Asia-Pacific Economic Cooperation

Study on Policy Measures to Promote Broadband Infrastructure in Underserved Areas

APEC Telecommunications and Information Working Group

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APEC Project: TELWG 201 2023A

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#APEC226-TC-01.1

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FOREWORD

Meaningful inclusion in the digital economy depends on reliable and affordable connectivity. Across APEC however, availability, quality, and price still differ greatly, most noticeably in underserved and hard-to-reach communities. This study was carried out to assess the current landscape, clarify the obstacles, and set out pragmatic options to narrow those gaps.

Our focus is comparative and evidence-led. We pair quantitative indicators—coverage, penetration, affordability, and adoption—with qualitative reviews of policy, regulation, and market structure. To reflect the region's diversity, economies are grouped into four contexts: (i) large landmass, (ii) archipelagic, (iii) mountainous/forested, and (iv) compact urban settings, thus recommendations can be tailored rather than treated as one-size-fits-all.

Several conclusions are clear. Progress has been uneven; last-mile costs remain high in remote areas and investment returns can be uncertain. Mobile networks continue to bridge access where fixed infrastructure lags, but next-generation rollout advances at different speeds. Policy and market design matter: where competition, open access, timely spectrum, and streamlined permitting are in place, adoption is faster and prices lower. And access alone is insufficient—skills, relevant services, and affordability programs are essential to convert connectivity into inclusion and impact.

The emphasis here is practical, not prescriptive. We highlight how successful approaches can be adapted across contexts and organize options around three pillars: fit-for-context technology choices, policy levers that align incentives and reduce deployment frictions, and inclusion measures that help households, schools, clinics, and small businesses realize tangible benefits. A concise decision pathway and an outcome-oriented KPI set are provided to help policymakers move from intent to implementation and to learn over time.

In this way, this report supports the spirit of the APEC Putrajaya Vision 2040—more inclusive, sustainable, and innovation-driven growth—by making universal, meaningful broadband a practical undertaking rather than an aspiration.

I also thank the APEC TELWG and co-sponsoring economies who supported this work, and acknowledge with appreciation the team of NIA and DETECON Asia-Pacific in developing this report. I hope this report will be of practical value to APEC and its member economies.

Jong Sung Hwang
President of National Information Society Agency

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LIST OF ABBREVIATIONS

ADSL	Asymmetric Digital Subscriber Line
APEC	Asia-Pacific Economic Cooperation
AI	Artificial Intelligence
CAF	Digital Ecosystem Development Index – CAF Development Bank of Latin America
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CSP	Communications Service Provider
DSL	Digital Subscriber Line
FBB	Fixed Broadband
FTTH/B/P	Fiber-to-the-Home / Building / Premises
FWA	Fixed Wireless Access
Gbps	Gigabits per second
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GNI	Gross National Incomes
ICT	Information and Communication Technology
IoT	Internet of Things
ISPs	Internet Service Providers
ITU	International Telecommunication Union
KII	Korean Information Infrastructure
KPI	Key Performance Indicator
LATAM	Latin America
LLU	Local Loop Unbundling
LTE	Long Term Evolution (4G standard)
M&A	Mergers and Acquisitions
NBN	National Broadband Network
OECD	Organisation for Economic Co-operation and Development
PPP	Public-Private Partnership
PON	Passive Optical Network
ROI	Return on Investment
SOE	State-Owned Enterprise
TELWG	Telecommunications and Information Working Group (APEC)
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
USO	Universal Service Obligation

Abbreviations for APEC economies:

AUS	Australia
BD	Brunei Darussalam
CDA	Canada
CHL	Chile
PRC	People's Republic of China
HKC	Hong Kong, China
INA	Indonesia
JPN	Japan
ROK	Republic of Korea
MAS	Malaysia

MEX	Mexico
NZ	New Zealand
PNG	Papua New Guinea
PE	Peru
PH or PHL	The Republic of the Philippines
RUS	Russia
SGP	Singapore
CT	Chinese Taipei
THA	Thailand
US or USA	United States
VN	Viet Nam

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EXECUTIVE SUMMARY

Objective and Approach

The study aimed to assess the broadband status, challenges, and opportunities across all 21 APEC economies, with a particular focus on underserved areas. The project sought to answer a central question: can successful broadband interventions from one economy can be effectively replicated in others, considering unique economic, geographic, and demographic conditions?

A data-driven methodology was applied, combining quantitative indicators (infrastructure coverage, penetration, affordability, and adoption rates) with qualitative assessments of policies, regulatory frameworks, and market structures. Economies were grouped into four clusters based on geography and underserved-area characteristics:

- Cluster A: Large landmass economies
- Cluster B: Archipelagic economies
- Cluster C: Mountainous / densely forested economies
- Cluster D: Compact urban economies

This clustering provided a basis for tailoring policy-service models and practical recommendations suited to each group's specific barriers and enablers.

Key Findings - Broadband Status and Gaps

The analysis reveals significant disparities in broadband access, adoption, and affordability across APEC economies:

- **Infrastructure Disparities**: High-income economies such as Japan; Korea; and Singapore report more than 80–90% of premises passed by fiber (FTTH/B), resulting in near-universal broadband availability, whereas economies such as Papua New Guinea and the Philippines still face large rural gaps, with cost per user up to 3–5× higher in remote areas.
- **Mobile Broadband Dominance**: Mobile networks are the main access channel in many emerging APEC economies, bridging connectivity where fixed broadband is scarce. However, 5G rollout remains uneven, with "Followers" (Malaysia; the Philippines; and Thailand) catching up and "Late Adopters" (Indonesia; Papua New Guinea; and Viet Nam) still in early phases.
- **Regulatory and Market Barriers**: Monopoly-like structures, slow spectrum allocation, and complex permitting processes hinder network rollout. Economies with competitive, open-access models (Australia; Republic of Korea) demonstrated faster adoption and lower costs.
- **Socioeconomic Gaps**: Rural areas, low-income groups, and elderly populations frequently remain underserved despite physical coverage, highlighting the importance of digital literacy, affordability programs, and locally relevant content.

Overall, these findings confirm that closing the broadband gap in APEC requires more than infrastructure deployment alone. It demands regulatory reform, targeted investment, and inclusive adoption programs. Addressing both supply- and demand-side barriers is essential to ensure that connectivity translates into equitable digital participation and sustains economic growth across the region.

Best Practices and Success Cases
The study documents a diverse set of successful broadband interventions across APEC, showing how targeted policies, financing models, and technology choices can close connectivity gaps.

Examples include:

- Australia's NBN Model: Open-access wholesale infrastructure with a mixed technology approach improved middle-mile access and created competitive retail markets.
- Korea's National Broadband Plan: Early public investment and Public-Private Partnership (PPP) models achieved near-universal fiber coverage and 5G leadership.
- Chinese Taipei's Resilience Programs: Satellite redundancy and cross-network roaming ensure service continuity during disasters.
- Papua New Guinea's ICT Hubs: Multi-sectoral collaboration supported community connectivity, e-learning, and mobile money adoption in remote areas.

Together, these success cases demonstrate that well-designed policies, public–private collaboration, and inclusive digital strategies can accelerate broadband rollout, bridge the digital divide, and generate measurable socioeconomic impact across diverse APEC economies.

Policy-Service Model and Toolkit
A customized policy-service model was designed for each cluster, integrating:

- Technology Measures: Fiber, FWA, satellite, and hybrid solutions for cost-effective last-mile coverage.
- Policy Instruments: Open-access regulation, fiscal incentives, PPPs, and performance-linked funding.
- Inclusion Measures: Affordability programs, community hubs, digital literacy initiatives, and local content development.

To support practical implementation, four-step decision framework guides policymakers through:

1. Readiness Assessment - Evaluate market, institutional, and funding readiness.
2. Gap Identification -Pinpoint infrastructure, service, and adoption deficits.
3. Instrument Selection - Match policy tools and funding models to context.
4. Governance & Monitoring – Define oversight, KPIs, and evaluation cycles.

A KPI framework is included to track coverage, affordability, quality of service, usage/inclusion, and socioeconomic impact.

The key outcome of this policy-service model and toolkit is a practical, evidence-based roadmap that enables policymakers to make data-driven decisions, prioritize investments, and align stakeholders around a common vision. By integrating technology, policy, and inclusion measures, the model helps economies accelerate broadband deployment in underserved areas, ensure open access, and translate connectivity into tangible social and economic benefits.

Strategic Relevance for APEC and Beyond
The study's findings were presented at the APEC TELWG forum, facilitating policy dialogue among member economies. The recommendations emphasize that geography matters, but

governance and inclusivity are equally critical. Economies must combine infrastructure investment with demand-side measures to ensure adoption and impact.

1. INTRODUCTION AND METHODOLOGY

1.1 OUR UNDERSTANDING AND OVERALL STRUCTURE

Broadband connectivity is a foundational driver of economic growth, social inclusion, and digital transformation across the 21 APEC economies. Yet access and adoption remain uneven, particularly in underserved areas where geographic constraints, market gaps, and socio-economic barriers limit meaningful connectivity. This report provides a comprehensive, data-driven assessment of these challenges and offers a structured set of policy and implementation tools to support inclusive broadband development across the region.

The study follows a multi-layered approach. Chapter 1 introduces the analytical framework, describing the data sources, research methodology, and the clustering logic used to group APEC economies into four underserved-area types—large landmass, archipelagic, mountainous/forested, and compact urban economies. This clustering enables tailored comparisons and ensures that recommendations throughout the report remain context-specific rather than one-size-fits-all.

Building on this foundation, Chapter 2 provides a detailed benchmarking of broadband infrastructure, adoption, affordability, and regulatory conditions across all 21 economies. The analysis highlights strong regional disparities (such as mature fiber markets in high-income economies and persistent gaps in remote rural regions) while also identifying supply- and demand-side barriers that shape connectivity outcomes. It emphasizes how regulatory effectiveness, competition levels, spectrum policies, affordability, and digital readiness jointly influence broadband expansion.

Chapter 3 narrows the focus to underserved areas within each APEC economy, examining their geographic characteristics, market gaps, and digital readiness challenges, and showing how these issues differ across the four clusters. The chapter highlights three universal enablers (technology, policy, and digital inclusion) while emphasizing that their influence and effectiveness vary significantly depending on local conditions. Case studies demonstrate transferable lessons, including the use of hybrid technology combinations, open-access wholesale frameworks, resilient infrastructure approaches, and community-driven connectivity initiatives.

Drawing on these insights, Chapter 4 transitions from analysis to action. It introduces a holistic Policy-Service Model that integrates technology solutions, policy instruments, and inclusion measures into a single practical blueprint for governments. The chapter first outlines the general model, then presents a unified set of technology, policy, and digital-inclusion instruments. These instruments are subsequently applied to each of the four clusters in Chapter 4.4, generating tailored strategic options for large landmass, archipelagic, mountainous/forested, and compact urban economies. The chapter culminates in a Policy-Service Model Implementation Toolkit—a decision-making framework and a KPI-based monitoring system to guide planning, execution, and evaluation of broadband interventions.

Together, these chapters form a cohesive narrative:

- **Chapter 1** defines the analytical base and clustering logic.
- **Chapter 2** describes the current broadband landscape and systemic barriers.

- **Chapter 3** explores underserved areas in-depth and extracts success factors.
- **Chapter 4** translates these insights into targeted strategies and practical toolkits.

This integrated structure ensures that policymakers can move from diagnosis to design and implementation using a clear, evidence-based roadmap. Ultimately, the study reinforces that bridging the digital divide across APEC requires coordinated, context-sensitive measures that align infrastructure investment with strong governance and inclusive adoption programs. By applying the frameworks and tools presented here, APEC economies can accelerate progress toward universal, meaningful connectivity and advance the region's broader goals of inclusive and sustainable growth.

1.2 DATA SOURCES AND RESEARCH APPROACH

To build a robust evidence base, we applied a mixed-method approach, combining quantitative data analysis with qualitative case research:

- **International Databases**: ITU, OECD, GSMA, World Bank, and regional telecom regulators for penetration rates, coverage maps, affordability indices, and investment data.
- **Policy and Regulatory Reviews**: Domestic broadband plans, universal service frameworks, and competition policies to understand institutional enablers and gaps.
- **Market Research Reports**: Omdia, Analysys Mason, and GSMA Intelligence for technology rollouts, CAPEX trends, and market structures.
- **Case Studies**: Success stories of broadband initiatives (e.g., Australia's NBN; Indonesia's Palapa Ring project; Korea's economy-wide fiber rollout) to identify proven approaches.
- **Stakeholder Inputs**: Insights from APEC TELWG workshops, regulators, and industry participants to validate relevance and feasibility

This combination of data sources ensured that our findings are evidence-based, policy-relevant, and regionally grounded, supporting practical recommendations for policymakers and development partners.

1.3 ANALYTICAL FRAMEWORK

The analytical framework was designed to mirror the structure of the subsequent chapters and provide a consistent lens for analyzing the broadband ecosystem:

(a) Supply-Side Analysis (Technology and Infrastructure)

- Fixed broadband coverage (fiber, DSL, cable, FWA)
- Mobile network coverage and technology migration (3G, 4G, 5G)
- Infrastructure investment levels and rollout speed

(b) Demand-Side Analysis (Digital Readiness and Inclusion)

- Adoption rates and household penetration
- Affordability of fixed and mobile broadband (as % of GNI per capita)
- Demographics (population density, age distribution, income levels)
- Digital skills and availability of relevant local content

(c) Policy and Regulatory Framework Analysis

- Spectrum management and licensing regimes
- Universal service obligation (USO) schemes and funding
- Market structure and degree of competition
- Policy incentives for public–private partnerships and open access

This structured approach enabled us to compare economies on a like-for-like basis, identify bottlenecks on both supply and demand sides, and understand which regulatory or institutional levers could most effectively close the gaps

1.4 CLUSTERING OF ECONOMIES

Based on these indicators, economies were grouped into four clusters to capture the heterogeneity of APEC and to allow for tailored recommendations:

- Cluster A: Large landmass economies - high cost per km², need for long-haul backbone investment
- Cluster B: Archipelagic economies - focus on submarine cable, satellite, and hybrid solutions
- Cluster C: Mountainous/forested economies - challenging terrain, need for community-led solutions and FWA
- Cluster D: Urban/compact economies - focus on capacity upgrades, inclusion programs, and 5G densification

Clustering was based on statistical correlations (coverage vs. population density, income levels, GDP per capita) combined with qualitative assessments of geography, policy readiness, and market conditions. This approach allowed us to design tailored policy-service models rather than "one-size-fits-all" recommendations, improving transferability and implementation potential.

1.5 VALIDATION AND SYNTHESIS

Ensuring that the results are credible, relevant, and actionable was a central part of the study design:

- **Triangulation:** Results were validated through cross-checking with independent data sources and case studies.
- **Benchmarking:** Economies were benchmarked against global leaders to identify gaps and best practice potential.
- **Toolkit Development**: Insights were distilled into a policy-service model implementation toolkit with a decision framework and KPI matrix to support evidence-based policymaking.
- **APEC Workshop Dialogue**: Preliminary findings were presented at the APEC TELWG meetings for feedback, ensuring policy relevance and alignment with member priorities.

This methodology ensures that the recommendations are data-driven, cluster-specific, and implementable, offering a clear roadmap for policymakers and stakeholders to bridge broadband gaps and promote inclusive digital transformation across the APEC region.

2. ANALYSIS OF BROADBAND STATUS IN APEC ECONOMIES

The Information and Communications Technology (ICT) sector serves as a fundamental engine driving economic growth and creating new opportunities across the diverse Asia-Pacific Economic Corporation (APEC) economies. Central to this growth is **"Broadband Connectivity"**, which underpins not only digital communication but also innovation, commerce, education, and social inclusion. Recognizing its critical role, government, regulators, broadband service providers, public sectors, and other relevant stakeholders have prioritized broadband deployment as a key strategic driver to enhance national economic development and competitiveness.

However, given the wide range of economic, geographic, and demographic characteristics across APEC member economies, the expansion and adoption of broadband technology and infrastructure vary considerably. Some economies are highly advanced with extensive broadband networks, while others are still in the early stages of infrastructure development. This diversity means that tailored approaches are necessary to address specific challenges and leverage opportunities unique to each APEC economy, ensuring inclusive and sustainable growth throughout the APEC economies.

This chapter provides a detailed analysis based on comprehensive research into the broadband status of each APEC member economy. It presents critical insights into broadband infrastructure deployment, adoption levels, regulatory frameworks and policies, and the principal drivers influencing both the supply and demand aspects of broadband connectivity and access. Through this analysis, the chapter elucidates the diverse broadband environments across APEC economies, offering a nuanced understanding of the challenges and opportunities that shape the deployment and expansion of broadband services throughout the APEC economies.

2.1 BROADBAND INFRASTRUCTURE AND SERVICES OVERVIEW

As of 2025, global broadband connectivity has experienced remarkable progress, transforming the way people access and interact with digital technologies worldwide. Both fixed and mobile broadband networks have undergone substantial advancements, driven by rapid optical network infrastructures and the widespread expansion of 5G technology. These developments have enabled faster, more reliable internet access, supporting growing demands for streaming, remote work, digital education, and smart devices.

Fixed Broadband Network Advancements

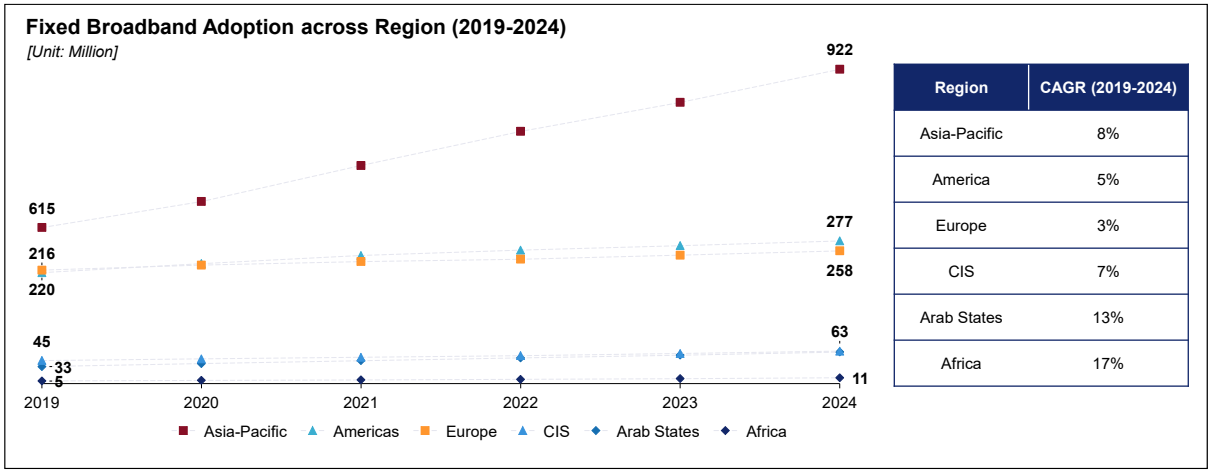
Over the last few years, fiber optic technology has rapidly expanded worldwide, becoming the backbone of fixed broadband networks. Fiber optic technology offers ultra-fast speeds, low latency and high reliability compared to older technologies, like DSL or cable. Based on the latest Organization for Economic Co-operation and Development (OECD) statistics, Fiber and Fixed Wireless Access (FWA) have experienced the fastest growth among fixed broadband

technologies over the past three years. Fiber subscriptions grew by 56% from June 2020 to June 2023, while FWA subscriptions rose by 64% during the same period.[1]

Based on the most recent data available, the International Telecommunication Union (ITU) provides detailed insights into fixed broadband subscription rates across different regions. In 2024, the worldwide average for fixed broadband subscriptions reached 21 per 100 inhabitants[2]. However, significant regional disparities are evident. Between 2019 and 2024, Africa recorded the highest growth rate in fixed broadband subscriptions at 17%, followed by the Arab States at 13%, and the Asia-Pacific region at 8%[3]. In contrast, Europe experienced a more modest growth rate of 3%, reaching a penetration rate of approximately 37% by the end of 2024[4].

Figure 2.1 illustrates the varied landscape of fixed broadband adoption across regions, emphasizing areas of rapid growth alongside those experiencing more gradual development.

Figure 2.1 Fixed Broadband Adoption across Regions (2019 – 2024)



Source: (1) Time Series of ICT data for the world, by geographic regions, by urban/rural and by level of development, "World Fixed and Mobile Subscription data." (2024, November). Itu.int; International Telecommunication Union / ICT Indicators Database. https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

The global fixed broadband landscape is characterized by the rapid expansion of fiber optic networks, the development of advanced technologies, such as Passive Optical Network (PON) technologies, and integration of FWA solutions, contributing to improve internet access and speeds worldwide.

[1] "OECD Broadband Statistics Update", "Organization for Economic Co-operation and Development." (2024, March 12). OECD. https://www.oecd.org/en/about/news/press-releases/2024/03/broadband-statistics-update.html
[2] Time Series of ICT data for the world, by geographic regions, by urban/rural and by level of development, "World Fixed and Mobile Subscription data." (2024, November). Itu.int; International Telecommunication Union / ICT Indicators Database. https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx
[3] Time Series of ICT data for the world, by geographic regions, by urban/rural and by level of development, "World Fixed and Mobile Subscription data." (2024, November). Itu.int; International Telecommunication Union / ICT Indicators Database. https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx
[4] Time Series of ICT data for the world, by geographic regions, by urban/rural and by level of development, "World Fixed and Mobile Subscription data." (2024, November). Itu.int; International Telecommunication Union / ICT Indicators Database. https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

Global Fixed Broadband Network Advancements as of 2025:

1. **BT Group's Full-Fiber Broadband Expansion – United Kingdom**
   BT Group, a global telecommunications and network services company, is aggressively expanding its full-fiber network, aiming to cover twenty-five million premises by 2026. This involves upgrading from legacy copper lines to pure fiber optic connections, providing ultra-fast reliable broadband across both urban and rural areas. Hundreds of millions of pounds have been invested to accelerate fiber rollout and improve network quality.

   Chief Executive of BT Group said *"BT is already building more full fiber broadband to homes and businesses. Today we are increasing our FTTP target from twenty million to twenty-five million homes and businesses. This has three massive benefits: it allows us to go faster, beefing up our capacity to build fiber to households and businesses; it allows us to go further, getting fiber to more people including rural communities, and it will help fuel UK economic recovery, with better connectivity and up to 7,000 new jobs."*

2. **Republic of Korea's Ubiquitous Fiber Adoption – Republic of Korea**
   As of 2022, approximately 88% of Republic of Korea's broadband connections were fiber-based, surpassing the OECD average of around 41% and leading all economies in fiber adoption. According to Ookla, Republic of Korea's fiber infrastructure offers some of the fastest fixed broadband speeds globally, at an average download speed of 507.59 Mbps, ranking second globally.

   Government initiatives have played a pivotal role in the development. Programs like the Korean Information Infrastructure (KII) and the Giga-KOREA Project have been instrumental in expanding fiber network domestically, including in rural and underserved areas. These efforts aim to achieve 100% FTTH coverage by 2030, ensuring universal access to high-speed internet.

Source: (1) Our Full Fibre Broadband Build Plans. (n.d.). Www.openreach.com; Openreach Limited 2025. https://www.openreach.com/fibre-broadband/where-when-building-ultrafast-full-fibre-broadband
(2) BT to increase and accelerate FTTP build to 25m premises by the end of 2026. (2021, May 13). British Telecommunications. https://newsroom.bt.com/bt-to-increase-and-accelerate-fttp-build-to-25m-premises-by-the-end-of-2026/
(3) National Policies and Projects Driving Fiber Expansion in APAC. (2024, October). Telecom Review Asia. https://www.telecomreviewasia.com/news/featured-articles/4601-national-policies-and-projects-driving-fiber-expansion-in-apac
(4) Asia leads in full fibre penetration. (2024, June 28). Insight Prysmian Magazine. https://www.prysmian.com/en/insight/nexst/digital-solutions/asia-leads-in-full-fibre-penetration

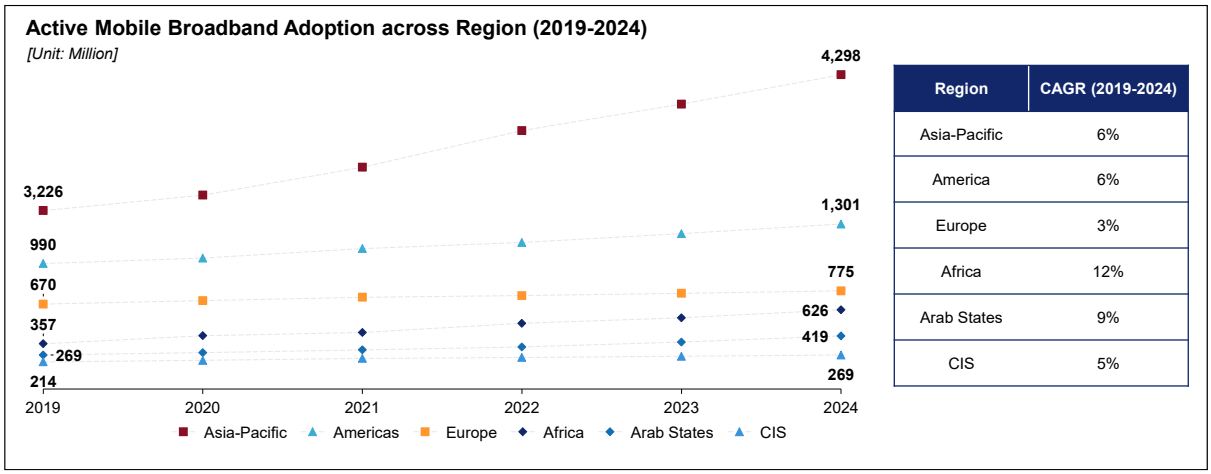
Mobile Broadband Network Advancements

Although mobile broadband subscription is near saturation in most regions, there is still room for growth in some lower- and middle-income regions. Most operators are now focusing on delivering the 5G Standalone Networks portfolio for better customer experience with over 60 operators, mostly in Asia-Pacific and Europe, offering commercial 5G Standalone Networks services. The global rollout, commercialization, and diversification of 5G ecosystems, especially 5G FWA, will drive share of 5G technology to approximately 50% by 2030[5].

[5] The Mobile Economy 2025. (2025). GSMA. https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-economy/wp-content/uploads/2025/02/030325-The-Mobile-Economy-2025.pdf

Based on the most recent data available, the International Telecommunication Union (ITU) provides insights into active mobile broadband subscriptions by region. In 2024, the global average for active mobile broadband subscriptions was 96 per 100 inhabitants[6]. Growth is minimal in all regions except for Africa at 12% growth rate, followed by the Arab States at 9%. The rest of the regions experienced sub-modest growth between 3% - 6%; the Americas at 6%, Asia-Pacific at 6%, CIS at 5%, and Europe at 3%. The figure below illustrates a near-saturation adoption of mobile broadband across regions, except for Africa, a late-adopter region due to its development.

Figure 2.2 Active Mobile Broadband Adoption across Regions (2019 -2024)



Region	CAGR (2019-2024)
Asia-Pacific	6%
America	6%
Europe	3%
Africa	12%
Arab States	9%
CIS	5%

Source: (1) Time Series of ICT data for the world, by geographic regions, by urban/rural and by level of development, "World Fixed and Mobile Subscription data." (2024, November). Itu.int; International Telecommunication Union / ICT Indicators Database. https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

Examples of Global Mobile Broadband Network Advancements as of 2025:

1. **China's Aggressive 5G Base Stations Implementation – The People's Republic of China**
   The People's Republic of China has built over 4.19 million 5G base stations economy-wide by the end of 2024 and plans to increase that number to 4.5 million by the end of 2025, hereby enabling '5G in every village'. This is part of China's 14th five-year plan, a broad economic set of strategies aimed to improve the economy. Due to this heavy investment in infrastructure, China already has over one billion 5G connections, which accounts for almost half of global total of 2.3 billion 5G connections.

2. **Gulf Cooperation Council's 5G Aims for Highest Penetration Rate Globally – Arab States**
   5G Standalone and 5G Advanced will be central to Communications Service Provider (CSP) strategies through 2030, shifting focus from data volume to value-driven services like AI, cloud, and network slicing. While mobile data traffic growth is slowing (21% YoY in 2024), it is still expected to triple by 2030, with 5G networks carrying 80% of that traffic. The GCC is projected to lead in 5G adoption, reaching 93% penetration by 2030. Globally,

[6] Time Series of ICT data for the world, by geographic regions, by urban/rural and by level of development, "World Fixed and Mobile Subscription data." (2024, November). Itu.int; International Telecommunication Union / ICT Indicators Database. https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

5G subscriptions are set to hit 2.3 billion by end-2024 and surpass 4G by 2027, with 6G deployments anticipated by 2030.

Source: (1) The Mobile Economy: China 2025. (2025). https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-economy/wp-content/uploads/2025/04/10042025-The-Mobile-Economy-China-2025.pdf
(2) Tomás, J. P. (2025b, April 28). China reaches nearly 4.4 million 5G base stations. RCR Wireless News. https://www.rcrwireless.com/20250428/5g/china-reaches-4-5g
(3) Ericsson mobility report: GCC countries projected to have highest 5G penetration in 2030. (2024, November 26). Ericsson. https://www.ericsson.com/en/press-releases/5/2024/ericsson-mobility-report-gcc-countries-projected-to-have-highest-5g-penetration-in-2030

2.1.1 Highlights of Broadband Infrastructure across 21 APEC Economies

APEC economies are among the most vibrant and fastest-growing telecommunications markets globally, especially in fixed and mobile broadband connectivity. Over the last ten years, the APEC economies have experienced remarkable expansion in broadband infrastructure, driven by significant investments in fiber optic networks and swift adoption of mobile technologies such as 4G and 5G.

This analysis explores a range of factors influencing the progressive development of broadband infrastructure across member economies. A comprehensive understanding of broadband infrastructure development across the member economies requires consideration of the diverse economic, technological, regulatory, and social factors that shape each economy's unique challenges and opportunities.

(1) Economic Development Levels

Economic development levels significantly influence broadband infrastructure development across APEC economies. For example, high-income economies within APEC, such as Australia; Japan; Republic of Korea; and Singapore, typically have fixed broadband penetration rates exceeding 80%, supported by extensive fiber optic networks and widespread 4G / 5G coverage. In contrast, emerging economies, such as Indonesia; the Republic of the Philippines; and Viet Nam, have lower fixed broadband penetration and more reliance on mobile broadband for internet access. These economies have experienced rapid mobile subscriber growth, but network coverage remains uneven, especially in rural areas.

Broadband infrastructure varies significantly across APEC economies, reflecting disparities in Economic Development Levels:

1. **High-Income Economies:**
   - **Japan:** Fiber optic broadband accounted for 84% of fixed broadband subscription by the end of 2023; Deployed more than 90% of 4G and 5G network economy-wide coverage
   - **Singapore:** Achieved 99% fiber optic broadband penetration by 2023 – with over half a million households to gain access to faster speed of up to 10Gbps by 2028; Achieved more than 95% of 5G network economy-wide coverage
   - **Republic of Korea:** Fiber optic broadband took up 89% of fixed broadband subscription by 2023; Achieved more than 90% of 5G network economy-wide coverage

2. **Middle- and Low-income economies:**
   - **Thailand:** Fixed broadband subscriptions accounted for only 53% of all households, while mobile subscriptions reached 136% by 2024; Mobile market is driven by prepaid segment.
   - **Indonesia:** Fixed broadband subscription only reached 19.7% of total households by 2024; while mobile subscription reached 125% by 2024 with 92% as 4G subscribers.
   - **Papua New Guinea:** Fixed broadband subscription reached 0.21% total population by 2021; while mobile subscription stood at 48% of total population in 2024.

Source: (1) World Bank Country and Lending Groups – World Bank Data Help Desk. (2025). World Bank Group. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519 and Metreau, E., Young, K. E., & Eapen, S. G. (2024, July 1). World Bank country classifications by income level for 2024-2025. World Bank. https://blogs.worldbank.org/en/opendata/world-bank-country-classifications-by-income-level-for-2024-2025
(2) Service Provider Market Report – 2024 for Japan, Singapore, South Korea, Thailand and Indonesia, August 2024, Omdia Research
(3) Fixed broadband subscriptions (per 100 people) for Papua New Guinea. World Bank Group; International Telecommunication Union (ITU) World Telecommunication / ICT Indicators Database. Retrieved September 2025, from https://data.worldbank.org/indicator/IT.NET.BBND.P2?locations=PG&view=chart.
(4) Digital in Papua New Guinea: All the statistics you need in 2021. (2021, February). DataReportal – Global Digital Insights. https://datareportal.com/reports/digital-2021-papua-new-guinea

(2) Geography and Demography Factors

Geographic and demographic characteristics are key drivers influencing the pace, scope, and type of broadband infrastructure development across APEC.

