolve some of these challenges and accelerate the pace of rollout of the services across the region.

Characteristics	SpaceX Starlink	OneWeb	Telesat Lightspeed	Amazon Project Kuiper
Number of LEO satellites launched[a]	1,445	146	1 (Telesat LEO 1)	0
Constellation size to initiate commercial service	1,440	648	298	578
Estimated total bandwidth throughput at the start of commercial operations	23.7 Tbps	1.56 Tbps	15 Tbps	unknown
Planned expansion (total future constellation size)	12,000 (FCC approved) to 30,000 (submitted to FCC)	2,000	1,600	3,236
Frequency	Ku-band	Ku-band	Ka-band	Ka-band
Orbit	560 km	1,200 km	1,000 km	590-630 km
Satellite mass	227-260 kg	150 kg	800 kg	unknown
Satellite life	5-7 years	-5 years	10-12 years	unknown
Latency	<50 ms	<50 ms	<50 ms	unknown
Required reported capital expenditure	$10 billion	$2.4 billion	$5 billion	$10 billion
Vertical markets publicly targeted	Consumer broadband, cellular backhaul	Backhaul, government, mobility, broadband	Government mobility, carrier-grade requirements	Broadband, backhaul

FCC = fedral Commission, kg = kilogram, km = kilometer, LEO = lower Earth orbit, ms = millisecond, Tbps = terabits per second.

Table 6. Differences in Deployments, Constellations, and Satellites. Source: Asia Development Bank, Digital Connectivity and Low Earth Orbit Satellite Constellations Opportunities for Asia and the Pacific.

[36] Interviews with OneWeb and Spacelink regional teams

4. Last-Mile Reach

4.1. Wireless

Despite the acceleration of 5G adoption in the GCC countries, 4G remains the main technology for mobile access in the Arab region. While the average 4G penetration in the MENA region is 37.2%, 3G and 2G penetrations are still significant at 36.8% and 25.8%, respectively. In the case of 4G adoption, Saudi Arabia has the highest rate (78.1%) followed by Bahrain at 69.9%, Qatar at 65.9%, and Kuwait at 57.6% (Figure 27). The GCC countries are also leading the region in the launch of 5G. Between May and June 2018, UAE, Qatar, Saudi Arabia, and Kuwait launched 5G mobile services. GCC operators Etisalat, Ooredoo, STC, and Zain are competing to deliver the fastest 5G services in their respective markets, leading to the early commercialization of 5G services. While some Arab countries are currently conducting 5G pilot testing, others have revealed plans to launch 5G mobile services between the years 2021 – 2025 (Figure 28).[37] However, it seems that the COVID-19 crisis has negatively affected those plans.

[37] Iacopino, Pablo, James Robinson, and Mike Meloan. "5G in MENA: GCC operators set for global leadership." GSMA Intelligence, November 2018. https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=35619025&file=5G%20in%20MENA%20GCC%20operators%20set%20for%20global%20leadership.pdf

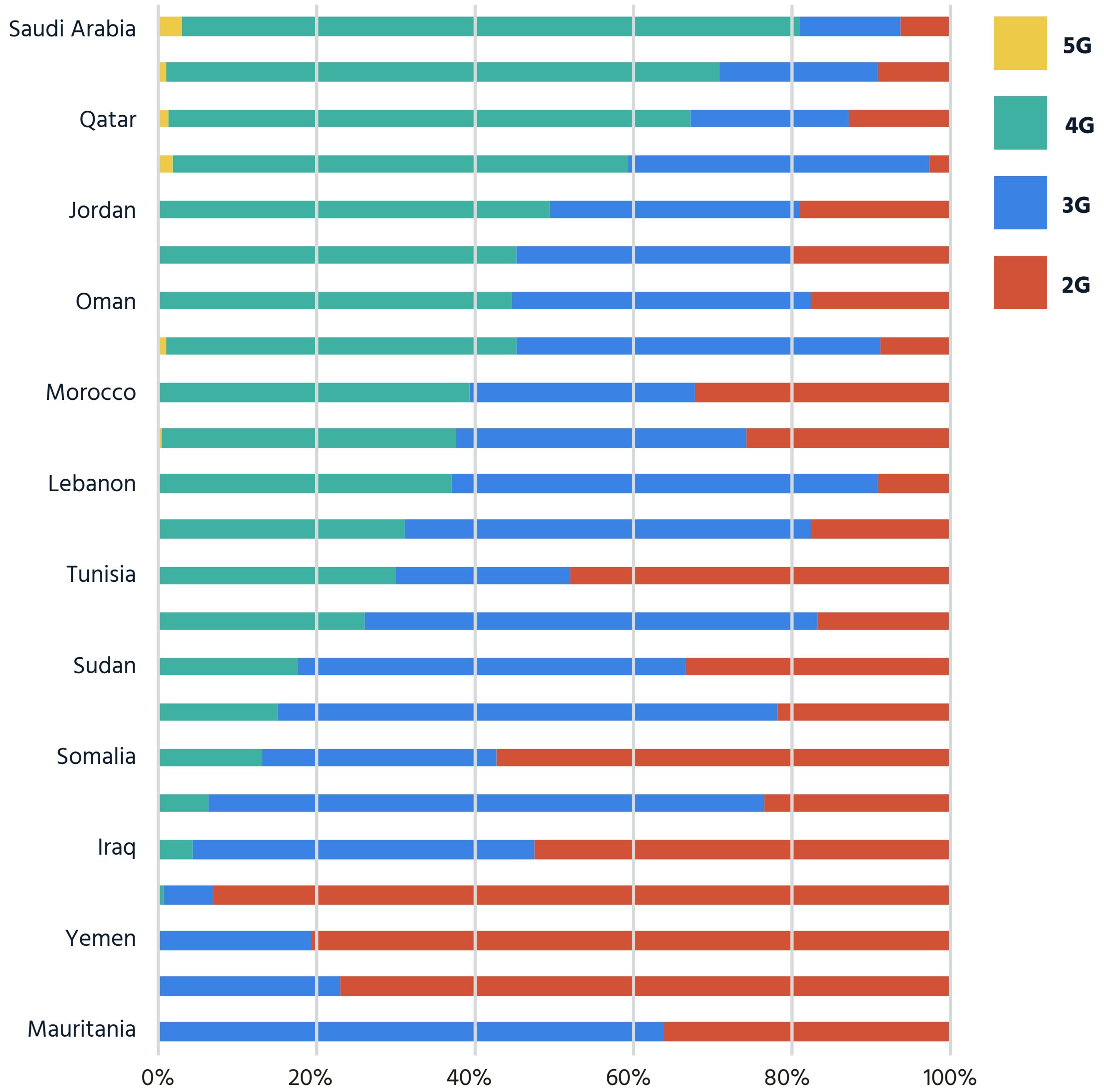
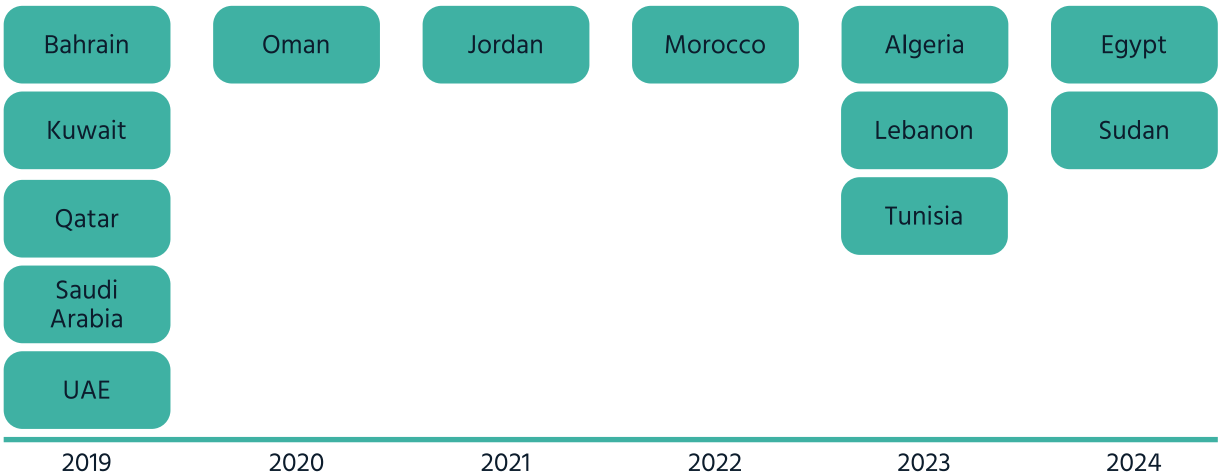


Figure 27. Breakdown of mobile users by technology. Source: GSMAi.



Note: excludes 5G-based fixed wireless
Source: operator announcements or GSMA Intelligence forecasts based on previous technology migration

Figure 28. Commercial launch of 5G mobile services in MENA. Source: GSMA, Team Analysis.

According to GSMAi's forecast of wireless technology adoption in the Arab countries, the Long-Term Evolution (LTE) of wireless broadband communication for mobile devices and data terminals will witness further development in the next five years. The highest 4G adoption rate in the Arab region was reported in KSA (39%). Between the years 2018 – 2025, 5G is expected to account for only 6% of total mobile connections, while most of the growth in connections will be in 4G (Figure 29).[38]

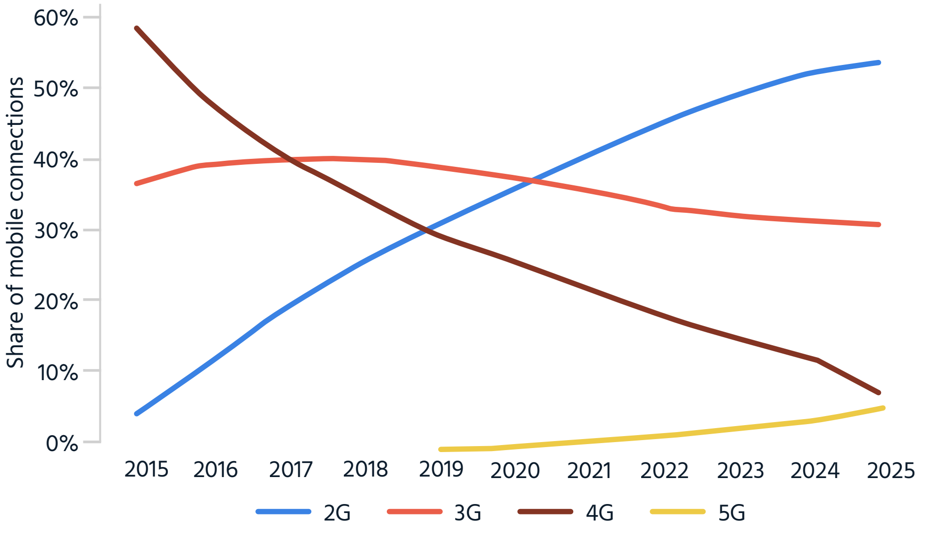


Figure 29. MENA mobile connections by technology (Excluding licensed cellular IoT and fixed wireless). Source: GSMAi.

Other significant aspects of wireless connectivity in the Arab countries represent major challenges. At one extreme, there were 264M mobile Internet subscribers, representing 43% of the population in the MENA region in 2019. At the other extreme, 47% of the MENA population was covered by mobile broadband networks but was not subscribed to mobile Internet because of various barriers. The remaining 10% of the population is still not covered by a mobile broadband network due to challenges related to network availability in rural areas (Figure 30).[39] This, in turn, necessitates a new definition of a universal service right that hinges on the lessons learned from the earlier application of universal service schemes and the commercial launches of zero-rating tariffs as in the case of Facebook Free Basics. Further elaboration on the concept of universal services is addressed in Section III of the report.

[38] Ibid

[39] GSMA. "The Mobile Economy Middle East & North Africa 2020." Accessed December 26, 2021. https://www.gsma.com/mobileeconomy/mena/

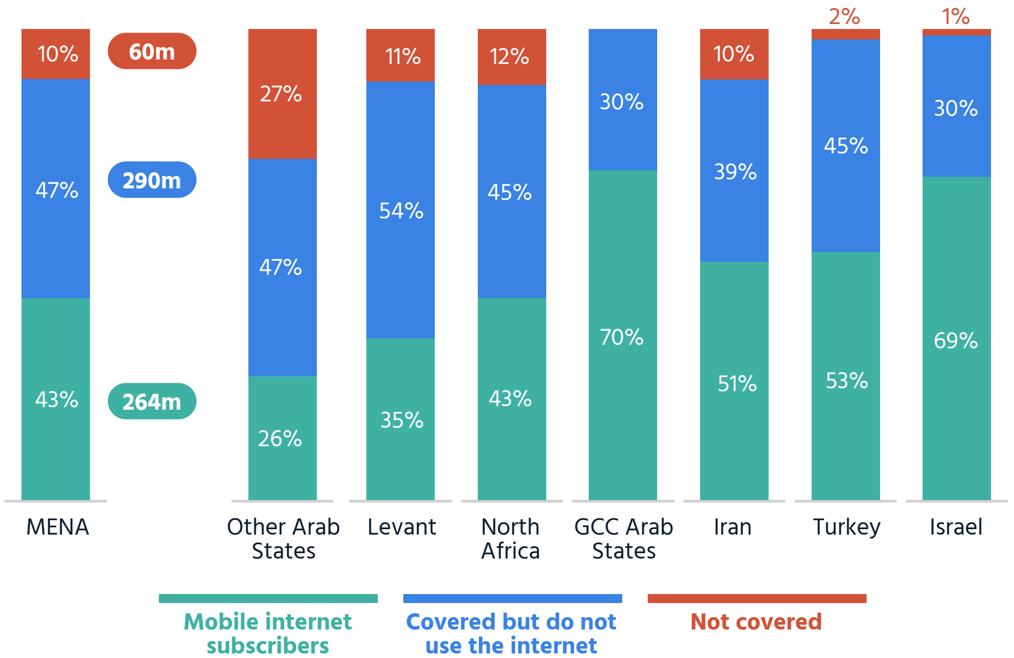


Figure 30. Population utilizing mobile Internet (2019). Source: GSMAi.

In terms of spectrum policies, many MENA countries have made less substantial spectrum available which has resulted in limiting network capacity, increasing the cost of network deployment, and, therefore, increasing prices to end users. For example, North African countries have spectrum holdings below the average amount licensed in other developing countries (100MHz per operator) as well as globally (150MHz per operator) (Figure 31).[40] Among all the Arab countries, Tunisia (339 MHz) and Saudi Arabia (340 MHz) has the highest available spectrum compared to the developing countries average (350 MHz per country) and the global average (480MHz per country) (Figure 32).

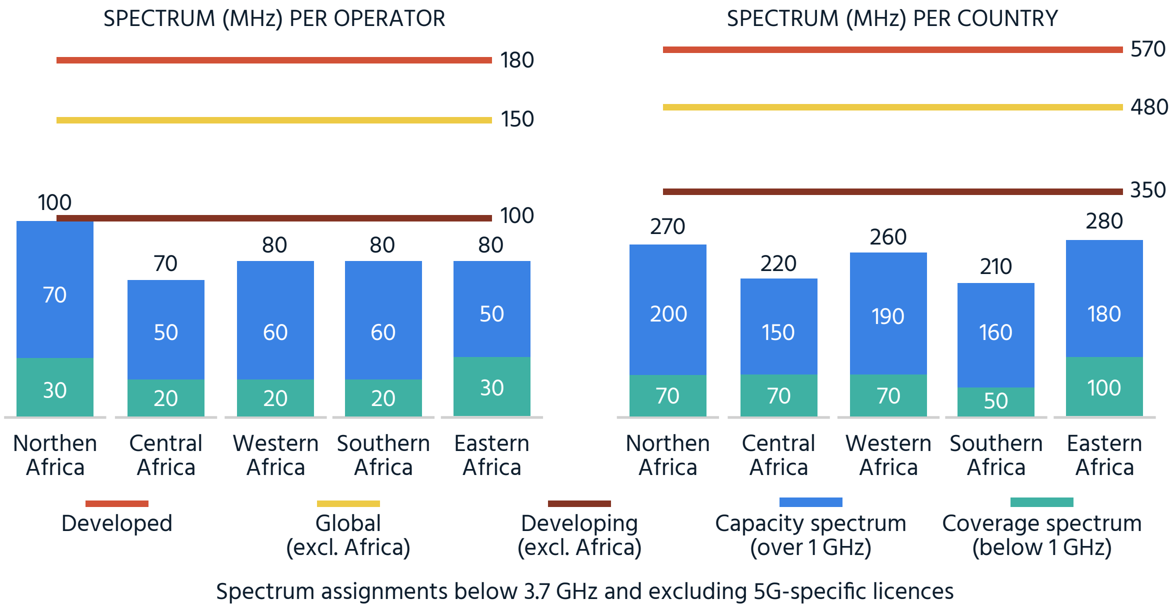


Figure 31. Average spectrum per operator and country, 2019. Source: GSMAi.

[40] Pedros, Xavier, Kalvin Bahia, Pau Castells, and Dennisa Nichiforov-Chuang. " Effective Spectrum Pricing in Africa: How successful awards can help drive mobile connectivity." GSMA. November 2020. https://www.gsma.com/spectrum/wp-content/uploads/2020/11/Effective-Spectrum-Pricing-Africa.pdf

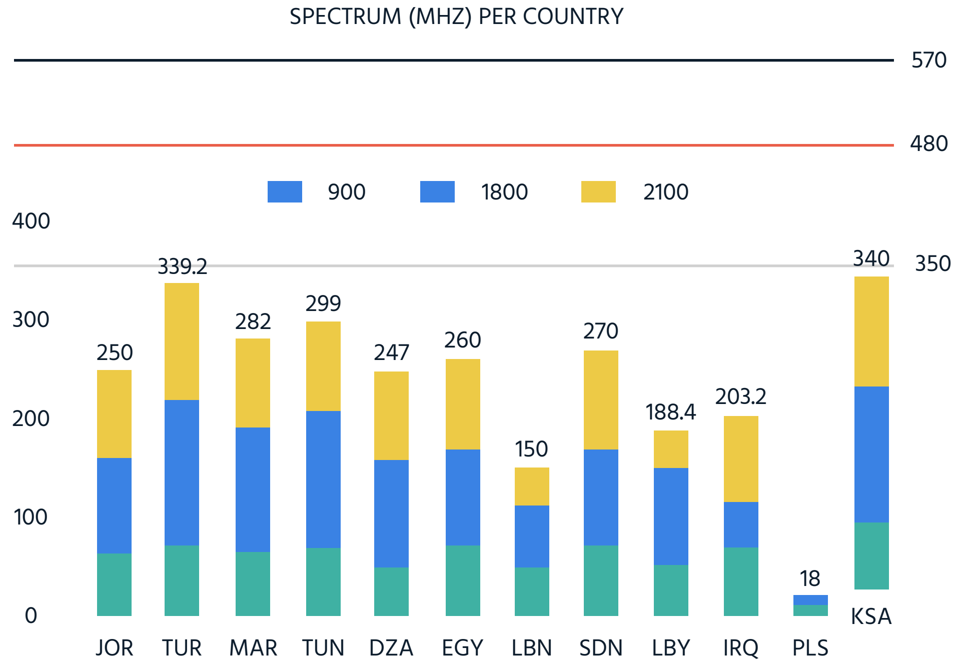


Figure 32. Spectrum allocation in North Africa and some MENA markets, 2019. Source: GSMAi.

The case of Saudi Arabia is a good illustration of the rollout of the 5G spectrum in the Arab region. Saudi Arabia was among the first countries in the region to allocate mid-band spectrum for 5G, with auctions of the 2.3 GHz, 2.6 GHz, and 3.5 GHz bands, which were completed in early 2019. Low band spectrum (700 MHz and 800 MHz bands) was awarded earlier mainly for 4G, but operators can use it for 5G alongside their licenses which are technology neutral. This was further espoused by the National Transformation Program (NTP) introduced in 2020 to secure more spectrum for the provision of mobile broadband or the International Mobile Telecommunications (IMT) spectrum. Since 2017, the Communications and Information Technology Commission (CITC) has held four auctions for existing and new IMT bands that varied between 700 - 1800 MHz and 2.3 – 2.5 GHz. This provided local operators with access to more than 1000 MHz of IMT licensed spectrum to be used in the sub-6 GHz range which raised the par in the country in line with developed countries in Europe, the Americas, and the Asia Pacific.[41]

[41] Jervis, Val, Tim Miller, Yi Shen Chan, Akhiljeet Kaur, and Aude Schoentgen. "MENA 5G spectrum – setting out the roadmap." GSMA. October 2020. https://www.gsma.com/spectrum/wp-content/uploads/2020/10/Roadmaps-for-awarding-5G-spectrum-in-the-MENA-region.pdf

As far as last-mile Internet connectivity is concerned, telecom Tower Companies (TowerCos) can promote network sharing and hence improve the rollout of 5G in the MENA region. TowerCo does not only provide a better approach to network investment, but it can also result in significant improvement in Internet affordability, Internet speed, and mobile Internet penetration. It could further promote the economics of wireless broadband deployment and the mobile connectivity market, address consumers' demand, and boost technological advancement (Figure 33). For these reasons, TowerCo started gaining momentum across the MENA region (Figure 34),[42] yet the region is still falling behind and had the lowest penetration rate (11%) compared to other emerging markets (Figure 35), with an average of four out of ten countries having no active ToweCo. This could be attributed to the absence of some regulatory measures to promote the entry of TowerCos vis-à-vis licensing, fees, access regulation, and business regulation.[43]

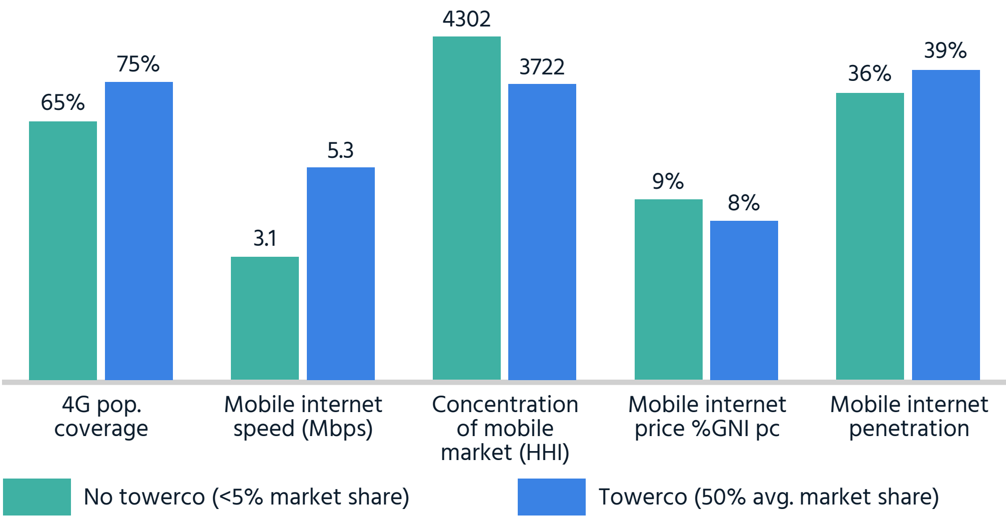


Figure 33. Towercos and Mobile Connectivity. Source: IFC, based on data from GSMA Intelligence, ITU, TowerXchange, and Ookla in 2019.

[42] Aninder Khera, "Finding value in MENA tower investments," TowerXchange, May 18, 2020. https://www.towerxchange.com/data/news/documents/b1qxdvrmwpwm96/finding-value-in-mena-tower-investments.

[43] Georges V. Houngbonon, Carlo Maria Rossotto, and Davide Strusani, "Enabling A Competitive Mobile Sector in Emerging Markets Through the Development of Tower Companies," International Finance Corporation, June 2021, https://www.ifc.org/wps/wcm/connect/938e73d8-94cc-40b5-a5af-aa7c016c8f67/EMCompass_Note_104-web.pdf?MOD=AJPERES&CVID=nEqOjj8.

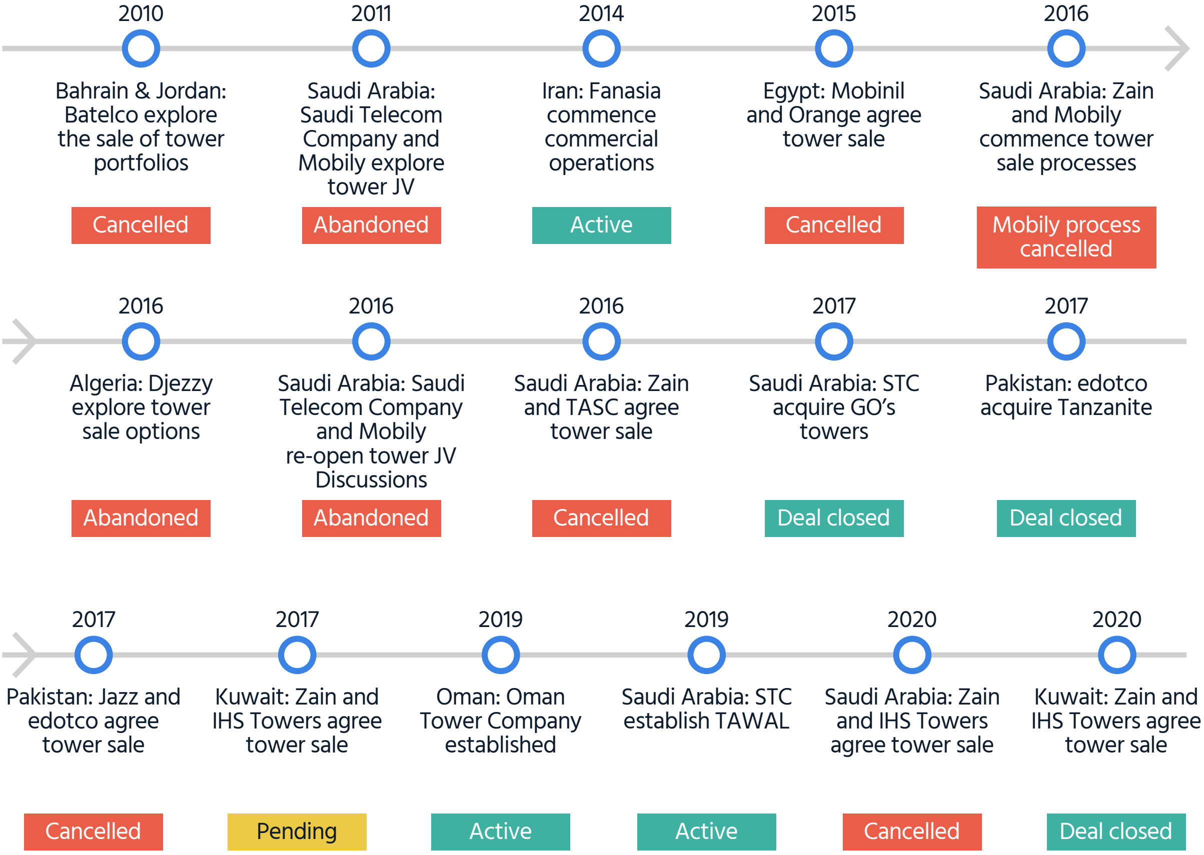


Figure 34. Recent history of tower transactions, joint ventures, and TowerCo activity in MENA. Source: TowerExchange

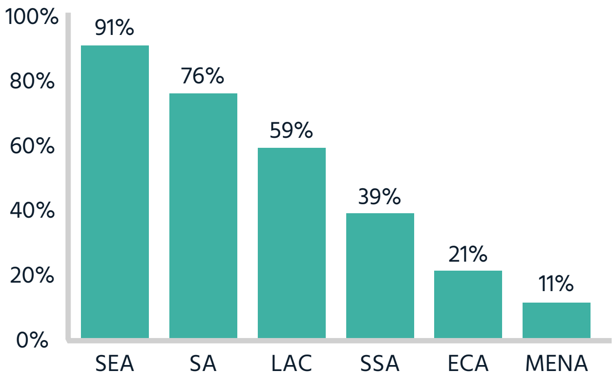


Figure 35. Share of Towers Managed by Towercos in Emerging Markets in 2020. Source: IFC estimates based on data from TowerXchange.

4.2. Wireline

On the question of fixed broadband in the MENA region, UAE (98%) and Qatar (86.6%) are leading the region in the Fiber-to-the-Home/Building (FTTH/B) take-up with significantly high adoption of fiber services (Figure 37). Saudi and Bahrain are following their lead as more customers are switching to fiber (Figure 38). Still, the majority of middle-income countries with historically extensive telephone networks are highly contingent on ADSL compared to FTTH or fixed wireless connection, i.e., Egypt, Morocco, Algeria, Syria, Lebanon, Tunisia, Jordan, and Palestine (Figure 37). However, the approach of these countries to upgrade the broadband infrastructure differs depending on the market structure (Figure 39). Whereas liberalized markets adopt an array of technology alternatives, concentrated markets tend to follow a single technology approach.

On the other hand, wireless broadband is offering an intermediate solution to overcome the limited reach of the copper/fiber network which is the key challenge for ADSL/FTTX services in the region. Several countries have opted to fixed wireless as a solution for broadband as in Iraq, Kuwait, Sudan, Libya, and Oman (Figure 37). These countries went to utilize the wide deployment of 4G and in some cases 5G, technologies to offer fixed broadband services. That said, the growth of 5G is promoting the deployment of FTTH in the region given the emerging need to interconnect base stations with fiber and the growing demand for higher bandwidth and low latency which can only be secured by FTTH.[44]

[44] FTTH Council MENA. "FTTH Council MENA - Panorama." September 2019. Accessed December 26, 2021. https://www.ftthcouncilmena.org/FTTH-Council-MENA-Panorama-2019.pdf

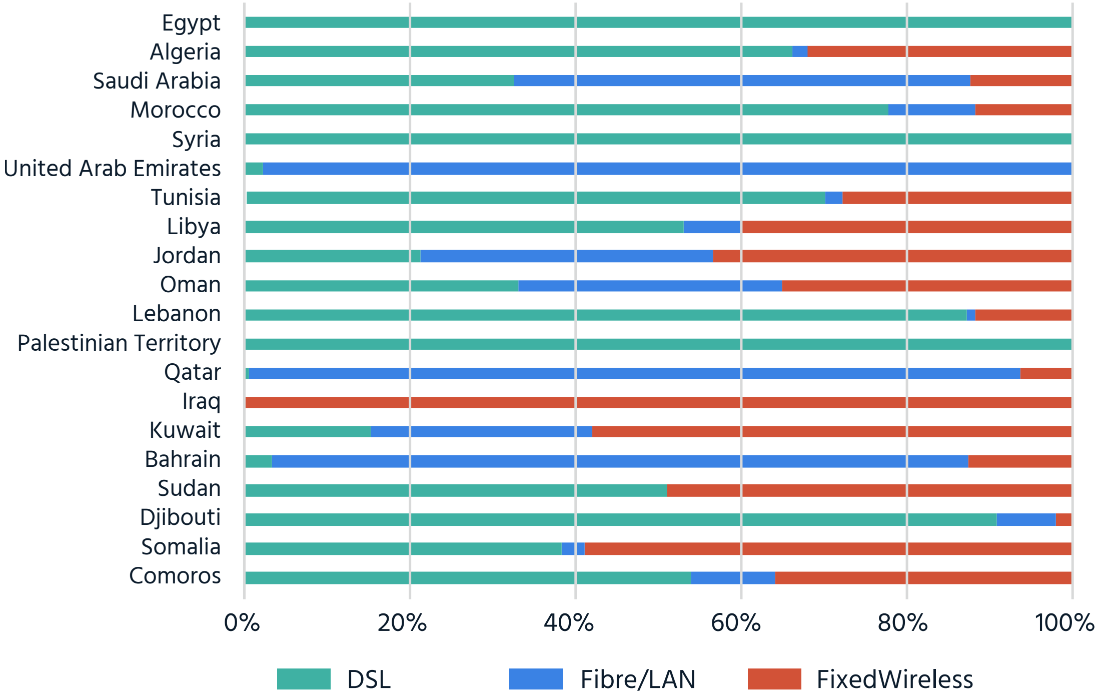


Figure 37. Fixed BB Access by Technology, 2020. Source: Telegeography, Global Comms.