Geographic Factors: Many APEC economies are characterized by challenging terrains such as mountains, dense forests, and remote islands, which make deploying broadband infrastructure, especially fixed broadband e.g., fiber optic networks, both logistically difficult and costly. For example, in Indonesia, an archipelago of over 17,000 islands, only about 19.7% of households had access to fixed broadband services in 2024. Due to these logistical challenges more remote islands rely heavily on mobile and satellite connectivity.

A significant gap also exists between urban and rural areas in broadband access throughout APEC economies. Urban areas benefit from dense populations, which make infrastructure deployment more cost-effective and commercially attractive, resulting in a higher broadband penetration rate. While in rural and remote areas, there is limited broadband coverage due to higher cost per user and sparse infrastructure.

Demographic Factors: Demographic characteristics are one of the key factors influencing the deployment and adoption of broadband infrastructure throughout APEC economies. Population size, population density, age distribution, income levels, and digital literacy directly impact both demand for broadband services and the economic feasibility of broadband network investment.

Demographic Factors Affecting Broadband Infrastructure Deployment and Adoption in APEC Economies:

1. Urbanization Rate:

The Republic of Korea is one of the most advanced fixed broadband markets globally, supported by high subscription levels, widespread fiber access, and fast connection speeds. A key factor behind this success is the economy's high urbanization rate: more than 80% of the population lives in cities, with a large share concentrated in metropolitan areas such as Seoul. High urbanization allows broadband providers to roll out infrastructure more efficiently, as large numbers of users can be served within compact service areas. This concentration reduces the cost per connection and increases the commercial viability of advanced fixed broadband networks. In contrast, economies such as Papua New Guinea face much greater challenges. With only about 13% of the population living in urban areas, most households are dispersed across remote and hard-to-reach rural regions. This low level of urbanisation significantly increases the cost of deploying broadband infrastructure, while limiting the potential customer base needed to recover investment. As a result, broadband rollout in such economies is slower and penetration remains substantially lower.

2. Age Distribution:

Younger populations drive internet adoption and demand, especially in mobile broadband, incentivizing operators to rapidly deploy broadband infrastructure. For example, only 5% of **the Republic of the Philippines** population is over 65 years old, while more than 50% is under the age of twenty-five. This young demographic contributed to the Philippines becoming one of the most active economies in online activities, dubbed the "Social Media Capital of the World". This youth-driven market means the operators focus on 4G / 5G mobile-first broadband deployment and other initiatives to create and maintain a robust mobile network.

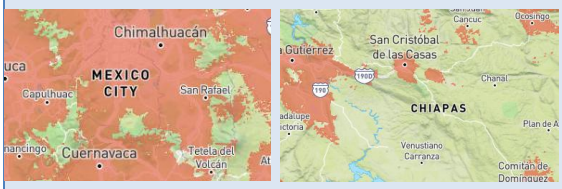
An aging society like **Japan** has issues with broadband adoption among the older age group, despite the near-universal broadband coverage. Many in the 65-year-old-and-up group only use their mobile phones for simple calling and SMS. This is a digital divide issue that cannot be mediated with more broadband upgrades or deployment, but rather an effort from the government to increase the digital literacy and skills for the aging population.

3. Income Inequality:

According to the World Bank's Gini index, a wealth gap indicator with a score of 0 (every citizen has the same level of wealth) to 100 (one citizen holds all the wealth), **Mexico** has the highest Gini index score out of APEC member economies (43.5, 2022 data). Broadband deployment is concentrated in wealthier areas where the population and businesses can afford more premium packages, in turn incentivizing operators to deploy broadband for a higher ROI.

The same correlation could be seen in economies such as **Peru** (Gini index 43.0, 2022), **the Philippines** (39.3, 2023), and many others, where the capital cities achieve strong broadband coverage while leaving the poorer areas behind In more equal economies such as Japan (32.3, 2020) and Korea (32.9, 2021), broadband coverage shows much smaller regional coverage gaps.

In Mexico, the coverage gap could be seen between Mexico City and Chiapas which is less developed. This illustrates that inequality could affect digital access and further broadening the gap without the government's intervention.



Left: Widespread Broadband Coverage in Mexico City (Urban/Wealthy) seen in red. Right: Limited Broadband Coverage in Chiapas (Rural/Poor) seen in red

Source: (1) World Bank. (2020). Population density (people per sq. km of land area) | Data. Worldbank.org. https://data.worldbank.org/indicator/EN.POP.DNST
(2) Population ages 65 and above (% of total population), World Bank Group, Accessed June 2025, https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS?view=chart
(3) Social media users in the Philippines 2030 | Statista. (2025). Statista. https://www.statista.com/forecasts/489180/number-of-social-network-users-in-philippines
(4) Happio-Kirk, L. (2024). Ageing with smartphones in Japan. UCLPress. https://discovery.ucl.ac.uk/id/eprint/10195247/1/Ageing-with-Smartphones-in-Japan.pdf
(5) World Bank. (n.d.). GINI index (World Bank estimate) | Data. Worldbank.org. Retrieved November 21, 2025, from https://data.worldbank.org/indicator/SI.POV.GINI?most_recent_value_desc=false
(6) Network coverage maps, GSMA, Accessed June 2025, https://www.gsma.com/coverage/

A number of studies have shown that robust broadband connectivity leads to higher GDP growth rates, as it enhances efficiencies and opens new markets. A 2025 ITU report[7], The impact of digital transformation on the economy: Econometric modelling, reports a 10% increase in fixed broadband penetration correlates to around 1.59% of GDP per capita increase. Similarly, a 10% increase in mobile broadband penetration also correlates to around 2.29% of GDP per capita increase. In addition, a 10% increase in the digitization index will result in 2.16% of GDP per capita increase and a 2.8% increase in productivity. This points to the importance of broadband connectivity to the overall growth of an economy.

Broadband infrastructure across the APEC member economies highlights a wide range of development levels and trends. In advanced economies, such as Australia; Japan; Republic of Korea; Singapore; and the United States, broadband adoption is extensive, characterized by robust fiber optic networks and comprehensive 4G and 5G coverage. Meanwhile, emerging economies, such as Malaysia; Thailand; and Viet Nam, are rapidly expanding their broadband infrastructure, driven by significant investments and efforts to increase rural connectivity, to bridge the digital divide. However, challenges remain in less developed economies, such as Papua New Guinea and the Republic of the Philippines, facing extreme conditions such as challenging terrains and limited financial resources for broadband expansion. To overcome these challenges, alternative technologies, such as satellite internet, wireless solutions, and strong drive and partnerships between governments and private companies are important to drive broadband adoption and connectivity access.

[7] The impact of digital transformation on the economy - Econometric Modelling - ITU. (2025, October 22). ITU. https://www.itu.int/hub/publication/d-pref-econ.mod-2025/

Table 2.1 Examples of Economies with Infrastructure Focus and Key Deployment Initiatives

APEC Economy	Infrastructure Focus	Key Deployment Initiatives
Australia	Local Broadband Network fiber and fixed wireless	Mix of fiber, fixed wireless, satellite for rural
China	Massive fiber rollout and 5G	Government-led broadband expansion in rural areas
Indonesia	Expanding fiber and wireless in urban and rural areas	Government programs to expand broadband access
Republic of Korea	Ultra-high-speed fiber and 5G	Economy-wide fiber, early 5G adoption
Papua New Guinea	Satellite and wireless solutions	International aid and government broadband programs
United States	Mix fiber, cable, DSL, and growing 5G	Private sector-led, but rural gaps remain

Broadband infrastructure deployment challenges vary across APEC economies, shaped by diverse geographic and economic conditions. A sizable portion of the population, approximately 60%, resides outside urban centers and in areas characterized by mountainous terrains, islands, and vast rural regions, making physical network expansion both costly and complex. The cost of deploying fiber optic networks in these rural areas can be 3-5 times greater than in urban locations, which discourages private investment, particularly in smaller markets with limited financial returns. In addition, regulatory hurdles, such as inefficient spectrum management, restrictions on infrastructure, and lengthy bureaucratic approval processes, further delay broadband rollout.

Closing the ICT infrastructure deficit, especially in rural areas, is vital for APEC economies' prosperity and sustainable development. Improved ICT infrastructure will facilitate increased intraregional and international trade, reduce the cost of doing business, and enhance APEC economies' competitiveness within itself and in the global economy as well as function as a catalyst to economic transformation and diversification through value addition and sustainable and inclusive growth.

2.1.2 Market Snapshot

The broadband markets across APEC economies reveal a diverse and uneven competitive landscape, shaped by differences in geography, regulatory frameworks, and levels of infrastructure maturity. The fixed and mobile segments both show consolidation around a small number of dominant players, with varying degrees of market competition and technology adoption.

Fixed Broadband Landscape

Fixed broadband markets across APEC economies are typically highly concentrated, with two or three operators controlling more than 70% of total subscriptions. In advanced markets such as Japan; the Republic of Korea; and Singapore, fiber-to-the-home/building (FTTH/B) has become the dominant technology, reflecting years of sustained investment and proactive domestic broadband programs. These economies now boast fiber coverage exceeding 80-90% of premises and are upgrading to multi-gigabit capabilities.

In contrast, emerging markets like Indonesia; the Philippines; and Viet Nam remain at earlier stages of fiber expansion. While major operators such as Telkomsel, PLDT, and VNPT continue to deploy fiber networks, legacy DSL infrastructure and the high cost of rural rollout constrain universal coverage. Fixed Wireless Access (FWA) is increasingly being used as a cost-effective complement to fiber, especially for reaching remote or low-density areas. Markets like Chile and Peru illustrate the growing role of open-access wholesale fiber networks, such as ON*NET Fibra, in promoting competition and expanding coverage to underserved regions.

Government-owned or regulated wholesale networks, such as Australia's NBN Co. or Brunei Darussalam's Unified National Networks (UNN), play a key role in ensuring equitable access by separating infrastructure from retail service provision. Overall, fixed broadband development in APEC reflects a mix of public investment, regulatory reform, and private sector innovation, with fiber emerging as clear long-term backbone technology.

Fixed Service Providers Landscape

Economy	Fixed Service Providers Landscape	Service Offering	Fixed Market Overview
Australia	• Telstra (36%) • Optus (13%) • TPG (21%) • Others (29%)	• xDSL, FTTH, FWA • xDSL, FTTH, FWA • xDSL, FTTH, FWA	• the market is dominated by government-owned operator – NBN co. – owning a mix of DSL, Cable, Fiber and FWA and spanning across 12.45m premises (Q2, 2024) • Number of premises able to access NBN's plans = 9.40m
Canada	• Bell Canada (27%) • TELUS (16%) • Rogers (28%) • Others (29%)	• DSL, Fiber, LTE FWA • DSL, Fiber, LTE & 5G FWA • Cable, Fiber, LTE & 5G FWA • Cable, DSL, Fiber, LTE FWA	• Major telcos and cablecos are focused on fiber deployment across Canada. • Fiber expansion programs by major operators are driving growth in fiber. Expanding FWA in rural areas will drive overall broadband growth in Canada.
Chile	• Movistar (31%) • VTR (23%)	• DSL, FTTP/B Cable, FTTP/B	• All FBB service providers provide retail FBB services,

Economy	Fixed Service Providers Landscape	Service Offering	Fixed Market Overview
	• Mundo (18%) • Entel Grupo (7%) • GTD (7%) • Others (13%)	• FTTP/B DSL, FTTH/B, FWA • DSL, FTTP/B Cable, FTTP/B, FWA	only "OnNet Fibra" provides wholesale FBB services to other ISPs (the largest FTTP/B network in Chile). • Several projects driven by operators to expand fiber connectivity in rural and remote areas
People's Republic of China	• China Mobile (48%) • China Telecom (30%) • China Unicom (18%) • China Broadnet (4%)	• FTTx, xDSL • FTTx, xDSL • FTTx, xDSL • Cable	• Gigabit adoption is increasing, number of subscribers with access to gigabit or above speed reached 177m in 1Q 2024, accounting for 27.4% of total FBB subscription • Aggressive competition between the 3 main service providers, owning wide fiber network coverage and targeting home broadband segments leveraging fiber.
Hong Kong, China	• HKT (52%) • HKBN (33%) • i-Cable Communication (6%) • Others (9%)	• FTTx, xDSL • FTTx, 5G FWA GPON, DOCSIS • FTTx, 5G FWA	• HKBN is the largest fiber broadband provider with more than 1 million connections on network, including 915,000 residential connections and 119,000 business connections • 5G FWA is a choice for residents in more remote areas.
Indonesia	• Telkomsel (92%) • LinkNet (4%) • IoH (2%) • XL Axiata (2%)	• ADSL, FTTH/B, LTE/5G FWA • FTTH/B • FTTH/B • FTTH/B	• Growth will remain at a low rate due to no real push for acceleration of broadband infrastructure expansion since the end of the Indonesia Broadband Plan (IBP) in 2019 and the Palapa Ring Project ended following year • Local broadband providers continue to promote their converged bundles (FBB, mobile and media bundles)
Japan	• NTT Docomo (17%) • KDDI (11%) SoftBank (11%)	• xDSL, FTTH/B, FWA • FTTH/B • FTTH/B, FWA	• Service providers have been steadily improving quality of broadband services, encompassing advancements in

Economy	Fixed Service Providers Landscape	Service Offering	Fixed Market Overview
	• Others (61%)	• FTTH/B, Cable, FWA	bandwidth capacity, internet speed and service reliability.
Republic of Korea	• KT Corp (41%) • SK Telecom (29%) • LG U+ (21%) • Others (9%)	• DSL, Fiber Cable modem, • DSL, Fiber Cable modem • Fiber	• Government intervention through broadband service pricing regulations has contributed to growth – reducing cancellation and early exit charges. • Expanding broadband coverage for high-speed internet in rural areas remains challenging due to high development costs – e.g. fishing communities and homes/businesses in mountainous regions.
Malaysia	• Telekom Malaysia (70%) • Maxis (18%) • TIME dotcom (8%) • Others (4%)	• DSL, FTTH/B, FWA • FTTH/B, FWA FTTH • FTTH/B, FWA	• Reducing wholesale prices by 50-60% from 2023-2035, benefited consumers with lower prices and/or higher speeds. • Competition has increased with at least 7 major players. Subscriber growth is largely driven by fiber.
Mexico	• Telmex Mexico (38%) • Izzi Mexico (23%) • Totalplay (17%) • Mega-cable (16%) • Others (6%)	• xDSL, FTTH • Cable, FTTH • FTTH • Cable • Cable	• Fixed broadband is growing faster than mobile and is a more competitive market. • Mexico has an established broadband provider market. • Fiber infrastructure is expanding, and FWA offerings are also growing (using 700MHz network)
New Zealand	• Spark NZ (33%) • One NZ (16%) • 2degrees (9%) • Others (42%)	• xDSL, FTTH/B, FWA • xDSL, FTTH/B, Cable, FWA • xDSL, FTTH/B	• Slow deployment of broadband technology in rural areas has resulted in slow growth. • Government urged operators to improve quality and connectivity options and led the “Rural Connectivity Study” and “Measuring Broadband

Economy	Fixed Service Providers Landscape	Service Offering	Fixed Market Overview
			New Zealand" for better guidelines.
Peru	• Telefonica Peru (31%) • Win Group (21%) • Wow (20%) • Claro (12%) • Others (14%)	• DSL, FTTH/B, Cable • DSL, FTTH/B, Cable • DSL, FTTH/B, Cable • DSL, FTTH/B, Cable	• In 2023, ON*NET Fibra de Perú launched the first economy-wide open-access fiber network, aiming to reach 5.2 million homes by 2026. • ~6 million rural residents still lack high-speed mobile internet, with 2.8 million having no operator coverage at all.
The Philippines	• PLDT (43%) • Converge ICT (27%) • Globe Telecom (20%) • Others (11%)	• DSL, FTTH, • LTE & 5G FWA FTH • DSL, FTTH, LTE & 5G FWA	• Fixed broadband subscriptions declined between 2Q22 and 3Q23, and experienced growth rate below 2% until 2Q24. • 10-year digital infrastructure project approved by the government, aims to expand broadband coverage in disadvantaged areas.
Russia	• Rostelecom (38%) • MTS Russia (12%) • ER-Telecom (12%) • Others (38%)	• DSL, Fiber • DSL, Fiber, Cable, Ethernet • Fiber • DSL, Fiber	• Total number of subscriptions grew by 2.4% YoY at end 2022, driven by the deployment of fiber networks in rural areas • Many broadband expansion programs are on hold due to a lack of equipment and funding, • There is a significant disparity in access to broadband services between urban and rural areas.
Singapore	• SingTel (43%) • StarHub (37%) • M1 Singapore (15%) • Others (5%)	• FTTH • FTTH • FTTH • FTTH	• Fixed broadband market dynamics are driven by value-added entertainment services and discounts. • Enhanced NBN will serve as a foundation for future applications and innovation, offering up to 10x faster speed than current capabilities. • The NBN upgrade is scheduled to occur from mid-2024 -2026.

Economy	Fixed Service Providers Landscape	Service Offering	Fixed Market Overview
Chinese Taipei	• Chunghwa Telecom (60%) • Taiwan Mobile (4%) • FarEasTone (7%) • Others (29%)	• xDSL, FTTx • Cable modem • xDSL, FTTx • Cable modem	• The growth in fiber subscription is driven by surging demand for high-speed broadband connectivity. • The government's "Smart Economy plan (2021-2025) aims to expand fiber broadband connectivity with minimum speed of 2Gbps to approx. 90% of the population by 2025.
Thailand	• AIS (36%) • TRUE (28%) • NT (22%) • Others (13%)	• FTTH/B, FWA • DSL, FTTH/B, Cable • DSL, FTTH/B	• The growth in FBB subscriptions and revenue will be driven by demand from urbanization trends and improved coverage in rural areas. • New development plan known as "Giga Thailand Infrastructure" aims to cover all households with a FTTH-based fixed broadband network by 2027.
The United States	• Comcast (23%) • Charter (22%) • AT&T US (12%) • Others (43%)	• DOCSIS 3.1, DOCSIS 4.0, FTTH • DOCSIS 3.1, FTTH • FTTH, LTE & 5G FWA • xDSL, FTTH, LTE & 5G FWA	• Strong subscription growth from FWA and fiber, however cable modem remains the dominant broadband technology. • The USD 42 billion Broadband Equity, Access, And Deployment (BEAD) Program is under overhaul in 2025 to allow satellite internet services for underserved areas, in addition to the previous slow-paced fiber-optic plans.
Viet Nam	• Viettel (42%) • VNPT (35%) • FPT (19%) • Others (4%)	• xDSL, FTTx • xDSL, FTTx • xDSL, FTTx	• Fiber continues to grow in line with expansion efforts by service providers. • Viet Nam's Digital Infrastructure Master Plan to 2030 prioritizes broadband expansion, targeting 99%

Economy	Fixed Service Providers Landscape	Service Offering	Fixed Market Overview
			population coverage with high-speed internet.

Sources: (1) Service Provider Market Report – 2024 (available for relevant APEC economies), Omdia Research, Updated by 2024.

Mobile Service Providers Landscape

Economy	Mobile Service Providers Landscape	Service Offering	Mobile Market Overview
Australia	• Telstra (54%) • Optus (32%) • TPG (13%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• Telstra and Optus launched 5G standalone networks in 2022. • TPG (Vodafone) aims to cover 99% of population in 12 largest cities with 5G by 2025.
Brunei Darussalam	• DST (68%) • Progresif (27%) • Imagine (5%)	• Mobile, FBB • Mobile, PayTV • Mobile, FBB	• Brunei Darussalam's government established UNN, an entity that owns and operates all local telecom infrastructure, enabling equal access to operators. • In 2024, UNN initiated a project to provide 5G services to remote communities using hybrid solar power systems.
Canada	• Rogers (33%) • Bell (28%) • TELUS Canada (26%) • Others (10%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• Bell deployed a 3800 MHz spectrum in selected areas in Toronto and Kitchener-Waterloo. • Rogers plans to re-farm 2G and 3G spectrum to LTE and 5G/5G+.
Chile	• Claro (22%) • Entel (34%) • Movistar (26%) • WOM (18%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• Entel and Movistar implemented the second phase of their 5G roll-out with increased sites.

Economy	Mobile Service Providers Landscape	Service Offering	Mobile Market Overview
People's Republic of China	• China Mobile (~58%) • China Telecom (~24%) • China Unicom (~16%) • China Broadnet (~1%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, Wholesale • Mobile, FBB, Wholesale	• It is anticipated that over 87% of mobile subscriptions will be 5G by 2028. • MIIT launched a pilot project aiming to open up the economy for telecom services funded by foreign enterprises.
Hong Kong, China	• Hutchison Telecom (22%) • HKT (32%) • SmarTone (14%) • China Mobile HK (31%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV	• HKT closed its network in 2024 and re-farmed spectrum for 5G. • SmarTone, CMHK, and Hutchison completed their 5G network for metro stations in 2024.
Indonesia	• Telkomsel (43%) • IoH (33%) • XL Axiata (15%) • Smartfren (9%)	• Mobile, FBB, PayTV • Mobile, FBB, PayTV • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• Telkomsel, IOH, and XL Axiata phased out their 3G network by 2023. • IOH signed a deal with Ericsson in March 2022 to expand 5G networks in new regions.
Japan	• NTT Docomo (44%) • KDDI (24%) • SoftBank (28%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• KDDI achieved its 5G roll-out target of reaching 90% population coverage by 2022. • NTT Docomo started testing 6G in 2023.
Republic of Korea	• KT Corp (32%) • SK Telecom (42%) • LG U+ (26%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• SKT, KT and LG Uplus completed their shared rural 5G network in 2024. • LG Uplus signed a MOU with Nokia to co-develop 5G Advanced and 6G technologies in 2022.
Malaysia	• Maxis (25%) • Celcom Digi (55%) • U Mobile (17%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• Maxis, Celcom Digi, and U Mobile offer 5G services over DNB's network. • The government granted a second economy-wide 5G license to U Mobile, removing an infrastructure monopoly and

Economy	Mobile Service Providers Landscape	Service Offering	Mobile Market Overview
			paving way for a dual network model.
Mexico	• Telcel (55%) • Movistar (16%) • AT&T (14%) • ALTAN Redes (15%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• Telcel acquired 5G spectrum from its fixed services sister company, Telmex, in 2020. • AT&T inherited its 5G spectrum after its Nextel acquisition. Its license was renewed for 20 years.
New Zealand	• Spark NZ (44%) • One NZ (32%) • 2degrees (24%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• Spark NZ aims to provide 5G to all towns with over 1,500 people by 2026. • By September 2025, One NZ has upgraded 155 mobile sites with 5G access.
Papua New Guinea	• Digicel (~50-60%) • Vodafone (~20-25%) • Telikom (5-15%)	• Mobile, FBB, PayTV • Mobile • Mobile, FBB, PayTV	• In 2024, the government approved a plan to assign spectrum directly to operators allowing them to commit to coverage investments with the aim to promote telco services using 5G SA technology.
Peru	• Calro (37%) • Entel (23%) • Bitel (21%) • Movistar (19%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• In 2023, ON*NET Fibra de Perú launched the first economy-wide open-access fiber network, aiming to reach 5.2 million homes by 2026. • ~6 million rural residents still lack high-speed mobile internet, with 2.8 million having no operator coverage at all.
The Philippines	• PLDT Smart (32%) • Globe Telecom (55%) • Dito (13%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, Wholesale • Mobile, FBB, Wholesale	• Smart continued to expand its 5G network economy-wide in 2024. • Globe ramped up its LTE and 5G rollouts, upgrading and adding hundreds of new sites as of 2024. • The economy's 5G subscriptions are projected to

Economy	Mobile Service Providers Landscape	Service Offering	Mobile Market Overview
			surpass 4G subscriptions by 2028.
Russia	• MTS (30%) • MegaFon (29%) • Beeline (21%) • T2 (18%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• In 2025, Russia began to conduct pilot testing of 5G networks using Russian-built base stations. • The government aims to provide 16 Russian cities with 5G network by 2030.
Singapore	• SingTel (45%) • StarHub (22%) • M1 (23%) • SIMBA (9%)	• Mobile, Fixed BB, PayTV, Wholesale (MVNO Hosting) • Mobile, Fixed BB, PayTV, Wholesale (MVNO Hosting) • Mobile, Fixed BB, PayTV, Wholesale (MVNO Hosting) • Mobile	• 3G shutdown in July 2024 • Mature mobile market with 4 MNOs and multiple smaller MVNOs. • Market is defined as weak spending by both businesses and consumers.
Chinese Taipei	• Chunghwa Telecom (38%) • Taiwan Mobile (32%) • FarEasTone (30%)	• LTE (4G) • 5G LTE (4G) • 5G LTE (4G) • 5G	• 3G voice services were shut down in June 2024 and were replaced by VoLTE. • All 3 MNOs have achieved over 90% of population coverage with their 5G networks • There are 3 MVNOs: SaveCom International, SunlineNP and Ibon Mobile.
Thailand	• AIS (44%) • TRUE (54%) • NT (2%)	• Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale • Mobile, FBB, PayTV, Wholesale	• AIS and True launched 5G services in February 2020 and March 2020 respectively. • There are 4 MVNOs in market, classified into “Others”.
The United States	• AT&T US (39%) • Verizon (35%) • T-Mobile US (24%) • Others (2%)	• LTE (4G), • 5G LTE (4G), • 5G, GSM LTE (4G), • 5G	• Mobile subscription is expected to see the strongest growth between 2024 to 2029, driven by IoT subscription. • Service provider landscape is shifting by M&A from T-Mobile (acquisition of Ka’ena and USCellular).

Economy	Mobile Service Providers Landscape	Service Offering	Mobile Market Overview
			• Service providers have planned for 5G SA deployment economy-wide.
Viet Nam	• Viettel (37%) • VNPT (20%) • Mobifone (31%) • Others (12%)	• xDSL, FTTx • xDSL, FTTx • xDSL, FTTx	• By 2025, Viet Nam aims to achieve full mobile coverage across local highways, main roads and railways. • Mobile connectivity services also extend to all remote areas that still lack connectivity, ensuring ongoing coverage along major transport routes. • 5G coverage is planned to be available in all provinces and cities, e.g., high-tech zones, research and innovation centers, industrial parks, airports and seaports.

Sources: (1) State of the telecoms market 2024 (available for relevant APEC economies), Analysys Mason Limited, Updated by 2024.
(2) Mobile Market KPIs by economy, 2000-2030 (available for relevant APEC economies), GSM Association / Wireless Intelligence, March 2023.

Mobile Service Provider Landscape

The mobile broadband segment remains the primary means of internet access in most developing APEC economies, with 4G still dominant and 5G expanding rapidly. In most markets, three to four major mobile network operators (MNOs) account for nearly all market shares. Competitive dynamics are evolving as operators consolidate and diversify into fixed broadband, content, and wholesale services.

5G deployment is now well underway across nearly all APEC economies, with early adopters such as China; Korea; Japan; and Singapore achieving extensive population coverage- often exceeding 90%. Meanwhile, economies such as Malaysia; Thailand; and Viet Nam are catching up, supported by domestic digital infrastructure plans and shared 5G networks. Rural connectivity remains a challenge, particularly in archipelagic and mountainous regions, where the cost per user can be three to five times higher than in urban areas. To address this, operators are increasingly turning to hybrid models using satellite, FWA, and solar-powered base stations to reach unserved communities, as seen in Brunei Darussalam and Papua New Guinea.

Regulatory reforms and universal service initiatives are also reshaping markets: Malaysia's dual network 5G model and Chile's coverage obligations exemplify efforts to enhance competition and ensure equitable access. Across the region, mobile and fixed markets are converging, as operators integrate services into unified digital platforms and bundled offerings, driving both affordability and user adoption.

2.2 BROADBAND SERVICE ACCESS: SUPPLY-SIDE PERSPECTIVES

Access to broadband services from the supply side depends on the availability and quality of infrastructure, network capacity, and investments made by services providers to expand coverage and enhance connectivity.

According to the ITU / UNESCO State of Broadband2024 report the number of internet users grew to 5.4 billion in 2023 and was estimated to reach 5.5 billion by the end of 2024. However, around 2.6 billion people remain offline, with an estimated 38% of the global population living within mobile broadband coverage but not using it, and 5% still lacking any mobile broadband coverage [8]. The ITU / UNESCO Broadband Commission for Sustainable Development Advocacy targets that by 2025, 75% of the world's population must have access to broadband internet and the entry-level broadband services should be made affordable in developing economies, amounting to less than 2% of monthly gross national income per capita[9].

Across APEC economies, the availability and quality of broadband services differ due to several factors. The key drivers influencing broadband service supply are analyzed below:

Broadband Infrastructure Availability

According to the OECD broadband data, broadband technologies, such as fiber optic and 5G mobile networks are rapidly expanding to meet the rising demand for high-quality, affordable, and widely accessible internet[10]. Across OECD, fiber connections accounted for 42% of all fixed broadband subscriptions by the end of 2023, marking a 4% increase from the end of 2022. Meanwhile 5G accounted for 28% of mobile broadband subscriptions, representing a 9% increase compared to the previous year[11].

(1) Fiber optic coverage continues to expand

Fixed broadband coverage initially relied on Digital Subscriber Line (DSL) technology, which used existing copper telephone lines to provide internet access. While DSL played a crucial role in the initial stages of broadband expansion, its limitations in speed and capacity became increasingly apparent as demand for faster and more reliable internet grew. By the early 2010s, DSL accounted for over 60% of fixed broadband subscriptions in many economies, but this share has steadily declined. In response, there has been a significant and accelerated shift towards deploying fiber optic networks, which represent approximately 42% of fixed broadband subscriptions across OECD economies by 2023. Fiber optic technology offers vastly superior speed, capacity, and future-proof capabilities.

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[8] The State of Broadband 2024: leveraging AI for universal connectivity; part one. (2024). In https://unesdoc.unesco.org/ark:/48223/pf0000390280. UNESCO International Telecommunication Union and Broadband Commission for Sustainable Development.

[9] The State of Broadband 2024: leveraging AI for universal connectivity; part one. (2024). In https://unesdoc.unesco.org/ark:/48223/pf0000390280. UNESCO International Telecommunication Union and Broadband Commission for Sustainable Development.

[10] Future-proof broadband access technologies gain ground for both fixed and mobile networks across the OECD in 2023. (2024, July 24). OECD. https://www.oecd.org/en/data/insights/statistical-releases/2024/07/future-proof-broadband-access-technologies-are-gaining-ground-for-both-fixed-and-mobile-networks-across-the-oecd-in-2023.html

[11] Future-proof broadband access technologies gain ground for both fixed and mobile networks across the OECD in 2023. (2024, July 24). OECD. https://www.oecd.org/en/data/insights/statistical-releases/2024/07/future-proof-broadband-access-technologies-are-gaining-ground-for-both-fixed-and-mobile-networks-across-the-oecd-in-2023.html

The rapid expansion of fiber "home passes"- homes located within reach of a fiber network and ready for service connection -drives subscription growth and supports the deployment of advanced digital services such as ultra-high-definition streaming, teleworking, cloud computing, and 5G backhauls.

Table 2.2 below illustrates fiber optic home passes and fixed broadband coverage in APEC economies.