To improve the fiber reach, some MENA countries have allowed local electric utilities to establish fiber optics networks using electricity infrastructure. This can be illustrated briefly by the example of Umniah Mobile Co and Jordan Electric Power Company (JEPCO) which established a joint venture (FiberTech) to roll out a fiber optic network to reach more than 1.3M households and businesses.[45] In a similar case in Saudi Arabia, the Integrated Dawiyat,[46] Saudi electricity company's fiber optics subsidiary, was founded in 2009 by the Saudi Electric Company (SEC) to establish fiber infrastructure across the country. Dawiyat has established 80,000 Km of Fiber Optics, 1500 points of presence (POPs), 200 telecom towers, and 2 data centers in Riyadh and Jeddah. The company also provides several services related to capacity (dark fiber and wavelength), data (ethernet and bitstream), and data Centers (colocation and site-sharing). In 2017, Dawiyat signed agreements with licensed operators for collaboration in the rollout of fiber to end users.

[45] Umniah. "JEPCO & Umniah Partnership for A Better Internet Service." Accessed December 26, 2021. https://www.umniah.com/en/explore-umniah/jepco-umniah-partnership-for-a-better-internet-service/

[46] See https://www.dawiyat.com.sa/

Other MENA countries have enabled legislation for alternative infrastructural solutions. For example, the law allows broadband-licensed ISPs to use the infrastructure established for non-telecommunications operators in Palestine. Recently, the Ministry of Telecom and Information Technology of the State of Palestine (MTIT) has permitted the Jerusalem District Electric Company (JDECO) to deploy fiber optics which rolled out around 380km of fiber optics along its electrical lines. The JDECO has also offered its fiber optics infrastructure to the ISPs, and it might lease infrastructure to other operators in the future.[47] In November 2021, MTIT further announced a partnership between North Electric Company and Mada (a licensed service provider since 2010) to roll out a fiber optic network in Naples and Jenin.[48]

There are different models of fiber rollout across the MENA countries depending on the market structure where the number of operators allowed to deploy the infrastructure as well as the market share of the main service provider influence the approach of fiber deployment. In this vein, different approaches to fixed broadband technology have been adopted depending on the market structure across competitive markets. In highly concentrated markets, a single technology is usually dominating, while in competitive markets operators usually resort to different technology options (xDSL, fiber, or wireless). For example, xDSL is dominant in the Egyptian market compared to UAE which has upgraded to fiber (Figure 39). However, Saudi Arabia and Bahrain, which have highly competitive markets, adopt a diverse technology mix that is changed often. For example, both countries embarked on wireless technology, as a swift solution for infrastructure competition, while the market is gradually upgrading to fiber (Figure 38).

[47] World Bank Group. "The Telecommunication Sector in the Palestinian Territories: A Missed Opportunity for Economic Development." January 2, 2016. https://openknowledge.worldbank.org/bitstream/handle/10986/24019/104263.pdf?sequence=5

[48] Palestinian Ministry of Telecom and Information Technology, "Palestinian Ministry of Telecom & IT, North Electricity, and Mada sign a collaboration agreement for rollout of fiber optic network," November 16, 2021, https://mtit.pna.ps/Site/New/307.

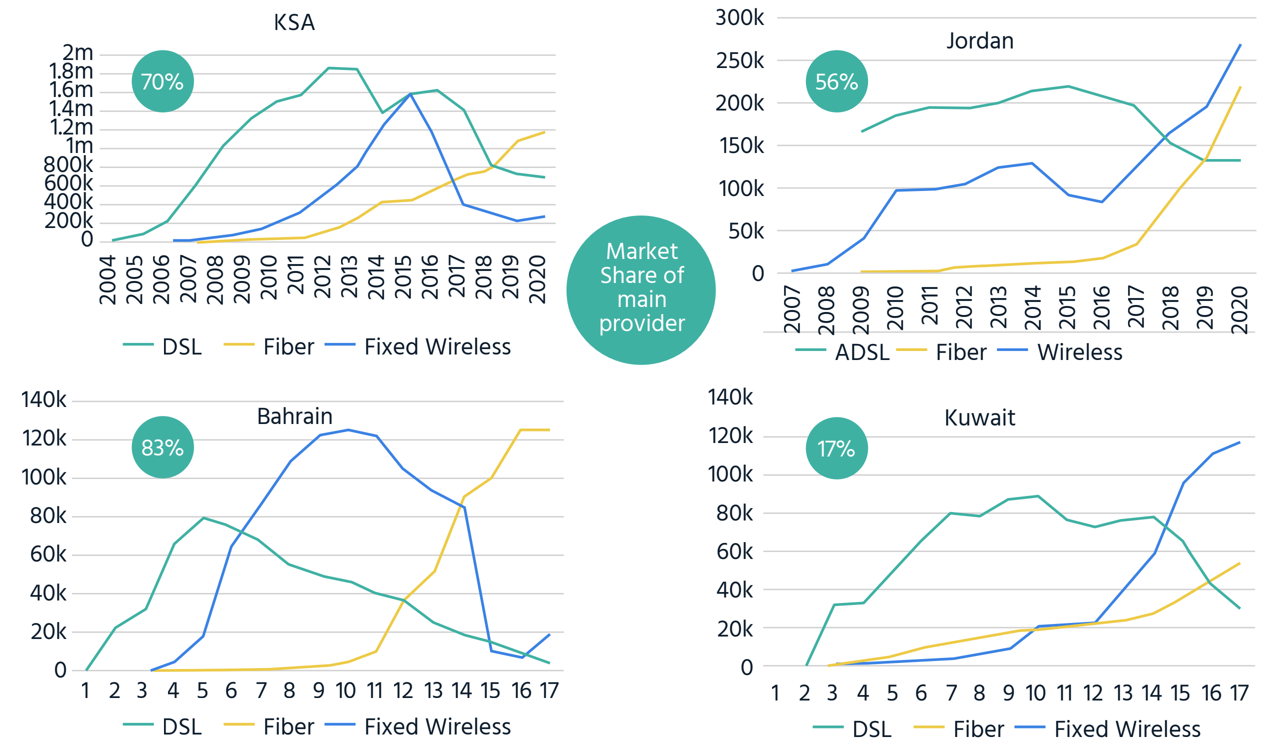


Figure 38. Different approaches to Fixed BB technology. Source: Telegeography.

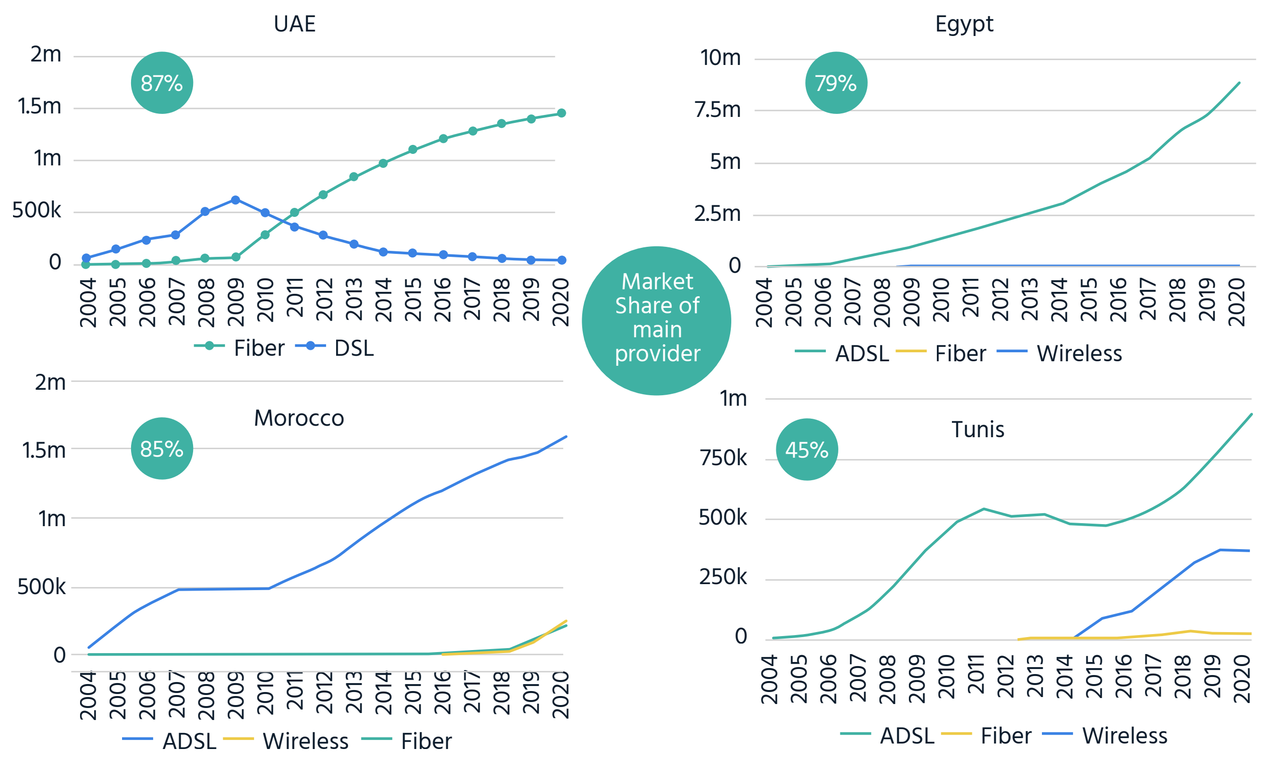


Figure 39. Different approaches to Fixed BB technology. Source: Telegeography

The World Bank contends that FTTH is a cost-effective option for domestic broadband development rather than incremental upgrades of xDSL technologies (ADSL, vDSL, and FTTH) (Figure 40). According to the World Bank's proposed business model of expanding the fiber-optic network, it is more expensive to upgrade from ADSL to VDSL and then to FTTH (US$600-1000) than to invest directly in fiber (US$400-600) mostly due to the continuous rise in the price of technology as well as the upgrading cost (Figure 41).[49] This business model was adopted by Orange Jordan which replaced copper with FTTH directly rather than gradually upgrading the ADSL.

Nonetheless, some incumbent operators in MENA countries have opted for the gradual upgrading of infrastructure rather than an immediate upgrade to fiber. Closer analysis demonstrates that this approach is usually espoused due to the interplay between the national technology policy and the economic interests of incumbent operators. In fact, with the absence of ambitious national broadband targets, the resolution is predominantly influenced by commercial motives. This is because incumbent operators tend to prioritize short-term benefits that are associated with gradual technology upgrades, i.e. fewer investments and minimal challenges with the operations and deployment of infrastructure. This is further reinforced by the absence of competitive pressures, such as the possibility of having new market entries that could utilize the existing infrastructure or develop cost-effective wireless technologies, which could make such a decision viable in the long term.

[49] World Bank. "Innovative Business Models for Expanding Fiber-Optic Networks and Closing the Access Gaps." December 2018. https://openknowledge.worldbank.org/handle/10986/31072

Technology	Perspective	Existing capability	Upgrade option	Long term
Copper/xDSL	Technology	1-20Mbit/s (ADSL)	20-50Mbit/s (VDSL)	>100Mbit/s (G.Fast)
	Business	Under commercial pressure if alternatives available	Valid upgrade with low competition, upgrade to fiber otherwise	Valid upgrade in niche cases only. Upgrade to fiber.
Coaxial cable/ DOCSIS	Technology	30-100Mbit/s (DOCSIS 3.0)	100-250Mbit/s (DOCSIS3.1)	>500Mbit/s
	Business	Under moderate commercial pressure from fiber-based service, if available	Valid upgrade for existing, modern DOCSIS networks, upgrade to fiber otherwise	Valid upgrade for updated DOCSIS networks, upgrade to fiber otherwise
Fiber/GPON	Technology	100-1000Mbit/s (GPON)	100-1000Mbit/s (GPON)	>1000Mbit/s (xxPON)
	Business	Competitive in performance and cost	Competitive in performance and cost	Competitive in per-formance and cost

Figure 40. World Bank, Evolution of Fixed Access Technologies. Source: TMG/Salience Consulting.

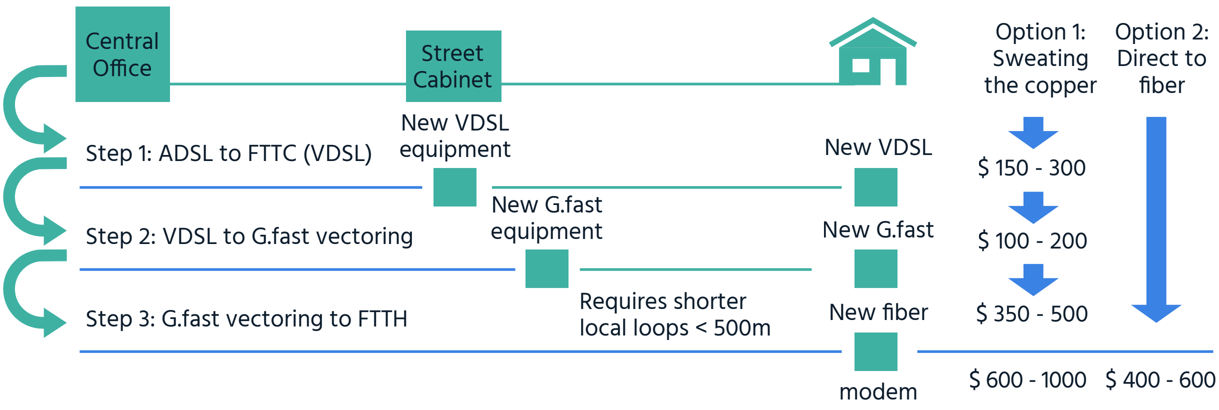


Figure 41. World Bank, The Case for Upgrading to Fiber. Source: TMG/Salience Consulting.

5. Additional Access Networks

5.1. National Research and Education Network (NREN)

The Arab States Research and Education Network (ASREN) was established in June 2011 under the patronage of the League of Arab States to provide e-Infrastructures and e-services to the Arab research and education communities. To this aim, ASREN provides high-speed data-communications networks to connect Arab education and research institutions and the wider global network through advanced computing technology.[50] It further connects National Arab Networks to European GEANT in London supported by the European Commission through EUMEDCONNECT and AFRICACONNECT projects (Figure 42).[51]

Figure 42. Connectivity of Arab States to European Research Networks. Source: ASREN

[50] See https://asrenorg.net/?q=content/what-asren

[51] Foley, Michael. "The Role and Status of National Research and Education Networks in Africa." World Bank. 2016. Accessed December 27, 2021. https://openknowledge.worldbank.org/handle/10986/26258

Since 1987 most Arab countries have established their NERNs. Now, most of the Arab countries are operating their own NRENs (Table 7), yet some of these networks are not operational or still in the planning phase (Figure 43).

Country	Name	Date	Conn-ection	POP	Intl	Gbps	Tech	Core Tech	Speed (Mbps)	Edge	Website
Egypt	EUN	1987	122		2	4.5		Ipv6	34-1000	IPv6	www.eun.eg
Algeria	ARN	1994	110	9	2	3.1	mpls/ GegaE	IPv6	10-100	IPv4	
Tunisia	(RNU)	1997	500			10			10-155		http://www.cck.rnu.tn/
Morocco	MARWAN	1998	200						100-5000	IPv6	www.marwan.ma
Syria	(SHERN)	2001				0.155					
Jordan	JUNet	2003	12		1	1	mpls		1000		http://www.junet.edu.jo/
Sudan	SudREN	2004	100	2	1	0.5	mpls				
Somalia	somaliREN	2006	21	8							https://somaliren.org/
UAE	(Ankabut)	2006	25	6	3	10	IPoE	IPv6	1000	IPv6	http://www.ankabut.ae
Palestine	PalNREN	2010	15								http://www.palnren.net/
Saudi	MAEEN	2011	53		1	1			10000		https://www.maeen.sa/en/
Qatar	QNREN	2013			3		Ether-net		10000-40000		http://www.qnren.qa
Lebanon	NREN	2016	7		1	5.26					
Oman	OMREN				5		mpls		250-1000		https://www.omren.om/

Figure 42. Connectivity of Arab States to European Research Networks. Source: ASREN

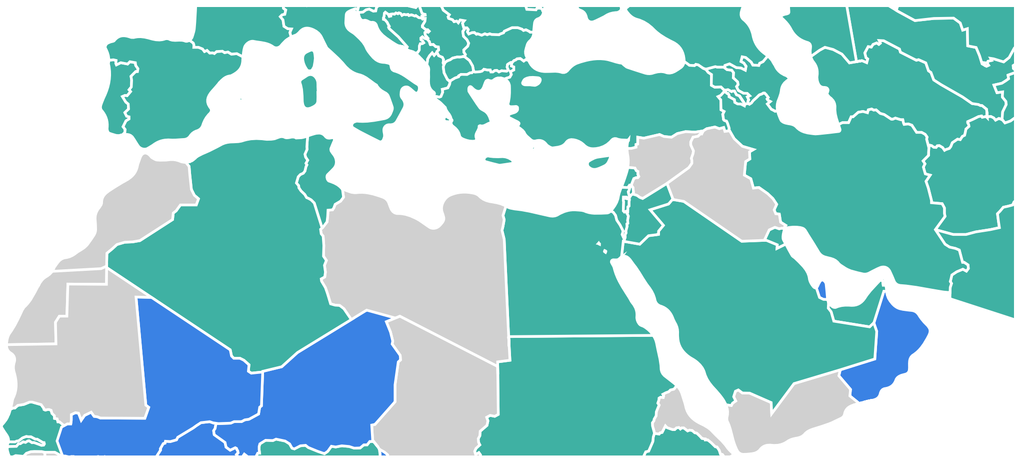


Figure 43. Countries with operational NRENs or in advanced planning for one. Source: World Bank[52]

[52] Ibid,

5.2. Community Networks

Community Networks can be described as communications infrastructure, designed and erected to be managed for use by local communities, in any part of the world. Community Networks provide a solution that addresses the connectivity challenges that exist in underserved areas of the world. They are well over forty-nine (49) community network initiatives in fifteen (15) African countries.[53]

Arab regions do not yet have Community Networks in their classical definition. However, media reports across Arab States show the spread of unregulated networks across several middle and low-income States: Egypt, Iraq, Lebanon, Palestine, and Yemen (Figure 44). These networks vary in size, location, ownership model, and technology used. Yet they all have the same background: initiatives by the local entrepreneurs to resolve the usage or coverage gaps in their respective communities.

Such networks result from a mismatch between the need of low-income communities for low-cost Internet service, and the prevailing market offerings aiming towards optimizing operations to achieve the highest return on operator's investments and sales. Although unlicensed networks prove themselves to be efficient means for providing basic access to users, it still represents a challenge as a reliable service. Challenges with degrading quality of service and risks of security breaches are 2 main concerns that are typical to such networks. Hence, governments in most of the Arab markets crack down on such unlicensed networks.

Although those networks do not fit the typical definition of a Community Network, several of them could be good candidates for upgrading to full-fledged community networks once the regulatory frameworks allow for that. Understanding of founders of those unlicensed networks to their customers' needs and economic capabilities, and the low-operational costs of unlicensed networks would allow affordable offerings that would accelerate access to Internet services and facilitate digital inclusion much faster than conventional offerings by service providers.

[53] Adebunmi Adeola Akinbo, "THE IMPORTANCE OF COMMUNITY NETWORKS: COMMUNITY NETHUBS", ISOC, https://isoc.ng/the-importance-of-community-networks-community-nethubs/

Figure 44. Media reports from Egypt, Jordan, Iraq, Lebanon, Yemen, and Palestine about unlicensed networks[54]

[54] Figure 44. Media reports from Egypt, Jordan, Iraq, Lebanon, Yemen, and Palestine about unlicensed networks

6. Toward Ubiquitous Access

Governments need to identify their role in infrastructure rollout depending on the economic setup of the market. To this aim, the World Bank provides a decision-making tool for policymakers to help them decide on any required infrastructure-specific deployment and to address relevant challenges. To successfully deploy infrastructure, the tool provides several business models including segmentation, financing, management, and revenue generation. It is designed around seven scenarios alongside a null scenario, which suggests that states should abstain from taking any action when there is "no demonstrable market or regulatory failure to address."[55] This model further suggests that regulations could be the hindering factor behind the lack of connectivity and/or market competition (Figure 45).

According to the estimation of the ITU of the required investment to provide universal access to broadband connectivity by 2030, policy and regulation require the least investment followed by ICT skills and the development of digital content. The most expensive intervention is the mobile infrastructure Capital expenditures (CAPEX) which requires almost 40% of the total global investment to reach the last mile of broadband (Figure 46).[56]

[55] World Bank. "Innovative Business Models for Expanding Fiber-Optic Networks and Closing the Access Gaps." December 2018. https://openknowledge.worldbank.org/handle/10986/31072

[56] International Telecommunication Union. "Connecting Humanity: Assessing investment needs of connecting humanity to the Internet by 2030." 2020. Accessed December 26, 2021. https://www.itu.int/hub/publication/D-GEN-INVEST.CON-2020/

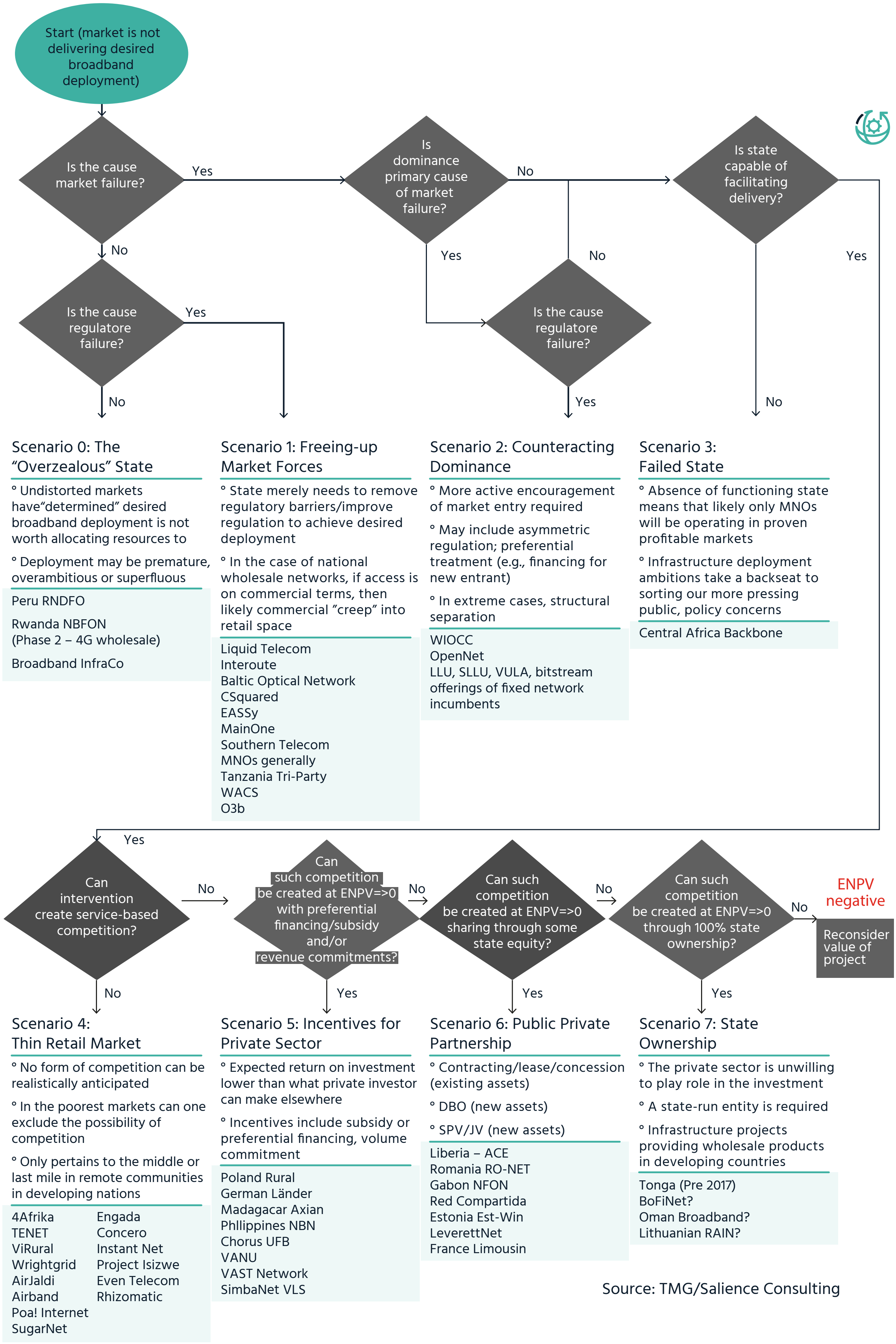


Figure 45. World Bank, Decision-tree for scenarios for the state's role in infrastructure deployment. Source: TMG/Salience Consulting.

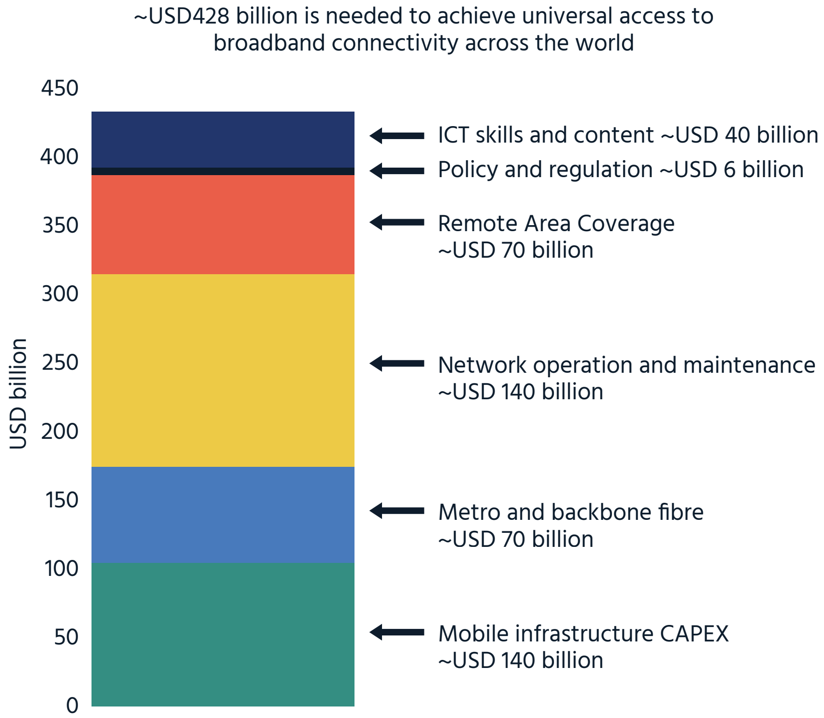


Figure 46. Investment is needed to achieve universal access to broadband connectivity by 2030.
Sources: Estimates based on ITU, GSMA, A4AI, operator, and regulator data.

In that sense, it is important to continue upgrading the regulations across the MENA region to accelerate infrastructure deployment. To help policymakers pinpoint the gaps in the regulatory frameworks, the ITU developed the ICT Regulatory Tracker which provides an assessment of the regulatory evolution from Generation 1 to Generation 5 in the collaborative regulation benchmark. While G1 represents a command-and-control approach, G2 represents partial liberalization and privatization. G3 signifies an enabling environment for investment, innovation, and access. The shift to address the socioeconomic policy goals is reflected in G3. Finally, G5, which hinges on the foundation of G3 and G4, represents a more collaborative approach to address the impact of the digital economy (Figure 47).[57]

[57] See https://app.gen5.digital/tracker/about?_ga=2.67074150.997689923.1640604273-1850564804.1640604273

Figure 47. Generations of regulation: G1 to G5. Source: ITU

Until 2019, only four Arab countries (18%) out of twenty-two have graduated to G4 and G5. The average score of the region (64,1) is below the global score (73,7). The first country to reach G4 was Morocco in 2009 which ranked 11th worldwide on the ITU's ICT Regulatory Tracker. Following Morocco, the GCC countries are leading the region in G4; Saudi Arabia (23rd), Oman(39th), and Bahrain (51st). Jordan, which is in G3, is the fifth Arab country and the 68th globally (Figure 48).[58]

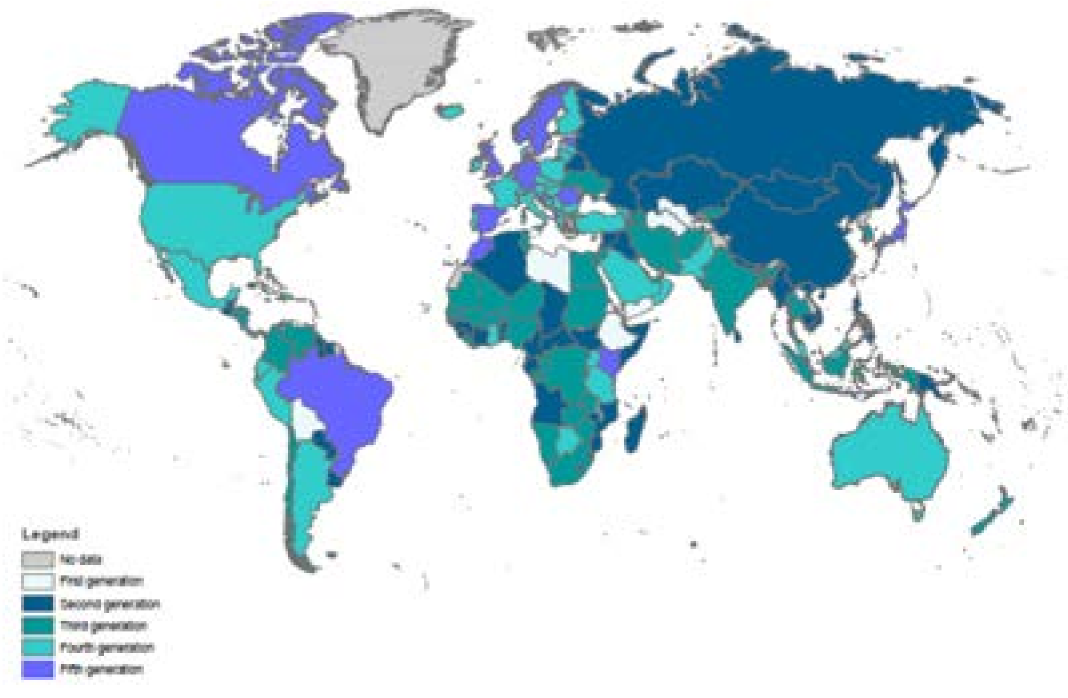


Figure 48. Generations of regulation – where do we stand in 2019? Source: ITU

[58] International Telecommunication Union. "Global ICT Regulatory Outlook 2020: Pointing the way forward to collaborative regulation." 2020. Accessed December 27, 2021. http://handle.itu.int/11.1002/pub/81510992-en

Progress up the generation ladder has been slower than in most other regions, although the pace is likely to accelerate over the next two years with major reforms in the pipeline in several Arab countries, on top of the Kuwait and UAE. While most of the improvements in the region have resulted from G2 countries moving up to G3 and, to a lesser extent, G3 countries to G4, one fifth of all Arab countries remain in the G1 group (Figure 49). This underscores the need to include more focus on Internet regulations to establish a level playing field for small and medium enterprises (SMEs) working in providing digital services (i.e., peering, unbundling of network elements, international gateway liberalization), while revisiting the regulatory frameworks in the region.