Table 2.2 Fiber Optic Home Passes / Broadband Coverage across APEC economies

APEC Economy	Estimated Fiber Homes Passed (millions)	Remarks
Australia	12.29	The National Broadband Network (NBN) deployed and upgraded fiber network nationwide.
Brunei Darussalam	0.22	The Unified National Networks Sdn Bhd (UNN) implemented a 5-year program of modernizing infrastructure and migrating legacy connections from copper to fiber optic.
Canada	11.2	Aggressive expansion of FTTH in urban and suburban areas, with gigabit-level speeds. Universal Broadband Fund, driven by government initiatives, to address Fiber rollout in underserved areas.
Chile	6	Fiber optics accounted for 70% of all connections in 2023. Service provider aggressively planned to complete the migration of all FBB users to fiber by end of 2024.
People's Republic of China	~500	Positioning in the global Top 5 of FTTH/B penetration rate (93.6% as of September 2024). Service providers and government strongly drive for more regional coverage (esp. in disparity areas) and gigabit speeds.
Hong Kong, China	2.6	One of the most advanced fiber optics broadband markets globally. Eighty-six percent of households connected via FTTH/B.
Indonesia	~45	Substantial room for growth in fiber adoption (21% of FBB penetration) while service providers aggressively expand their fiber home passes.
Japan	~56	Japan achieved near universal fiber coverage by the end of 2024 -with over 40m FTTH

APEC Economy	Estimated Fiber Homes Passed (millions)	Remarks
		subscriptions. Government aims to reach 99.9% Fiber network coverage by 2027.
Republic of Korea	~24	The world's most advanced fiber optic broadband market, with 96.6% of FTTH connections, as of 2024. Government drives multiple comprehensive initiatives (e.g., Giga-KOREA Project and BcN)
Malaysia	7.7	Fiber accounted for over 97% of total fixed infrastructure in 2024. Expansion in rural and underserved areas required significant investments and coordination with local authorities
Mexico	25	Mexico is the second biggest FTTH market in LATAM region.
New Zealand	1.84	Ultra-fast Broadband program by the government drove the coverage to 87% of New Zealand homes
Papua New Guinea	N/A	Papua New Guinea is still in the pilot stages of broadband connections, with only ~27.68% of the population subscribed to the internet (penetration rate).
Peru	1.5	By 2023, fiber accounted for almost 50% of all fixed connections.
Republic of the Philippines	17.2	By 2023, PLDT had passed 17.2 million homes with its network.
Russia	~50	By 2020, Russia was leading the European region in home passed coverage.
Singapore	1.58	NetLink NBN Trust pushed more fiber network infrastructure to enhance the end-user experience.
Chinese Taipei	~7	Government's "Smart Country Plan (2021-2025) to extend Fiber broadband connectivity with minimum 2Gbps speed to about 90% of population by 2025
Thailand	23	Market consolidation through M&A has occurred, with fiber subscriptions expected to grow significantly. Government initiatives to bridge the digital divide e.g., USO and Net Pracharat.
The United States	88	New annual record of 10.3million new homes with fiber broadband passed in 2024.
Viet Nam	21.6	New mandate from the government will increase the number of homes by 2.7 million each year (2024 and 2025).

Source:

(1) Fiber optics close to 50% of fixed broadband in Peru. (2023, August 22). BNamericas. https://www.bnamericas.com/en/news/fiber-optics-close-to-50-of-fixed-broadband-in-peru
(2) Giles, M. (2023, February 28). Chile Writes the Blueprint for Fixed Network Improvement in Latin America. Ookla. https://www.ookla.com/articles/chile-fixed-broadband-performance-2023
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(5) 2023 innovation panorama. (2024). Fiber Network Council APAC. https://fibernetworkap.org/wp-content/uploads/2023/12/Innovation-Panorama-APAC-2023_Low.pdf
(6) Combs, D. (2024, March 22). HKBN's Owners Exploring Deal Options for Hong Kong Broadband Provider. Inside Towers. https://insidetowers.com/hkbns-owners-exploring-deal-options-for-hong-kong-broadband-provider/
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(9) Japan to cover 99.9% of households by fiber-optic networks in 2028. (2022). Kyodo News+. https://english.kyodonews.net/news/2022/06/e450761baecb-japan-to-cover-999-of-households-by-fiber-optic-networks-in-2028.html
(10) Alam, R. (2023). History of the Deployment Policy of Fiber Optics in Japan and Future plan by MIC – Fiber Network Council – Asia Pacific. Fibernetworkap.org. https://fibernetworkap.org/history-of-the-deployment-policy-of-fiber-optics-in-japan-and-future-plan-by-mic/
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(12) Digital & Connectivity Indicators - Papua New Guinea | Forecast. (2024). Statista; Statista. https://www.statista.com/outlook/co/digital-connectivity-indicators/papua-new-guinea
(13) Leading countries for fiber-to-the-home (FTTH) and fiber-to-the-building (FTTB) homes passed in Europe in 2020 and 2026. (2025). Statista. https://www.statista.com/statistics/1226729/top-European-countries-fiber-ftth-fttb-homes-passed/
(14) Marcin Frąckiewicz. (2025a, May 15). Internet Access in Russia. TS2 Space. https://ts2.tech/en/internet-access-in-russia/
(15) Middleton, J. (2010, October). Eastern Europe leads fibre boom. Telecoms.com. https://www.telecoms.com/fibre/eastern-europe-leads-fibre-boom
(16) Fixed broadband service revenue in Chinese Taipei to grow at 1.9% CAGR over 2023-2028, forecasts GlobalData. (2023, October 25). GlobalData UK Ltd. https://www.globaldata.com/media/technology/fixed-broadband-service-revenue-in-taiwan-to-grow-at-1-9-cagr-over-2023-2028-forecasts-globaldata
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(18) MWC 2024: Movistar Chile to migrate all fixed broadband users to fibre | Fibre Systems. (2024). Fibre-Systems.com. https://www.fibre-systems.com/article/mwc-2024-movistar-chile-migrate-all-fixed-broadband-users-fibre
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(24) Fiber Broadband Association Reports Record Fiber-To-The-Home Deployment in 2024. (2025, January 23). Fiber Broadband Association. https://fiberbroadband.org/2025/01/23/fiber-broadband-association-reports-record-fiber-to-the-home-deployment-in-2024

(25) U.S. Home Fiber Deployments Top 88M homes passed. (2025, April 17). Fiber Broadband Association. https://fiberbroadband.org/2025/04/17/u-s-home-fiber-deployments-top-88m-homes-passed

While fiber optic network coverage continues to expand steadily across APEC economies, there remains significant potential for increased adoption of fiber broadband services in several member economies. Despite the progress made in infrastructure deployment, the actual take-up or subscription rates for fiber broadband still have considerable room to grow in many markets.

Within the APEC economies, there is a noticeable variation in fiber broadband penetration. Some economies have achieved notably high subscription rates, reflecting strong consumer demand, and effective market strategies.

Major fiber broadband markets among APEC economies:

The People's Republic of China – As of 2023, approximately 98% of the China's broadband subscriptions are fiber optic connections. The economy's telecom regulator, MIIT, reported that around 110 cities were connected to gigabit fiber networks by February 2023, up from 81 cities in 2022.

Other APEC member economies with a high share of Fiber-to-the-home (FTTH) service subscriptions are also expanding fiber coverage to remote areas and upgrading fiber transmission speed:

Singapore – NetLink NBN Trust, the sole fiber network builder in Singapore, reported 1.58 million homes passed by June 2023, further expanding fiber infrastructure to improve user experience. Major ISPs in Singapore offer fiber broadband plans with download speeds up to 2.5 Gbps and upload speeds up to 1.25 Gbps.

The Republic of the Philippines – PLDT Inc., the largest telecom operator in the economy, had passed 17.2 million homes with fiber as of Q1 2023. Service providers have been actively rolling out Fiber infrastructure and deploying fiber ports since 2015. Another major fixed broadband provider, Converge Information and Communications Technology Solutions Inc., reached 15.1 million homes by early 2023, covering key localities.

Source: (1) Fiber coverage in APAC markets continues to expand, The Asian Business Review, 2024, https://asianbusinessreview.com/analysis/fibre-coverage-in-apac-markets-continues-expand
(2) APAC Fiber deployment expands with national policies, telcon strategies, S&P Global Market Intelligence, 4 September 2023, https://www.spglobal.com/market-intelligence/en/news-insights/research/apac-fiber-deployment-expands-with-national-policies-telco-strategies
(3) Fiber continues to dominate APAC fixed communication, Smart Cities Tech, 2 February 2024, https://smartcitiestech.io/2024/02/fiber-continues-to-dominate-apac-fixed-communication/

The deployment of fiber optic networks faces a range of complex challenges, especially in remote or underserved areas. These challenges include securing substantial infrastructure investments, navigating regulatory requirements, and effectively engaging multiple stakeholders. To overcome these challenges, in some APEC economies, the expansion of fiber optic networks is driven by strong collaboration between governments and private sector companies, fostering widespread fixed broadband coverage, and upgrading existing infrastructure to support higher bandwidth capacities. The combined efforts, in terms of resources, expertise and incentives, shall overcome challenges to deploy fiber optic networks

in specific areas or conditions. Government provides critical policy frameworks, regulatory support and, often, financial incentives or subsidies to reduce investment risks. Meanwhile private sector companies bring in expertise, technology expertise, operational efficiency and capital investment required to build, maintain, and innovate network infrastructure.

Government and Public sector companies' collaboration for Broadband Infrastructure Expansion:

Indonesia – as the largest archipelago among APEC economies – Indonesia faces unique challenges in deploying broadband infrastructure due to its vast and complex geography, consisting of more than 17,000 islands, many of which are remote and underserved. To address this, the Indonesia government has adopted **"Public-Private Partnership - PPP"** as a central strategy for expanding broadband access.

One of the flagship initiatives under this approach is the **"Palapa Ring project"**, launched in 2015, which aims to build a domestic fiber-optic network connecting all major islands. This ambitious project involves collaboration with private telecom operators, such as Telkom Indonesia, XL Axiata, and others, with the goal of delivering high-speed internet to remote areas.

The Palapa Ring is divided into three segments – Western, Central and Eastern Indonesia – and its backbone network spans approximately 36,000 kilometers of fiber-optic cables, linking over 500 cities and districts across the economy.

According to Indonesian Internet Service Provider Association (APJII)'s survey, it revealed that Indonesia's internet user penetration reached 79.5% (or approximately 221.5 million users – out of 278.6 million of Indonesia's population) in 2023, increased 1.31% compared to internet user penetration in 2022.

Source: (1) Palapa Ring Project to Boost Indonesia's Internet Penetration. (2016, June 27). Indonesia-Investments.com. https://www.indonesia-investments.com/news/todays-headlines/palapa-ring-project-to-boost-indonesia-s-internet-penetration/item6955
(2) Case Study Indonesia: Fibre-optic cables across an archipelago -Palapa Ring Project Switch your economy on for all Finances. (2019). University of Oxford and Blavatnik School of Government. https://pathwayscommission.bsg.ox.ac.uk/sites/default/files/2019-11/Indonesia_Palapa_Ring_Project.pdf
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Through collaborations or partnerships, the pace of infrastructure deployment can be significantly accelerated, enabling broader geographic coverage and fostering more affordable access to fiber broadband. Such cooperative efforts help balance public interest objectives, like digital inclusion and equitable access, with the commercial viability necessary to attract and sustain private sector environment.

(2) 4G network dominant while 5G network aggressively rolled out

Mobile broadband has become the primary mode of internet access for many consumers across APEC economies. Several factors contribute to this dominance of mobile broadband, for example:

- **Infrastructure and Coverage Advantages** – Deploying fixed broadband networks is costly and logistically complex, particularly in geographically dispersed, rural, or remote areas. Mobile broadband, utilizing wireless technology, requires less physical infrastructure, allowing for faster and more cost-effective network expansion.
- **Rapid Technology Adoption and Smartphone Penetration –** Many APEC economies have seen rapid growth in smartphone adoption, driven by affordable devices and competitive mobile plans. Mobile broadband aligns well with changing consumer behaviors and lifestyles, offering convenient internet access anytime and anywhere.
- **Government Policies and Industry Focus –** In several APEC economies, governments and regulators have prioritized mobile broadband deployment through strategic spectrum allocation, investment incentives, and public-private partnerships. These efforts have accelerated the rollout of 3G, 4G and 5G networks, significantly improving mobile broadband coverage and speeds.

Therefore, mobile broadband's flexibility, affordability, and rapid deployment have made it the primary form of internet access in many APEC economies. As demand for faster, more dependable, and ubiquitous internet connectivity grows, government and telecom providers have therefore accelerated investment in next-generation mobile technologies.

While 4G networks now cover the vast majority of urban and many rural areas the introduction of 5G is rapidly gaining momentum.

Examples of APEC economies driving 5G Network coverage rollout:

Chile – Chile is a 5G leader in Latin America, with over 5.2 million 5G connections as of 2024. In 2024, spectrum was awarded to Claro with a strict obligation to cover 366 isolated communities, 199 hospitals, and sixty-five critical routes. Further 5G spectrum allocation plans are in development aligning with the government's aim to achieve 90% 5G coverage by this year.

People's Republic of China – Deployment of more than 1.8 million 5G Base Stations boosted more than 450 million 5G subscribers.

Republic of Korea – The first economy globally to have launched economy-wide 5G coverage and commercialized 5G services through early spectrum auctions, tax breaks for emerging 5G industries, and 5G infrastructure deployment cost-sharing model between operators. To date, Republic of Korea boasts 33.4 million 5G subscribers and 97% coverage.

Malaysia – In the beginning of January 2025, the government granted a second 5G license to U Mobile, meaning a move to 5G Dual-network instead of the original single wholesale network controlled by the government-linked DNB. This move will drive the previously low capital expenditure (CAPEX) spent on 5G infrastructure, releasing pent-up investments and subsequent demands for faster connections.

Source: (1) 5G Launches in Korea Volume 1: Key Success Factors for Early 5G Launch. (2019). Samsung Electronics Co., Ltd. https://images.samsung.com/is/content/samsung/assets/global/business/networks/insights/white-paper/5g-launches-in-korea-get-a-taste-of-the-future/5G-in-Korea-Vol-1-Get-a-taste-of-the-future.pdf
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(4) 5G and the tech economy in Malaysia: tapping the untapped. (2025). GSMA Intelligence. https://www.gsma.com/about-us/regions/asia-pacific/wp-content/uploads/2025/02/200225-Malaysia-tech-economy.pdf
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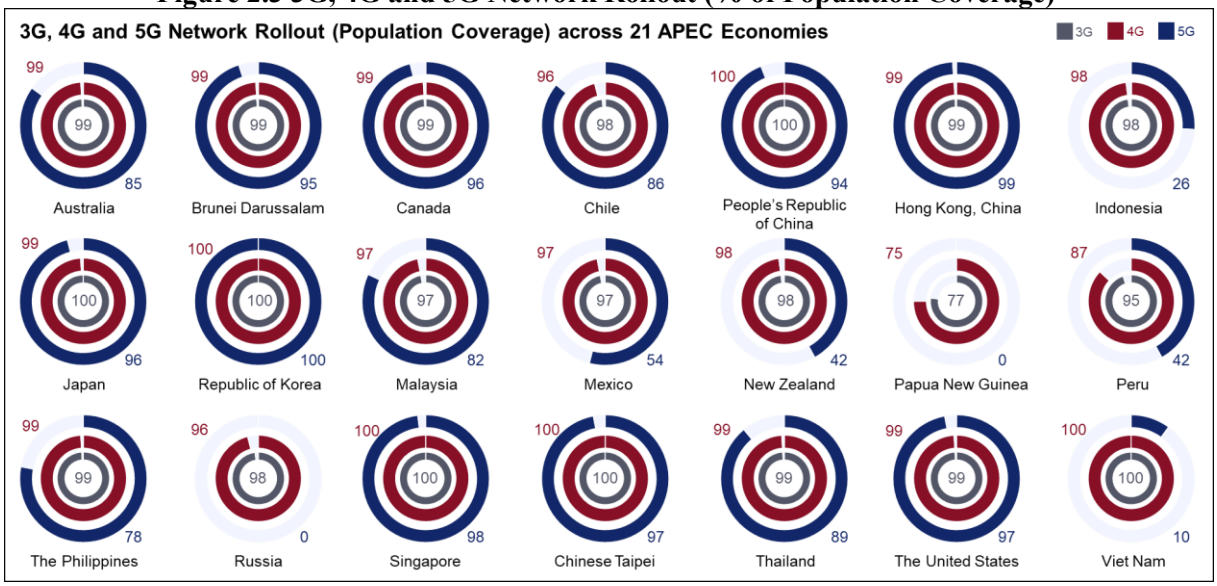
(7) BNamericas. (2025, June 4). Chilean telcos have invested US$2.3bn in 5G infrastructure since 2022. BNamericas.com; BNamericas. https://www.bnamericas.com/en/features/chilean-telcos-have-invested-us23bn-in-5g-infrastructure-since-2022

The impact of mobile network upgrades extends across key sectors among APEC economies. For example, in agriculture, 5G-enabled IoT devices facilitate precision farming and resource management, increasing productivity and sustainability in economies such as New Zealand and Indonesia. The manufacturing sector, such as in Thailand and Viet Nam, also benefits from automation and real-time data analytics powered by 5G connectivity. The rapid deployment of 4G and 5G networks is not only bridging digital divide in underserved communities but also fostering innovation, enhancing productivity, and driving sustainable economic growth throughout APEC economies.

Considering the rollout of 3G, 4G and 5G network coverages across the 21 APEC economies, significant differences can be observed among them in terms of coverage, adoption rates, and technological readiness. Figure 2.3 illustrates 3G, 4G and 5G network coverages of 21 APEC economies.

Figure 2.3 3G, 4G and 5G Network Rollout (% of Population Coverage)



Source: (1) APEC In Charts 2024, APEC Secretariat, APEC Policy Support Unit, November 2024, https://www.apec.org/docs/default-source/publications/2024/11/224_psu_apec-in-chart-2024.pdf?sfvrsn=1699dc13_1
(2) State of the telecoms market 2024 (available for relevant APEC economies), Analysys Mason Limited, Updated by 2024.
(3) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies), GSM Association / Wireless Intelligence, March 2023.
(4) Service Provider Market Report – 2024 (available for relevant APEC economies), Omdia Research, Updated by 2024.

Observations of network coverage reveal significant variations across APEC economies. While 3G and 4G networks have been widely deployed and dominate in most member economies, Papua New Guinea remains an exception, with 3G coverage reaching approximately 77% of the population and 4G coverage at around 75%, leaving a substantial portion of its population underserved.

Regarding 5G network deployment, significant gaps exist across APEC economies, reflecting differences in technological readiness, infrastructure investment, and regulatory environment. While some economies, such as the People's Republic of China; Japan; Republic of Korea; Singapore; and the United States, have rapidly rolled out extensive 5G networks, other economies are still in the early stages of deployment or still facing challenges related to funding, spectrum allocation, and infrastructure deployment.

APEC member economies with 5G network rollout challenges:

Indonesia – Multiple challenges are affecting Indonesia's low 5G coverage; 1) Weak market demands slowing 5G rollout, resulting in operators focusing on improving existing 4G connections instead, 2) Archipelago geographical factors driving infrastructure rollout costs, and 3) No standalone 5G networks, only operating on 4G's frequency bands making latency and maximum speeds an issue.

Papua New Guinea – 5G development for Papua New Guinea is a lower priority since it still has not achieved universal coverage of 4G technology to date.

Viet Nam – As a low-income economy, the rollout of 5G networks faces key challenges, including high deployment costs and uncertain return on investment. Consumer demands remain limited, as many people cannot yet afford 5G-compatible devices. Furthermore, the telecommunications sector is largely dominated by state-owned enterprises (SOE), such as Viet Nam Posts and Telecommunications Group (VNPT), which restrict market competition and may slow the pace of 5G deployment and commercialization.

Source: (1) Y&S Insights: Kompa Rasi Implementasi 5G di Indonesia dan Negara-Negara Lain. (2024, November 20). TechnoBusiness. https://technobusiness-id.translate.goog/insight/ys-insights/2024/11/20/ys-insights-komparasi-implementasi-5g-di-indonesia-dan-negara-negara-lain/?_x_tr_sl=auto&_x_tr_tl=en&_x_tr_hl=en&_x_tr_pto=wapp
(2) Kearney Report: 5G adoption in Indonesia is low, but can still soar. (2025). VOI website. https://voi.id/en/technology/471796#:~:text=Since%20its%20launch%20in%202021,networks%2C%20and%20limited%20frequency%20availability
(3) Accelerating 5G in Indonesia: A spectrum roadmap for success. (2025). https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2025/03/GSMA_Accelerating-5G-in-Indonesia.pdf
(4) Bagano, J. (2024, June 24). Indonesia's telcos hold back on 5G rollout plans. TelecomTV. https://www.telecomtv.com/content/5g/indonesia-s-telcos-hold-back-on-5g-rollout-plans-50675/
(5) Digicel PNG invests PGK20 million in network upgrade in Lae. (2025). Asian Wireless Communications website. https://asianwirelesscomms.com/news-details?itemid=9139&post=digicel-png-invests-pgk20-million-in-network-upgrade-in-lae-473369
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Based on available data and observations, the rollout status of 3G, 4G and 5G networks across APEC economies can be categorized into three distinct groups: **Coverage Group 1: The Leaders, Coverage Group 2**: **The Followers, and Coverage Group 3: The Late Adopters.**

Across APEC economies, the availability of 3G and 4G services is already near universal, with most economies covering almost their entire populations. As a result, the key point of differentiation in recent years has shifted toward the extent of 5G population coverage. This coverage varies widely due to differing investment strategies, regulatory environments, demographic structures, market sizes, and the cost of extending networks to lower density regions. For this reason, the grouping presented here is based solely on the current level of 5G population coverage rather than on the timing of 5G launch or the overall maturity of each economy's telecommunications sector.

It is important to note that early commercial availability of 5G services does not necessarily translate into extensive population coverage. New Zealand, for example, launched 5G relatively early, yet its total coverage remains limited because local expansion provides limited financial returns in a highly dispersed population. Similar variations can be observed across the region where operators prioritize coverage in areas with higher demand and postpone investment in regions that involve high deployment costs and low population density. The grouping below therefore reflects measured 5G coverage outcomes.

Coverage Group 1: The Leaders consists of economies with the highest levels of 5G population coverage. These economies have already built comprehensive 3G and 4G networks that reach nearly all residents. Building upon this foundation, operators have expanded 5G rapidly across both urban and suburban areas and, for some economies, into regional zones as well. This group includes Brunei Darussalam; Canada; People's Republic of China; Hong Kong, China; Japan; Republic of Korea; Singapore; Chinese Taipei; and the United States. In these economies, 3G and 4G approach 100%, while 5G coverage exceeds 90%.

Several factors contribute to the exceptionally high 5G coverage in these economies. One of the most important is their relatively strong economic capacity. Many of the economies in this group have higher GDP per capita levels compared to the broader APEC region, which enables greater investment in network infrastructure and stimulates stronger consumer demand for high-speed broadband. Higher household purchasing power, combined with digitally mature industries and workforces, creates a market environment where operators can justify rapid 5G deployment and densification.

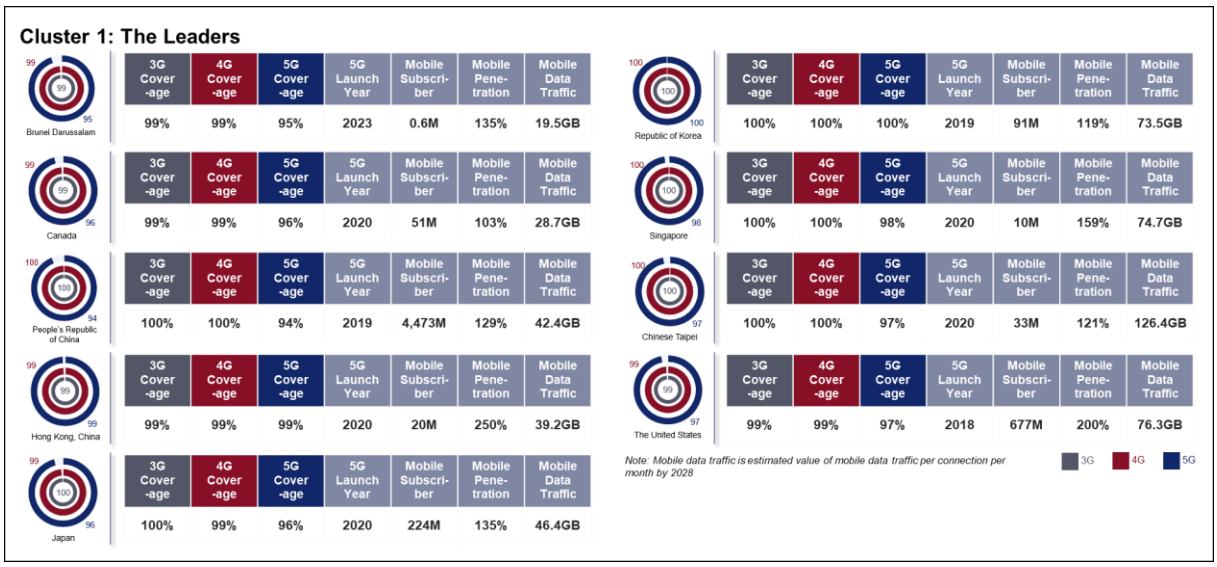
Secondly, many of these Coverage Group 1 economies are densely populated with high urbanization rates, which encourage infrastructure deployment. The concentration of user base in urban areas offers a high return on investment for operators, further driving the rapid rollout of 5G networks.

Although some economies in this group face significant geographic challenges or large land areas, such as Canada and China, these constraints have been managed through coordinated and sustained investment in domestic infrastructure. Long-term planning, coupled with consistent policy support, has enabled operators to extend 5G availability even in regions where

deployment is technically complex or economically less favorable. As a result, these economies have achieved broad 5G coverage that underpins advanced applications in manufacturing, logistics, healthcare, and public services.

In addition, authorities in Coverage Group 1 economies have introduced digital investment policies that further accelerate the rollout of 5G and related infrastructure. The United States provides a clear example through the MOBILE NOW Act, which was enacted in 2018 and facilitated wireless development by reducing regulatory barriers and identifying at least 255 megahertz of spectrum for fixed and mobile broadband use by 2022. The legislation also mandated studies on the commercial use of mid-band and high-band spectrum, creating clearer pathways for future expansion. Similar policy initiatives across other economies in this group have strengthened regulatory certainty, encouraged operator investment, and supported faster improvements in broadband accessibility. Taken together, these efforts reinforce the position of Coverage Group 1 economies as leaders in achieving extensive 5G population coverage across the region.

Figure 2.4 Coverage Group 1: The Leaders and Mobile Market View



Source: (1) APEC in Charts Years 2024. (2024). APEC Policy Support Unit. https://www.apec.org/docs/default-source/publications/2024/11/224_psu_apec-in-chart-2024.pdf?sfvrsn=1699dc13_1
(2) State of the telecoms market 2024 (available for relevant APEC economies), Analysys Mason Limited, Updated by 2024.
(3) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies), GSM Association / Wireless Intelligence, March 2023.
(4) Service Provider Market Report – 2024 (available for relevant APEC economies), Omdia Research, Updated by 2024.

Coverage Group 2: The Followers includes economies that have successfully deployed 3G and 4G networks across much of their populations. They have achieved moderate to high levels of 5G rollout, but the difference lies in the expansion which is still progressing to cover the entire economy. The economies falling into this group are Australia; Chile; Malaysia; the Republic of the Philippines; and Thailand. In these economies, 3G and 4G coverages approach 100% while 5G coverage ranges from 60% to 90%.

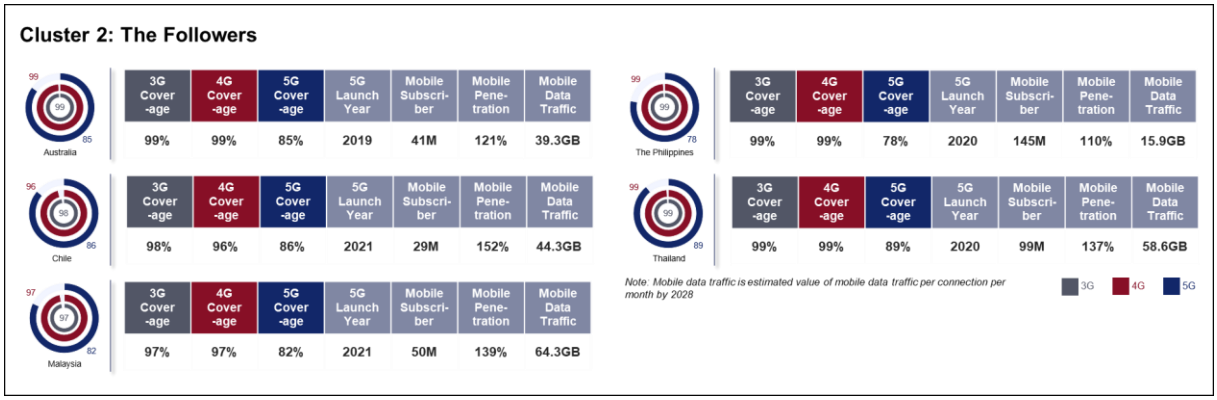
Several structural factors influence the medium-to-high 5G coverage levels observed in this group. Many of these economies contend with constraints such as lower household spending capacity for broadband services, varying levels of digital literacy, and a digital labor market

that is still maturing. These elements can reduce near-term consumer readiness for 5G adoption and may contribute to slower demand growth in areas where uptake is less certain. As a result, operators may prioritize deployment in commercially viable urban zones and delay expansion into regions where returns on investment are more limited.

A second influence relates to the spatial distribution of population. Four of the five economies in this group are emerging markets with high urban concentrations, which facilitates efficient deployment in major cities and supports early improvements in coverage quality. At the same time, this concentration can intensify the digital divide between urban and rural communities. Although operators can upgrade infrastructure rapidly in metropolitan areas, extending comparable levels of 5G availability to rural, remote, or geographically dispersed regions remains challenging. Consequently, overall coverage levels are strong, yet noticeable connectivity gaps continue to appear in less populated areas.

In summary, Coverage Group 2 economies demonstrate substantial progress and perform close to Coverage Group 1 in terms of 5G reach. Nevertheless, differences between urban and rural coverage persist, reflecting varying economic and geographic conditions that shape deployment decisions. These patterns highlight the need for targeted and inclusive government policies that encourage private sector investment and support the expansion of advanced mobile services in underserved regions.

Figure 2.5 Coverage Group 2: The Followers and Mobile Market View



Source: (1) APEC in Charts Years 2024. (2024). APEC Policy Support Unit. https://www.apec.org/docs/default-source/publications/2024/11/224_psu_apec-in-chart-2024.pdf?sfvrsn=1699dc13_1
(2) State of the telecoms market 2024 (available for relevant APEC economies), Analysys Mason Limited, Updated by 2024.
(3) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies), GSM Association / Wireless Intelligence, March 2023.
(4) Service Provider Market Report – 2024 (available for relevant APEC economies), Omdia Research, Updated by 2024.

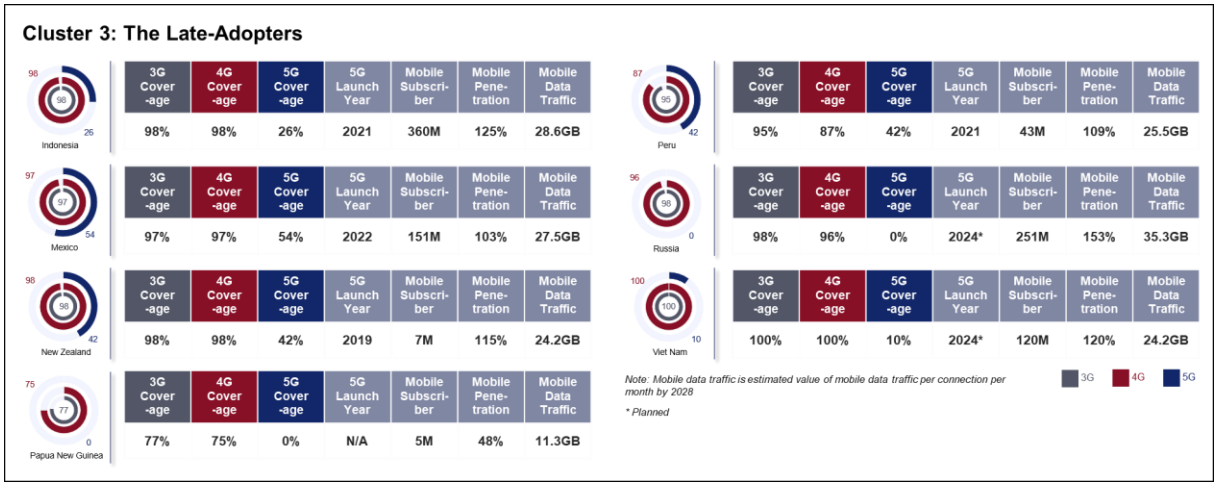
Coverage Group 3: The Late Adopters are economies where 5G population coverage remains relatively limited, generally falling below 60 percent. Despite this, these economies have already achieved broad 3G and 4G coverage. The lower level of 5G availability therefore reflects deployment constraints that are specific to advanced mobile infrastructure, rather than deficiencies in basic network access. Economies include Indonesia; Mexico; New Zealand; Papua New Guinea; Peru; Russia; and Viet Nam, where digital infrastructure development is ongoing but yet to reach comprehensive coverage.