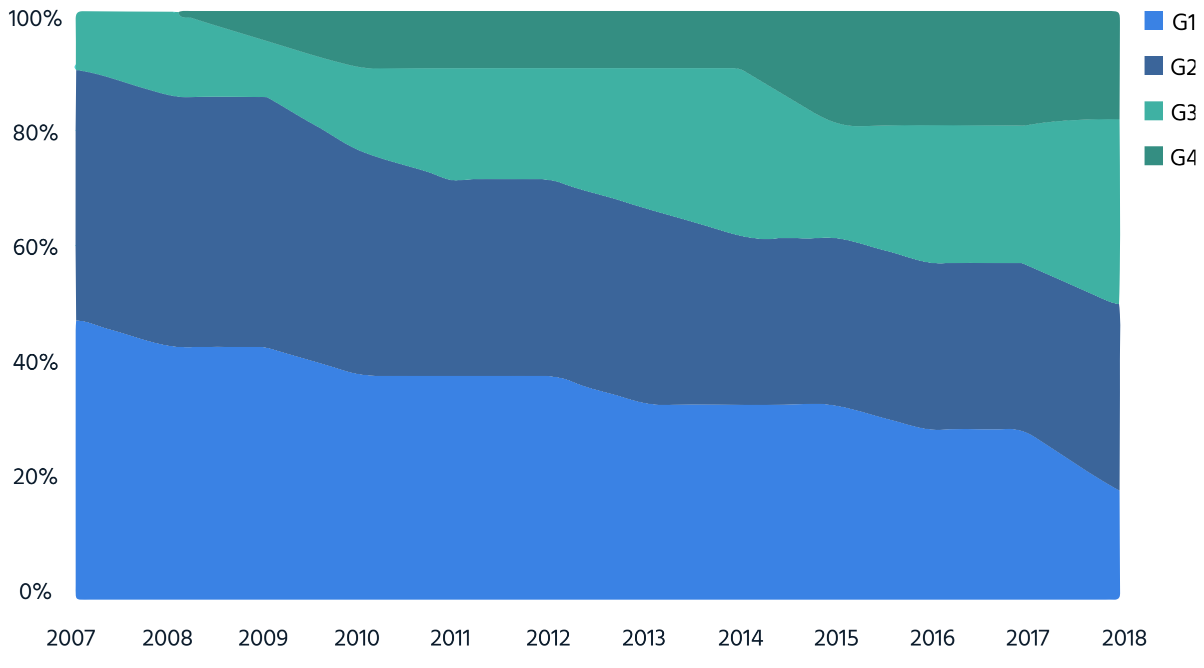


Figure 49. Evolution of the generations of ICT regulations, in Arab countries. Source: ITU

Moreover, the ITU analysis reflects the strong correlation between improved regulatory frameworks and wider broadband access. An analysis of the ICT Regulatory Tracker from 2017 – 2020 indicates that higher generations of G4 and G5 regulations boost mobile and fixed broadband penetration. Regarding mobile broadband, good regulatory frameworks can support the surge of mobile broadband while upholding new technologies to address the market needs (Figure 50). The regulatory frameworks have further proved to be quintessential to developing the fixed broadband market (Figure 51).[59]

[59] International Telecommunication Union. "Global ICT Regulatory Outlook 2020: Pointing the way forward to collaborative regulation." 2020. Accessed December 27, 2021. http://handle.itu.int/11.1002/pub/81510992-en

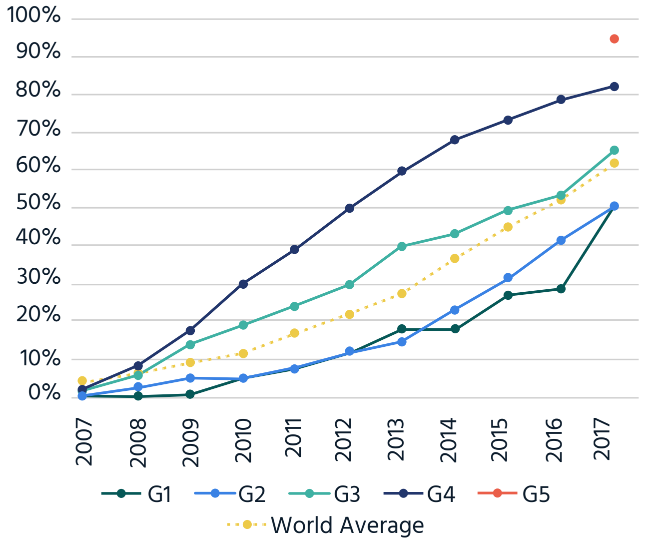


Figure 50. Active mobile broadband subscriptions per 100, per generation of regulation, 2007-2017. Source: ITU.

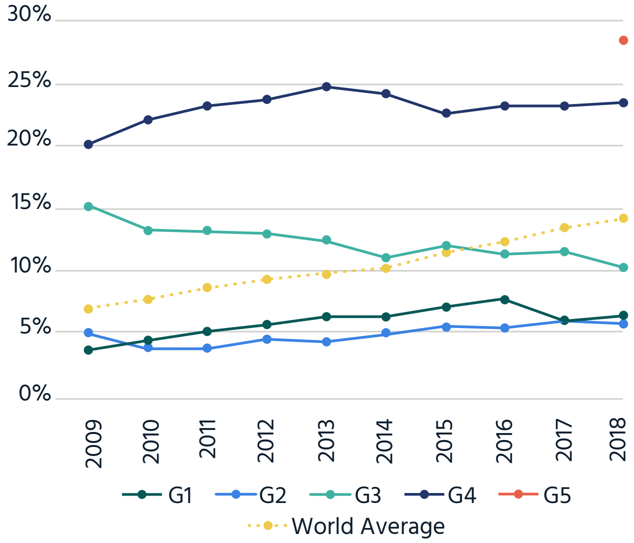


Figure 51. Fixed broadband subscriptions per 100, per generation of regulation, 2009-2018. Source: ITU

Recommendations for governments to work toward ubiquitous connectivity

- **Enhancing the governing structures by identifying the role of governments in undertaking the investment required to upgrade the legal frameworks and enhancing the regulatory effectiveness:**
  - ◊ Promoting a collaborative approach for national technology planning and network development and capitalizing on the National Network Operator Groups (NOGs) as a channel to engage technical professionals in the decision-making process.
  - ◊ Establishing creating sustainable mechanisms for connecting society as a key policy objective for 5G licensing.
  - ◊ Supporting spectrum and infrastructure sharing and monetization. This shall unlock the value for telecom operators to reduce debt, fund CAPEX requirements, enhance network coverage, and promote densification to support data growth. It would also support the emergence of new operators in remote and rural areas.
- **Promoting cybersecurity efforts as the complexity of telecom networks grows. The number of reported breaches worldwide has significantly increased quarter on quarter (QOQ) since the COVID-19 crisis due to the augmented complexity of telecom networks and the surge of remote work in many continues.**

- **Revisiting the national broadband plans to develop a backbone and fixed infrastructure and establishing a transparent collaborative process between pertinent stakeholders:**
  - ◊ Facilitating the deployment of fixed broadband networks wherever feasible while considering a direct shift to FTTH rather than gradual upgrading of xDSL and encouraging new partnerships among different stakeholders and network operators' groups to roll out fiber networks.
  - ◊ Improving the utilization of existing fiber networks deployed by electric utilities to provide backbone transmission and access. This necessitates partnerships between utilities and telecom providers to offer backbone networks and open access.
  - ◊ Encouraging FTTH rollout to support a Gigabit society, increase penetration, and improve speeds up to 1Gbsp.
- **Adopting new technologies and partnerships to facilitate the deployment of new technologies:**
  - ◊ Enabling the upgrade of wireless technologies by providing operators with access to spectrum, promoting spectrum trading, and encouraging network sharing (i.e. TowerCos)
  - ◊ Facilitating the deployment of new technologies to overcome challenges vis-à-vis infrastructure limitations. For example, LEO satellite Internet service provides a quick solution to infrastructure restrictions in the short-medium term.
  - ◊ Encouraging pan-Arab harmonization and integration to establish harmonized laws and regulations across the region and facilitate the launch of national and cross border LEO and IXPs.

Recommendations to support ubiquitous connectivity

- Supporting collaborative approach for network development and incubating national Network Operator Groups to improve network resilience.
- Encouraging partnerships for infrastructure development, dissemination of success stories, and best practices
- Encouraging coordination and collaboration in the development of harmonized laws and regulations to reap the benefits of LEO and IXPs.

III.

Network Resilience

7. Measuring Internet Resilience

Network resilience refers to the stability and reliability of connectivity to the Internet. While high-income countries usually have reliable Internet infrastructure with adequate networks and robust cable infrastructure and interconnection systems, many low-income countries suffer from Internet outages. This is because faults and challenges to normal operation can only be mitigated by a resilient Internet connection.[60]

To better improve Internet Resilience, the Internet Society and AFRINIC have developed a methodology for the calculation of Internet Resilience based on several factors:[61]

- **Infrastructure:** The existence and availability of the physical infrastructure that provides Internet connectivity
- **Performance:** The ability of the network to provide end users with seamless and reliable access to Internet services
- **Security:** The ability of the network to resist intentional or unintentional disruptions through the adoption of security technologies and best practices
- **Market Readiness:** The ability of the market to self-regulate and provide affordable prices to end users by maintaining a diverse and competitive market

[60] Internet Society. "Internet Resilience." Accessed April 20, 2022, https://pulse.internetsociety.org/resilience.

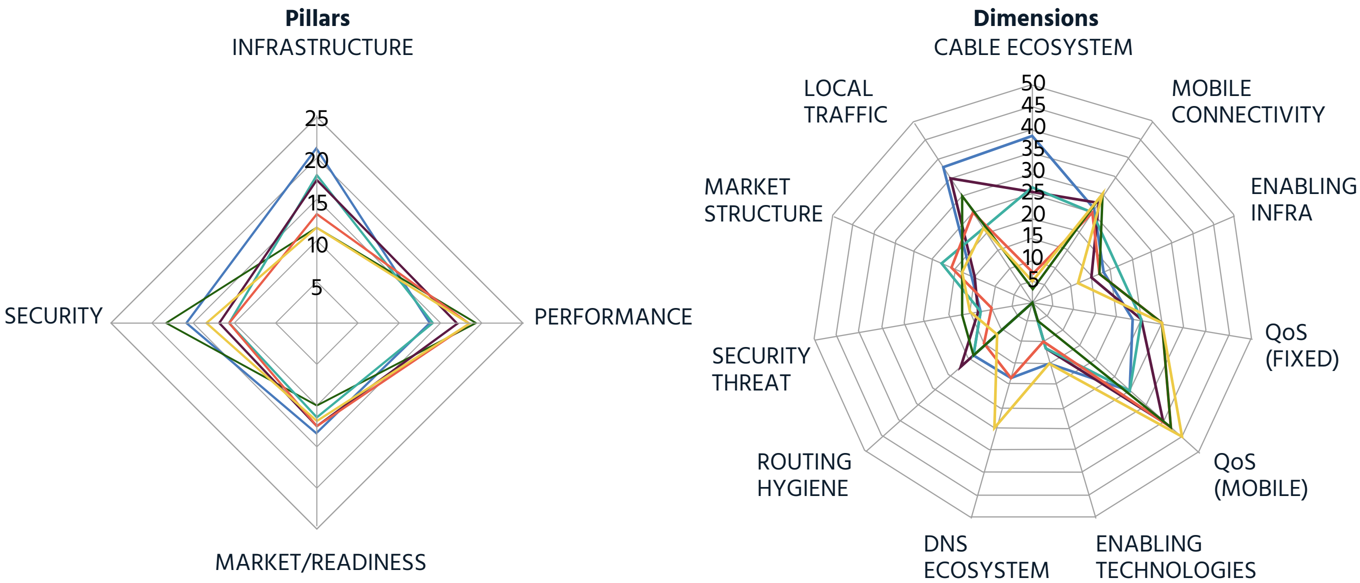
[61] Internet Society, https://www.internetsociety.org/blog/2021/11/a-new-tool-to-measure-internet-resilience-why-it-matters/

Indicator	Name	Date
Exit points (Gateways)	Number of physical exit points (terrestrial or submarine) used for upstream connectivity.	Africabandwidthmaps
10-km Fibre reach	% of the population within 10 km of a fiber connection point	ITU
Network Coverage	Mobile Network coverage (composite score)	GSMA
Spectrum allocation	Spectrum allocation (composite score)	GSMA
Number of IXPs	Number of IXPs per 10 million	PCH/PeeringDB
Power availability	Getting Electricity Index (incorporates the quality of power supply)	World Bank
Data centres	Number of data centers per 10 million population	Datacentermap
Mobile/Fixed Latency	Median latency observed to the nearest Ookla server	Ookla
Mobile/Fixed Upload	Median upload throughput measured to the nearest Ookla server	Ookla
Mobile/Fixed Download	Median download throughput measured to the nearest Ookla server	Ookla
IPv6	% of IPv6 adoption	Internet Society Pulse
HTTPS	% of HTTPS usage	Internet Society Pulse
DNSSEC Validation	% of DNSSEC validation by country	Internet Society Pulse
DNSSEC Adoption	% of DNSSEC adoption	Internet Society Pulse
MANRS	MANRS score by country	MANRS Observatory
Secure Internet Servers	Secure Internet Servers per 1000 population	World Bank
Global Cybersecurity Index	Global Cybersecurity Index (Composite score)	ITU
DDOS Potential	Country overview of DDOS Potential	Cybergreen
Spam infections	% of allocation listed in the spam list	Spamhaus
Affordability	Affordability (% of GNI per capita) of fixed and mobile broadband	ITU/A4AI
Market concentration	Herfindahl-Hirschman Index calculates the market concentration based on market share information per network.	APNIC
AS Hegemony	GINI Coefficient is used on AS Hegemony data to calculate the inequality in the dependency on specific network for upstream connectivity.	IIJ
Peering efficiency	% of ASN peering at local IXPs	PCH/PeeringDB
Domain count	Number of domains registered by ccTLD per 1000 population	Zonefiles.io
EGDI	E-Government Development Index	UN

Thanks to the support of the IRI team, IRI mythology was applied to Arab States, and the results were much in alignment with the results of the I3 highlighting that Gulf countries were leading on resilience as much as they were leading on connectivity, followed by middle-income countries in North Africa and the Levant, while the group of distressed Arab States (due to political and economic instabilities) were lagging.

Gulf States

Across GCC countries, Bahrain is in a leading position: mainly due to its scores with Infrastructure (due to a developed Cable Ecosystem) and Market Readiness (due to high Traffic Localization). Cable ecosystem scoring depends on Fiber reach which is comparable in Bahrain to other smaller Gulf states and international gateways, where Bahrain leads compared to the rest of the region due to its deregulated international gateways policy. Traffic localization resulted in a higher score for Bahrain on the Market Readiness pillar due to the highly efficient peering between ISPs (83.16% in Bahrain vs. 20.5% in Saudi Arabia) despite the relatively concentrated market (63.92% in Bahrain vs. 51.36% in Saudi Arabia).

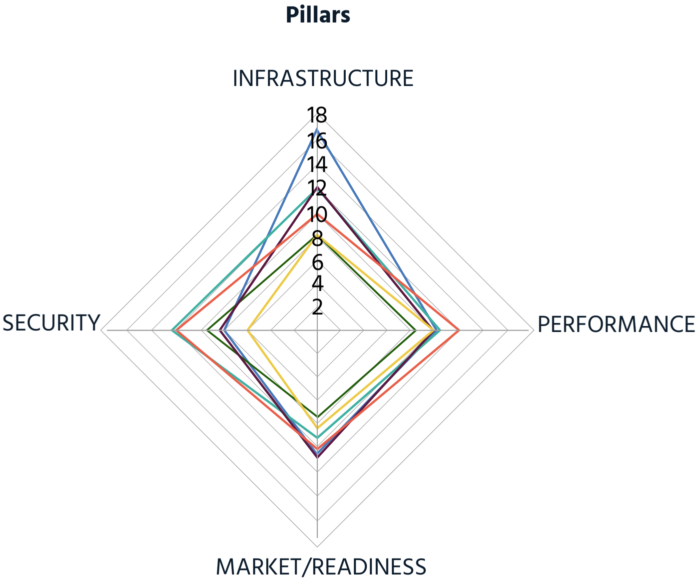


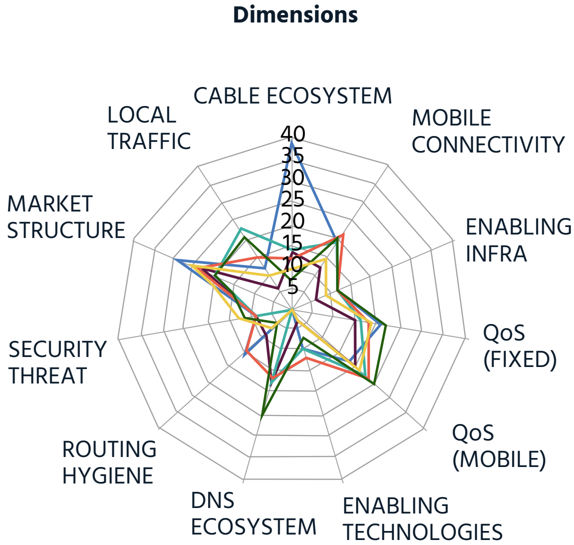
Country Id	Iri	Infrastructure	Performance	Security	Market Readiness
Bahrain	61.24	20.25	13.11	15.16	12.73
Saudi Arabia	57.15	11.06	18.78	17.6	9.71
Qatar	55.92	16.57	16.17	11.28	11.91
Kuwait	52.92	11.37	17.64	12.72	11.19
Oman	51.66	17.24	13.53	10.05	10.84
UAE	51.27	12.61	17.49	9.9	11.27