Several factors contribute to the slower pace of 5G expansion in these economies. Geographic and demographic challenges, such as dispersed rural populations, archipelagic layouts, and difficult terrain, can significantly increase deployment costs. In addition, operators may face modest commercial incentives due to lower demand for 5G services or the relatively high cost of 5G-capable devices. Regulatory processes and the need to strengthen existing infrastructure can also delay wider rollout.

It is also important to note that limited coverage does not always reflect late technological adoption. New Zealand, for example, launched 5G early in 2019 but has not extended coverage for the whole economy because deployment in low-density regions offers limited financial returns. This highlights how economic geography, rather than capability, can shape the scale and speed of expansion.

Despite these constraints, Coverage Group 3 economies continue to make steady progress. Many are focusing on upgrades in major cities, implementing pilot projects, and expanding coverage gradually as market conditions improve. Some economies, particularly lower-income ones such as Papua New Guinea and Viet Nam, receive support from international development organizations, including the Asian Development Bank, which helps address funding gaps and complements domestic efforts to improve digital infrastructure. These combined initiatives contribute to ongoing improvements in coverage and are moving these economies toward broader 5G availability in the future.

Figure 2.6 Coverage Group 3: The Late Adopters and Mobile Market View



Source: (1) APEC in Charts Years 2024. (2024). APEC Policy Support Unit. https://www.apec.org/docs/default-source/publications/2024/11/224_psu_apec-in-chart-2024.pdf?sfvrsn=1699dc13_1
(2) State of the telecoms market 2024 (available for relevant APEC economies), Analysys Mason Limited, Updated by 2024.
(3) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies), GSM Association / Wireless Intelligence, March 2023.
(4) Service Provider Market Report – 2024 (available for relevant APEC economies), Omdia Research, Updated by 2024.

Market Structure and Competition

Market structure and competition are fundamental factors influencing the pace and extent of broadband infrastructure expansion across all APEC economies. The number and diversity of broadband service providers within a market significantly influences investment incentives and the pace of network expansion. In general, when market is highly concentrated with few

dominant players, with limited competition or monopolistic tendencies, the pace of network expansion is slower. Without competitive pressure, dominant players may lack the incentive to invest in upgrading networks or extending coverage, especially in less profitable rural or remote areas.

Market Structure is an indicator explaining how the market is dominated by players / service providers and how concentrated the market is (such as to which extent the market share is dominated by a few large players versus being distributed among many players).

Competition Level refers to the intensity of rivalry among players / service providers within a market. It describes how aggressive players / service providers compete for customers, market share, and profits. Competition level depends on factors such as number of competitors, product differentiation, customer loyalty, and ease of market entry or exit. High competition usually means lower prices and more innovation while low competition can lead to higher prices and less incentive to innovate.

Based on current market landscape information, it is revealed that across 21 APEC economies, broadband service markets can be categorized into three main clusters according to their market structure and competition level.

Table 2.3 Classification of Market Structure and Competition Levels across APEC economies

Cluster	Characteristics	APEC Economies	Observation of Broadband Infrastructure
Market Structure Group 1: Highly Competitive	• Multiple ISPs • Low entry barriers • Diverse offerings	• Australia • Hong Kong, China • Japan • Republic of Korea • Malaysia • New Zealand • Chinese Taipei	• Advanced and Widespread (economy-wide) fiber network • Advanced 5G deployment (Except New Zealand, where 5G rollout is mature (2019) but not covering the majority of the population)
Market Structure Group 2: Oligopolistic	• Few dominant players • Moderate entry barriers • Some competition	• Canada • People's Republic of China • Mexico • Russia • Singapore • Thailand • The United States	• Extensive fiber coverage in urban areas • Growing fiber access in rural and remote areas • Growing / Rolling out 5G network coverage

Cluster	Characteristics	APEC Economies	Observation of Broadband Infrastructure
Market Structure Group 3: Less Competitive / Monopolistic	• Dominated by state or few players • High entry barriers • Limited competition	• Brunei Darussalam • Chile • Indonesia • Papua New Guinea • Peru • The Republic of the Philippines • Viet Nam	• Limited fiber coverage • Growing of fiber and 5G coverage (both in urban and rural areas) • High access gaps in rural areas • High dependency on alternative solutions to bridge the gaps (e.g., wireless coverage or satellite technology)

In highly competitive markets, multiple broadband service providers aggressively invest in innovative infrastructure, including widespread fiber optic networks and advanced 5G deployment. Aggressive competition influences these broadband service providers to continuously upgrade for faster speeds, broader coverage, and improved reliability of their broadband services to ensure customers benefit from innovative and affordable broadband services.

A competitive market structure fosters broadband infrastructure growth by motivating service providers to invest, innovate and improve services, which can accelerate expansion into underserved areas. However, for extremely challenging regions, complementary government policies and interventions are often necessary to ensure equitable access.

Service Availability – Inclusive Internet Index

Service availability and affordability serve as key indicators for evaluating the effectiveness of broadband infrastructure in reaching consumers. Service availability measures the extent to which broadband networks are accessible to consumers within a given area, reflecting the physical presence and coverage of the broadband infrastructure.

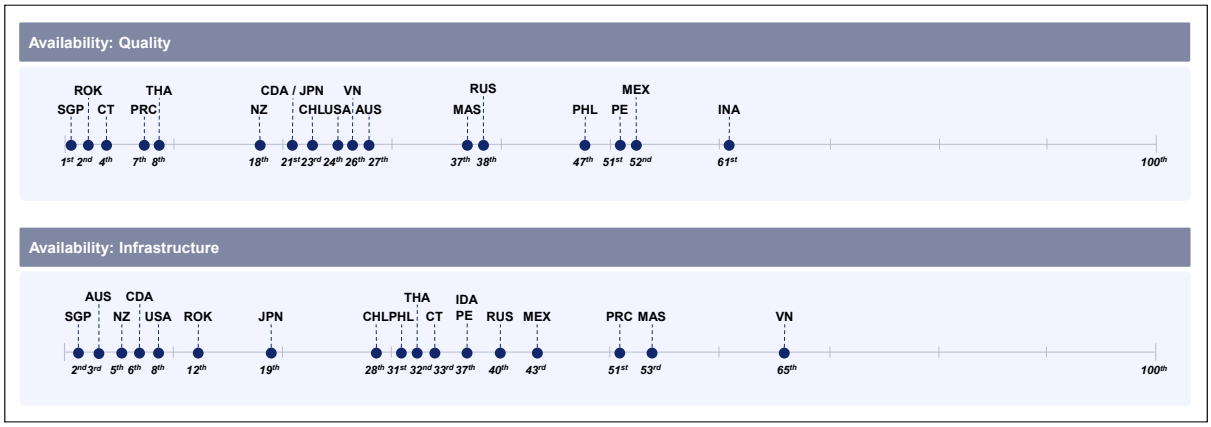
According to the 2022 Inclusive Internet Index, published by Economist Impact, the rankings are evaluated based on four main categories: Availability, Affordability, Relevance and Readiness, across one hundred economies, representing approximately 99% of the global population and 97% of global GDP[12]. A deep dive into the "Availability" index reveals insights into the quality and extent of infrastructure necessary for internet access and usage levels. This analysis focuses specifically on two subcategories: "quality" and "infrastructure".

The "quality" subcategory assesses the user experience of the connected population, reflecting factors such as connecting speed, reliability, and overall performance. Meanwhile, the "infrastructure" subcategory evaluates the presence and accessibility of networks and connection points for both internet and mobile services.

[12] Economist Impact: The Inclusive Internet Index, supported by Meta. (2022). Economist.com. https://impact.economist.com/projects/inclusive-internet-index

The figure below illustrates the ranking of 21 APEC economies based on these two subcategories. These rankings show the current position of each economy relative to one hundred economies globally, providing comparative view of their broadband infrastructure quality and availability.

Figure 2.7 Inclusive Internet Index for Availability Category



Source: (1) Economist Impact: The Inclusive Internet Index, supported by Meta. (2022). Economist. https://impact.economist.com/projects/inclusive-internet-index. No data about Inclusive Index available for 4 APEC economies (Brunei Darussalam; Hong Kong, China; Papua New Guinea,).

The "quality" assessment is based on several parameters such as average fixed broadband upload / download speeds, average fixed broadband latency, average mobile upload / download speeds, average mobile latency, and bandwidth capacity. Most of the APEC economies are ranked above the 40th position in this evaluation.

Chinese Taipei; Singapore; and Republic of Korea, are in the leading position among the other APEC economies, ranked in 1st, 2nd, and 4th respectively. As of January 2024, Singapore boasts the world's highest average fixed broadband internet speeds, with an average of 278 Mb/s[13].

According to Ookla's internet speed 2024 report, Chile; Hong Kong, China; Singapore; Thailand; and the United States, are ranked among the Top 10 economies globally for the fastest fixed internet speeds[14]. Meanwhile, Republic of Korea is listed among the Top 10 worldwide for the fastest mobile broadband internet speed in the same year[15].

The report also highlights that the smaller economies often have an edge in boosting internet speeds, as upgrading infrastructure tends to be a slower and more challenging process in larger economies. For instance, the United States ranks eighth in Infrastructure Availability, indicating widespread coverage across its vast territory. However, in terms of Infrastructure Quality, the United States falls to the 24th place, suggesting that substantial efforts and investment are still needed to implement advanced infrastructure upgrades economy-wide.

[13] Asia leads in full fibre penetration. (2024, June 28). Insight Prysmian Magazine. https://www.prysmian.com/en/insight/nexst/digital-solutions/asia-leads-in-full-fibre-penetration
[14] Internet Speeds by Country 2025, Top 10 Countries with the Fastest Mobile Internet Speeds (Mbps). (2025). World Population Review. https://worldpopulationreview.com/country-rankings/internet-speeds-by-country#top-10-countries-with-the-fastest-mobile-internet-speeds-mbps---2024
[15] Internet Speeds by Country 2025, Top 10 Countries with the Fastest Mobile Internet Speeds (Mbps). (2025). World Population Review. https://worldpopulationreview.com/country-rankings/internet-speeds-by-country#top-10-countries-with-the-fastest-mobile-internet-speeds-mbps---2024

Most Available Broadband Connectivity among APEC economies:

1. **National Broadband Network Strategy – Republic of Korea**
   Republic of Korea ranks second in availability due to its long-term domestic broadband plan, which began as early as the 1990s. The government deployed fiber optic infrastructure even in less densely populated areas, supported by policies that promoted competition and Local Loop Unbundling (LLU). Public funding ensured that rural areas were not left behind, helping Republic of Korea achieve near-universal high-speed internet access. Such example includes a public-private partnership (PPP) initiative, targeting 1,300 rural and remote villages, which combined the effort of local governments and major internet service providers in sharing the cost of broadband infrastructure in underserved areas.

2. **Rural Broadband Program – New Zealand**
   New Zealand ranks sixth in availability, significantly due to its Rural Broadband Program, which was designed specifically to address the broadband access gap in rural communities. The program subsidized private providers to build out high-speed wireless and fiber networks in underserved areas. The initiative significantly improved fixed and wireless broadband coverage for over 84,000 rural households, plus schools and hospitals, and or around 9.8% of land covered.

Source: (1) *South Korea's Binary Broadband Push: Bridging the Digital Divide, One Village at a Time - Telecom Review Asia*. (2025, May 9). Telecom Review Asia. https://www.telecomreviewasia.com/news/featured-articles/13330-south-koreas-binary-broadband-push-bridging-the-digital-divide-one-village-at-a-time/
(2) *Rural broadband | national infrastructure funding and financing | New Zealand*. (2025, August 12). National Infrastructure Agency. https://nationalinfrastructure.govt.nz/rural-broadband

2.3 BROADBAND SERVICE ADOPTION TRENDS: DEMAND-SIDE PERSPECTIVES

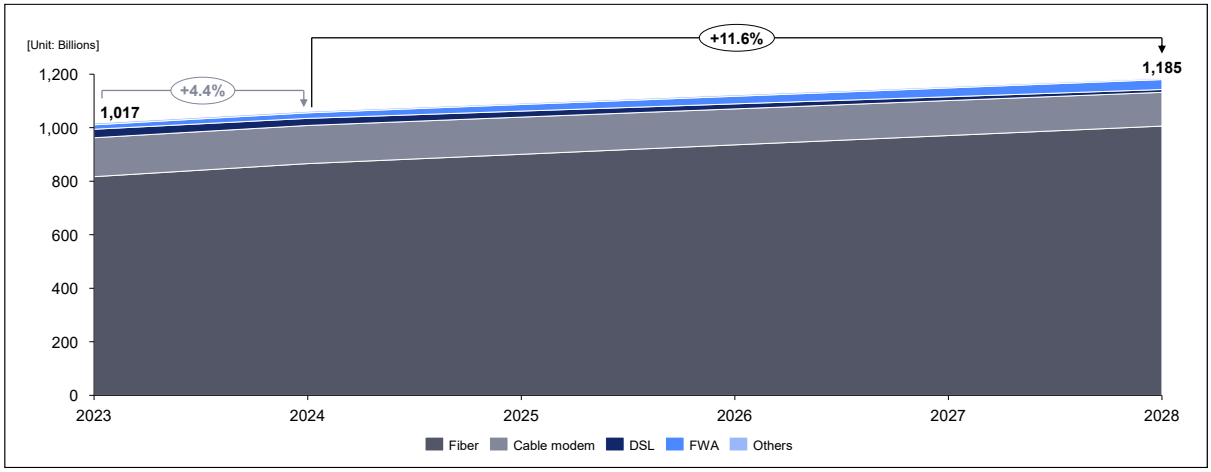
Broadband service adoption in APEC member economies highlights a dynamic and evolving landscape shaped by varying levels of economic development and digital infrastructure. These economies range from advanced markets, such as Japan; Republic of Korea; and the United States; to emerging economies, such as Indonesia; the Republic of the Philippines; and Viet Nam.

As a result, broadband demand reflects diverse stages of technological advancement and consumer adoption patterns. Over the past decade, broadband subscriptions across APEC have grown steadily, driven by increasing connectivity needs, government initiatives and expanding digital services that cater to both mature and developing markets.

Fixed Broadband Penetration

The figure below illustrates the total fixed broadband subscription across 19 APEC economies (excluding Brunei Darussalam and Papua New Guinea) from 2023 to 2028. The fixed broadband subscription base is projected to grow robustly, with an annual growth rate of approximately 11.6% between 2024 and 2028. This strong expansion is primarily driven by rising demand and ongoing infrastructure deployment across those specific member economies.

Figure 2.8 Fixed Broadband Subscription across 19 APEC Economies (2023-2028)



Source: (1) State of the telecoms market 2024 (available for relevant APEC economies), Analysys Mason Limited, Updated by 2024.
(2) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies), GSM Association / Wireless Intelligence, March 2023.
(3) Service Provider Market Report – 2024 (available for relevant APEC economies), Omdia Research, Updated by 2024.

As fiber uptake has grown there has been a gradual decline in DSL and cable modem subscriptions across many APEC economies. For instance, Canada; Mexico; and Peru are experiencing high annual growth rates in fiber broadband subscriptions of 14.0%, 13.1%, and 11.4%, respectively. Fiber's superior speed and reliability have prompted many consumers and service providers to move away from older copper-based technologies.

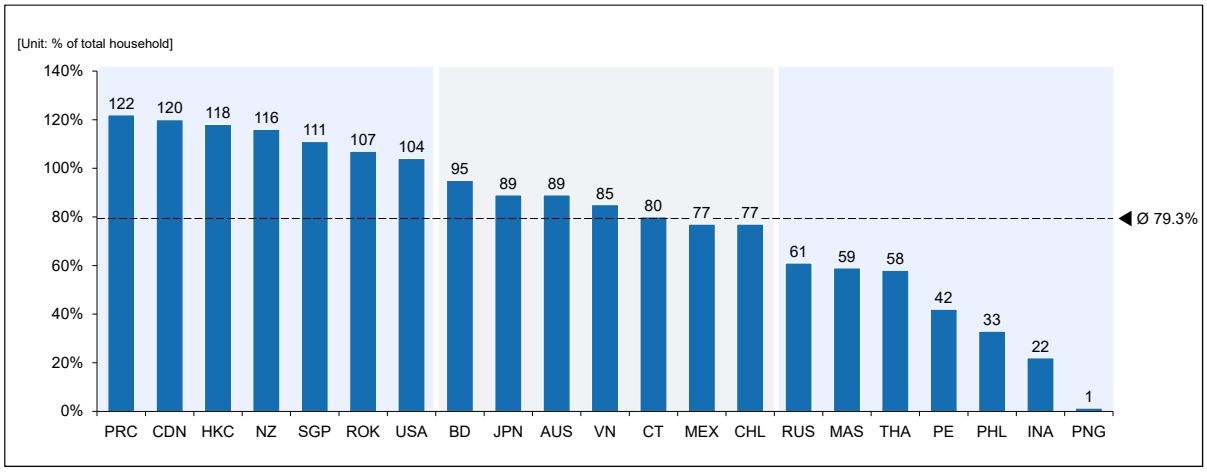
Meanwhile, Fixed Wireless Access (FWA) is slowly gaining traction as an alternative broadband solution, particularly in APEC economies where deploying fiber infrastructure is challenging due to geographic or cost constraints. Some APEC economies have shown significant growth in FWA subscription rates e.g., Hong Kong, China; Indonesia; Japan; Mexico; and New Zealand.

The figure below illustrates fixed broadband penetration rates across all APEC economies. A group of economies, including, Canada; the People's Republic of China; Hong Kong, China; Republic of Korea; New Zealand; Singapore; and the United States, demonstrate exceptionally high household penetration rates, exceeding 100%. This indicates that in this market, on average, there is more than one fixed broadband subscription per household, reflecting widespread availability and strong consumer demand.

The second cluster comprises economies such as Australia; Brunei Darussalam; Chile; Japan; Mexico; Chinese Taipei; and Viet Nam, where household fixed broadband penetration falls within the mid-range, between 70% to 95%. These economies show solid adoption rates, though there remains room for growth and further market development.

Finally, the third group includes economies with fixed broadband household penetration rates below 61%. This group consists of Indonesia; Malaysia; Papua New Guinea; Peru; the Republic of the Philippines; Russia; and Thailand, where penetration varies below 60%. These figures highlight the ongoing challenges and opportunities for broadband expansion in these markets, including infrastructure development and affordability.

Figure 2.9 Fixed Broadband Penetration 2024

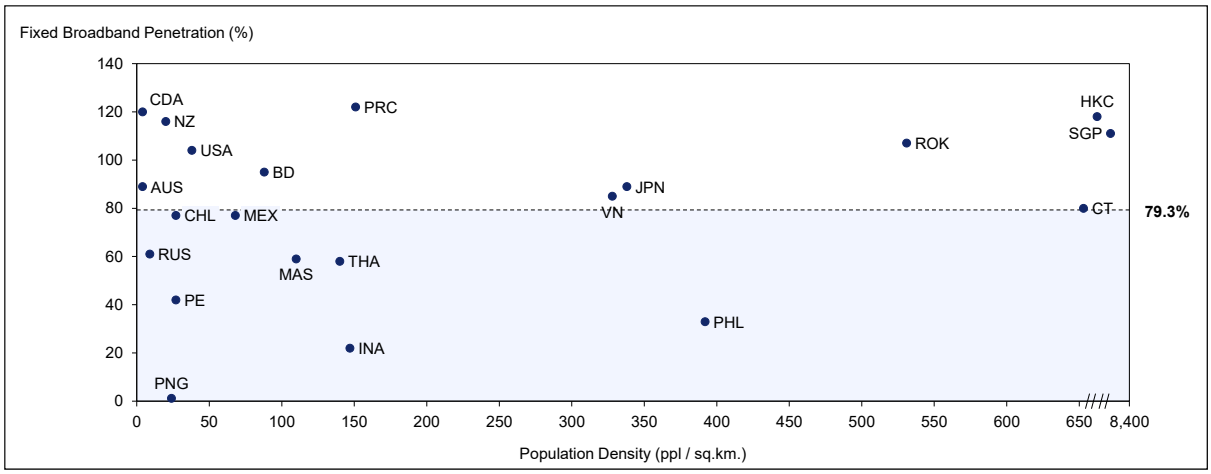


Source: (1) State of the telecoms market 2024 (available for relevant APEC economies), Analysys Mason Limited, Updated by 2024.
(2) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies), GSM Association / Wireless Intelligence, March 2023.
(3) Service Provider Market Report – 2024 (available for relevant APEC economies), Omdia Research, Updated by 2024.

Based on the observations, higher population density is a key driver of increased broadband penetration. Although other factors such as investments in broadband infrastructure, regulatory adjustments, and affordability also play important roles in expanding coverage and boosting penetration.

The figure below shows the differences between broadband penetration rates along the population density per APEC economy in 2024.

Figure 2.10 Fixed Broadband Penetration and Population Density of APEC Economies



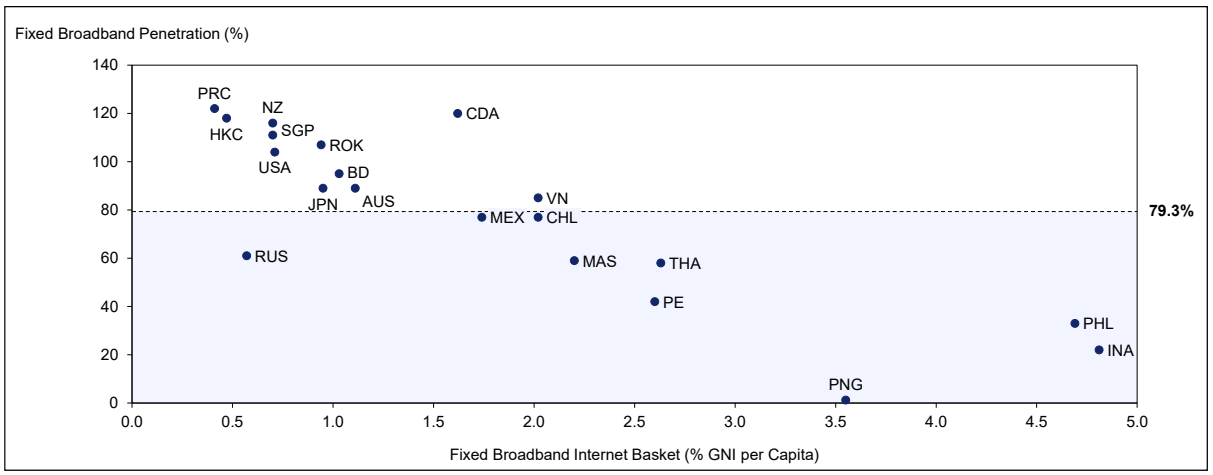
Source: (1) State of the telecoms market 2024 (available for relevant APEC economies), Analysys Mason Limited, Updated by 2024.
(2) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies), GSM Association / Wireless Intelligence, March 2023.
(3) Service Provider Market Report – 2024 (available for relevant APEC economies), Omdia Research, Updated by 2024.
(4) Population density, 2025, Our World in Data, 2025, https://ourworldindata.org/grapher/population-density

There is a notable relationship between fixed broadband penetration rates and population density across different regions. In general, higher population density tends to correlate with higher fixed broadband penetration rates. This offers economies of scale that make broadband infrastructure deployment more cost-effective and efficient for service providers. With more households located close together, the per-unit cost of deploying cables or installing fixed broadband infrastructure decreased, encouraging wider coverage and adoption.

However, economies such as Australia; Canada; New Zealand; and the United States, despite having population densities below 50 people per square kilometer, still exhibit higher fixed broadband penetration rates than many developing APEC economies.

In contrast, economies with low population density (e.g., Papua New Guinea and Peru), face challenges in achieving high fixed broadband penetration. The dispersed nature of households increases infrastructure costs and complexity, which limits service availability or makes broadband subscriptions more expensive relative to incomes. This also leads to lower penetration rates in these less densely populated economies.

Figure 2.11 Fixed Broadband Penetration and Fixed Broadband Internet Basket of APEC Economies



Source: (1) State of the telecoms market 2024 (available for relevant APEC economies), Analysys Mason Limited, Updated by 2024.
(2) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies), GSM Association / Wireless Intelligence, March 2023.
(3) Service Provider Market Report – 2024 (available for relevant APEC economies), Omdia Research, Updated by 2024.
(4) Affordability: Fixed Broadband Internet Basket. ITU Datahub. https://datahub.itu.int/
Data for Chinese Taipei is not available.

Cost of fixed broadband internet packages as a percentage of the average income per person (GNI per capita) show how affordable broadband is relative to people's incomes or how expensive fixed broadband service is compared to the average income in the economy. In general, the lower broadband costs relative to income tend to encourage higher fixed broadband penetration rates, as services become more affordable for a larger proportion of the population.

When the cost of fixed broadband internet basket represents a smaller proportion of an individual's or household's income, the financial barrier to subscription is significantly lowered, leading to wider adoption and higher penetration rates. For example, APEC economies such as the People's Republic of China; Hong Kong, China; New Zealand; and

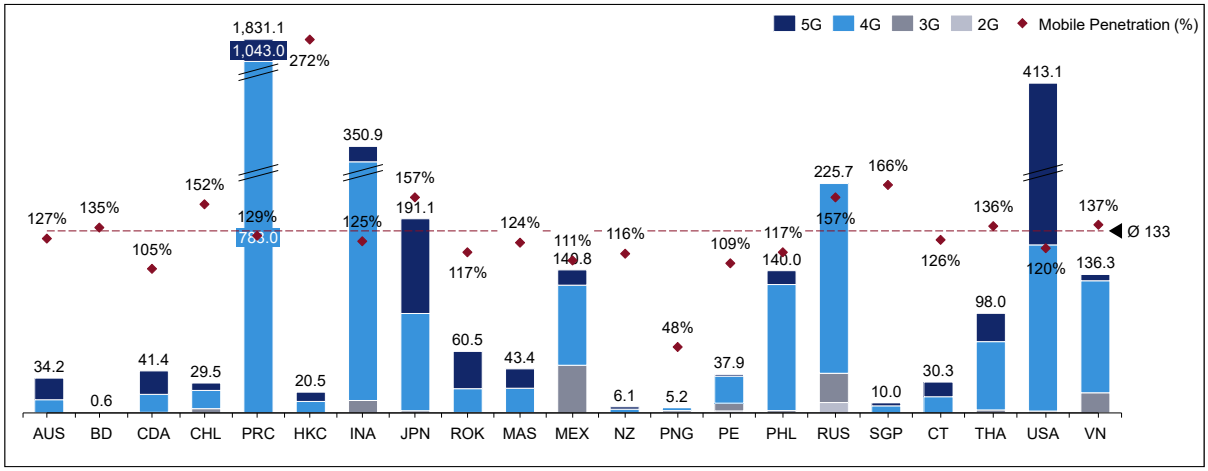
Singapore, which are among those with the highest fixed broadband penetration rates, have relatively low fixed broadband internet basket costs - 0.41%, 0.47%, 0.70% and 0.71% of income, respectively.

In contrast, economies like Indonesia; the Republic of the Philippines; and Papua New Guinea experience lower fixed broadband penetration rates alongside higher fixed broadband internet basket costs, recorded at 4.81%, 4.69% and 3.55% of income, respectively. This inverse relationship highlights the importance of role that both competitive pricing and economic capacity play in driving broadband adoption. To boost penetration, regulators and service providers typically prioritize reducing service costs, improving infrastructure, and implementing subsidies or support programs aimed at making broadband more affordable relative to household income.

Mobile Broadband Domination within APEC Economies

In some APEC economies, limitations in fixed infrastructure deployment and fixed broadband adoption have made mobile technologies the dominant solution, providing an alternative to help close the broadband gap.

Figure 2.12 Mobile Broadband Subscription and Penetration of APEC Economies 2024



Source: (1) State of the telecoms market 2024 (available for relevant APEC economies), Analysys Mason Limited, Updated by 2024.
(2) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies), GSM Association / Wireless Intelligence, March 2023.
(3) Service Provider Market Report – 2024 (available for relevant APEC economies), Omdia Research, Updated by 2024.

As illustrated in figure 2.12, most APEC economies have mobile penetration rates exceeding 100%, with the exception of Papua New Guinea, which has a rate of only 48%. 4G technology remains the most commonly used for mobile subscriptions, while 5G adoption is gradually increasing. Meanwhile, 2G technology is being phased out, and although 3G technology is still present in APEC economies, it is experiencing a declining trend in subscriptions across the APEC economies.

Hong Kong, China (272%); China (129%); Japan (157%); Russia (157%); and Singapore (166%) are ranked as the top five leaders in active mobile subscriptions. The average mobile penetration across APEC economies stands at 133%, significantly higher than the fixed

broadband penetration rate of 81.5%. This highlights the crucial role of mobile technologies in bridging the digital divide.

The People's Republic of China; Japan; Republic of Korea; Singapore; and the United States are the leaders in 5G rollout and 5G adoption, with widespread network coverage and high subscriber adoption rates.

Leading 5G Adopters in APEC Economies:

Republic of Korea:

Republic of Korea is widely regarded as a global leader in adoption of 5G. The economy's three major telecom providers began limited 5G trials for enterprises and select consumers as early as late 2018. A local commercial launch followed in April 2019. Within just six months, approximately 3.5 million users, about 5% of all wireless subscribers, had already adopted 5G. By 2024, Republic of Korea had achieved a 5G penetration rate of 40% of its population, totaling over thirty-four million connections.

The People's Republic of China:

China began 5G trials in late 2018 and launched full commercial services at the end of 2019. By the close of 2020, the economy had approximately 129 million 5G subscribers, representing about 8% of all mobile connections. This number surged to 390 million subscribers within two years, making up 24% of the market. By 2024, China had established itself as a global leader in 5G adoption, with 981 million subscribers, accounting for roughly 55% of total mobile subscriptions.

Japan:

Japan began 5G trials in 2017 with major carriers conducting tests in urban areas. The 5G commercial rollout launched locally in March 2020. By 2024, almost 92.4 million 5G subscriptions were recorded.

Singapore:

Singapore's domestic commercial 5G rollout commenced in May 2021. By 2022, 5G subscriptions had reached 1.2 million, around 13% of the economy's total mobile connections. By 2024, that figure rose to approximately 2.2 million, accounting for about 22% of all mobile subscriptions.

Source: (1) Where 5G Is Available Around the World. (2023, September). Lifewire Tech for Humans Website. https://www.lifewire.com/5g-availability-world-4156244?
(2) Osio, J., & Keith, E. (2023). 5G tracker: 97 markets worldwide have commercial 5G services. S&P Global Market Intelligence. https://www.spglobal.com/market-intelligence/en/news-insights/research/5g-tracker-97-markets-worldwide-have-commercial-5g-services
(3) Hadi, H. A. (2024a, September 12). 5G in South Korea – 2024. Omdia. https://omdia.tech.informa.com/om122733/5g-in-south-korea--2024?vid=Tech&processId=b9b12db2-5225-41c4-a95c-b53a87973419
(4) Zhao, R. (2025, January 23). 5G in China – 2024. Omdia. https://omdia.tech.informa.com/om124384/5g-in-china--2024
(5) Bell, P. (2024, February 6). China: The World's Biggest 5G Market. Blog.telegeography.com. https://blog.telegeography.com/china-the-worlds-biggest-5g-market
(6) China's 5G subscriptions surpass 1 billion amid strong uptake. (2024). Www.gov.cn; The State Council The People's Republic of China. https://english.www.gov.cn/archive/statistics/202412/24/content_WS676a16aec6d0868f4e8ee3ce.html

(7) Japan: number of 5G subscriptions 2024 | Statista. (2024, September). Statista. https://www.statista.com/statistics/1347340/japan-number-5g-subscriptions/
(8) NTT DOCOMO to Launch 5G Service in Japan on March 25. (2020). NTT DOCOMO Home; NTT Docomo Press Release Website. https://www.docomo.ne.jp/english/info/media_center/pr/2020/0318_00.html
(9) 5G Trial Sites | About DOCOMO | NTT DOCOMO. (2017, May). Docomo.ne.jp; NTT Docomo Website. https://www.docomo.ne.jp/english/corporate/technology/rd/docomo5g/trial_site/index.html
(10) Statistics on Telecom Services for 2022 (Jul – Dec). (2024, April). Infocomm Media Development Authority. https://www.imda.gov.sg/about-imda/research-and-statistics/telecommunications/statistics-on-telecom-services/statistics-on-telecom-services-for-2024-jul
(11) Statistics on Telecom Services for 2022 (Jul – Dec). (2024, April). Infocomm Media Development Authority. https://www.imda.gov.sg/about-imda/research-and-statistics/telecommunications/statistics-on-telecom-services/statistics-on-telecom-services-for-2024-jul

Australia; Canada; Malaysia; Mexico; the Republic of the Philippines; and Thailand, are now actively expanding their 5G infrastructure, focusing on achieving network reach goals and affordability to boost 5G adoption among urban and rural populations.

Emerging 5G Adopters in APEC Economies:

Malaysia:
Malaysia started 5G trials as early as 2019, with Maxis and Celcom conducting live tests. However, commercial 5G services only began rolling out after the state-owned Digital Nasional Berhad (DNB) established the local 5G network infrastructure. YTL Corporation Berhad was the first operator to launch 5G commercially in 2022, with other providers following suit in late 2022 and 2023. Initially, 5G adoption was slow, with only about 1.2 million subscriptions, representing a 3.1% adoption rate, reported in 2023 despite DNB covering approximately 60% of the population. By 2024, however, 5G uptake dramatically increased to eighteen million subscribers, achieving around 53.4% market penetration.

Thailand:

Thailand officially entered the 5G era in February 2020, shortly after the National Broadcasting and Telecommunications Commission (NBTC) auctioned off spectrum in February 2020. By end of 2022, Thai operators had roughly 10 million 5G users equaling 9.2% of all mobile connections. At the end of 2023, the number surged to 19.7 million 5G subscribers accounting for 20% of mobile market. By Q2 of 2024, 27% of connections were 5G connections.

Mexico:

Mexico's 5G commercial launch primarily began in February 2022. While this marked a significant step for the economy, its overall rollout has slowed due to challenges and disagreements surrounding spectrum auctions. By late 2023, Mexico had approximately 6.6 million 5G users. As of beginning of 2024, Mexico had around thirteen million 5G subscriptions representing 9.1% of the economy's total mobile market.

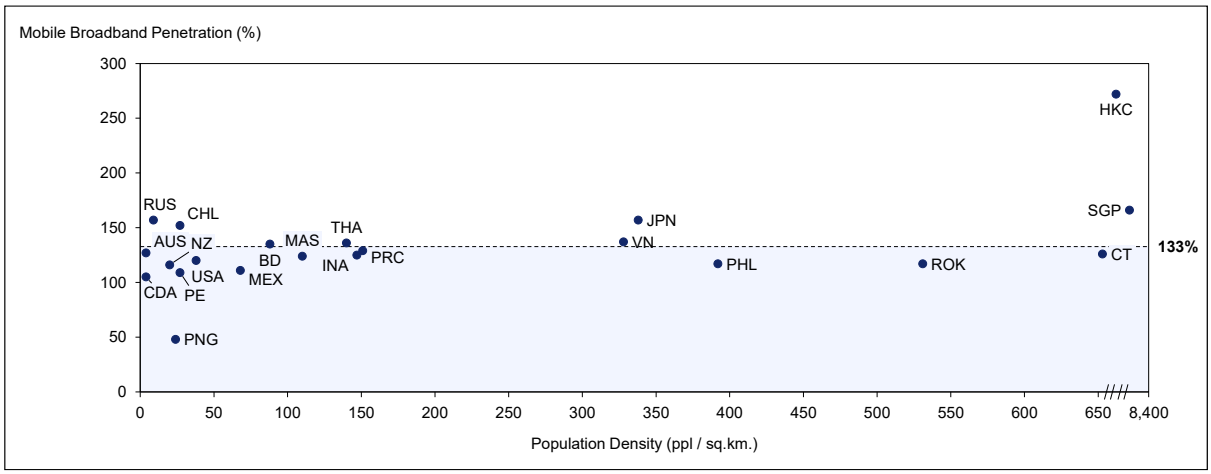
Australia:

Australia started its 5G trials around 2018 and commercially launched its 5G services in 2019. In 2023, around 36% of all mobile services used 5G.

Source: (1) Pham, M. (2024, September 18). The Convoluted Journey of Malaysia's 5G Plan. Developing Telecoms. https://developingtelecoms.com/telecom-business/operator-news/17329-the-convoluted-journey-of-malaysia-s-5g-plan.html
(2) Malaysia's 5G adoption rate remains low at 3.1pc despite DNB having 59.5pc 5G population coverage. (2023, June). Malay Mail; Malay Mail. https://www.malaymail.com/news/malaysia/2023/06/01/malaysias-5g-adoption-rate-remains-low-at-31pc-despite-dnb-having-595pc-5g-population-coverage/72006

(3) DNB and Ericsson Supercharge Malaysia's 5G Network with 5G Advanced Capability. (2025, February 4). Ericsson.com; Ericsson. https://www.ericsson.com/en/press-releases/2/2025/2/dnb-and-ericsson-supercharge-malaysias-5g-network-with-5g-advanced-capability
(4) Accelerating 5G and 5G-Advanced in Thailand: A roadmap for success. (2024). GSMA. https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2024/12/GSMA_Accelerating-5G-and-5G-Advanced-in-Thailand-2024.pdf
(5) Tomás, J. P. (2022, October 25). Thailand to reach 5G coverage of 85% by end-2022: True. RCR Wireless News. https://www.rcrwireless.com/20221025/5g/thailand-reach-5g-coverage-85-end-2022-true
(6) Rasmussen, A. (2024, February 23). Thailand's Mobile Duopoly Market End of Year 2023 • Yozzo. Yozzo. https://www.yozzo.com/insights/thailands-mobile-duopoly-market-end-of-year-2023/
(7) Thailand, November 2021, 5G Experience Report | Open signal. (2021). Opensignal.com. https://www.opensignal.com/reports/2021/11/thailand/mobile-network-experience-0
(8) Santa, R. (2024, July 27). 5G Landscape in Mexico: Adoption and Challenges - TV y Video Latinoamérica. Tvyvideo.com; TV y Video Latinoamérica. https://www.tvyvideo.com/en/news/latest-news/290-enterprises/21549-5g-landscape-in-mexico-adoption-and-challenges.html
(9) BNamericas. (2023b, November 15). 5G gains ground in Mexico with 6.6 million users. BNamericas.com; BNamericas. https://www.bnamericas.com/en/news/5g-gains-ground-in-Mexico-with-66-million-users
(10) Sheinbaum Cancels IFT Spectrum Auction Amid Regulatory Overhaul. (2024, December 30). Mexico Business News. https://mexicobusiness.news/infrastructure/news/sheinbaum-cancels-ift-spectrum-auction-amid-regulatory-overhaul
(11) Trends and developments in telecommunications 2023-24 Communications and media in Australia. (2024). Australian Communications and Media Authority (ACMA). https://www.acma.gov.au/sites/default/files/2024-12/Trends%20and%20developments%20in%20telecommunications%202023-24.pdf

Figure 2.13 Mobile Broadband Penetration and Population Density of APEC Economies



Source: (1) State of the telecoms market 2024 (available for relevant APEC economies). (2024, May). Analysys Mason Limited.
(2) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies). (2023, March). GSM Association / Wireless Intelligence.
(3) Service Provider Market Report – 2024 (available for relevant APEC economies). (2024). Omdia Research.
(4) Our World in Data. (2025). Population density. Our World in Data. https://ourworldindata.org/grapher/population-density

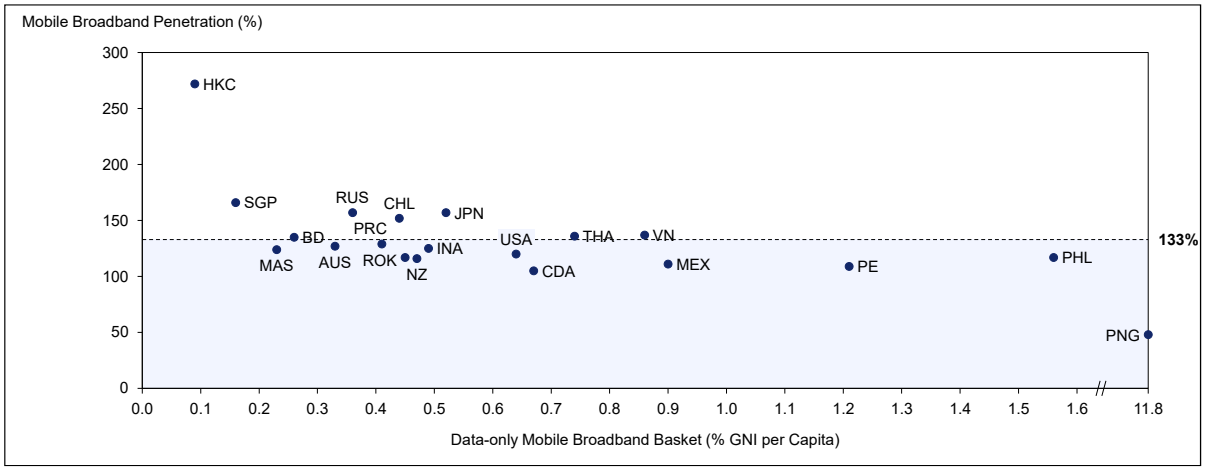
There is a positive correlation between mobile broadband penetration and population density across APEC economies. In areas with higher population density, such as cities and urban centers – mobile service providers find it more cost-effective to deploy mobile infrastructure because larger numbers of consumers are concentrated in a smaller geographic area. This allows mobile service providers to achieve economies of scale, reducing the cost per subscription and encouraging higher adoption rates.

In APEC economies, the relationship between mobile penetration and population density follows a similar pattern to global trends, where higher population densities generally correlate with greater mobile penetration. Economies with high urbanization and dense population, such as Hong Kong, China and Singapore tend to have remarkably high mobile penetration rates. Hong Kong, China, as the most densely populated economy, has 272% of mobile penetration rate.

There are some APEC economies with lower population density (e.g., Australia; Russia; and the United States), where significant investments in mobile infrastructure have been made, resulting in relatively high mobile penetration rates. Although other APEC economies like Indonesia and the Republic of the Philippines have mobile penetration rates near the APEC average, this is largely due to the geographic challenges and high infrastructure costs associated with deploying fixed broadband in rural and remote areas. As a result, mobile technology serves as the most practical alternative in these regions.

Those APEC economies with large rural populations and lower population densities, (e.g., Papua New Guinea), experience lower mobile penetration rates. The dispersed population makes infrastructure rollouts more challenging and expensive, contributing to coverage gaps and reduced adoption rates.

Figure 2.14 Mobile Broadband Penetration and Data-only Mobile Broadband Basket of APEC Economies



Source: (1) State of the telecoms market 2024 (available for relevant APEC economies). (2024, May). Analysys Mason Limited.
(2) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies). (2023, March). GSM Association / Wireless Intelligence.
(3) Service Provider Market Report – 2024 (available for relevant APEC economies). (2024). Omdia Research.
(4) Affordability: Fixed Broadband Internet Basket. (n.d.). Datahub.itu.int; ITU Datahub. https://datahub.itu.int/

The affordability of data-only mobile broadband services – measured by the cost of a standard mobile broadband basket as a percentage of Gross National Incomes (GNI) per capita – is a key factor influencing mobile broadband penetration rates across APEC economies.

Those economies where the mobile broadband basket costs less than 1% of GNI per capita show higher mobile penetration rates, as service affordability removes a major barrier to access. For example, Hong Kong, China, and Singapore have the lowest-cost mobile broadband

baskets, at just 0.09% and 0.16% of GNI per capita respectively, and also demonstrate significantly high mobile penetration rates of 250% and 159%.

On the other hand, APEC economies, such as Papua New Guinea and the Republic of the Philippines, experience higher relative costs for mobile broadband services – 11.8% and 1.56% of GNI per capita, respectively – which corresponds with lower mobile penetration rates. It is indicated that high service costs limit affordability, especially among lower-income populations, therefore restricting the uptake of mobile subscriptions.

According to the ITU's 2023 Facts and Figures Report, the ongoing trend of increased affordability for both fixed and mobile broadband services persisted throughout 2023. Across all global regions, the cost associated with data-only mobile broadband and fixed broadband services continues to decline, making internet access more accessible worldwide. Specifically, the global median price for mobile broadband services decreased from 1.5% to 1.3% of GNI per capita, reflecting improved affordability for consumers. Similarly, the cost of fixed broadband services dropped from 3.2% to 2.9% of GNI per capita, demonstrating progress in reducing barriers to fixed-line internet access[16]. Looking ahead, the report projects that by 2025, entry-level broadband service should become affordable in low- and medium-income economies, with costs falling below 2% of monthly GNI per capita[17]. This milestone is expected to significantly enhance digital inclusion and bridge the connectivity gap in underserved regions.

Service Affordability – The Inclusive Internet Index

Service affordability assesses whether the consumers can reasonably pay for broadband services without financial hardship. Together these indicators provide comprehensive understanding of how well broadband infrastructure not only exists but is also practically usable and accessible to the general population. This helps gauge the success of efforts to bridge the digital divide and ensure inclusive connectivity.

According to the 2022 Inclusive Internet Index, published by Economist Impact, the rankings are evaluated based on four main categories: Availability, Affordability, Relevance and Readiness, across 100 economies, representing approximately 99% of the global population and 97% of global GDP[18]. A deep dive into the "Affordability" index provides insights into the cost of access relative to income and level of competition in the internet marketplace. The "Affordability" index consists of two subcategories: (1) Price and (2) Competitive Environment.

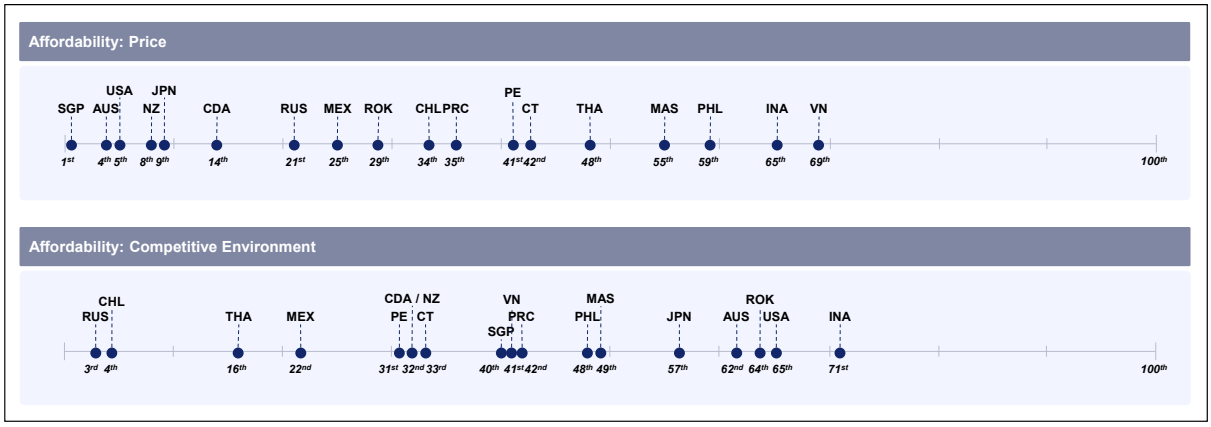
The "price" subcategory measures the cost of internet access relative to income while the "Competitive Environment" subcategory measures the concentration of the marketplace for internet service provision.

The figure below illustrates the ranking of 21 APEC economies based on these two subcategories. These rankings show the current position of which each economy relates to 100

[16] Broadband Advocacy Target 2: Make Broadband Affordable. (2025). Broadband Commission for Sustainable Development. https://www.broadbandcommission.org/advocacy-targets/2-affordability/
[17] 2025 Advocacy Targets - Broadband Commission. (2024, September 10). Broadband Commission. https://www.broadbandcommission.org/advocacy-targets/#target2
[18] Economist Impact: The Inclusive Internet Index, supported by Meta. (2022). Economist.com. https://impact.economist.com/projects/inclusive-internet-index

economies globally, providing comparative view of their broadband infrastructure price and competitive environment.

Figure 2.15 Inclusive Internet Index for Affordability Category



Source: (1) Economist Impact: The Inclusive Internet Index, supported by Meta. (2022). Economist.com. https://impact.economist.com/projects/inclusive-internet-index

The "price" assessment consists of multiple factors, including the cost handsets, Mobile tariffs, and fixed-line monthly broadband costs. Observations show that APEC economies vary widely in their rankings – for example, Singapore ranks first globally – the best in term of price, while Viet Nam is positioned 69th – based on cost of internet access relative to income.

The competitive environment is evaluated by examining the market concentration in internet service provision, incorporating factors such as average revenue per user (ARPU), market share of mobile operators and market share of broadband providers. Within the APEC region, the competitive landscape is varied, with most economies positioned in the mid-range category. Recent development underscores the dynamic nature of market competition in the Asia-Pacific region, highlighted by significant mergers and acquisitions in the telecom sector, particularly in Indonesia; Malaysia; Chinese Taipei; and Thailand.

Example of Leading Affordable APEC Economies:

1. **IMDA's DigitalAccess@Home Scheme – Singapore**
   To promote digital inclusion, the IMDA introduced the DigitalAccess@Home scheme in 2023. This initiative provides subsidized broadband and digital devices (laptops and tablets) to low-income households to better support such households with affordable digital access. The scheme will be able to support 60,000 households.

2. **Competitive Market – Russia**
   The Russian internet service market is characterized by a prominent level of competition among providers. This competition drives prices down and encourages service providers to offer better quality services to attract and retain customers. Apart from leading companies, such as MTS and Megafon, every region also has small local companies. As of 2021, there are over 3,000 internet providers, with more than 6,500 telecom operators in Russia.

Source: (1) Empowering Singaporeans: New DigitalAccess@Home Scheme to Strengthen Digital Inclusion. (2023, February). Ministry of Digital Development and Information. https://www.mddi.gov.sg/newsroom/empowering-singaporeans-new-digitalaccessathome-scheme
(2) Russia's Internet audience reaches 124 mln people in 2021, says federal service. (2021, October 19). TASS Russian News Agency. https://tass.com/economy/1351245

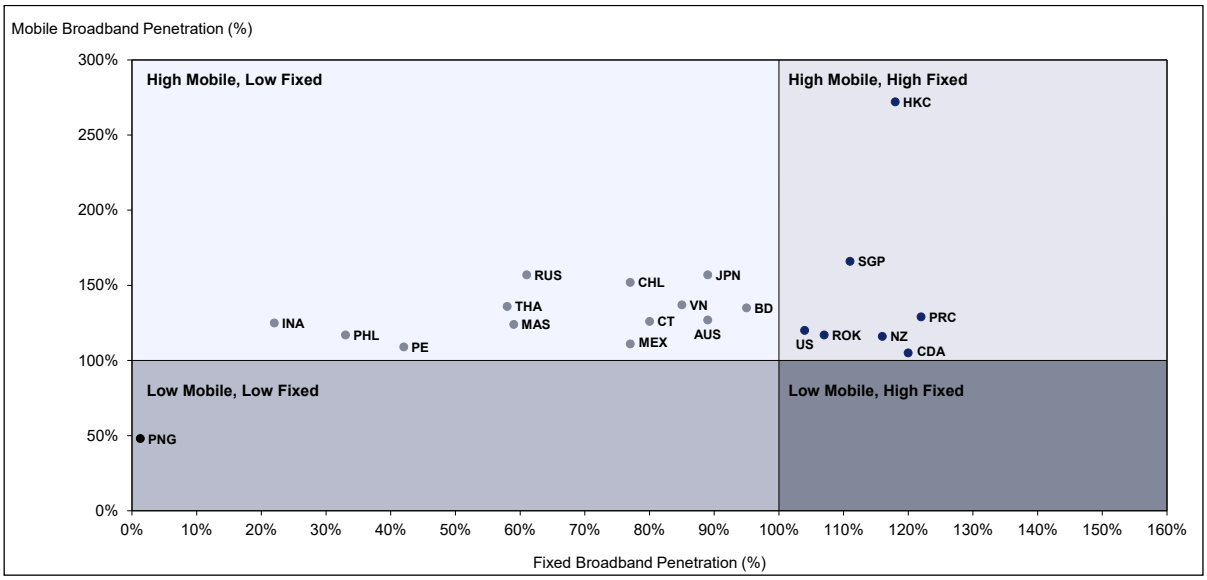
(3) South Korea's Binary Broadband Push: Bridging the Digital Divide, One Village at a Time - Telecom Review Asia. (2025, May 9). Telecom Review Asia. https://www.telecomreviewasia.com/news/featured-articles/13330-south-koreas-binary-broadband-push-bridging-the-digital-divide-one-village-at-a-time/
(4) Rural Broadband | National Infrastructure Funding and Financing | New Zealand. (2024). National Infrastructure Funding and Financing Website. https://nationalinfrastructure.govt.nz/rural-broadband

Fixed Broadband Penetration vs Mobile Penetration

The relationship between fixed broadband penetration and mobile penetration is a key indicator of digital connectivity and infrastructure development within APEC economies. Fixed broadband connectivity typically provides stable, high-speed internet access in residential and business premises. Conversely, mobile penetration reflects the accessibility and usage of wireless internet services across a population.

In many APEC economies, the correlation between fixed broadband penetration and mobile penetration sheds light on how different infrastructure investments and socioeconomic factors influence internet adoption patterns, bridging gaps between urban and rural connectivity and driving digital inclusion.

Figure 2.16 Fixed Broadband Penetration vs Mobile Penetration



Source: (1) State of the telecoms market 2024 (available for relevant APEC economies). (2024, May). Analysys Mason Limited.
(2) Mobile Market KPIs by Economy, 2000-2030 (available for relevant APEC economies). (2023, March). GSM Association / Wireless Intelligence.
(3) Service Provider Market Report – 2024 (available for relevant APEC economies). (2024). Omdia Research.

From the figure above, the relationship between fixed broadband and mobile penetration across 21 APEC economies is classified into three categories.

(1) Complementary Growth

In many APEC economies, fixed broadband and mobile penetration tend to grow together, reflecting broader digital infrastructure development. High mobile penetration often reflects widespread access to internet services, while broadband penetration reflects more stable, high-speed connectivity, especially in urban and residential areas.

APEC economies classified in this category are Canada; the People's Republic of China; Hong Kong, China; Republic of Korea; New Zealand; Singapore; and the United States.

(2) Variation by Development Level

In this category, the relationship between fixed broadband and mobile penetration is categorized based on development level of the APEC economies: Advanced economies and developing economies.

- Advanced economies show high penetration for both fixed broadband and mobile broadband. These economies benefit from extensive fiber optic infrastructure and mature mobile infrastructure, resulting in high adoption rates of both technologies.

- Developing economies show higher mobile broadband penetration relative to fixed broadband due to lower cost and easier deployment of mobile infrastructure compared to fixed broadband infrastructure. In these economies, mobile broadband serves as the primary means of internet connectivity.

For the purpose of this study, APEC economies were classified into two broad groups - developed and developing - to simplify analysis and highlight structural contrasts in broadband development. While institutions such as the World Bank and OECD commonly use three- or four-income categories, a two-tier approach provides a clearer analytical distinction between economies with mature, high-capacity broadband ecosystems and those still expanding access and affordability. This simplification enables more focused comparison of policy priorities, investment gaps, and digital inclusion challenges without diluting insights across multiple intermediate groups. Moreover, within APEC, broadband development patterns tend to cluster naturally around these two levels of maturity, making the binary classification both practical and analytically robust for policy-oriented discussion.

(3) Inverse / Lagging Patterns

Papua New Guinea is the only economy classified in this category, showing both relatively low mobile and fixed broadband penetrations. This is due to geographical challenges, economic factors, and infrastructure investment gaps.

In conclusion, economies with high fixed broadband penetration typically also boast mature mobile markets, indicating well-balanced and robust digital ecosystems. Conversely, in some economies where fixed broadband access is limited, mobile penetration plays a crucial role in bridging connectivity gaps, thereby promoting greater inclusion and broader internet access.

2.4 POLICY AND REGULATORY DRIVERS OF BROADBAND INFRASTRUCTURE DEPLOYMENT

In the early 2000s infrastructure policies were oriented towards the potential for long-term market failures amongst competing operators and geographic areas.

2.4.1. Regulatory and Competition Policies

Access policies were designed for service competition whereby some operators invested and deployed new broadband infrastructure. This involved the enhancement of existing copper lines for the deployment of Asymmetric Digital Subscriber Line (ADSL), incentivized by the regulation of LLU[19] - i.e.by mandating that incumbent local exchange lease parts of their network infrastructure to competitors. The LLU and the wide availability of wholesale DSL products led to strong retail and wholesale competition, which in turn resulted in falling prices and stimulated elevated levels of take-up.

However, regulatory intervention in the United States for instance[20], resulted in mixed long-term effectiveness. Over time, the sector-regulator's policies shifted to favor facilities-based competition, where competing operators begin building and operating their own network infrastructure, thereby reducing reliance on LLU.

Nevertheless, because the transmission capacity of ADSL decreased over distance, this investment resulted in a patchwork of broadband availability where, for the vast proportion of consumers, practical broadband speeds varied massively between 1 and 24 Mbps (downstream). A significant minority of users saw no real improvement in their broadband access speeds during this time[21].

2.4.2. Universal Service Obligations Policy

Policies requiring some kinds of minimum Universal Service Obligations (USO) were designed to tackle the lack of availability of broadband[22]. At the time, governments acknowledged that it was unlikely that operators would be able to deploy broadband access technologies ubiquitously across economies. Therefore, the retention use of USO's funds to ensure a minimum level of connectivity required to deliver broadband access in underserved areas was considered. In 2006 the OECD[23] did argue that the funding arrangements for USO might be unsuitable for broadband and that governments should have considered funding a USO from general taxation revenue.

This resulted in programs such as Ubiquitous Canadian Access Network (UCAN)[24], implemented through various programs e.g., Connecting Canadians Program (CCP) - aimed to

[19] Cave, M. (2006). Encouraging infrastructure competition via the ladder of investment. *Telecommunications Policy*, *30*(3-4), 223–237. https://doi.org/10.1016/j.telpol.2005.09.001
[20] Berkman Center Report (Next Generation Connectivity). (2010). Cyber.harvard.edu; The Berkman Center for Internet & Society at Harvard University. https://cyber.harvard.edu/pubrelease/broadband/
[21] Leonard, B. (2010). *Connecting America: The National Broadband Plan*. DAINE Publishing. https://books.google.co.th/books?hl=en&lr=&id=l8oI5rA_NpQC&oi=fnd&pg=PR9&dq=Leonard
[22] USO policies have been instrumental in bridging digital divides. Countries like Thailand and Malaysia have implemented USO-financed broadband backbones and community access centers targeting underserved populations. Reforms Promoting Competition and Increasing Investment for Broad- band Infrastructure A Policy Note. (2024). The World Bank. https://documents1.worldbank.org/curated/en/099011824231036851/pdf/P502027179f71d08418678193f2fabcdbec.pdf
[23] Rethinking Universal Service for a Next Generation Network Environment. (2025). OECD. https://www.oecd.org/en/publications/rethinking-universal-service-for-a-next-generation-network-environment_231528858833.html
[24] Atkinson, R. D., Correa, D. K., & Hedlund, J. A. (2008). Explaining International Broadband Leadership. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.1128203

achieve near-universal broadband coverage by 2010 with 'smart subsidies' to determine which service providers (telco, cable, wireless, satellite) can provide coverage at lowest cost.

2.4.3. Status Quo

Since 2015 APEC economies, are generally at or near the top of global broadband access rankings. For example, Japan and Republic of Korea have been global leaders in fiber broadband penetration and overall fixed broadband access for many years. Meanwhile, other APEC economies are advancing but still face challenges in achieving universal coverage. APEC's policy remains focused on closing digital divides and promoting inclusive digital transformation.

From a policy perspective, the APEC economies are considering latest technological and market developments through domestic programs or regulatory provisions on achieving policy targets e.g., via a process of facilitation of connectivity through competition and/or universal service obligations and funds.

These are the key policy target areas denoted in APEC economies:

- Promotion of access connectivity and take-up;
- Promotion of competition including efficient infrastructure-based competition;
- Promotion of the consumers interests in terms of choice, price, and quality.

These policy aims have resulted in a diversity of digital infrastructure and market conditions which can be broadly categorized into three policy-driven groups.

Policy Group 1: includes advanced economies such as Japan; Republic of Korea; Singapore; and the United States[25,26,27] and targeted subsidies for underserved communities. These economies often emphasize ultra-fast broadband and emerging technologies like 5G and FTTH.

Policy Group 2: comprising of Chile; Malaysia; Mexico; and Thailand, implements mixed approaches by combining regulatory reforms (such as infrastructure sharing[28] and competition enforcement) with government-led rural broadband initiatives and USO funds to extend access. These policies aim to bridge the urban-rural digital divide while encouraging market competition.

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[25] Next Generation Nationwide Broadband Network (Next Gen NBN). (2013, July). iDA Singapore. https://www.imda.gov.sg/-/media/imda/files/community/consumer-education/fibre-broadband/nextgennbnfactsheet.pdf

[26] OECD DIGITAL ECONOMY PAPERS DEVELOPMENTS IN SPECTRUM MANAGEMENT FOR COMMUNICATION SERVICES. (2022). https://www.oecd.org/content/dam/oecd/en/publications/reports/2022/10/developments-in-spectrum-management-for-communication-services_ae18e03f/175e7ce5-en.pdf

[27] Connect America Fund (CAF). (2012, April 25). Federal Communications Commission. https://www.fcc.gov/general/connect-america-fund-caf

[28] PUBLIC-PRIVATE-PARTNERSHIP LEGAL RESOURCE CENTER. (2024, October 10). PUBLIC-PRIVATE-PARTNERSHIP LEGAL RESOURCE CENTER. https://ppp.worldbank.org/public-private-partnership/telecom-and-ict/telecom-infrastructure-sharing-thailand; MCMC Launches MOCN Guidelines to Improve Network Coverage. (2025, January). Malaysian Wireless Internet, Teleco & More. https://www.malaysianwireless.com/2025/01/mcmc-mocn-guidelines-network-coverage/

Policy Group 3: including Papua New Guinea[29]; Peru[30]; and the Republic of the Philippines[31], relies heavily on international development support and public investment in backbone infrastructure. Their strategies prioritize affordability, digital literacy, and basic connectivity through community networks, often constrained by limited fiscal resources and institutional capacity. For instance, in Papua New Guinea have been significantly shaped by international development support - such as Australia's funding of the Coral Sea Cable System[32] - and public investment in backbone infrastructure through state-owned DataCo, aimed at reducing wholesale prices and extending local fiber coverage. Each group reflects varying levels of maturity in digital policy and infrastructure, tailored to specific economic and developmental contexts.

Table 2.4 Classification of Policy-driven Groups accelerating Broadband Connectivity

Policy Feature	Group 1: Advanced Economies *(Japan; Republic of Korea; Singapore; USA)*	Group 2: Mixed-Approach Economies *(Chile; Malaysia; Mexico; Thailand)*	Group 3: Emerging Economies *(Papua New Guinea; Peru; The Philippines)*
Infrastructure Modernization	Emphasis on ultra-fast broadband (FTTH, 5G) and next-gen tech	Partial upgrades in urban areas; rural lag remains	Limited; focus on basic backbone rollout via public investment
Spectrum Efficiency	Advanced spectrum planning and auctions (5G, mmWave)	Selective reforms; some constraints in deployment	Limited capacity; often reliant on donor-funded planning
Demand Stimulation (PPP/Subsidies)	Strong use of public-private partnerships and targeted subsidies for underserved populations	Moderate use: USO funds and state-run programs support expansion	Present via donor or community-driven models; scope constrained by funding
Universal Service Obligations (USO)	Applied selectively in remote regions	Key tool to drive rural access	Strong reliance; core to connectivity strategy
Competition and Market Structure	Focus on infrastructure-based and service-level competition	Regulation-driven competition with infrastructure sharing	Emerging; markets are often dominated by a few providers
Affordability and Digital Inclusion	Secondary priority; addressed through subsidies and plans	Targeted support to low-income users, rural schools	Central focus; includes community networks, literacy campaigns

[29] For instance, Australia-PNG Economic Partnership, supporting digital inclusion and submarine cable links (e.g., the Coral Sea Cable) (Australian High Commission in. (2019). Embassy.gov.au; Department of Foreign Affairs and Trade. https://png.embassy.gov.au/pmsb/1029.html)
[30] Red Dorsal Nacional de Fibra Óptica. (2024, August 2). Www.gob.pe. https://www.gob.pe/institucion/pronatel/campa%C3%B1as/11369-red-dorsal-nacional-de-fibra-optica
[31] USAID Launches New Project to Increase Digital Connectivity in the Philippines. (2021, October 29). U.S. Embassy in the Philippines. https://ph.usembassy.gov/usaid-launches-new-project-to-increase-digital-connectivity-in-the-philippines/.
[32] Australian High Commission in. (2019). Embassy.gov.au; Department of Foreign Affairs and Trade. https://png.embassy.gov.au/pmsb/1029.html

Policy Feature	Group 1: Advanced Economies *(Japan; Republic of Korea; Singapore; USA)*	Group 2: Mixed-Approach Economies *(Chile; Malaysia; Mexico; Thailand)*	Group 3: Emerging Economies *(Papua New Guinea; Peru; The Philippines)*
International Development Support	Not applicable	Occasionally leveraged for rural projects	Significant; critical for backbone and broadband programs

Promotion of competition, including efficient infrastructure-based competition, is a central pillar of broadband policy across APEC economies, with economies adopting varied approaches based on market maturity and regulatory capacity. Below is the economy group:

Competition Group 1: comprising economies such as Japan; Republic of Korea; Singapore; and the United States, focuses on fostering infrastructure-based competition through policies that encourage private investment in parallel with fiber and mobile networks, alongside streamlined access to passive infrastructure like ducts and poles[33]. These economies often combine competitive neutrality with advanced regulatory frameworks that prevent market dominance. For instance, Republic of Korea allows multiple infrastructure providers (e.g., KT, SK Broadband, LG U+) to build and operate their own networks, while the government facilitates shared use of infrastructure (ducts, poles, in-building wiring). Japan's regulatory framework encourages facility deployment by multiple operators, leading to parallel fiber rollouts by providers like KDDI and SoftBank.