Figure 52. IRI for the Gulf States

North Africa & Levant

Jordan is leading across the group of middle-income Arab States in North Africa and Levant. The high reach of Fiber cables across Jordan and its highly competitive market (as reflected by low market concentration, HHI: 49% vs. 70.84% in Egypt) resulted in

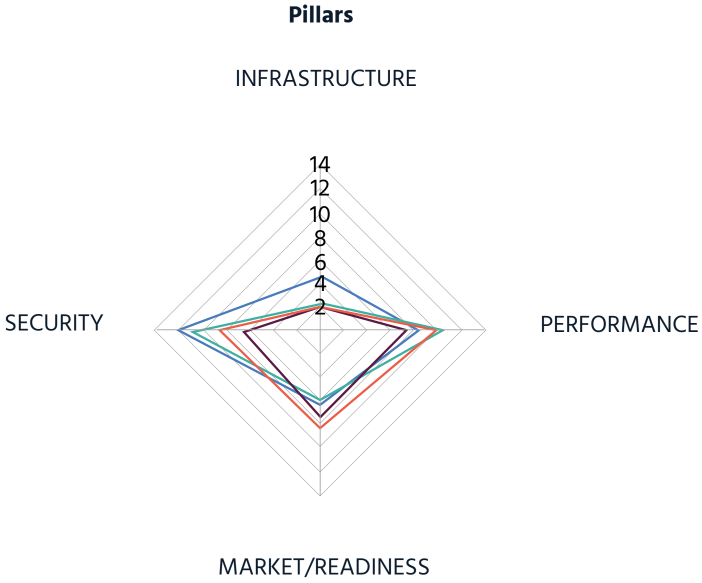


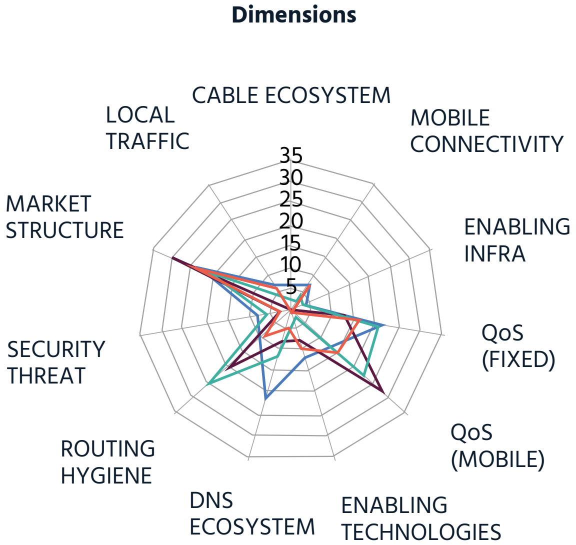


Country Id	Iri	Infrastructure	Performance	Security	Market Readiness
Jordan	46.27	17.34	9.91	8.24	10.77
Lebanon	44.11	11.47	10.45	12.83	9.36
Morocco	44.02	9.84	11.92	12.1	10.17
Tunisia	40.84	11.35	9.7	8.8	10.98
Algeria	33.38	7.78	8.59	9.67	7.35
Egypt	32.57	8.01	9.91	6.07	8.6

Figure 53. IRI for North Africa and Levant

Other Arab States





Country Id	Iri	Infrastructure	Performance	Security	Market Readiness
LY	31.72	4.51	8.49	12.49	6.23
IQ	29.5	2.18	10.74	10.83	5.75
YE	28.77	1.96	9.95	8.7	8.16
SY	23.21	2.01	7.4	6.57	7.23

Figure 54. IRI for other Arab States

8. Data Infrastructure

8.1. Data Centers

Datacenters provide the opportunity to host the servers of content providers close to the end users with higher availability due to: improved connectivity, reliable power supply, and a secured environment. Thus, data centers have become the industry norm for hosting the content of major content providers (usually referred to as Hyperscalers). Hence the presence of data centers improves the performance of the network as well as the experience of the end users as it was reflected in the Internet Resilience Index.

Globally, North America has the highest number of commercially available data centers followed by Europe and Latin America and the Caribbean (Table 8). Middle East and North Africa are tailing the international landscape with 77 commercial data centers vs. more than 300 data centers in Sub-Saharan Africa and 176 in LATAM.

Region	Colocation data centers
North America	2,291
Europe	2,396
Latin America and Caribbean	176
Asia Pacific	978
Sub Saharan Africa	307
Middle East and North Africa	77

Table 8. Colocation data centers across different regions in the world.[62]

[62] Source: Data Center Map, https://map.datacente.rs/ Team Analysis

Data centers established across Arab States are driven so far by telecom operators and domestic players due to the lack of legal and regulatory frameworks required by multinational corporation (MNCs) to operate. The only exception is the GCC where UAE, Qatar, and Bahrain are hosting major hyperscalers thanks to the presence of international connectivity as well as regional exchange points which uphold the delivery of services to several operators across the region (Table 9). On the other side, Corporate data centers are expanding at a much faster pace across the Arab States, possibly because of the lack of competitive and reliable data centers offerings. Uptime Institute provides a listing of certified data centers across the world.[63] Its listing shows that Arab State currently hosts 248 centers of various tiers: I, II, III, and a few tier IV centers as well.

Country	Uptime Institute Certified Data Centers[64]	Commercially listed Data Centers[65]
KSA	108	22
UAE	67	9
Qatar	18	3
Morocco	15	5
Egypt	12	14
Kuwait	10	3
Jordan	6	6
Lebanon	5	2
Bahrain	3	2
Oman	2	4
Tunisia		2
Algeria		3
Libya		1
Palestine		1
Total	**246**	**77**

Table 9. Data Centers across Arab States.

[63] Uptime Institute is the Standard bearer for Digital Infrastructure performance. Its Tier Standard has been used in the design, construction and operations of sites in more than 110 countries. Source: https://uptimeinstitute.com/

[64] Source: https://uptimeinstitute.com/tier-certification/tier-certification-list

[65] Source: https://map.datacente.rs/

9. Internet Resources Utilization

9.1. Autonomous System Number (ASN) Adoption

The Autonomous System Number (ASN) is "a globally unique identifier that defines a group of one or more IP prefixes run by one or more network operators that maintain a single, clearly-defined routing policy."[66] Alongside the IP addresses, ASN adoption is important to improve the performance of the Internet. Nonetheless, there is still a limited number of entities that are interested in owning their network and IP addresses. In the Arab region, most of the ASN identifiers are owned by service providers or financial institutions. The adoption of the ASN varies widely across Arab countries depending on two main determinants. First, the competition in the infrastructure market and the availability of alternative providers/gateways allow users to enjoy significant competition in the development of infrastructure, which promotes ASN adoption and utilize multi-homing, e.g. Kuwait and KSA (Figures 51 and 52). Second, the complexity of business needs since clients with special needs are more inclined to utilize their own ASN, if possible, to have Layer 3 redundancy, e.g. financial institutions in Egypt (Table 10).

[66] Autonomous System Number (ASN) from AFRINIC: https://afrinic.net/asn#:~:text=Autonomous%20System%20Number%20(ASN)%20is,are%20known%20as%20autonomous%20systems.

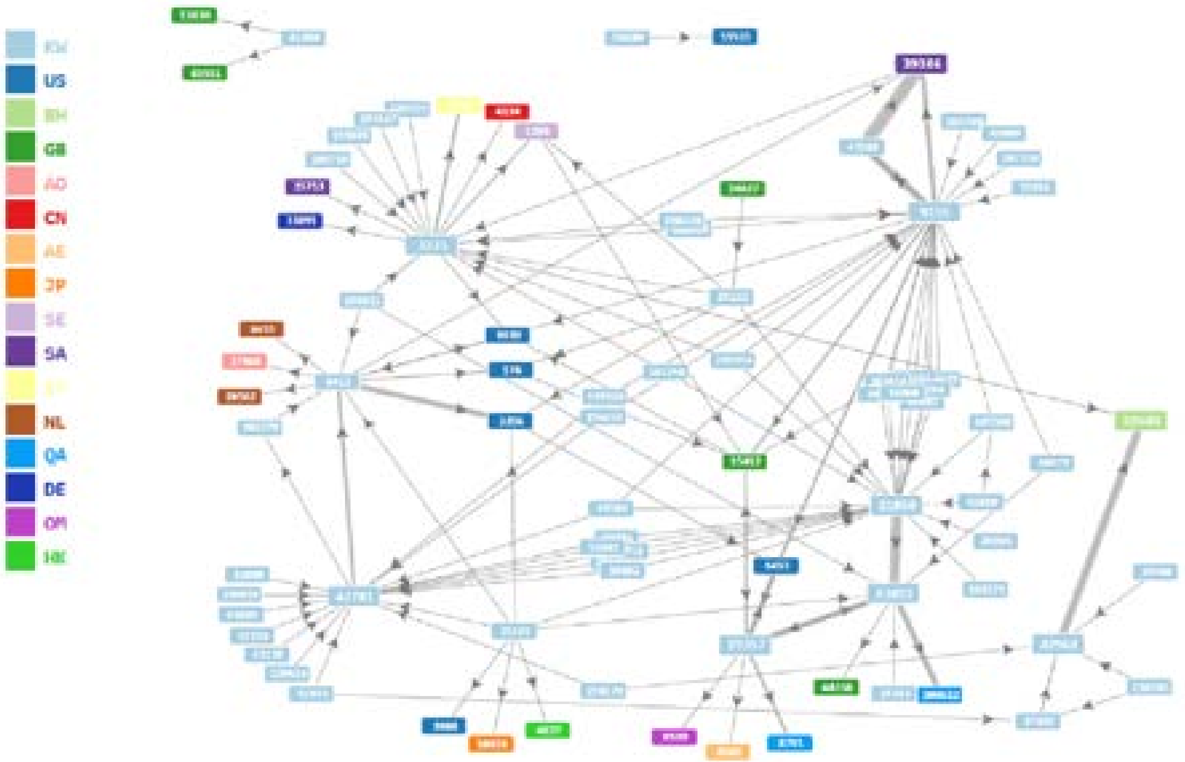


Figure 51. Kuwait network connectivity. Source: RIPE NCC.

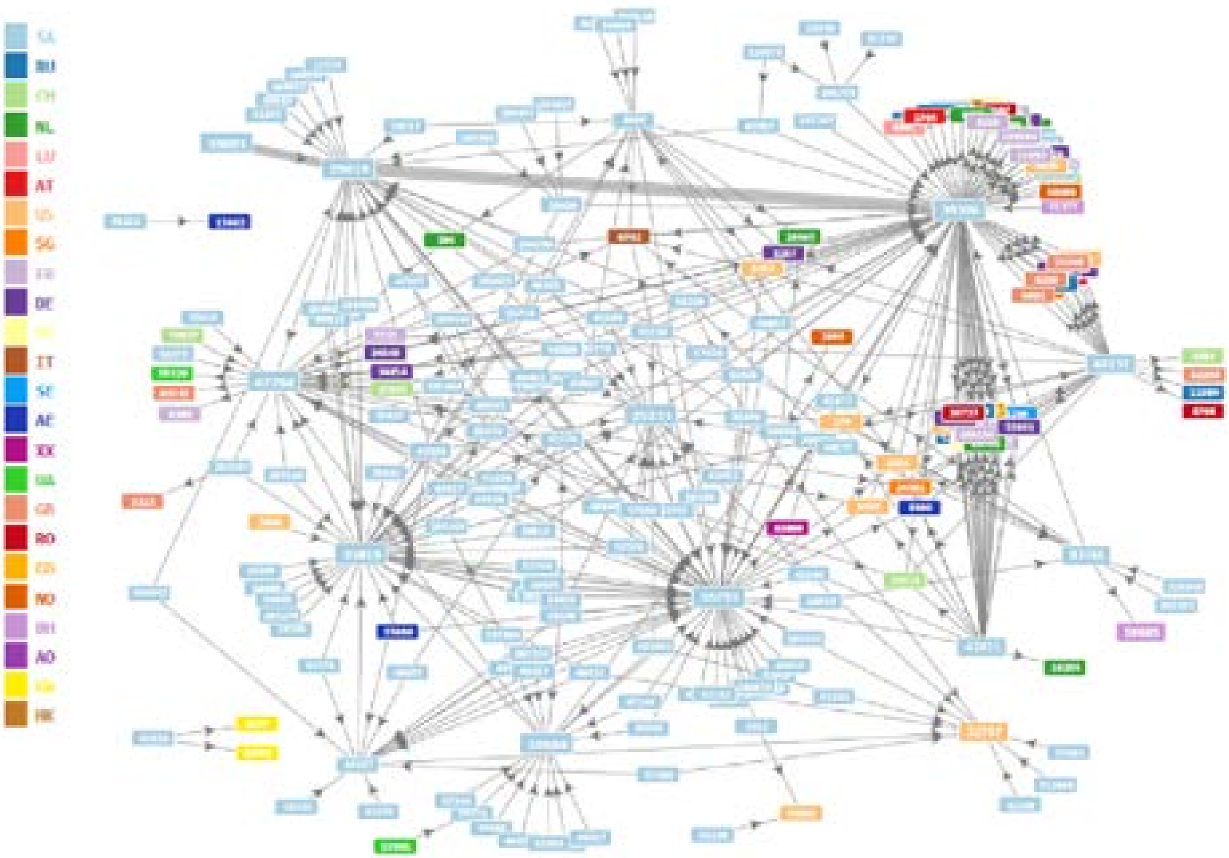


Figure 52. KSA networks connectivity. Source: RIPE NCC.

Egypt	ISP	Financial	Academia	Government	Commercial
93 ASN	31	26	7	9	18

Table 10. ASNs in Egypt. Source: IPinfo.io

9.2. Internet Protocol Version 6 (IPv6) Adoption

The allocation of the IP addresses in the Arab region is managed by Network Coordination Centre (NCCs) and Regional Internet Registry for Europe (RIPE NCC) in GCC and Levant region, and the African Network Information Centre (AFRINIC) in North Africa. However, the deployment of IPv6 varies widely across the region. On one hand, the GCC countries have acquired several IPv4 blocks and hence have accelerated the adoption process of IPv6 (e.g. KSA and UAE) (Figure 53). On the other hand, the rest of the countries are still relying on IPv4 due to the abundance of IPv4 and the challenges of deploying IPv6 vis-à-vis the prerequisites of upgrading the infrastructure hardware and the network management systems (i.e. Egypt, Jordan, and Oman) (Table 10). Nonetheless, only a few operators have accelerated the adoption of IPv6 due to policies of their owners.

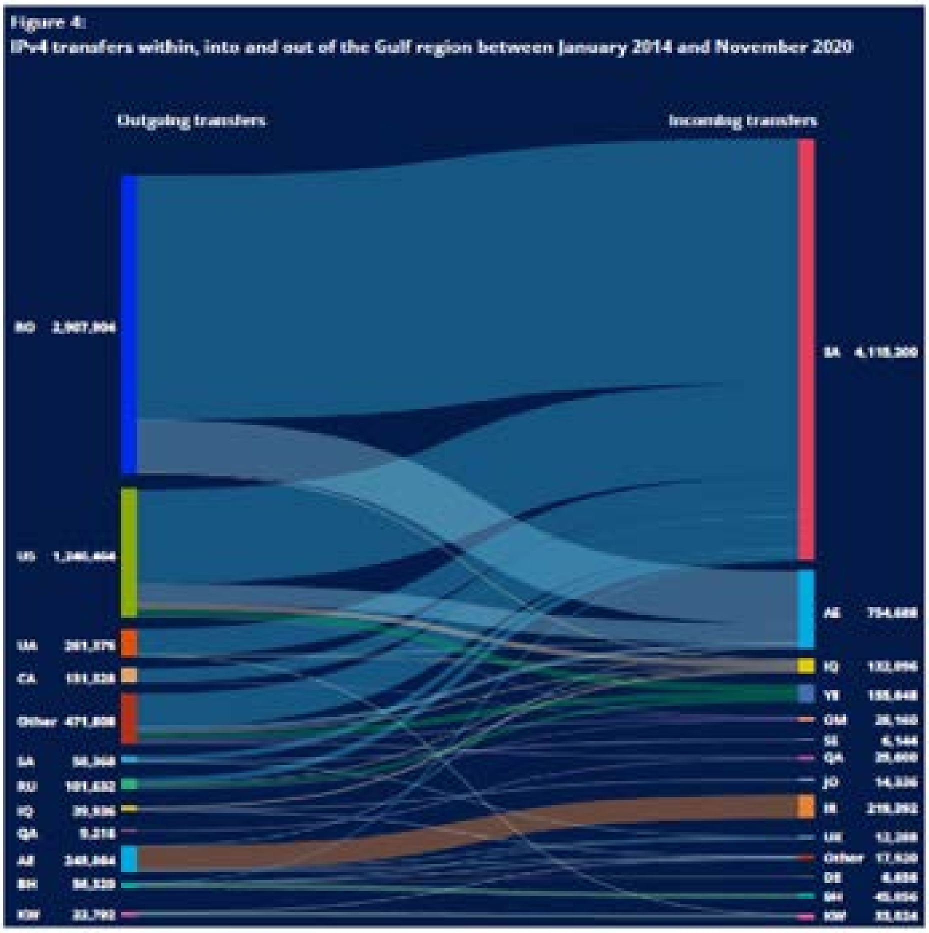


Figure 53. IPv4 transfers within, into, and out of the Gulf region between January 2014 and November 2020. Source: RIPE NCC Internet Country Report: Gulf Region, 2020.