Competition Group 2: comprising economies such as Australia; Canada; Chinese Taipei; and Malaysia, emphasizes open-access models and regulated wholesale networks to ensure service-level competition even where infrastructure duplication is limited. The Australian Government created NBN Co[34], a government-owned corporation that builds and operates a wholesale-only broadband network. In Canada, the incumbent telecom providers (e.g., Bell, Rogers, Telus) are mandated to provide wholesale access to their broadband networks. In Chinese Taipei, the National Communications Commission (NCC) [35] promotes unrestricted access to fiber networks developed under public-private initiatives. These policies support efficiency and affordability while enabling smaller internet service providers (ISPs) to compete on equal terms.

Competition Group 3: comprising economies such as Indonesia; Papua New Guinea; Peru; and the Republic of the Philippines, relies more heavily on public-private partnerships and state-led infrastructure, often through local broadband networks or wholesale-only models, to stimulate competition in underserved areas. This group often combines market liberalization with targeted subsidies or regulatory interventions to expand access and affordability where commercial incentives are weak.

[33] Husar, A., Jeong, Y., & Garrity, J. (2023). Cross-Sector Infrastructure Co-deployment: Closing Digital Connectivity Gaps through Collaboration and Sharing. ADB Sustainable Development Working Paper Series, 86. https://doi.org/10.22617/wps230262-2

[34] Wholesale providers | nbn. (2020). Nbnco.com.au. https://www.nbnco.com.au/rsps/become-an-nbn-provider/wholesale-providers

[35] NATIONAL COMMUNICATIONS COMMISSION. (2024). Ncc.gov.tw. https://www.ncc.gov.tw/english/gradation.aspx?site_content_sn=350&is_history=0

Table 2.5 Classification of Policy-driven Groups supporting Infrastructure-based Competition

Policy Feature	Group 1: Infrastructure-Based Competition *(e.g., Japan; Republic of Korea; Singapore; USA)*	Group 2: Open-Access and Regulated Wholesale *(e.g., Australia; Canada; Malaysia; Chinese Taipei)*	Group 3: State-Led and PPP Competition in Underserved Areas *(e.g., Indonesia; Papua New Guinea; Peru; The Philippines)*
Core Strategy	Private sector builds competing infrastructure; gov't supports passive infra-access	Centralized or incumbent networks with regulated wholesale access to enable service competition	Government-driven backbone or domestic broadband networks with PPPs; competition stimulated via regulation and subsidies
Infrastructure-Based Competition	Strong, multiple operators deploy parallel fiber/mobile networks (e.g., KT, SoftBank, Verizon)	Limited, duplication discouraged; competition via wholesale access models	Minimal, reliance on shared local infrastructure to support market entry in high-cost, low-return areas
Access to Passive Infrastructure	Streamlined access to ducts, poles, and in-building wiring	Regulated or bundled within wholesale obligations (e.g., NBN, CRTC, NCC mandates)	Often limited or state-owned; shared access encouraged for cost efficiency
Open-Access Regulation	Less central, emphasis on competition via full infrastructure	Core, enforced by regulators (e.g., ACCC, CRTC, NCC, MCMC) to enable diverse service providers	Central, domestic networks (e.g., Red Dorsal, BB4G) operate on open-access principles
Regulatory Neutrality and Market Entry	Emphasis on non-discrimination, neutrality in spectrum and infra-access	Rules ensure incumbents provide fair access to wholesale network capacity	Government plays active role in selecting partners; liberalization remains incomplete in some cases
Role of Public Investment	Indirect, mostly facilitative (e.g., subsidies or passive infra investment)	Direct, NBN Co in Australia; public-private fiber projects in Chinese Taipei	Major infrastructure is often publicly funded or co-financed with development support
Targeted Competition in Underserved areas	Through subsidies and competitive grant programs (e.g., RDOF in USA)	Occasional programs for remote/rural connectivity	Focused on rural and underserved zones; regulatory tools used to promote new entrants

Promotion of consumer interests, especially regarding choice, price, and quality of broadband services, is a key objective across APEC economies, but approaches vary.

Consumer Interests Group 1: economies such as Australia; Canada; and Singapore prioritize regulatory oversight and structural separation to ensure a competitive retail environment. In

Australia, the NBN Co's wholesale-only model[36] supports service-level competition, while Canada[37] mandates wholesale access at regulated prices to increase consumer options and affordability. Singapore enforces functional separation through NetLink Trust[38], ensuring quality and non-discriminatory access for ISPs.

Consumer Interests Group 2: economies like Japan; Republic of Korea; and Chinese Taipei rely on infrastructure sharing and access regulation to stimulate service-based competition and drive consumer benefits. These economies use policies such as LLU and mandated passive infrastructure sharing to ensure multiple providers can offer affordable, high-quality services.

Consumer Interests Group 3: economies, including Malaysia; Mexico; and the Republic of the Philippines, focus on consumer protection rules and affordability initiatives - often through universal service programs, subsidies, and price controls - while gradually enhancing competition. For instance, Peru has adopted a state-led and public-private partnership (PPP) model to expand broadband in underserved areas, underpinned by strong governance and legislative frameworks - Law No. 29904 (Broadband Promotion Law) and the General Telecommunications Law. The National Telecommunications Program (PRONATEL[39]) - established under the Ministry of Transport and Communications - oversees rural connectivity projects using PPPs to deploy regional fiber-optic networks, targeting remote regions through long-term concession contracts. These economies face infrastructure gaps, so policies increasingly emphasize extending access while also improving service quality and consumer choice in underserved areas.

Table 2.6 Classification of Policy-driven Groups promoting Consumer Interests

Policy Focus Area	**Group 1: Structural Separation and Wholesale Regulation *(e.g., Australia; Canada; Singapore)***	**Group 2: Infrastructure Sharing and LLU Access *(e.g., Japan; Republic of Korea; Chinese Taipei)***	**Group 3: Affordability and Consumer Protection in Underserved Areas *(e.g., Malaysia; Mexico; The Philippines)***
Core Strategy	Enhance retail competition through regulated wholesale access and structural or functional separation	Promote service-based competition via infrastructure sharing and LLU mandates	Improve affordability and quality via consumer protection, universal service programs, and subsidies
Regulatory Oversight	Strong oversight by regulators (e.g., ACCC, CRTC, IMDA)	Targeted regulations for access pricing, network sharing	Regulatory frameworks are still evolving; some dependence on state-led enforcement mechanisms

[36] NBN Co launches new Wholesale Broadband Agreement focused on speed and reliability | nbn. (2020). Nbnco.com.au. https://www.nbnco.com.au/corporate-information/media-centre/media-statements/nbn-co-launches-new-wholesale-broadband-agreement-focused-on-speed-and-reliability

[37] CRTC sets rates that will allow for greater choice of Internet services. (2024, October 25). Canada.ca; Government of Canada. https://www.canada.ca/en/radio-television-telecommunications/news/2024/10/crtc-sets-rates-that-will-allow-for-greater-choice-of-internet-services.html

[38] Nationwide Broadband Network. (2023, December). Infocomm Media Development Authority. https://www.imda.gov.sg/regulations-and-licensing-listing/nationwide-broadband-network

[39] Programa Nacional de Telecomunicaciones - Pronatel. (2025, May 30). Www.gob.pe. https://www.gob.pe/pronatel

Policy Focus Area	Group 1: Structural Separation and Wholesale Regulation *(e.g., Australia; Canada; Singapore)*	Group 2: Infrastructure Sharing and LLU Access *(e.g., Japan; Republic of Korea; Chinese Taipei)*	Group 3: Affordability and Consumer Protection in Underserved Areas *(e.g., Malaysia; Mexico; The Philippines)*
Separation Models	Structural (Australia: NBN Co) / Functional (Singapore: NetLink Trust) separation ensures neutral wholesale access	Separation not emphasized; focus on competition over shared infrastructure	Not implemented; competition limited in many regions due to infrastructure concentration
Wholesale Access and Pricing	Regulated wholesale access to ensure retail competition and price discipline	Access to passive infrastructure like copper, ducts, fiber mandated at cost-oriented rates	Wholesale regulation is present but weaker; price caps/subsidies often used for affordability
Consumer Choice	High, substantial number of competing ISPs offering differentiated broadband services	Medium to High, service differentiation via access to shared infrastructure	Limited, often constrained by infrastructure reach and market concentration
Quality of Service (QoS)	Enforced via competition and regulatory standards	Market-driven improvements, supported by competition	Variable, QoS may be poor in remote/rural areas due to lack of infrastructure investment
Affordability Programs	Targeted (e.g., concessional pricing for low-income users)	Less central, focus is on affordability programs	Adopt a mix of subsidy programs, USO, price regulation, to improve inclusion

2.5 OVERARCHING ISSUES AND CHALLENGES IN BROADBAND INFRASTRUCTURE DEPLOYMENT

Broadband infrastructure deployment is a critical driver of economic growth and digital inclusion across the APEC economies. However, despite considerable progress in expanding internet access and connectivity, many APEC economies continue to face a range of challenges that hinder the widespread and equitable deployment of broadband networks. These challenges include geographical barriers, high infrastructure costs, regulatory complexity, and disparities in technological advancements.

To develop effective strategies that bridge the digital divide, improve connectivity, and promote sustainable development across the diverse APEC economies, it is essential to address these challenges. The following section provides a detailed explanation of the key obstacles faced by APEC member economies.

2.5.1 Geographical Barriers for Broadband Infrastructure Rollout

The APEC economies encompass a wide range of geographical features, each presenting distinct challenges for deploying broadband connectivity infrastructure. These challenges

include high deployment costs with low returns on investment, as well as heavy reliance on undersea cables. As a result, distinct types of underserved areas arise from the unique characteristics of each economy, underscoring the need for customized strategies to effectively address these issues.

The 21 APEC economies can be broadly classified based on their diverse geographical characteristics, which significantly influence their connectivity and infrastructure needs. The details of geographical characteristics are classified as follows:

(1) Large landmasses with extensive rural and remote regions:

Some economies are predominantly large landmasses with extensive rural and remote areas (e.g., Australia; Canada; China; Russia; and the United States). Table 2.7 illustrates areas and population density of "Large Landmasses" APEC economies.

Table 2.7 Land Areas and Population Density of "Large Landmasses" APEC Economies

APEC Economy	Land Areas (million sq. km.)	Population Density (ppl / sq. km.)
Australia	7.7	4
Canada	10	4
People's Republic of China	9.6	151
Russia	16	9
The United States	9.8	38

Source: (1) List of all economies by area. Geodatos. Retrieved June 2025, from https://www.geodatos.net/en/areas
(2) Largest Countries in the World by Land Area. (2025, June). Worldometers. https://www.worldometers.info/geography/largest-countries-in-the-world/
(3) Our World in Data. (2025). Population density. Our World in Data. https://ourworldindata.org/grapher/population-density

As noted earlier, these economies face unique challenges in implementing telecommunication infrastructure due to their vast landmass, which makes it difficult to provide coverage in rural and sparsely populated areas. Service providers must incur high CAPEX costs to lay infrastructure such as fiber optic cables over long distances. Coupled with a limited number of service subscriptions in these areas, this often reduces the incentive for investment, given the inflated costs and low immediate returns. Additionally, maintaining the extensive infrastructure presents its own set of challenges.

(2) Archipelagic economies with remote islands:

The Archipelagic economies, characterized by numerous remote islands, face unique challenges in deploying broadband infrastructure across dispersed and hard-to-reach areas. Within the characteristics of archipelagic islands, there are two subcategories: (1) highly urbanized island or peninsula economies with concentrated populations and advanced infrastructure networks, such as Japan; Republic of Korea; and Chinese Taipei and (2) economies consisting of numerous islands with sparsely populated regions, such as Indonesia; Papua New Guinea; and the Republic of the Philippines.

Geographic isolation makes large-scale infrastructure rollout complex. Terrestrial networks like cell towers and fiber cables lose effectiveness at shorelines, requiring heavy reliance on submarine cables and satellite systems. Sustaining reliable services across hundreds or

thousands of small islands adds further strain, with high maintenance costs and logistical barriers limiting consistent coverage.

(3) Economies with complex mountainous and densely forested landscapes

Several APEC economies are distinguished by their complex mountainous terrains and dense forested regions, which present significant challenges for infrastructure development. For example, Chile and Peru are characterized by rugged mountain ranges that make land-based connectivity projects difficult and costly to implement while Brunei Darussalam; Malaysia; and Thailand feature extensive dense forest areas, which complicate the deployment and maintenance of infrastructure due to limited accessibility and environmental considerations.

The natural barriers not only increase construction expenses but also restrict access to remote communities, making it hard to expand reliable communication networks. In addition, these hard-to-reach terrains often suffer from unstable electricity supply to telecommunications equipment, making infrastructure deployment highly unattractive to service providers without external support.

Finally, broadband infrastructure deployment challenges are not confined to rural or remote areas; service providers also face significant obstacles in urbanized regions, especially in densely populated metropolitan areas. High population density often leads to increased demand for bandwidth and network capacity, requiring substantial upgrades and expansions of existing infrastructure. Additionally, physical constraints such as limited space for new equipment, regulatory hurdles and complex rights-of-way issues can further complicate deployment efforts. These factors collectively make it challenging for service providers to deliver reliable, high-speed broadband services in urban settings, despite their concentrated population.

There are numerous “black spots” with little to no broadband connectivity across regions in Latin America and Southeast Asia. These connectivity gaps are predominantly found in lower-income and informal settlement areas within larger urban centers. Rapid, unregulated urbanization in developing economies frequently outpaces planned infrastructure deployment, exacerbating the digital divide. Furthermore, the informal and unauthorized nature of these settlements often prevents the installation of smaller-scale equipment such as signal amplifiers, typically mounted on rooftops, thereby limiting network coverage and quality.

APEC Economy Facing Difficulties Due to Geographical Challenges

The Republic of the Philippines – According to a 2023 report from UN-Habitat, there are approximately 3.7 million informal settler families in The Republic of the Philippines, around ~500,000 families are living in slums in Metro Manila.

These informal settlement and housing areas having have low broadband coverage within the highly urbanized Metro Manila area, Infrastructure is unevenly deployed due to the lack of land / house legal tenure, so telco operators cannot legally install any equipment to boost connectivity within those areas.

The high number of people living in these densely packed areas result in higher broadband connectivity demands per unit area that the operators cannot keep up with, when factored in the uneven infrastructure deployment. Affordability is an additional challenge. According to World Bank data, fixed broadband cost in the Philippines is twice the ASEAN average, and mobile cost is 1.5x more. These contribute to the Philippines’ growing digital divide, particularly in the informal settlers’ areas within Metro zones.

Source: (1) UN-Habitat Philippines Country Report 2023. (2023). United Nations Human Settlements Programme (UN-Habitat) . https://unhabitat.org/sites/default/files/2023/06/5._un-habitat_philippines_country_report_2023_final_compressed.pdf
(2) Updating policies to upgrade the Internet for all Filipinos. World Bank Blogs. https://blogs.worldbank.org/en/eastasiapacific/updating-policies-upgrade-internet-all-filipinos

2.5.2 Socioeconomic Factors Impacting on Technology Adoption

APEC economies face diverse challenges in technology adoption shaped by socioeconomic conditions. Low income constrains affordability of devices and services, while limited education and digital literacy reduce the ability to use them effectively. Employment status also matters, as informal workers or those in precarious jobs are less able to sustain regular digital access. Together, these factors slow adoption in underserved regions and reinforce existing gaps between connected and unconnected populations.

(1) Income Levels

Affordability remains a critical barrier. In lower-income households and economies, high device and service costs restrict adoption, creating stark divides between urban centers and poorer rural or marginalized communities. Informal or irregular employment reduces household income stability, making regular broadband subscriptions or device purchases harder to sustain. This is particularly acute in developing APEC economies with elevated levels of informal labor. In economies with large informal sectors, employment type directly shapes digital access and adoption. For example, in Indonesia, where around 59% of workers are in informal employment (2022-2024), most workers lack stable incomes, employer-provided benefits, or access to workplace digital tools. This reduces their ability to purchase devices, pay for broadband subscriptions, or develop ICT skills compared to formal sector employees, who often access digital services through their jobs. As a result, informal workers are more likely to remain excluded from digital platforms such as e-commerce, online banking, and remote learning, reinforcing broader digital divides across income and geography.

These affordability constraints directly affect whether families can access digital services, regardless of network availability. Table 2.8 highlights these disparities, showing household internet access and individual usage across APEC economies segmented by income levels.

Table 2.8 Number of Household with Internet Access and Individuals Using Internet [40,41]

APEC Economy	GDP Per Capita (USD)	Households with internet access at home (Rural)	Households with internet access at home (Urban)*	Individuals using Internet (Rural)**	Individuals using Internet (Urban)**
Viet Nam	4,282	84%	93.6%	74%	84.7%
Indonesia	4,876	81.6%	91%	59.3%	76.3%
Republic of Korea	33,121	99.9%	100%	96.2%	97.7%
Canada	53,431	77.2%	86%	92%	95%

[41]Households with Internet access at home - ITU DataHub. (2025). Itu.int. https://datahub.itu.int/data/?c=701&i=12047
[42]Individuals using the Internet - ITU DataHub. (2025). Itu.int. https://datahub.itu.int/data/?c=701&i=11624

***Households with internet access at home**: Refers to the proportion of households with Internet access at home. Access can be via a fixed or mobile network. If one member of the household has a mobile phone with connection to the Internet and makes it available for all members, then it should be considered that the household has access to the Internet.
****Individuals using Internet:** Refers to the proportion of individuals who used the Internet from any location in the last three months. Access can be via a fixed or mobile network.

From observations, high-income economies (Canada and Republic of Korea) possess high household internet access and extremely high individual internet usage (92% to 97.7%). Households in lower-income economies (Indonesia and Viet Nam) also seem to have high internet access as both economies reported over 80% of households have access. However, these high numbers in lower-income economies might be due to ITU's definition of counting even one mobile internet sharing per household, particularly when the numbers of individuals using the internet drop sharply in both rural and urban areas ranging from 59.3% to 84.7, a huge difference to higher-income economies.

Moreover, across all APEC economies but particularly in lower-income economies, rural areas consistently exhibit lower internet usage by individuals when compared to urban areas; Indonesia 59.3% (rural) to 76.3% (urban) and Viet Nam 74% (rural) to 84.7% (urban). Canada and Republic of Korea's differences between internet usage in the rural and urban areas are not as pronounced, but the numbers still favor towards urban usage.

Individual usage is lower in lower income economies, indicating that device ownership, skill gaps, or service costs may be preventing meaningful use. High GDP per capita in economies like Canada and Korea support both household access and individual usages in both rural and urban areas, however, lower GDP per capita in some economies like Indonesia and Viet Nam will contribute to low adoption/usage rates and face an adoption ceiling without initiatives like providing affordable smart devices that can access the internet.

(2) Education and Digital Literacy

Educational levels and digital literacy significantly influence technology adoption across APEC economies. Higher education and strong digital skills enable individuals to understand, access, and effectively use innovative technologies and services, fostering faster adoption and greater benefits from digital technologies.

Navigating website interfaces, online forms, and digital content all require basic literacy and numeracy knowledge. In economies where the general education level among the population remains low, the citizen's ability to engage and utilize those digital services is limited.

Building on top of basic literacy skills is Digital Literacy - ability to use devices, access online information, and use online tools to improve productivity. Utilizing smartphones or computers, from installing mobile applications to signing up for digital government services, is often difficult for those with fewer digital literacy skills and less exposure to digital daily life. People living in rural and/or low-income areas often possess less digital literacy than those living in urban and/or high-income areas.

Schools and related educational institutions in rural areas often receive smaller budgets for ICT equipment and education, while those in urban areas often receive higher levels of funding and can attract more digitally trained teachers As a result, it is often the case that students and citizens in the rural areas tend to not receive the same exposure and education that will equip them for the digital future.

All the above reasons contribute to the lack of broadband adoption, even when there is broadband infrastructure available in the more rural and/or lower-income communities across APEC group.

(3) Age and Social Inclusion

Another vital issue regarding broadband access and adoption across all APEC economies is inclusivity across different age and social, often marginalized groups. Some economies face the challenge of aging populations, while others face the challenge of Indigenous groups living in rural areas (such as hill tribes of Thailand, Aboriginal and Torres Strait Islanders in Australia, First Nation tribes in Canada) being excluded in this digital world.

Japan has one of the world's oldest populations, where many older individuals struggle with digital literacy and accessing broadband services, creating a generational digital divide despite the economy's advanced infrastructure.

Below in Table 2.9, is the data of internet usage among seniors from the Ministry of Internal Affairs and Communications of Japan.

Table 2.9 Internet Usage Rate among Senior Citizens in Japan (2023) [42]

Age Groups	Total	Male	Female
60-64 Years Old Group	92.7%	93.1%	92.3%
65-69 Years Old Group	87.7%	90.0%	85.6%
70-79 Years Old Group	67.0%	73.0%	61.7%
Over 80 Years Old Group	36.4%	46.2%	30.9%
Usage rate for those aged 65 and over	60.9%	69.4%	54.4%
Usage rate for those aged 75 and over	44.7%	55.3%	37.9%
Usage rate across the economy	86.2%	89.5%	83.1%

While internet usage is high in the 60-64 years old age group, the numbers drop sharply to only 36.4% in the over 80 years old group. The average of those older than 65 years old sits at 60.9%, much lower than the economy's average of 86.2%. Considering that approximately 28% of the entire population is over 65 years old, Japan will likely continue to experience a steady decline of internet usage in the future. It indicates that universal broadband infrastructure and coverage alone do not solve age inclusion issues.

On the other hand, economies with deep and rich history of Indigenous groups also face a unique challenge in digital inclusion as well. For example, Indonesia and the Republic of the Philippines are economies experiencing social inclusion challenges where rural and Indigenous communities (with lower-income groups) have limited access to affordable broadband connectivity and support on digital skills training.

[42] Internet usage rate among seniors. (2025, May). Ministry of Internal Affairs and Communications. https://barrierfree.nict.go.jp/relate/statistics/elder_net.html

The Republic of the Philippines has over 100 Indigenous groups with most living in rural/remote areas where infrastructure is hard to reach. These groups face slow infrastructure improvements, higher cost of connectivity and services, language, and cultural barriers to access digital tools and content, and low access to digital literacy programs. Indonesia is no different, with over 17,000 islands and 300 Indigenous groups, they face the same challenges that hinder their broadband adoption but also encounter digital deserts in some areas where infrastructure could not reach due to its archipelago characteristics.

2.5.3 Complexity and Uncertainty in Regulatory and Policy Driving Competition

One of the key challenges to broadband connectivity expansion within APEC economies is regulatory inconsistency, stemming from the region's diverse political statuses, varying geographical proximities to neighboring economies, differing regulatory frameworks, and disparate levels of infrastructure development. These varied regulatory factors significantly influence the progress of broadband connectivity in each APEC economy.

Several APEC economies experience significant regulatory and policy challenges that impact the deployment of broadband infrastructure. These challenges include complex approval processes, restrictive licensing regimes, limited competition among service providers, and inconsistent regulatory frameworks, which slow down infrastructure rollout.

In some APEC economies, outdated regulations, or lack of clear policies around spectrum allocation, rights of ways, and cross-border data flows further hinder investment and innovation in broadband services. Additionally, bureaucratic delays create uncertainty for both public and private sector stakeholders.

One example of regulatory and policy challenges is the delay in spectrum auctions in Viet Nam, which is noticeably slowing the rollout of 5G coverage compared to other regional peers. Complex bureaucratic procedures and administrative bottlenecks have slowed the auctioning and allocation of 5G spectrum, hindering connectivity improvements especially for those in rural and underserved areas. This discourages private sector investment, causing further delays in expanding broadband connectivity infrastructure.

Another example of regulatory and policy challenges is the restriction on alternative broadband connectivity solutions, especially in underserved areas. Non-traditional technologies such as satellite internet remain underutilized in some regions due to regulatory barriers that prevent private companies, such as Starlink or AST SpaceMobile from the United States, from partnering with local service providers to deliver broadband connectivity to rural communities.

There is a pressing need for more flexible regulatory frameworks that support emerging technologies and foster collaboration, ultimately enhancing connectivity across APEC economies.

In Papua New Guinea, the telecommunications sector has traditionally been dominated by state-affiliated providers, which has limited the growth of a competitive market. Regulatory hurdles, such as complex licensing processes and limited enforcement of unrestricted access policies, have made it difficult for private and foreign companies to enter the market or to expand their services. The lack of competition contributes to higher costs of services and slower infrastructure deployment, especially in rural and remote areas / islands.

Addressing these regulatory and policy hurdles is crucial to accelerating broadband expansion and improving broadband connectivity across these diverse APEC economies.

APEC Economy Facing Difficulties in Regulatory Hurdles:

Viet Nam – For more than a decade, multiple regulatory challenges caused the delay in spectrum auctioning and allocating compared to regional equals. Before the 2024 spectrum auction, Viet Nam's spectrum allocation had been dormant since 2010, only limited to the 340 MHz of spectrum in the 900 MHz, 1800 MHz, and 2.1 GHz bands.

In 2023, the government was set to auction the 2.3 – 2.4 GHz spectrum but failed to gain any bidders due to its debated auction approach: (1) Only 90 MHz was made available, but the market demand calls for more International Mobile Telecommunications (IMT) spectrum which caused artificial scarcity. (2) For 5G deployment, the 30 MHz channels are not optimal and could increase CAPEX for operators among other issues. (3) High reserve prices (USD 228 million) limiting operators to conduct price discovery mechanism of the auction. The auction resulted in no operators applying for bidding and left the spectrum unsold.

Viet Nam subsequently adjusted their auction approach in the successful 2024 auction for 2.6 GHz and 3.5 GHz bands

Source: (1) Accelerating 5G in Vietnam: A Spectrum Roadmap for Success. (2024). GSMA. https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2024/11/GSMA_Accelerating-5G-in-Vietnam-2024.pdf

3. ANALYSIS OF BROADBAND STATUS IN APEC ECONOMIES' UNDERSERVED AREAS

In Chapter 3, a deeper focus is on the analysis of the broadband underserved areas of each economy, based on detailed analysis and comprehensive research into the broadband status of each APEC member economy in Chapter 2. "Underserved Areas" refers to areas where access to reliable and high-speed internet is either restricted or absent due to factors such as geography, infrastructure gaps, and economic limitations. These underserved areas and its citizens face challenges that prevent meaningful connectivity that could better their lives.

This chapter examines the statuses of the underserved areas within APEC economy group, showing each area's topological and geographical characteristics that are hindering connectivity. For example, the Andes mountain range e of Peru or the vast outback areas of Australia face distinct broadband infrastructure and adoption challenges.

To better probe the main challenges to connectivity in each underserved areas type, the economies are grouped into four different clusters based on geographical characteristics; Cluster A: Economies with Landmasses, Cluster B: Economies with Archipelagic, Cluster C: Economies with Mountainous / Dense Forest Landscape, and Cluster D: Compact Economies with Urban Hubs. Within each cluster, the main barriers to connectivity, the examples from the cluster's economies, and potential broadband opportunities are thoroughly examined.

Lastly, the chapter explores certain successful cases of broadband vitalization of underserved areas in APEC economies. By analyzing the common enablers across the success cases, such as broadband infrastructure deployment, building resilience, and policy framework, meaningful suggestions for other economies facing similar challenges in their own broadband underserved areas could be made in the subsequent chapter.

3.1 STATUS OF UNDERSERVED AREAS BY APEC ECONOMY

Underserved areas across 21 APEC economies experience varying degrees of broadband connectivity challenges, shaped by each economy's geography, economic development, and policy environment. In many developing member economies, such as Papua New Guinea; Peru; and the Republic of the Philippines, substantial portion of rural and remote communities remain without reliable internet access[43]. Geographic isolation, especially in archipelagic and mountainous regions, makes infrastructure rollout costly and logistically difficult. Limited government resources and low population densities in these areas often deter private investment, leaving many communities dependent on slower, less reliable mobile or satellite connections.

Even in more advanced APEC member economies, significant disparities persist between urban centers and rural or Indigenous communities. While domestic broadband coverage may appear high overall, pockets of digital exclusion remain due to prohibitive costs, lack of infrastructure or insufficient service quality. In archipelagic economies such as Indonesia and the Philippines, dozens of islands remain underserved due to high infrastructure costs and complex coordination. Efforts are underway to address these gaps, through local broadband

[43] Extending Broadband Connectivity in Southeast Asia. (2023). OECD Publishing. https://doi.org/10.1787/b8920f6d-en

plans, public-private partnerships, and the exploration of emerging technologies like Low Earth Orbit (LEO) satellites, but progress is uneven[44].

Table below outlines the detailed characteristics and associated specific conditions across each APEC economy:

Table 3.1 Underserved regions and relevant factors across APEC economies

APEC Economy	Major Underserved Regions	Associated Conditions
Australia	• Remote Indigenous communities and outback SA and WA regions • Far North Queensland and western QLD shires[45]	• Limited or inconsistent mobile network coverage • Slow and unreliable fixed broadband connectivity due to in adequate backhaul infrastructure
Brunei Darussalam	• Low-income households • Very niche remote geographical areas (Temburong district, deep jungle, or isolated settlements)[46]	• Lack of digital literacy of seniors to fully utilize digital services • Affordability of premium services • Minor last-mile connectivity challenges • Scattered population in remote areas (dense forests)
Canada	• Northern territories • Remote Indigenous and First Nations communities • Rural Atlantic Regions[47]	• High dependence on satellite • Large geographic expanse difficult for universal fiber and high-speed wireless coverage
Chile	• Rural areas, particularly in the more sparsely populated southern regions and mountainous areas[48]	• Limited or no high-speed broadband, particularly fixed line • Mobile broadband is more prevalent but also have coverage gaps
People's Republic of China	• Western and High-altitude regions • Rugged mountain villages	• Rely on satellite or limited broadband connectivity

[44] Featherstone, D., Thomas, J., Holcombe-James, I., & Ormond-Parker, L. (2023). Closing the digital gap for remote first nations communities: 5G and beyond? Media International Australia, 190(1). https://doi.org/10.1177/1329878x231201746
[45] Remote Aboriginal communities. (2025, July). The Government of Western Australia. https://www.wa.gov.au/organisation/department-of-housing-and-works/remote-aboriginal-communities
[46] Country profile – Brunei Darussalam. (2011). Food and Agriculture Organization of the United Nations (FAO). https://openknowledge.fao.org/server/api/core/bitstreams/54e49072-318c-465d-acc7-8365594a180f/content
[47] Rural and Remote Communities. (n.d.). https://natural-resources.canada.ca/sites/nrcan/files/GNBC/Chapter%203_Rural%20and%20Remote%20Communities_Final_EN.pdf
[48] OECD. (2014). OECD Rural Policy Reviews: Chile 2014. OECD Publishing.