Country	IPv6 Adoption	Latency Impact
Egypt	3.85%	0
Jordan	8.84%	0
Oman	13.7%	0
Kuwait	15.07%	0
UAE	32.91%	0
KSA	46.74%	-10ms

Table 11. IPv6 adoption in the Arab countries[67]

Figure 54. Accelerated deployment of IPv6 by Etisalat in Egypt[68]

[67] Source: https://www.google.com/intl/en/ipv6/statistics.html

[68] Source: https://www.akamai.com/visualizations/state-of-the-internet-report/ipv6-adoption-visualization

10. Towards Reliable Access

Recommendations for Governments to Buttress Reliable Internet Access

Encouraging more entities to acquire their own ASN/IP as ownership of customers to ASN/IP will improve network resilience and preserves customer rights (as it lowers switching costs).

- Reviewing pricing mechanisms for IP/ASN to encourage more users to acquire their resources. This could be supported by linking the pricing of IP/ASN to the type/size of the organization to encourage academia, government, and small and medium enterprises (SMEs) in middle income Arab States to acquire their IP/ASN.

Establishing IXP as closer as possible to users since the presence of IXP on the metro/regional level would improve network performance and resilience and encourage local content development. This should also include the promotion of business models for establishing IX as closer as possible to users and the development of business models to encourage non-governmental organizations (NGOs) and academic institutes to run local IXPs in metro areas, replicating the initial model of Palestine IX.

IV.

Covid-19 Crisis: Regional Impact And Responses

11. Community responses

The Internet is crucial for the wellbeing of individuals and societies at large. This was further demonstrated during the COVID-19 crisis. The pandemic has accentuated the digital transformation process since technology proved to be quintessential for the well-being of people during time of crisis. This, in turn, underlines the importance of reliable Internet access to support the online provision of healthcare, and education services among other public and private services. Business is no different, COVID-19 has brought surge in e-commerce and promoted remote working.

In response to this, governments and businesses have embraced long-term policy responses which include but not limited to emergency telecommunications, accessibility, affordability, and broadband availability. At the onset of the pandemic, many of these measures were provisional. However, the impact of COVID-19 has established evidence to be permanent seeing the number of Internet users that was amplified ten-fold since 2000 leading to more online activities and growth in the digital economy. This led many governments to put in force large-scale and long-terms plans, substantial investments, and new policies and regulations aiming at addressing the limitation of the digital infrastructure. For example, Arab countries have adopted ICT policy responses with a special focus on emergency telecommunications (24), accessibility (31), affordability (22), broadband availability (20), and spectrum management (12) (Figure 55).[69]

[69] International Telecommunication Union (ITU), "The State of Broadband 2021: People-Centred Approaches for Universal Broadband Connectivity," September 2021, https://www.itu.int/itu-d/reports/broadbandcommission/state-of-broadband-2021/.

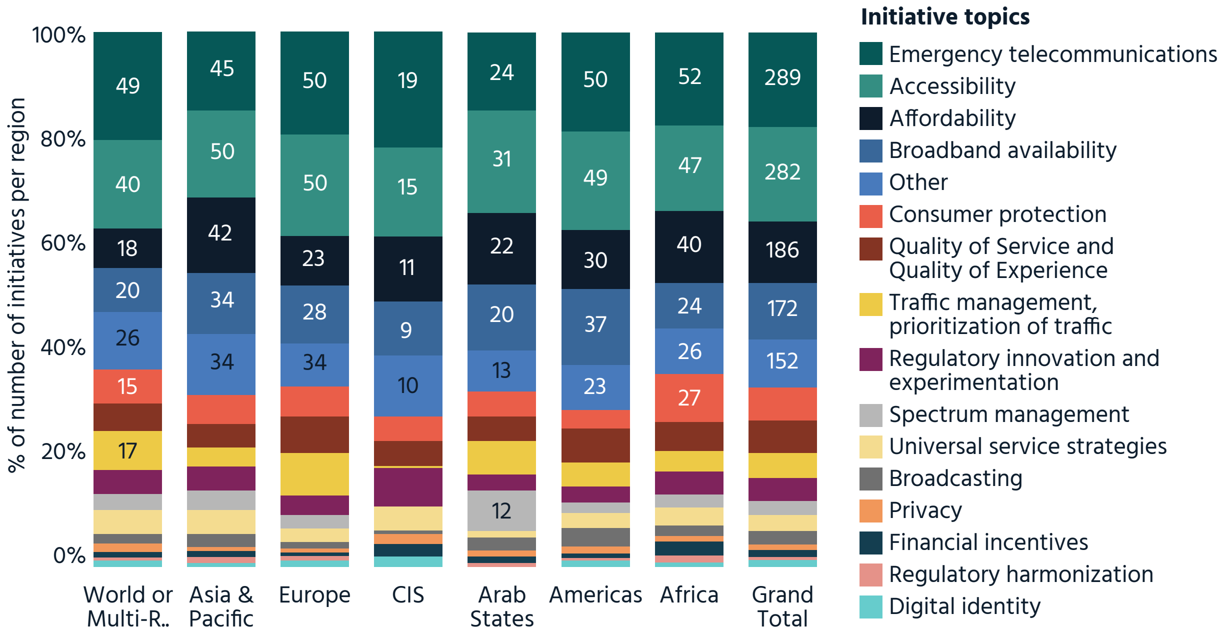


Figure 55. ICT Policy Responses to COVID-19, worldwide and by region (ITU REG4COVID).
Source: ITU. 2021. REG4COVID database.

As far as the responses to the broadband challenges imposed by COVID-19 are concerned, most countries have adopted some emergency ICT policy or regulatory initiatives. According to the ITU's Global Network Resiliency Platform (REG4COVID), more than 480 policy responses have been tracked varying between emergency telecommunications, accessibility, affordability, broadband availability, consumer protection, QoS issues, among several others, all undertaken by various stakeholders from policymakers and regulators, operators and service providers, international and regional organizations, and the technical community and civil society (Figure 56).[70]

[70] International Telecommunication Union (ITU), "The State of Broadband 2021: People-Centred Approaches for Universal Broadband Connectivity," September 2021, https://www.itu.int/itu-d/reports/broadbandcommission/state-of-broadband-2021/.

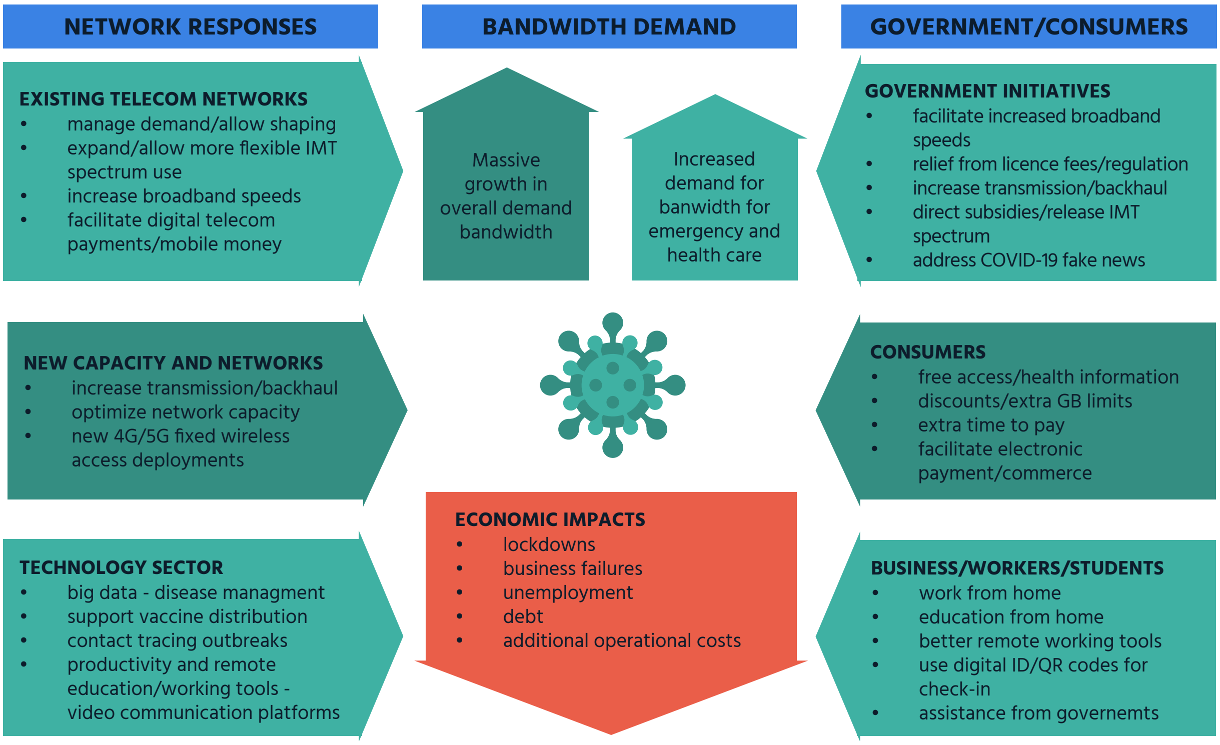


Figure 56. COVID-19 Telecommunications sector responses (ITU, 2021). Source: ITU-WPC, May 2020

Internet affordability and availability during the COVID-19 crisis

The quality and affordability of the Internet were accentuated by COVID-19 crisis in both developed and developing countries. At one extreme, in developed countries with national levels of broadband affordability, low-income populations struggled with affordability challenges. At the other extreme, low-income countries have staggering affordability issues since individuals who had to move to remote working and distance learning were unable to access the full bandwidth amount. At large, a raft of individuals and households are still marginally connected and unable to access basic levels of connectivity despite their readiness to shift to remote work and distance learning. In the MENA region, Internet affordability is still a challenge since 1GB data is on average 1.6% of monthly GDP and 8.2% for low-income quintile (Figure 57).[71]

[71] International Telecommunication Union (ITU), "The State of Broadband 2021: People-Centred Approaches for Universal Broadband Connectivity," September 2021, https://www.itu.int/itu-d/reports/broadbandcommission/state-of-broadband-2021/.

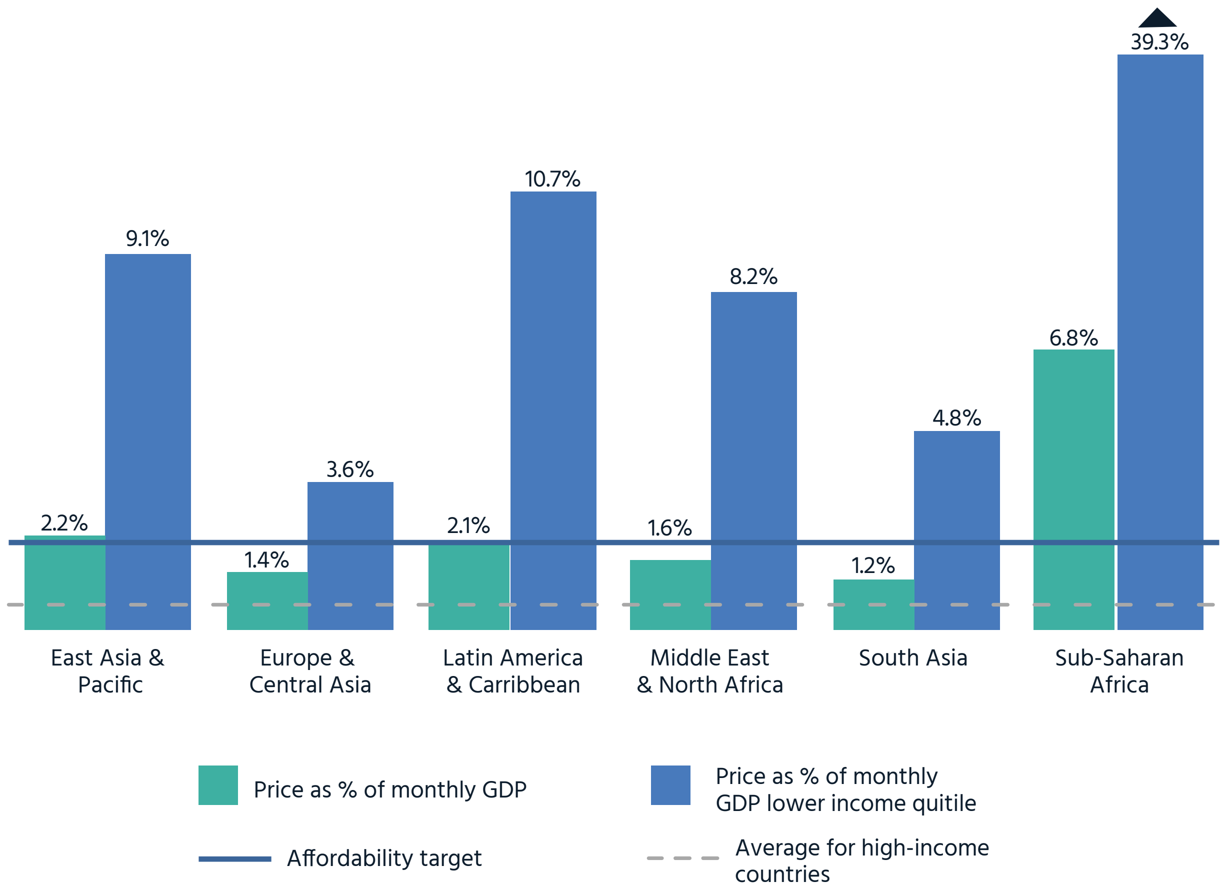


Figure 57. Affordability of 1GB package as % of average monthly GDP/Capita. Source: GSMA. 2019. "State of Mobile Internet Connectivity Report 2019".

To improve affordability, Vodafone UK improved its VOXI For Now plan to help households going through financial hardship to stay connected. The VOXI For Now tariff, which was previously provided for limited time during the COVID-19 crisis, was relaunched with unlimited 5G data, calls, and texts for £10 a month for up to six months without any credit check or signed contract. The plan, which can be paused or canceled at any time, would cost £35 a month (70% discount).[72] Regarding the affordability of Internet access, the cost of mobile phones being the cheapest Internet-enabled devices remains the main challenge. This was further escalated with the expansion of 4G/LTE networks and the provision of 5G which require higher cost smartphones compared to the low-cost devices that were compatible with the 2G and 3G services. Globally, the cost of the most affordable smartphones is 25% of average monthly income of more than 2 billion people. In low-middle-income countries, entry-level Internet-enabled phones are on average 34% of monthly income and 22.4% on average in MENA countries (Figure 58).[73]

[72] Vodafone UK, "Vodafone enhances VOXI For Now social tariff to boost support for those in financial hardship," April 13, 2022, https://newscentre.vodafone.co.uk/press-release/voxi-for-now-social-tariff-to-boost-support-for-those-in-financial-hardship/?utm_source=Max&utm_medium=3&utm_campaign=4&utm_id=Ahmed&utm_term=5&utm_content=6.

[73] International Telecommunication Union (ITU), "The State of Broadband 2021: People-Centred Approaches for Universal Broadband Connectivity," September 2021, https://www.itu.int/itu-d/reports/broadbandcommission/state-of-broadband-2021/.