APEC Economy	Major Underserved Regions	Associated Conditions
	• Vast inland rural and low-density areas[49]	• Lack investment due to low population density and profitability
Hong Kong, China	• Limited underserved areas • Very isolated small islands or underdeveloped rural fringes (remote villages in the New Territories)[50]	• Ensuring equitable access for remote communities, overcome socio-economic barrier to adoption • Affordability of services and accessibility to devices
Indonesia	• Eastern Indonesia • Rural areas in Sumatra, Java, and Bali[51]	• Geographic difficulties, remote locations, causing infrastructure deployment complex and costly • Less financial attractiveness for service providers • Insufficient investment in infrastructure • Significant disparities in digital literacy
Japan	• Remote rural areas e.g., deep mountain villages (some remote parts of Hokkaido) • Outlying islands (less populated islands)[52]	• Disparities in speed, reliability, and the availability of FTTH or high-speed mobile services • High deployment costs and low return on investment (very sparsely populated community)
Republic of Korea	• Remote rural villages and mountainous regions • Less populated offshore islands[53]	• High deployment costs and low return on investment (very sparsely populated community) • Slow and complex for "Last mile" connection for every single remote household
Malaysia	• Rural areas of Peninsular Malaysia • East Malaysia[54]	• Low return on investments (low population density causes less profitability for private service providers

[49] Liu, Y., Zang, Y., & Yang, Y. (2020). China's rural revitalization and development: Theory, technology and management. Journal of Geographical Sciences, 30(12), 1923–1942. https://doi.org/10.1007/s11442-020-1819-3
[50] 2 THE DIVERSE LANDSCAPES OF HONG KONG. (n.d.). Www.pland.gov.hk. https://www.pland.gov.hk/studies/landscape/e_executive_summary_hp/e_ch2.htm
[51] Ralston, L., & Tiwari, S. (2020). NO ONE LEFT BEHIND Rural Poverty in Indonesia. The World Bank. https://documents1.worldbank.org/curated/en/289991593339788378/pdf/No-One-Left-Behind-Rural-Poverty-in-Indonesia.pdf
[52] Mori, T. (2023). The Progress of Digitalization by Prefecture as Seen in the DCI -2022: The Year That Digitalization Made Progress in Rural Areas. https://www.nri.com/content/900013077.pdf
[53] Enrique, G., Springare Laura-Sofia, Mai, S., & Higuera, O. (2019). Rural study of Korea. OECD Regional Development Working Papers. https://doi.org/10.1787/50e33932-en
[54] Bahrudin, M. Z., Tahir, Z., & Tambi, N. (2025). The Impact of Rural – Urban Relations on Rural Areas in Malaysia. International Journal of Research and Innovation in Social Science, IX(IV), 5244–5253. https://doi.org/10.47772/ijriss.2025.90400376

APEC Economy	Major Underserved Regions	Associated Conditions
		• Challenging geography e.g., difficult terrain, hilly areas • Logistic and financial hurdle for "last mile" connectivity • Lack of reliability for electricity supply • Affordability of services and devices
Mexico	• Remote rural areas in Southern States • Indigenous communities[55]	• Geographical barriers e.g., vast mountains, jungles and deserts and located in extreme isolation • Low population density resulting in low commercial viability • Lack of consistent and reliable electricity • Low-income and lack of affordability to services
New Zealand	• Remote rural areas (beyond fiber footprint) • Outlying islands[56]	• Geographic isolation and terrain with dispersed populations • Low economic viability for private service providers to serve small number of distant households, including last mile connectivity • Elderly population and low-income households
Papua New Guinea	• Remote rural areas (85% of populations live in rural areas) • Western provinces, southern highlands, and remote parts of Sepik and Momase regions • Outlying islands[57]	• Extreme geographical barriers, high mountain ranges, dense rainforests, vast river systems, and volcanic islands • Low population density and dispersion, commercially unviable for private service providers • Lack of basic infrastructure (roads and electricity) • Prohibitive cost of international and domestic connectivity

[55] Ornelas, P. (2016). Rural poverty in Mexico: prevalence and challenges. https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2019/03/RURAL-POVERTY-IN-MEXICO.-CONEVAL.-Expert-Meeting.-15022019.pdf

[56] Strategy | Supporting towns and regions to flourish. (n.d.). Strategy | Supporting Towns and Regions to Flourish. https://tewaihanga.govt.nz/the-strategy/6-a-thriving-new-zealand-what-we-need-to-do/6-2-supporting-towns-and-regions-to-flourish

[57] The World Bank. (2022, November 28). The World Bank in Papua New Guinea. World Bank. https://www.worldbank.org/en/country/png/overview

APEC Economy	Major Underserved Regions	Associated Conditions
		(limited capacity of submarine cables and terrestrial backhaul) • Socio-economic digital divide (affordability, digital literacy, language barrier, regulatory and policy)
Peru	• Remote rural areas (Andes mountains and Amazon rainforest regions)[58]	• Extreme geographical barriers (high altitude, deep valleys, dense rain forest areas) • Low population density and dispersion, insufficient return of investment for service providers • Lack of basic infrastructure (roads, electricity) • Underutilization of local fiber optic backbone network (difficulties in connecting last mile to households) • Socio-economic digital divide (affordability, digital literacy, limited access points, regulatory and policy) • Vulnerability to natural disasters (lack of resilient alternatives)
The Republic of the Philippines	• Mountainous regions (parts of Cordillera Administrative Region (CAR)), parts of Luzon, Visayas and Mindanao • Small remote islands • Remote villages in Mindanao, Eastern Visayas and Caraga[59]	• Archipelagic geography and rugged terrain (mountainous landscape and dense jungles) • Low population density causes low commercial viability • Lack of basic infrastructure (electricity and road access) • Last mile problem to connect individual households • Low-income households (both urban and rural) • Quality of connection in densely populated informal settlements • Vulnerability to natural disasters (lack of resilient alternatives)

[58] Menton, M., & Cronkleton, P. (2019). Migration and forests in the Peruvian Amazon. https://www.cifor-icraf.org/publications/pdf_files/WPapers/WP251Menton.pdf

[59] Astrologo, C. (2018). Republic of the Philippines ICT Statistics in the Philippines: A Situationer ITU Asia-Pacific ICT Indicators Workshop. https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2018/aspidi2018/Session_4.2_Philippines_PSA.pdf

APEC Economy	Major Underserved Regions	Associated Conditions
Russia	• Remote rural areas, especially in Siberia, the East and North • Specific Federal subjects (Regions) with lower development[60]	• Immense geographical scale (expensive and logistically complex) • Low population density and harsh climates causing commercially unviable and high maintenance costs for service providers • Lack of basic infrastructure (reliable road access and electricity supply) • Intermittent outages– disruption to daily life and connectivity reliability
Singapore	• Construction sites or temporary facilities • Certain industrial or remote utility locations • Deep underground or maritime areas	• Access in niche geographical areas where migrant workers reside • Low meaningful digital literacy among migrant workers that reside within the underserved areas
Chinese Taipei	• Remote villages and mountainous areas • Offshore islands	• Geographical barriers and high deployment costs due to low population density • Ensuring quality, resilience, and equitable utilization of high-speed broadband across entire population
Thailand	• Remote rural areas, especially in the North, Northeast, and some Southern parts	• Geographical barriers (dense forests, mountains, and numerous islands) • Low population density, less commercially attractive for private service providers • Last-mile connectivity to connect individual households or businesses in scattered villages • Reliance on older technology e.g., copper lines • Lack of basic infrastructure (reliable electricity in rural villages)

[60] Maria Rossotto, C., Gelvanovska, N., Hohlov, Dr. Y., Shaposhnik, S., & Mačiulė, Dr. V. (2016, August 30). A Sector Assessment: Broadband in Russia. World Bank; World Bank Group. https://www.worldbank.org/en/country/russia/publication/broadband-in-russia

APEC Economy	Major Underserved Regions	Associated Conditions
		• Low-income households and digital literacy and skill gaps
The United States	• Remote rural areas • Native American tribal lands • Low-income urban and suburban neighborhoods[61]	• Low population density, commercial unprofitable to invest (without significant government subsidies) • Geographical obstacles (challenging terrains e.g., mountains, deserts, dense forests, and wetlands) • Last-mile connectivity is prohibitively expensive • Regulatory hurdles and permitting (complexity of local, state, and federal regulation for permitting processes) • Funding barriers
Viet Nam	• Rural remote areas, mountainous regions, and border areas (the north provinces, central highlands and Mekong Delta and Southern provinces) • Ethnic minority communities • Low-income households (across urban and rural settings)[62]	• Geographical barriers (high mountains, river deltas) • Low commercial viability due to sparse population and lower income levels • Last-mile connectivity due to prohibitively expensive and technical difficulty • Basic infrastructure gaps (lack of reliable electricity) • issues with poverty, affordability, digital literacy, and language barrier

Based on the assessment of underserved areas and the challenges related to broadband infrastructure deployment across the 21 APEC economies, coupled with World Bank's classification of economy (High, Upper-middle, Lower-middle, and Low Income) defined by their GNI per capita for FY26[63], these characteristics can be broadly categorized into three main groups:

(1) Advanced Economies (including Australia; Brunei Darussalam; Canada; Hong Kong, China; Japan; Republic of Korea; New Zealand; Singapore; Chinese Taipei; and the United States)

[61] Leonard, B. (2010). Connecting America: The National Broadband Plan. DAINE Publishing. https://books.google.co.th/books?hl=en&lr=&id=l8oI5rA_NpQC&oi=fnd&pg=PR9&dq=Leonard

[62] Dao, N. D., Phan, T. H., & Chau, H. M. T. (2022). Tackling unequal access to digital education in Viet Nam during the COVID-19 pandemic. Asian Development Bank Institute. https://doi.org/10.56506/omlv4181

[63] Metreau, E., Young, K. E., & Eapen, S. G. (2024, July 1). World Bank country classifications by income level for 2024-2025. World Bank. https://blogs.worldbank.org/en/opendata/world-bank-country-classifications-by-income-level-for-2024-2025

- **Focus:** Primarily "digital inclusion" (affordability, digital literacy, device access for specific demographics e.g., seniors or low-income households) and connecting the "last few percent" in extremely remote areas
- **Main Tasks:** Maintaining innovative infrastructure (continuously upgrading networks in terms of speeds) and ensuring trustworthy digital environment (e.g., cybersecurity)

(2) Emerging Economies with Mixed Connectivity and Ongoing Infrastructure Expansion (including Chile; the People's Republic of China; Malaysia; Mexico; Peru; Russia; Thailand; and Viet Nam)

- **Focus:** Bridging the significant urban-rural divide by extending fiber and reliable mobile broadband to remote areas. Ensuring quality of service and affordability for broader citizens
- **Main Tasks:** Promoting effective digital usage for economic and social development

(3) Developing Economies with Significant Gaps and Fundamental Access Challenges (including Indonesia; Papua New Guinea; and The Republic of the Philippines)

- **Focus:** Fundamental access to any reliable broadband for large rural and island population due to extreme geography, lack of basic infrastructure (roads and power supply) and low commercial viability. Deep affordability issues and basic digital literacy are major barriers, vulnerability to natural disasters
- **Main Tasks:** Heavy government subsidies and innovative public-private partnerships, understanding of broadband benefits, building of widespread and reliable basic infrastructure

3.2 KEY ENABLERS AND ASSOCIATED CHALLENGES IN UNDERSERVED AREAS

Understanding the state of broadband in underserved areas requires more than simply describing coverage or adoption gaps. To design actionable solutions, it is essential to look at the underlying enablers that make broadband expansion possible - and the challenges that hold it back.

This chapter therefore focuses on three critical dimensions that cut across all economies: technology enablers, policy enablers, and digital inclusion enablers. These three dimensions represent the building blocks of successful broadband ecosystems in underserved areas:

- **Technology** determines how infrastructure is deployed -from global gateways and domestic backbones to last-mile connections.

- **Policy** sets the framework for investment, competition, and execution through local broadband plans, regulation, and public-private collaboration.

- **Digital inclusion** ensures that infrastructure is used by citizens and businesses through affordability programs, skills development, and relevant services.

By structuring the analysis around these dimensions, we can identify root causes of connectivity gaps and define which levers have the greatest potential to accelerate broadband rollout and adoption. This approach moves the discussion beyond "where" the gaps are to understanding why they persist and how they can be closed through targeted technical, regulatory, and social measures.

3.2.1 Technology Enablers and Challenges

Broadband connectivity in underserved areas hinges on four core infrastructure pillars: (1) First Mile, (2) Middle Mile, (3) Last Mile, and (4) Resilience to Natural Disasters and Extreme Climates. Together, these layers form the broadband infrastructure stack, and progress requires all four to function as interdependent systems.

- The first mile establishes international subsea gateways linking economies to the global internet.
- The middle mile extends capacity across economy-level backbones, connecting core nodes to regional networks.
- The last mile delivers high-capacity access directly to households, businesses, and institutions, often at the highest cost per user.
- Finally, resilience technologies, such as redundant routing, underground cabling, satellite backup, and hardened data centers, ensure service continuity in the face of extreme weather and natural disasters.

Addressing challenges across all four dimensions is essential for closing the digital divide in APEC.

A. First Mile Infrastructure Sub-Enabler

Establishing the first mile of broadband connectivity, the critical link between an economy and the global internet, presents a unique set of challenges. This phase primarily involves the deployment of submarine fiber optic cables, which are the main lines of the global internet. The difficulties faced here are not just technical but span environmental, geopolitical, and financial dimensions, making it one of the most complex undertakings in digital infrastructure.

Key challenges within the sub-enabler include:

Immense Capital Investment: Laying and maintaining subsea cables requires billions of dollars in upfront investment, involving specialized cable-laying ships, deep-sea robotics, and extensive marine surveys. The financial risks are enormous, and the return on investment can be long-term, making private sector engagement challenging without government support policy.[64]

Harsh and Unpredictable Environment: The deep-sea environment is challenging. Cables must hold up against extreme pressures, fluctuating temperatures, and unpredictable terrains.

[64] Brake, D. (2019). Submarine Cables: Critical Infrastructure for Global Communications. https://www2.itif.org/2019-submarine-cables.pdf

The risk of damage from natural events like underwater earthquakes and landslides is constant, requiring meticulous cable design and strategic routing.[65]

Geopolitical and Regulatory Hurdle: Deploying international cables requires navigating complex international laws, obtaining permissions from numerous economies for landing rights, and securing environmental permits. The process can be long, politically sensitive, and subject to delays, with different regulatory frameworks in each economy.[66]

B. Middle Mile Infrastructure Sub-Enabler

The middle mile of broadband infrastructure serves as the essential link between high-capacity global gateways and the local networks that reach end users and faces its own set of challenges. While often less visible than the last mile connection to a home, its absence or inadequacy can severely affect broadband expansion, especially in rural areas.

Key challenges within the sub-enabler include:

Geographical Distribution and Diverse Terrain: Unlike dense urban centers, middle mile networks often extend through vast landscapes, from sparsely populated plains and remote forests to mountainous regions and archipelagic stretches. Laying fiber across such distances is costly and logistically complex, requiring specialized equipment and resources and extended project duration.

High Cost Per User in Low-Density Areas: The economics of middle mile network become challenging in areas with low population density. The cost of deploying extensive backbone must be spread across fewer potential users, making the financial return on investment less attractive for private entities without public support.[67]

Right of Way and Permitting Complexities: Securing the necessary permits and rights of way to lay cable or install equipment across multiple land ownerships, authorities, and environmental sensitivities can make deployment challenging. Delays in obtaining such permits can cause significant increases in the project costs and timelines.

Lack of Redundancy and Competition: Many regional areas suffer from a lack of middle mile redundancy, where only a single route connects them to the broader internet. This creates significant vulnerabilities where a cable or equipment failure can lead to widespread, prolonged outages for affected communities. A lack of middle mile competition can also lead to higher wholesale prices for last mile providers, ultimately increasing costs for end users.

Integration with Diverse Last Mile Technologies: The middle mile must efficiently connect with a variety of last mile technologies (such as Fiber-to-the-Premises, fixed wireless access,

[65] Submarine Cables and Climate Change Intersect. (2025, February 19). Telecom Review Asia. https://www.telecomreviewasia.com/news/featured-articles/12503-submarine-cables-and-climate-change-intersect

[66] Wijaya, T. (2023). Regulatory risks key barrier to investment in submarine cables. Asia News. Network. https://asianews.network/regulatory-risks-key-barrier-to-investment-in-submarine-cables

[67] KRAUSE, R., & Daily, I. B. (2022, October 31). Digital Divide: Can Federal Funding For Rural Broadband Narrow The Gap? Investor's Business Daily. https://www.investors.com/research/industry-snapshot/digital-divide-can-federal-funding-for-rural-broadband-narrow-the-gap/

satellite). Ensuring seamless and high-performance integration across different platforms adds another layer of technical complexity.

C. Last Mile Infrastructure Sub-Enabler

The last mile is arguably the most challenging and costly segment of broadband deployment. It represents the final stretch of the network that connects individual homes, businesses, and mobile base stations directly to the broader internet. The ultimate complexities involved often dictate the success, speed, and affordability of broadband for the end user.

Key challenges within the sub-enabler include:

High Cost Per Connection: Deploying infrastructure for the last mile, especially Fiber-to-the-Home/Premises, is extremely costly. This involves extensive civil works, such as digging trenches, installing poles, running cables to buildings, specialized resource, and acquiring customer premises equipment. The cost significantly increases in rural, remote, and densely populated areas where access is difficult.

Right of Way and Access Permissions: Similar to middle mile, gaining physical access to lay cables or installing equipment on private property, or along public establishments is a logistical and regulatory hurdle. Negotiations with property owners and local authorities can be complex and bureaucratic.

Physical Obstacles and Terrain: Urban environments often congest underground conduits, legacy infrastructure, and limit space for new fiber. Rural and mountainous regions face long distances, difficult terrain, extreme weather conditions, and sparse population density, making traditional deployment economically unfeasible.

Consumer Adoption and Demand Aggregation: Even when last mile infrastructure is in place, ensuring high adoption rates among consumers requires attractive service offerings, competitive pricing, and digital literacy. Without sufficient take-up, the financial viability of the network is put at risk.

Technology Choice and Obsolescence: Deciding on the optimal last mile technology (FTTH, FTTN, fixed wireless, satellite) involves trade-offs between cost, speed, scalability, and futureproofing. Rapid technological advancements mean that chosen solutions can quickly become outdated, requiring even more investment.[68]

D. Building Resilience Sub-Enabler

Natural disasters and extreme weather events pose a significant and challenging threat to broadband infrastructure across all APEC economies. From wildfires and severe blizzards impacting large landmasses, typhoons and undersea earthquakes hitting archipelagic states, or landslides and floods in mountainous regions, these natural events directly and indirectly damage critical network components. They often lead to widespread outages, repair complications, and communication blackouts that affect emergency response, economic

[68] Sector, D. (2020). The Last-mile Internet Connectivity Solutions Guide Sustainable connectivity options for unconnected sites 2020. https://www.itu.int/dms_pub/itu-d/opb/tnd/D-TND-01-2020-PDF-E.pdf

activity, and daily life of residents. Building and designing resilient broadband networks is therefore essential for ensuring continuous connectivity and daily functions.

To safeguard their broadband networks in the case of natural emergencies, APEC economies have developed advanced strategies centered on three fundamental areas: building more resilient infrastructure, implementing rapid response and restoration procedures, and developing effective backup and alternative connectivity solutions.

Infrastructure Hardening and Resilient Network Design: A fundamental vulnerability of broadband networks lies in their physical components, which are susceptible to direct damage from natural forces. Earthquakes can rupture cables and collapse buildings, intense winds from typhoons can tear down poles and antennas, and floods can submerge critical equipment making it inoperable. The challenge involves designing and constructing networks that can withstand these forces, reduce the likelihood of initial damage, and minimize the need for extensive repairs following such events. This effort requires significant investment and meticulous planning to protect physical assets and ensure their operational ability under unforeseeable circumstances.

Emergency Response and Rapid Restoration Procedures: Even with hardened infrastructure and meticulous broadband planning, severe natural disasters inevitably cause damage. Physical paths blocked by debris, prolonged power outages, and functioning resources being overwhelmed. The critical challenge is the speed and efficiency where communications can be restored to support emergency services and allow affected communities to connect. This requires pre-planned protocols, specialized equipment, and effective coordination between network operators and government emergency agencies.

Developing Effective Backup and Alternative Connectivity Solutions: Building true resilience in telecommunications extends beyond merely hardening existing infrastructure or rapid disaster recovery. It requires a strategic shift towards establishing fundamentally alternative and independent connectivity solutions. This challenge addresses the critical need to diversify communication channels, ensuring that essential services remain operational even when primary networks are compromised by large-scale failures, prolonged outages, or other threats. The focus is on implementing systems that offer redundancy and can sustain critical communications for all. [69]

3.2.2 Policy Enablers and Challenges

Establishing a domestic broadband network is a monumental undertaking that requires huge investment, sophisticated coordination, and a clear strategic vision for its societal and economic impact. A pivotal decision for governments in this regard is determining the primary deployment model, as this choice significantly influences funding mechanisms, risk allocation, market dynamics, and the aim of rollout.

Governments typically consider three main approaches, or a hybrid of them:

[69] Gupta, Y., Liu, Z., & Mostafavi, A. (2023, December 13). Digital Divide in Disasters: Investigating Spatial and Socioeconomic Disparities in Internet Service Disruptions During Extreme Weather Events. ArXiv.org. https://doi.org/10.48550/arXiv.2312.08640

- **Private-Led Model:** In this approach, the private sector (telecommunications operators and internet service providers), takes the primary lead in financing, building, and operating broadband infrastructure, driven by market demand and commercial viability. This approach relies heavily on competitive market forces and the government's role is often limited to regulation, licensing, and creating a favorable investment climate, such as through less complicated permitting and tax incentives.

- **State-Owned-Entity (SOE) or Government-Led Model:** This approach is when a government entity or a SOE is the primary driver, directly investing, building, and often operating broadband infrastructure. This approach involves centralized planning and execution, dominant public funding, and often aims for universal broadband connectivity over commercial viability.

- **Public-Private Partnership (PPP) Model:** This model involves a collaborative agreement between a government entity and one or more private companies to finance, build, and/or operate infrastructure projects. This can take various forms, such as Build-Operate-Transfer (BOT) or joint ventures. This approach requires shared investment, risks, and responsibilities, leveraging private sector efficiency and expertise with public sector strategic oversight and funding support.

Ultimately, regardless of the chosen model, governments face critical decisions regarding how to incentivize private investment, address funding gaps, and ensure effective management to achieve universal high-speed broadband access. The success of a local broadband concept requires selecting and implementing the model best suited to an economy's unique economic, geographical, and political landscape.

A. Economy-wide Broadband Concept Sub-Enabler

A primary challenge in establishing a local broadband network lies not just in its physical construction, but in the complex decisions regarding its ownership, financing, and operational model. Without a clearly defined broadband concept, determining the roles of public and private sectors, incentivizing investment, and addressing financial viability across diverse geographies can be difficult. Rollout efforts can stall, leading to uneven access and continuous digital divide. The challenge involves designing and implementing a model that stimulates necessary investment, leverages appropriate expertise, and ensures equal access. This effort requires meticulous strategic planning, careful financial structuring, and a clear understanding of the mix between government oversight and market dynamics to build the backbone of a digitally connected economy.[70]

B. Policy Execution Excellence Sub-Enabler

Even the most meticulously crafted domestic broadband plans can fail without proper implementation and management. The deployment of complex, economy-wide broadband

[70] Broadband Policy and Technology Developments. (2021). OECD DIGITAL ECONOMY PAPERS. https://www.oecd.org/content/dam/oecd/en/publications/reports/2021/09/broadband-policy-and-technology-developments_b864b38e/e273ff77-en.pdf

infrastructure is loaded with potential hurdles, including bureaucratic inefficiencies, inter-agency coordination failures, prolonged permitting process, supply chain disruptions, and shortages of skilled labor. These challenges can lead to significant delays, budget overruns, and ultimately, a failure to meet connectivity goals.

Therefore, effective execution requires a focus on operational excellence. This includes strong central project management, smooth administrative processes, transparent allocation of funds, continuous monitoring and evaluation, and adaptable strategies that can respond to unforeseen obstacles. It also requires collaboration between various government entities, private sector partners, and local communities to translate strategic visions into tangible, economy-wide broadband connectivity. [71]

C: Comprehensive Regulatory Frameworks Sub-Enabler

Beyond strategic planning and execution, the long-term success of a universal broadband connectivity heavily depends on a well-designed regulatory framework. Without effective regulations, market failures such as monopolies, anti-competitive practices, and underinvestment in crucial infrastructure can halt growth, limit consumer choice, and discourage innovation. A comprehensive framework aims to create a level playing field, manage market power, and provide clear incentives for both infrastructure development and service differentiation.

Such a framework typically involves a range of policy tools, including principles of unrestricted access to bottleneck infrastructure, fair rates, transparent spectrum allocation, and consumer protection mechanisms. The challenge lies in finding the right balance, providing sufficient oversight to ensure healthy competition and protect consumers, while allowing enough flexibility and commercial freedom to encourage private sector investment.[72]

3.2.3 Digital Readiness Enablers and Challenges

Another major key factor in broadband coverage is the uptake of the citizens. If people do not see the importance in adopting broadband for work and daily life or do not have the financial means to subscribe to one, then deploying universal infrastructure would not mean anything. Hence, the great reliance on improving the digital readiness of both economies and their citizens. There are various economies that successfully funded their digital readiness initiatives, but lower-income economies often require assistance from international organizations to propel forward their digital future.

'Digital Readiness' refers to how prepared an economy is to benefit from different digital technologies. It is not purely about digital infrastructure that is in place, but more on policies, institutions, and citizen readiness that will allow maximum adoption.[73]

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[71] Broadband Policy and Technology Developments. (2021). OECD DIGITAL ECONOMY PAPERS. https://www.oecd.org/content/dam/oecd/en/publications/reports/2021/09/broadband-policy-and-technology-developments_b864b38e/e273ff77-en.pdf

[72] Closing Broadband Connectivity Divides for All. (2025). OECD. https://www.oecd.org/en/publications/closing-broadband-connectivity-divides-for-all_d5ea99b2-en.html

[73] DIGITAL READINESS ASSESSMENT OF THE ORGANISATION TOOLKIT FOR PLANNING DIGITAL TRANSFORMATION IN THE PUBLIC SECTOR. (n.d.). https://www.undp.org/sites/g/files/zskgke326/files/2023-10/digitalna_transformacija_eng.pdf

Digital Readiness has been difficult to measure universally across the board among 21 economies since the parameters to be considered are too various and complex. However, there are credible indexes that measure broadband usage readiness scores. For example, the Inclusive Internet Index measures 'Readiness' score, which explains 'The Readiness category examines the capacity to access the Internet, including skills, cultural acceptance, and supporting policy', while the Global System for Mobile Communications (GSMA) Mobile Readiness Index 'Consumer Readiness' score considers 'Citizens with the awareness and skills needed to value and use the internet.'. The table below shows the example of digital readiness scores from both sources.

Table 3.2 Digital Readiness Scores Across APEC Economy Members[74,75]

APEC Economy	Internet Inclusive Index; Readiness Score (2022)	GSMA Mobile Readiness Index; Consumer Readiness Score (2024)
Australia	71.1	93.5
Brunei Darussalam	-	79.2
Canada	75	81.8
Chile	79.4	88.2
People's Republic of China	68.1	88.6
Hong Kong, China	-	93.2
Indonesia	76.3	79.1
Japan	71.8	84.4
Republic of Korea	76.6	92.1
Malaysia	81.6	83.7
Mexico	80	83.2
New Zealand	58	92
Papua New Guinea	-	44.3
Peru	77.9	79
The Republic of the Philippines	58.1	82.6
Russia	63.2	89.6
Singapore	72.3	92.1
Chinese Taipei	72.9	-
Thailand	62.2	88.4
The United States	76.4	90.4
Viet Nam	64.1	85.7

[74] Economist Impact: The Inclusive Internet Index, supported by Meta. (2022). Economist.com. https://impact.economist.com/projects/inclusive-internet-index
[75] 2023 – GSMA Mobile Connectivity Index. (2023). Global System for Mobile Communications. https://www.mobileconnectivityindex.com/index.html

A. Digital Literacy Development Sub-Enabler

A critical barrier to broadband adoption is the lack of digital literacy among segments of the population[76]. Even with infrastructure in place, individuals who lack basic digital skills may not be able to access or benefit from online services. This challenge is particularly acute in rural areas, among older populations, and in lower-income communities. Governments must invest in economy-wide digital education initiatives, including school curricula, community training programs, and public awareness campaigns. These efforts should focus not only on basic internet usage but also on cybersecurity awareness, digital financial literacy, and the use of digital tools for employment and entrepreneurship. Building a digitally literate population is essential to ensure that broadband infrastructure translates into meaningful socio-economic impact.

B. Affordability Sub-Enabler

Affordability remains a major obstacle to broadband adoption, especially in developing and lower-income economies. Even when infrastructure is available, high subscription costs, expensive devices, and limited prepaid options can prevent widespread usage[77]. Governments and regulators must work with service providers to develop pricing models that cater to different income levels, including subsidized plans, community Wi-Fi zones, and device financing schemes. Additionally, targeted policies such as universal service funds and digital vouchers can help bridge the affordability gap. Ensuring inclusive access means recognizing that digital connectivity is not a luxury, but a fundamental enabler of education, employment, healthcare, and civic participation.

C. Policy Readiness Sub-Enabler

Digital readiness is not solely about individuals; it also depends on the preparedness of institutions and the robustness of enabling policies. Governments must ensure that public institutions, such as schools, hospitals, and local administrations are equipped to deliver services digitally. This includes digitizing public services, streamlining e-government platforms, and ensuring interoperability across systems. At the policy level, frameworks must support innovation, protect user data, and promote digital inclusion. Coordination across ministries, alignment with domestic development goals, and engagement with international organizations are key to building a resilient digital ecosystem. Institutional readiness ensures that broadband adoption is not just widespread, but also impactful and sustainable.[78]

3.3 ANALYSIS OF UNDERSERVED AREAS BY CLUSTERS

This section analyses underserved areas across the 21 APEC economies, focusing on the geographical challenges that impact broadband infrastructure deployment. By examining the physical landscapes, population distribution, and territorial characteristics, the analysis

[76] Digital Skills Insights 2021 International Telecommunication Union Development Sector ITU Publications. (2021). https://academy.itu.int/sites/default/files/media2/file/21-00668_Digital-Skill-Insight-210831_CSD%20Edits%206_Accessible-HD.pdf

[77] Facts and Figures 2024 - Affordability of ICT services. (2024). Itu.int; ITU. https://www.itu.int/itu-d/reports/statistics/2024/11/10/ff24-affordability-of-ict-services/

[78] Oughton, E. J., Comini, N., Foster, V., & Hall, J. W. (2021). Policy choices can help keep 4G and 5G universal broadband affordable. ArXiv (Cornell University). https://doi.org/10.48550/arxiv.2101.07820

highlights how geography influences the scale and complexity of connectivity gaps. Grouping economies by similar geographical constraints helps identify common barriers and inform more targeted and effective policy responses.

The 21 APEC economies are grouped into four clusters based on geographical challenges affecting broadband infrastructure deployment in their underserved areas, as explained in the table below.

Table 3.3 Geography-based Clustering of Economies

Characteristics	Cluster A: Economies with Landmasses	Cluster B: Economies with Archipelagic	Cluster C: Economies with Mountainous / Dense Forest Landscape	Cluster D: Compact Economies with Urban Hubs
Economies	• Australia • Canada • People's Republic of China • Russia • The United States	• Indonesia • Japan • New Zealand • Papua New Guinea • The Republic of the Philippines	• Brunei Darussalam • Chile • Republic of Korea • Malaysia • Mexico • Peru • Thailand • Viet Nam	• Hong Kong, China • Chinese Taipei • Singapore
Key Characteristics	• Enormous distances between scattered populations • Diverse and often extreme climates (permafrost, heavy snowfalls, deserts) • Remote interior regions • Navigating Indigenous / tribal lands	• Extreme Fragmentation (hundreds of islands) • Rugged interiors (dense jungles, high mountain ranges, volcanic activities) • Remote coastal / riverine communities • Vulnerability to natural disasters (typhoons, earthquakes, tsunamis, volcanic eruption)	• Medium-sized economies with mixed landscape e.g., mountains, plateaus, dense forests • Densely packed urban environments with rural population in remote areas • Remote interior regions with mountain or dense forest terrains	• Small landmass • Most of the areas are urbanized, with minimal undeveloped areas • Extensive broadband coverage and infrastructure in place • Centralized critical networks • Extremely high adoption with some groups left behind

In this section, we detail the technology and policy challenges for each geographical cluster, as both dimensions are strongly influenced by physical characteristics such as distance, terrain, and population distribution. Large landmass, archipelagic, mountainous, and compact urban settings each face distinct barriers that shape how infrastructure is deployed and how policies are implemented.