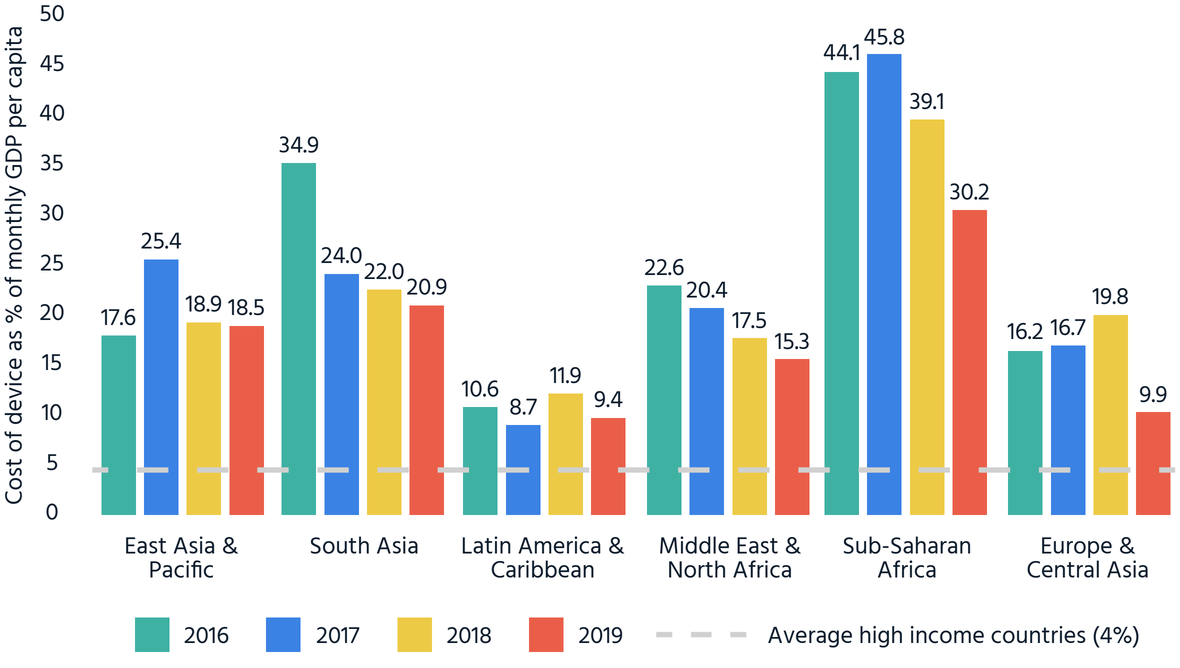


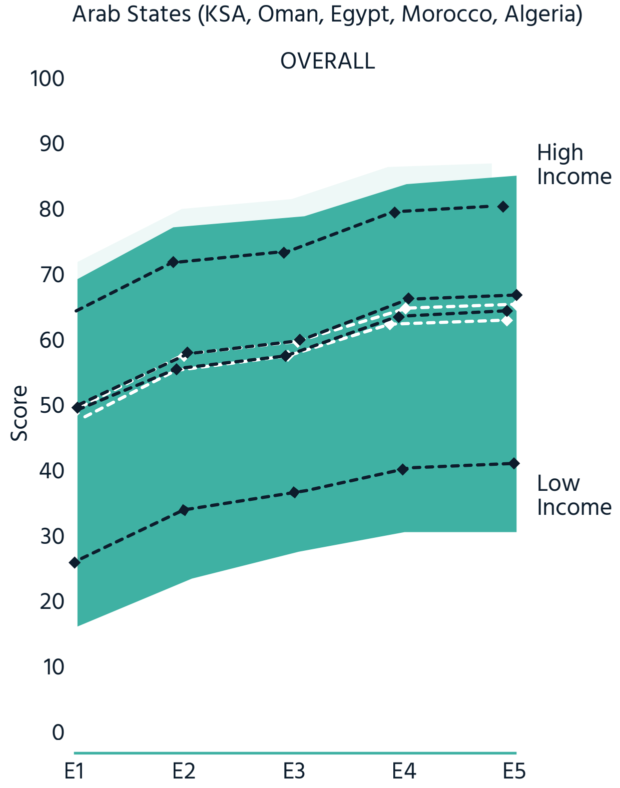
Figure 58. Affordability of an entry-level Internet-enabled phone in Low- & Middle-Income Countries 2016-2019. Source: GSMA. 2020. "The State of Mobile Internet Connectivity 2020".

On the question of the availability of online content, the COVID-19 crisis laid more emphasis on online content and the lack of Arabic digital content particularly. On one hand, the lack of available fiber optics in the Arab region hinders the setting up of data centers and IXPs which depend on cables to link online content providers and the national backbone network. On the other hand, the lack of relevant Arabic content exacerbates the digital divide for Arabic citizens since it limits their capacity to use the Internet and online applications. This is an impasse at the regional level where the ISPs expect more content to be availed and content providers expect service providers to improve the infrastructure first. For this reason, local content is still hosted overseas due to the lack of local data centers.[74]

[74] Alexander Farley & Manuel Langendorf, "COVID-19 and2 Internet Accessibility in the MENA Region: Maximizing digital skills and connectivity for economic recovery," Wilson Center, December 2021, https://www.wilsoncenter.org/sites/default/files/media/uploads/documents/MEP_211129_OCC%2040%20v4.pdf.

Steady World Progress from 2016-2020 Despite a Gap between High- vs. Low-Income States

The world has demonstrated steady progress between the years 2016 – 2020 despite the persistent gap between the high- and low-income countries which is increasing. The composite EIU's Inclusive Internet Index shows that the gap between the average of high-income and low-income countries listed on the index has increased from 39 to 40.8 points over 5 years. This was a reflection of the increase in the gap of Availability between those 2 groups from 44.4 to 47.98. This is expected to grow even more as low-income countries continue to lag in the deployment and utilization of broadband technologies like 5 G and FTTH. However, the Arab States listed (KSA, Oman, Egypt. Morocco, and Algeria) performance has been aligned with World Average, with a slight improvement in the last 2 reports.



Overall Score	E1	E2	E3	E4	E5
High Income	66	74.3	75.5	81.5	82.5
Low Income	26.8	34.8	37.5	41	41.7
Gap	39.2	39.5	38	40.5	40.8

Avail-ability Score	E1	E2	E3	E4	E5
High Income	60.2	71.426	72.95	77.34	79.37
Low Income	15.8	24.4	24.46	29.97	31.39
Gap	44.4	47.026	48.49	47.37	47.98

Figure 59. widening digital gap demonstrated by Inclusive EIU's Internet Index between High- and low-income countries between 2016-2020. Source: EIU's Inclusive Internet Index

Arab States Ranking on the Inclusive Internet Index (3I)

According to the Inclusive Internet Index (3I), high-income countries are leading the availability pillar. Geography is also another factor where smaller countries are ranking high compared to bigger countries that have large challenging geography.

Overall		1) Availability		2) Affordability		3) Relevance		4) Readiness	
Kuwait	80.1	UAE	81.3	Kuwait	86.2	Saudi Arabia	87.1	Qatar	86.7
Qatar	78.0	Qatar	79.0	Tunisia	75.8	UAE	85.1	Oman	80.2
UAE	76.2	Kuwait	76.7	Bahrain	71.4	Bahrain	84.3	Bahrain	73.6
Bahrain	74.7	Oman	73.4	Qatar	70.2	Kuwait	84.3	Saudi Arabia	72.9
Oman	72.7	Saudi Arabia	73.1	UAE	67.2	Qatar	83.0	Kuwait	66.8
Saudi Arabia	72.2	Bahrain	72.8	Egypt	64.5	Oman	82.0	UAE	65.0
Morocco	67.6	Morocco	68.5	Morocco	64.5	Jordan	76.7	Egypt	61.7
Jordan	66.5	Jordan	66.3	Oman	63.1	Morocco	76.1	Jordan	59.0
Tunisia	65.8	Tunisia	63.2	Jordan	62.4	Egypt	69.9	Tunisia	57.4
Egypt	64.5	Lebanon	62.6	Algeria	61.3	Tunisia	60.1	Morocco	55.9
Lebanon	58.8	Egypt	62.4	Saudi Arabia	60.6	Lebanon	56.4	Algeria	53.7
Algeria	58.2	Algeria	58.0	Lebanon	60.4	Algeria	56.3	Lebanon	43.3

Score out of 100

Overall weights: Availability (40%) Affordability (30%) Relevance (20%) Readiness (10%)

Figure 60. Scoring of Arab States on various pillars of EIU 3I3. Source: Inclusive Internet Index.

Figure 61. Relative progress in the scoring of Arab States on various pillars of EIU's 3I. Source: Inclusive Internet Index.

12. COVID-19 Regional Initiatives

To improve Internet connectivity during the COVID-19 crisis, a raft of regulatory, commercial, and technology initiatives were adopted by policymakers, operators, and technology companies in the Arab region. Such initiatives are aimed at addressing the infrastructural gaps and providing reliable Internet access.

In this vein, Arab governments launched major initiatives with a special focus on Increasing broadband capacity and speeds, while ensuring the quality of service (QoS) is maintained, without any extra cost (Lebanon, Iraq, and Bahrain); establishing New Fixed Wireless Access (FWA) networks to provide rapid augmented coverage for health care facilities; allowing more flexible use of spectrum for International Mobile Telecommunications (IMT); and granting permanent or temporary IMT spectrum licenses (Jordan and Saudi Arabia). They have also opted for covering the additional cost of upgrading monthly packages for Internet subscribers (Egypt). To facilitate communication during the lockdown and support the dissemination of medical information, some governments have unblocked Voice over Internet Protocol (VoIP) services, such as WhatsApp, Skype, and Zoom (UAE and Oman).

To further improve broadband networks and services, mobile network operators (MNOs) have increased broadband speeds, upgraded Internet speeds including transmission and backhaul capacity, and removed usage caps on all fiber broadband packages (Zain Bahrain). They have also allowed prepaid users to pay after consumption (Egypt, Tunisia, and Palestine).[75]

Additionally, technology companies have provided a range of free services including but not limited to offering free enterprise videoconferencing features to everyone (Google), Webex service with no time restrictions (Cisco), a premium version of Teams for six months (Microsoft), and removing restrictions on the use of free applications (Zoom).

Some public-private partnerships were also launched. For example, the Kuwaiti Communication and Information Technology Regulatory Authority (CITRA) has provided additional free services and frequencies to mobile companies and Internet service providers (ISPs), and in

[75] BOUTHEINA GUERMAZI, "Digital transformation in the time of COVID-19: The case of MENA," World Bank Blog, JULY 29, 2020, https://blogs.worldbank.org/arabvoices/digital-transformation-time-covid-19-case-mena

return, the companies have provided 5GB of Internet speed and local free calls daily to their customers. Moreover, the Egyptian National Telecommunication Regulatory Authority (NTRA) and the main mobile operators had an agreement to provide free 3,000 minutes of calls and 10 gigabytes mobile Internet package per month to all doctors, nurses, and administrative staff working at COVID-19 isolation hospitals nationwide.

12.1. Regional Responses to Support Distance Learning during the Lockdown

Special Initiatives were kicked off to promote distance learning during the lockdown. For example, MNOs provided free services (zero-rating) to educational applications and learning platforms as well as additional data packages and high-speed Internet access to schools and education providers. Some have also provided hosting services and cloud infrastructure to support digital e-classes platforms and free SIM cards for the educational tablet and offered a "Go Education" discounted bundle (Orange Egypt). Additionally, to support online learning, the Egyptian Ministry of Communications and Information Technology (MCIT) has increased the download quota of household Internet packages by 20%, at a cost of EGP200 million (USD12.6 million) subsidized by the government. It has also enabled free browsing of educational platforms and websites to ensure education is not affected.

The National Research and Education Network (NREN) alongside different public and private educational entities across the Arab region have proactively played an active role in addressing the connectivity gap and promoting research and education during COVID-19 in many Arab countries.

In Lebanon, the Technology Cooperation Agreement for Research and Education (TechCARE) has actively promoted distance learning by supporting its associated universities to swiftly transition to online education through several digital solutions. This included voice-over PowerPoint and recorded videos for asynchronous lessons, web conferencing tools (Zoom, Webex, and MS Teams) for synchronous learning, and the online invigilating tool Respondus for online student assessment. TechCARE has further lobbied the Ministry of Higher Education and the Ministry of Telecommunications to reduce the 4G charges for students. Additionally, the American University of Beirut (AUB) has volunteered to share its best practices in online virtual labs, teaching in times of crisis, and working remotely, and has received recognition from EDUCAUSE, a non-profit association of information technology (IT) leaders and professionals that helps higher education elevate the impact of IT.

The Palestinian Ministry of Higher Education has developed an online portal for educational content to be uploaded for grades 1-12 [Palestine_eLPortal] and broadcast recorded lessons by local TV stations and via a dedicated YouTube channel. Students and teachers have also resorted to communicating via social media applications. Universities, i.e. Al-Quds Open University, have their open educational resources (OER).

In Jordan, three TV channels were allocated for delivering primary and secondary education, and digital platforms such as NoorSpace and Darsak were developed to provide educational resources and materials as well as exams and evaluations for public education. Moreover, the Jordanian Universities Network (JUNet) has secured Internet services to public universities. ISPs have also provided extra bandwidth to students in rural areas.

The Saudi Research and Innovation Network (Maeen) has secured up to a 50% capacity increase at no extra cost for connected members. It also provided unlimited access to the Zoom collaboration service hosted on the Maeen Cloud as well as unlimited bandwidth access to e-learning providers in KSA.

The Ministry of Education in Oman has broadcast schools' lessons on Oman TV. The Oman Research and Education Network (OMREN) has also lobbied the government to allow videoconference tools that were previously restricted (e.g., Zoom and Google Classroom) OMREN has also developed a file transfer service (Mirsal). Additionally, the ISPs provided free access from mobiles and households to edu.om domains for students to have access to educational materials.

The UAE's NREN Ankabut has developed an online learning ecosystem, primarily for Khalifa University, with a variety of virtual classroom platforms to choose from (BigBlueButton, MS Teams, Blackboard Collaborate) and provided training for faculties and students. Morocco's NREN MARWAN has also hosted an e-learning portal developed by the Ministry of Education. The Tunisian Computing Center al Khawarizmi (CCK) has established a Jitsi-based videoconferencing tool in local universities for online classes as well as a VPN-SSL service for easy access to scientific resources for the academic community. The Egyptian Universities Network (EUN) has coordinated with IT vendors to support university services in Egypt.

13. Towards Sustainable Access

Designing long-term policies to stabilize the COVID-19 initiatives that were launched by the government, private sectors, academia, and civil society and to support a digitally enabled economy. For example, the unblocking of VoIP services and the provision of zero-rating services.

- COVID-19 has spurred several governmental or industry initiatives for availing relevant content for free to users during the early days of the lockdown.
- Experiences from COVID-19 have shown that technical and regulatory collaboration and coordination between stakeholders can deliver the most resource-consuming content to users utilizing minimum resources.
- Availing Free access to online social and state services needs to be considered as a policy objective to partially overcome the Usage Gap, especially in light of the ambitious national plans for digital transformation.
- Middle- and Low-income Arab States have a historical opportunity to review their Universal Service policies to include such an objective in their licensing conditions while preparing for licensing 5G services.

Developing large-scale regional initiatives focusing on accelerating access to digital content while addressing the digital divide which hampers the capacity of individuals and societies, utilizing the lessons learned during crisis time, i.e. COVID-19 pandemic.

- Availing health, educational, and entertainment content online in local languages to make it accessible to the wider population.
- Develop the digital infrastructure to support the establishment of local data centers to encourage content providers to develop local Arabic content at lower prices and ISPs to avail of this content.
- Encourage the development of content that could be utilized over low-speed connectivity to make it more accessible/affordable to users with low-quota packages or living in areas with slow connectivity.
- Improving regional connectivity to improve access to useful educational and health-related content among Arab States.

- Design online educational content that is compatible with mobile phones and tablets being the most affordable devices for students.

Adopting necessary measures to improve access with a special focus on affordability and availability as part of the economic recovery strategies. In this vein, the government should encourage public-private partnerships to make the Internet more affordable:

- Utilization of ducts/fiber networks rolled out by utility providers could encourage the faster rollout of high-speed broadband networks
- Licensing of community networks especially in rural and low-income regions would lower the cost of ownership of broadband services and hence encourage wider adoption of broadband services