The third dimension, digital inclusion, is less dependent on geography and more closely linked to socio-economic factors such as income levels, education, and digital skills. For this reason, we analyze digital inclusion challenges by differentiating between developed and developing economies, rather than by geographic cluster

3.3.1 Cluster A: Economies with Large Landmasses

Economies with large landmasses are grouped in Cluster A. These economies face distinctive barriers and opportunities in their aim to obtain universal broadband connectivity. The territories typically include remote, sparsely populated, and often climatically harsh areas that require extensive investment on capital expenditure for extending broadband to underserved areas.

3.3.1.1: Cluster A Policy Challenges

For large landmass economies policy challenges in broadband deployment stem largely from their vast and diverse geographies. The sheer size of these territories requires governments to craft policies that balance investment between dense urban centers and remote interior regions, where deployment is far less commercially viable. Regulators must also navigate complex jurisdictional issues, including coordination across federal, state, provincial, or local authorities, which can slow decision-making and increase costs. Climate extremes, from deserts to permafrost, further complicate regulatory frameworks by requiring flexible standards that account for varied infrastructure needs. Ultimately, the policy challenge lies in designing mechanisms, such as targeted subsidies, public–private partnerships, or universal service obligations, which incentivize private sector participation while ensuring inclusivity and sustainability.

The United States' Regulatory Divide: The Local Permitting Barrier

Despite substantial federal investments and ambitious goals to achieve universal broadband connectivity, the United States faces persistent deployment challenges from its fragmented and inconsistent local regulatory framework. Besides the technical and economic hurdles of reaching underserved regions, the administrative complexities of obtaining permits and managing Rights-of-Way (RoW) at the local level significantly increase costs and delay infrastructure projects.

Inconsistent local permitting and Right-of-Way processes: In the United States, broadband infrastructure deployment, especially fiber, is subject to permitting and RoW regulations from multiple individual local authorities in cities, counties, and even districts. Each entity may have its own unique set of rules, fees, processes, and timeline. For example, Michigan's plan "details how a lack of standardized requirements can lead to confusion in the application process, as inconsistencies in permitting fees and timelines differ among the 'sometimes-overlapping permitting authorities'." This disadvantage creates a large administrative burden for broadband providers. Navigating dissimilar requirements across a single project that involves multiple localities can lead to significant delays. According to Competitive Carriers Association President Steve Berry, "the average time frame for a fiber deployment in rural areas is from five to ten years." These delays and complexities are major inhibitors to scaling broadband deployment, especially for last-mile connections in underserved regions where the cost per

subscriber is already high. Permitting delays and associated inefficiencies can increase the cost of fiber deployment projects by as much as 30%.

High and non-standardized fees: Beyond administrative complexity, local governments can impose fees for permits and RoW access that are perceived by providers as excessive and not always reflective of actual costs incurred by the municipality. These fees can vary significantly, with some cities charging more per linear foot of fiber or per pole attachment than others. Dig Once policies, which require broadband conduit to be laid whenever a road is opened for utility work, are recognized as cost-saving measures, their adoption and effective implementation vary across states and localities.

Source: (1) Wright Tremaine, D. (2017). The Need for Speed: FCC Circulates Proposal to Accelerate Broadband Deployment | Insights | Davis Wright Tremaine. Dwt.com. https://www.dwt.com/insights/2017/04/the-need-for-speed-fcc-circulates-proposal-to-acce
(2) Reimagining Fiber Deployment. (2025, July 25). Ftidelta.com. https://www.ftidelta.com/insights/perspectives/reimagining-fiber-deployment
(3) States Target the Paperwork That Slows Broadband Expansion. (2024, April 23). Governing. https://www.governing.com/infrastructure/states-target-the-paperwork-that-slows-broadband-expansion
(4) Beranek, C. (2023, June 22). Broadband Permitting Processes Must Change. Thefastmode.com. https://www.thefastmode.com/expert-opinion/32496-broadband-permitting-processes-must-change
(5) How States Are Expanding Broadband Access. (2020, February 27). Pew.org; The Pew Charitable Trusts. https://www.pew.org/en/research-and-analysis/reports/2020/02/how-states-are-expanding-broadband-access
(6) Preparing for Permitting to Accelerate Broadband Deployment. (2022). https://broadbandusa.ntia.doc.gov/sites/default/files/2022-12/IFA_Permitting_101_PDF.pdf

3.3.1.2: Cluster A Technology Challenges

In Cluster A economies vast distances and varying climates mean that infrastructure strategies must rely on a mix of technologies, including satellite, Fixed Wireless Access (FWA), and resilient terrestrial backbones, rather than a one-size-fits-all solution.

Australia's Digital Divide: Performance and Access Disparities

While Australia has made significant investments in domestic broadband infrastructure, a persistent digital divide exists, especially in its vast regional and rural areas. This divide is characterized by substantial disparities in the quality, stability, and speed of broadband services, which often fail to meet the needs of residents despite having 'coverage.'

Fixed-line performance disparity: The Australian Competition and Consumer Commission's (ACCC) "Measuring Broadband Australia" reports consistently highlight performance differences. While the gap has narrowed, urban areas still receive better speeds. In September 2023, urban fixed-line NBN services achieved 99% of their maximum plan download speed during busy hours, compared to 97.2% for regional areas. More critically, the ACCC also found that 7% of regional services were underperforming, compared to 4% in urban areas. Underperforming services are those that "rarely or never achieve the plan download speed" resulting in a digital divide.

Mobile network experience disparity: The quality gap is also evident in mobile connectivity. In 2019, an Opensignal report revealed a significant drop in mobile download speed experience, decreasing by 39% for Telstra and 61% for Vodafone when moving from major cities to inner regional areas. The more recent Opensignal report from 2025 titled "Retention Starts with Reception: How Mobile Network Experience Drives Churn in Australia" continues to confirm these significant regional disparities. It is reported that a substantial portion of

regional Australia, such as Western Australia and the Northern Territory, show inferior scores for the Excellent Consistent Quality category. This category measures how consistent mobile networks support demanding applications, like video streaming, video calls, and gaming.

Regional spotlight: Ali Curung, Northern Territory: Ali Curung is a remote Indigenous community in the Northern Territory of Australia. A 2018 case study by Australian Digital Inclusion Index (ADII) showed the community's low digital inclusion score of 42.9 (economy's average is 60.2), due to a high reliance on mobile-only connectivity with no fixed broadband. This resulted in an extremely low affordability score of 25.8 due to the higher cost of mobile data per gigabyte, more expensive compared to fixed broadband. Residents in Ali Curung therefore are less likely to consume internet daily when compared to the economy's average.

Source: (1) Broadband performance in smaller towns nears metro levels. (2023, December 12). Australian Competition and Consumer Commission. https://www.accc.gov.au/media-release/broadband-performance-in-smaller-towns-nears-metro-levels
(2) The difference between Australian rural and urban mobile network experience. (2019, October 10). Opensignal. https://www.opensignal.com/2019/10/10/the-difference-between-australian-rural-and-urban-mobile-network-experience
(3) Retention starts with reception: how mobile network experience drives churn in Australia. (2025). Opensignal. https://www.opensignal.com/2025/04/28/retention-starts-with-reception-how-mobile-network-experience-drives-churn-in-australia/dt
(4) Ingrid. (2018, December 1). Case study: Remote Indigenous community – Ali Curung. Australian Digital Inclusion Index. https://www.digitalinclusionindex.org.au/case-study-remote-indigenous-community-ali-curung/

3.3.2 Cluster B: Economies with Large Archipelagic

The Archipelagic economies, composed of numerous islands scattered over vast maritime regions, experience unique geographical and infrastructural challenges in delivering broadband connectivity services. Many remote areas in these archipelagic economies remain underserved. The fragmented geography, limited infrastructure, high deployment costs, and logistical difficulties impact on the efforts to expand broadbands infrastructure across all islands. The following section examines the specific barriers and challenges across these archipelagic conditions of these APEC economies.

3.3.2.1: Cluster B Policy Challenges

For archipelagic economies such as Indonesia; Japan, New Zealand; Papua New Guinea; and the Republic of the Philippines, broadband policies must contend with extreme fragmentation across hundreds of islands, each varying needs. Coordinating domestic broadband strategies with local and regional authorities can be complex, particularly when communities are dispersed and economically uneven. Policymakers must also integrate disaster resilience into regulations, given the high vulnerability to typhoons, earthquakes, and volcanic activity. Ensuring universal service obligations that meaningfully reach remote coastal and riverine communities requires sustained public funding and strong public–private partnerships.

Table 3.4 Cluster B Policy Challenges

APEC Economy	Backbone Initiatives	Last-mile Challenges	Regulatory / Sharing Issues
Indonesia	Palapa Ring Project to deploy fiber network across 13,000 kms of undersea cables and 22,000 kms of onshore networks	Distance of remote islands and terrain make village connectivity difficult Limited commercial viability for service provider participation	Completion of local links by private service providers has experienced delays
Japan	Subsidy program for local governments to develop super high-speed broadband infrastructure Indefeasible Right of Use (IRU) agreement to build fiber networks in remote islands	Underfunded by private service providers on submarine lines to mainland	Public service providers need to complete the connections
Malaysia	Co-funding programs between regulator and service providers e.g., Jalinan Digital Negara (JENDELA) plan, deploying towers and fiber networks and upgrading 4G networks	Despite the deployment of community internet centers, reliable connectivity on islands remains limited and fragmented	Infrastructure sharing is not always prioritized, concerns about quality of services or lack of coordination incentives
New Zealand	Government-led and Public-Private Partnership (PPP) initiatives e.g., Rural Broadband Initiative (RBI). Mobile Black Spot Fund (MBSF), Rural Capacity Upgraded Program (RCU), managed through National Infrastructure Funding and Financing Limited (NIFFCo)	Coordination dependence on remote islands	Multi-Operator Core Network (MOCN) model fostering collaboration among service providers to share RAN and spectrum resources
The Republic of the Philippines	Public broadband infrastructure through National Fiber Backbone (NFB) project, with USF-funded by fragmented	Network coverage in remote island areas remains limited and insufficient	Poor KPI enforcement and oversight of progress

APEC Economy	Backbone Initiatives	Last-mile Challenges	Regulatory / Sharing Issues
Papua New Guinea	Mainly driven by state-owned entity with significant government and international co-funding support National Transmission Network (NTN) by PNG DataCo provide wholesale models for service providers	Delivering network capacity affordably and reliably across a highly dispersed population presents significant challenges	High retail costs for internet services, despite efforts to reduce wholesale internet prices Poor KPI enforcement and oversight of the progress

3.3.2.2: Cluster B Technology Challenges

Broadband deployment in these economies faces inflated costs due to rugged terrains, undersea cables for inter-island connectivity, and dispersed, low-density communities. Harsh geographies such as dense jungles and mountainous interiors increase the difficulty of terrestrial rollouts, while exposure to frequent natural disasters heightens the risk of network disruption. Many areas also lack supporting transport and power infrastructure, delaying reliable broadband access. As a result, infrastructure strategies must combine undersea fiber, satellite, and resilient wireless technologies - such as Microwave backhaul, Fixed Wireless Access, LEO - to maintain connectivity across islands.

The Republic of the Philippines: Addressing Broadband Connectivity in Eastern Visayas

Eastern Visayas – comprising the islands of Leyte, Samar, and Biliran, remains one of the underserved regions in the Republic of the Philippines in term of broadband connectivity. Geographically situated along the typhoon belt and Pacific seaboard, the region is highly vulnerable to severe weather events, including strong typhoons, storm surges, flooding, and landslides.

In 2013, super typhoon “Haiyan” (locally known as Yolanda) devastated the region, destroying over 550,000 homes and disabling power and communication networks for weeks. Since then, the region has experienced recurring typhoons on an annual basis, further damaging critical infrastructure and impeding long-term recovery.

The region’s vulnerability to natural disasters is compounded by slow recovery efforts and significant gaps in infrastructure development. As of 2024, the median fixed broadband download speed in Eastern Visayas was only 38.43Mbps, significantly lower than Luzon’s average of over 90Mbps and the economy average of 94Mbps.

To address these disparities, the Department of Information and Communications Technology (DICT) launched the Philippine Digital Infrastructure Project (PDIP). This initiative aims to expand the middle-mile broadband infrastructure from the local backbone to underserved areas, including Western Visayas, Central Visayas, Eastern Visayas, Zamboanga Peninsula, Northern Mindanao, Davao Region, Soccsksargen and Caraga. The PDIP also incorporates climate risk assessments and resilience measures into its infrastructure design to ensure durability against extreme weather conditions, such as high winds and flooding.

Source: (1) Verdejo, G. (2024, July 26). PH expands fiber backbone, cuts internet costs. The Manila Times. https://www.manilatimes.net/2024/07/27/supplements/ph-expands-fiber-backbone-cuts-internet-costs/1960033?
(2) Ayeng, R. (2024, October 11). World Bank approves $287.24-M Phl digitalization loan. Daily Tribune. https://tribune.net.ph/2024/10/11/world-bank-approves-28724-m-phl-digitalization-loan
(3) Lopez, E. (2025, March 18). Gov't vows enhanced Internet access for Eastern Visayas, remote areas. Newsbytes.PH. https://newsbytes.ph/2025/03/18/govt-vows-enhanced-internet-access-for-eastern-visayas-remote-areas/
(4) The Philippines: Connectivity for Digital Inclusion in Eastern Visayas. (2025, March 17). Opengovasia.com. https://opengovasia.com/2025/03/17/the-philippines-connectivity-for-digital-inclusion-in-eastern-visayas/

3.3.3 Cluster C: Economies with Mountainous / Dense Forest Landscape

The economies clustered within this group are Brunei Darussalam; Chile; Republic of Korea; Mexico; Peru; Thailand; and Viet Nam. They are generally mountainous and heavily forested.

3.3.3.1: Cluster C Policy Challenges

In these economies broadband policy must balance investments between densely populated urban centers and sparsely populated rural or mountainous regions. Regulatory frameworks are challenged by geographic inequalities, where private investment gravitates toward profitable cities while leaving remote areas underserved. Policymakers also face the task of aligning digital inclusion goals with environmental protection, as broadband expansion may affect sensitive forest ecosystems. Targeted subsidies and incentives for rural broadband are essential, but governance coordination across multiple administrative levels often delays implementation.

Mexico's UNESCO-listed Calakmul Biosphere Reserve and Broadband Deployment

The Calakmul Biosphere Reserve in Mexico's Yucatan Peninsula region is a large reserve spanning over ~7,000 square kilometers. The Reserve holds one of the most important cultural heritages, the Mayan civilization ruins, along with over 70,000 living organisms. Thus, the area was decreed to be a reserve under International Union for Conservation of Nature (IUCN) Category V in the year 1989, designed as a UNESCO World Heritage site in 2002, and governed under the Secretariat of Environment and Natural Resources (SEMARNAT) of Mexico.

However, environmental conservation policies prioritize nature preservation over infrastructure development. Local communities are left with limited access and rights over their native lands. Many have voiced complaints over the years of the restricted activities permitted on the land, with the governing body denying requests to conduct any activity, even for subsistence such as hunting within the reserve. This protection regulatory issue spans to the broadband infrastructure deployment as well; since clearing lands, building towers, or laying cables are not permitted within the reserve or even around the buffer zones around the reserve itself.

Statistics of internet access support the assumption that the internet penetration and adoption for the population living within that area are lower due to the environmental protection and restriction. According to the data from Mexico's Population and Housing Census in 2020, only around ~8% of Calakmul households have access to the internet, while ~65% of the household

possesses cell phones. This penetration rate is considered as low compared to other regions in Mexico such as Izamal, a comparable municipality with similar amount of population (~30,000 people) and is also an important historical site without strict reservation regulatory, has a considerably higher adoption; Izamal's household's internet access upwards of ~26% and ~84% of the household possesses cell phones.

Source: (1) Abulu, L. (2024, March 5). Global protected area policies spark conflicts with Mexico Indigenous groups. Mongabay Environmental News. https://news.mongabay.com/2024/03/global-protected-area-policies-sparks-conflicts-with-Mexico-indigenous-groups
(2) Oliva, M., & Eduardo García Frapolli. (2024). Conservation backfire: Local effects of international protected area policy. Environmental Science & Policy, 153, 103676–103676. https://doi.org/10.1016/j.envsci.2024.103676
(3) Scherer, G. (2022, December 20). Nations adopt Kunming-Montreal Global Biodiversity Framework. Mongabay Environmental News. https://news.mongabay.com/2022/12/nations-adopt-kunming-montreal-global-biodiversity-framework
(4) Calakmul. (n.d.). DataMexico; Government of Mexico. Retrieved July 2025, from https://www.economia.gob.mx/datamexico/en/profile/geo/calakmul
(5) Izamal. (n.d.). DataMexico; Government of Mexico. Retrieved July 2025, from https://www.economia.gob.mx/datamexico/en/profile/geo/izamal

3.3.3.2: Cluster C Technology Challenges

Mountainous terrains, plateaus, and dense forests significantly increase the difficulty of laying fiber and building terrestrial networks. Construction costs are amplified by landslides, flooding, and erosion risks in remote areas. Rural communities are often isolated, requiring long backhaul connections across difficult terrain. Power availability is inconsistent in forested regions, further complicating infrastructure sustainability. As a result, broadband strategies rely heavily on hybrid solutions; fiber in urban centers, complemented by satellite, microwave, or fixed wireless in rugged interior areas.

Chile and its extremely diverse terrain

Chile is an economy located in Latin-America, located between the Andes Mountain range and the Pacific Ocean. Its geographical characteristics are some of the most diverse in the world, from glaciers to the Atacama Desert. Most of the area mass is entirely covered by forested mountains and rugged coastlines.

Chile's extremely diverse terrain causes issues in operators trying to expand their broadband infrastructure.

Deploying terrestrial infrastructure such as fiber cables on rugged terrains such as mountains or fjords is a great challenge since subsurface digging and physical connection to each house is required to lay fiber cables. Other fiber cable deployment could be employed such as aerial cables on poles for rocky areas or deep trenches for clay/sandy soils, however, each method needs specialized equipment and skilled labor which add to the costs of deployment per kilometer for operators. Furthermore, fiber cables require a 'middle-mile' infrastructure in between network core and the households, which tend to cost more due to more distances needed.

Without the government's intervention in subsidizing the deployment costs or innovative alternative technology such as satellites, operators may not see any commercial viability in these regions.

Source: (1) Chile Maps & Facts. (2021, February 24). WorldAtlas. https://www.worldatlas.com/maps/chile
(2) BROADBAND MAPPING: CHALLENGES AND SOLUTIONS. (2022, March). GovInfo; the U.S. Government Publishing Office. https://www.govinfo.gov/content/pkg/CHRG-116shrg42446/html/CHRG-116shrg42446.html

3.3.4 Cluster D: Urban/Compact Economies

Cluster D comprises advanced and compact economies with small landmass and dense urban infrastructure, namely Hong Kong, China and Singapore. While these city-states have already achieved near-universal broadband coverage and some of the world's highest internet penetration and speeds, their challenges lie not in physical coverage, but in ensuring long-term network resilience, inclusivity, and global competitiveness in a rapidly evolving digital environment.

3.3.4.1: Cluster D Policy Challenges

For compact economies such as Hong Kong, China; Singapore; and Chinese Taipei, policy challenges lie less in geographic barriers and more in managing equitable access. While broadband adoption rates are high, certain groups, such as the elderly, low-income households, or migrant workers, risk being left behind without targeted inclusion policies. Regulators must also focus on cybersecurity, resilience, and redundancy, as the concentration of critical networks in small territories creates vulnerabilities to systemic risks. Elevated levels of urbanization also demand continuous upgrading of standards and regulatory frameworks to maintain competitiveness in digital infrastructure.

Policy Gaps in Regulating High-Density Broadband Infrastructure

In Hong Kong, China, broadband improvement is constrained less by coverage than by systemic risk created by extreme physical concentration of critical assets such as cable landing sites, backbone nodes, Internet exchanges, and multi-tenant data centers. In a compact territory where operators co-locate equipment and share utility corridors, single-site failures can cascade across networks and providers, turning operational incidents into territory-wide service disruptions. Ultimately, the policy challenge lies in recognizing clustering as unavoidable and regulating co-location, shared utilities, and landing-point concentration as systemic risks rather than isolated technical issues.

Recent incidents illustrate how localized technical faults become ecosystem outages in Hong Kong, China's dense infrastructure stack.

In April 2024, the fiber optic lines that serve the operator HKBN (Hong Kong Broadband Network) were accidentally damaged due to a third-party construction along the Castle Peak road. The damage disrupted broadband connectivity for thousands of citizens trying to access internet for work or web access across Tuen Mun, Yuen Long, and Tin Shui Wai. This recent incident highlights the fragility of shared physical infrastructure in a dense urban economy. One accidental damage can propagate through the stack, affecting multiple vital online services. From a policy angle, this exposes the limits of relying on voluntary engineering practice without stronger, enforceable uptime and interdependency standards for shared facilities.

This is an example of a policy gap rather than isolated engineering mistakes: (i) no uniform, binding resilience baseline for fiber-optic networks that underpin broadband services; (ii) insufficient, harmonized incident-reporting and audit requirements across telecom operators and construction contractors; and (iii) incomplete treatment of shared underground routes and metro-node concentration as systemic risk, not merely as logistical choices. Hong Kong, China's government has issued guidance on infrastructure coordination and data security, but these documents remain non-binding and cannot substitute for enforceable cross-sector obligations where cascading risk is high. Closing these gaps will require moving beyond voluntary guidelines to mandatory resilience standards and coordinated excavation protocols, an essential step if Hong Kong, China is to safeguard its position as a regional digital hub.

Source (1) Major HKBN network outage reported across HK. (2025, April 11). Thestandard.com.hk; The Standard. https://www.thestandard.com.hk/hong-kong-news/article/300303/Major-HKBN-network-outage-reported-across-HK
(2) HKBN Fully Restored Network Services in Yuen Long, Tuen Mun, and Tin Shui Wai Press Releases | HKBN. (2025). Hkbn.net. https://www.hkbn.net/group/newsroom/press-releases/20250411-Fully-Restored-Network-Services
(3) Telecommunications Regulatory Affairs Advisory Committee. (2022). *Proposed Guidelines for Telecommunications Operators for Reporting Network/Service Outages and Emergency Incidents*. Office of the Communications Authority. https://www.ofca.gov.hk/filemanager/ofca/en/content_757/traac5_2022_p.pdf

3.3.4.2: Cluster D Technology Challenges

These economies benefit from extensive broadband infrastructure, but face challenges in sustaining resilience and capacity. With limited landmass, networks are highly centralized, meaning outages or cyberattacks can have disproportionate impacts. Dense urban environments require constant upgrading to support high user demand, smart city applications, and emerging

technologies like 5G and beyond. In compact urban economies, the main challenge lies less in basic access and more in overcoming in-building barriers that limit network performance. While technology and resilience are largely in place, achieving world-class speed, redundancy, and service quality requires addressing building regulations and infrastructure standards to ensure consistent technical performance across all users.

Chinese Taipei's Great Vulnerability towards Natural Disasters

Chinese Taipei is an island sitting on top of the 'Ring of Fire', prone to both severe earthquakes and typhoons. In 2024, a 7.2 magnitude earthquake near Chinese Taipei's east coast, knocking out around 172 telecommunications base stations according to the National Communications Commission (NCC). After the earthquake, these base stations were forced offline due to disruptions in power transmissions. "Overall, the affected areas are mainly in Yilan and Hualien, with mobile network-related services primarily affected", said NCC Chairperson.

This was not the first time Chinese Taipei experienced broadband disruptions due to natural disasters, due to its geographical location between two tectonic plates. In 2006, eight submarine cables were damaged after a 7.0 magnitude earthquake hit the southwest coast. This not only caused disruptions in Chinese Taipei, but throughout other regions of Asia as well. Chunghwa Telecom reported 100% internet outage for Hong Kong, China, and Southeast Asia. As a result of this outage, many financial transactions such as the foreign exchange markets were severely impacted.

Although Chinese Taipei has built up resilience in their broadband infrastructure in the past few decades such as positioning undersea cables at coasts less prone to earthquakes and utilizing several Internet Exchange Points (IXPs), their geological location is still vulnerable to future disruptions, highlighting the need for a resilient infrastructure that will withstand disasters and provide uninterrupted connectivity for all.

Source: (1) Lipscombe, P. (2024, April 3). More than 170 base stations are offline in Chinese Taipei following earthquake. Datacenterdynamics.com. https://www.datacenterdynamics.com/en/news/more-than-170-base-stations-offline-in-taiwan-following-earthquake/
(2) Over 100 telecom base stations in Chinese Taipei were disrupted by quake. (2024). Taiwan News. https://www.taiwannews.com.tw/news/5135822
(3) Polk, R. (2024, April 3). Limited Internet Outage in Chinese Taipei Highlights the Importance of Resilient Internet Infrastructure. Internet Society Pulse. https://pulse.internetsociety.org/blog/limited-internet-outage-in-taiwan-highlights-the-importance-of-resilient-internet-infrastructure
(4) Chinese Taipei earthquake knocks nearly 200 base stations offline. (2024, April 3). UK Fibre Connectivity Forum. https://www.ukfcf.org.uk/taiwan-earthquake-knocks-nearly-200-base-stations-offline
(5) Qiu, W. (2011, March 19). Submarine Cables Cut after Chinese Taipei Earthquake in Dec 2006. Submarinenetworks.com. https://www.submarinenetworks.com/en/nv/news/cables-cut-after-taiwan-earthquake-2006
(6) Chinese Taipei earthquake: The mountain "rained rocks like bullets" - survivor. (2024, April 4). Www.bbc.com. https://www.bbc.com/news/world-asia-68729048

3.3.5 Cross-Cutting Digital Readiness Challenges

Section 3.3.5 examines APEC economies by their level of economic development, using the World Bank's 2025 income classification. By distinguishing economies in this way, it provides a practical lens for understanding that the digital readiness across APEC is not uniform: in developed contexts, it is one of inclusion and meaningful use, whereas in developing contexts, the challenge is primarily one of access and affordability. By combining both geographic and

economic perspectives, we gain a fuller picture of the factors that shape the broadband ecosystem.

APEC economies are divided into developed and developing groups using the World Bank's 2025 income classification[79]. Under this system, economies with a GNI per capita below USD 1,145 are classified as low-income, those between USD 1,146 and USD 4,515 as lower-middle income, and those between USD 4,516 and USD 14,005 as upper-middle income. Economies with GNI per capita of USD 14,006 or higher are considered high-income. For this report, high-income economies are treated as developed, while all others fall into the developing category.

Developed Economies

APEC's developed economy members (Australia; Brunei Darussalam; Canada; Hong Kong, China; Japan; Republic of Korea; New Zealand; Chinese Taipei; Singapore; the United States) face digital readiness challenges less in broadband access and affordability, and more in digital inclusion, with uptake lagging among elderly and marginalized groups.

Singapore's Digital Access

Singapore is considered one of the most digitally connected economies in the world, with fiber broadband penetration at 99% of residential premises and high digital infrastructure investment. However, access and usage still vary slightly across demographic lines, particularly among migrant worker populations, who face distinct types of access and adoption challenges.

Migrant Workers and Access Gaps: Singapore is home to over 1.2 million foreign workers, many of whom live in dormitories or shared housing. While mobile data is widespread, many migrant workers lack reliable access to Wi-Fi, especially for large file transfers, such as video calls, remote education, or government services. Barriers include prepaid SIMs with data caps, lack of familiarity with local digital systems, fear of surveillance or data misuse, and limited digital support in native languages.

Source: (1) IMDA. (2023). Singapore digital society report 2023. https://www.imda.gov.sg/-/media/imda/files/infocomm-media-landscape/research-and-statistics/singapore-digital-society-report/singapore-digital-society-report-2023.pdf
(2) Zalizan, T. (2021). Not just cheap labour: The case for greater integration of Singapore's migrant workers. CNA. https://www.channelnewsasia.com/today/big-read/not-just-cheap-labour-case-greater-integration-singapores-migrant-workers-5177546

Developing Economies

APEC's developing economy members (Chile; People's Republic of China; Indonesia; Malaysia; Mexico; Thailand; Russia; Papua New Guinea; Peru; The Republic of the Philippines; and Viet Nam) face structural digital readiness challenges, including limited digital literacy, affordability constraints for devices and services, and gaps in electricity or broadband infrastructure.

[79] World Bank. (2024). *World Bank Country and Lending Groups*. The World Bank. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

Lack of Smartphone Access in Papua New Guinea

Papua New Guinea is a lower-middle-income economy (World Bank, 2025). Despite steady growth of around 4-5% annually, its digital readiness is constrained not only by connectivity but by the inflated cost of devices relative to income. While mobile coverage has expanded, adoption remains limited because smartphones are still unaffordable for large segments of the population. Even basic Android devices, often priced at around USD 50-100, represent a prohibitive expense in an economy where GDP per capita is just over USD 3,500 and many households earn far less. Import duties, shipping costs, and limited supply chains further inflate prices, making internet-capable devices a luxury rather than a necessity. This affordability barrier is reflected in adoption data: as of January 2025, only 36.7% of Papua New Guineans owned a smartphone, despite mobile connections covering nearly half the population. In practice, this means a significant share of users rely on basic feature phones, which allow calls and SMS but cannot meaningfully support internet use, mobile banking, or e-government services. Research by DevPolicy further shows that mobile internet prices, while relatively stable, still rank among the least affordable in the Pacific when adjusted for income, amplifying the device cost barrier since even those who manage to buy smartphones face ongoing affordability challenges for connectivity.

The gap between coverage and ownership underscores that infrastructure improvements alone cannot close the digital divide; without targeted policies to lower device costs, substantial portions of the population will remain excluded from meaningful participation in the digital economy.

Source: (1) Digital 2025: Papua New Guinea. (2025, March 3). DataReportal – Global Digital Insights. https://datareportal.com/reports/digital-2025-papua-new-guinea
(2) H A Watson, A. (2025, January 6). Mobile internet prices stable in Papua New Guinea. Devpolicy Blog from the Development Policy Centre. https://devpolicy.org/mobile-internet-prices-stable-in-papua-new-guinea-20250107
(3) GDP per capita (current US$) - Papua New Guinea | Data. (n.d.). Data.worldbank.org. https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=PG

3.4 CLUSTER-BASED ANALYSIS OF BROADBAND VITALIZATION SUCCESS CASES IN UNDERSERVED AREAS

Through the analysis of the underserved areas' status across 21 economies by grouping the economies by their geographical characteristics, complex yet common barriers to connectivity emerged across the four clusters. The challenges do not lie within the coverage (supply) side alone, but within the adoption of broadband (demand) as well. Four recurring issues emerged across four clusters: limitations of broadband infrastructure, gaps in domestic broadband programs from the government, vulnerability to natural events, and low levels of digital literacy.
These four themes also serve as the foundation for the success cases of broadband vitalization of underserved areas. Each barrier corresponds to a success enabler needed for meaningful connectivity. One enabler contains sub-enablers such as policy execution, public-private partnerships, or natural disaster recovery, illustrated with real-world examples from selected economies.

By examining the following success cases, this section highlights the way economies have turned barriers into opportunities to provide better connectivity for their citizens, providing

practical samples to further improve broadband access and adoption in underserved areas in APEC economies.

3.4.1 Cluster A: Economies with Large Landmasses

Cluster A economies (Australia; Canada; People's Republic of China; Russia; the United States) face challenges of vast geography, sparse populations, and costly backbone networks. The success cases in this cluster, Australia's NBN, Russia's state-led backbone expansion, and Canada's Qiniq network, show how large landmass economies can overcome distance and scale barriers through targeted policy, strategic investment, and hybrid technologies.

Cluster A Technology Success Case

Australia's NBN illustrates how large landmass economies can overcome vast distances through strategic middle-mile investment and wholesale network models that foster competition and access.

Australia's Middle Mile Success

Australia's ambitious National Broadband Network (NBN) stands as a prominent case study for addressing the complexities of middle mile broadband deployment. Given its vast geographical size and dispersed population, connecting regional and remote communities to the local and international backbone presented a monumental challenge. The NBN project, initiated by the Australian government, recognized that building an extensive middle mile network was crucial to achieving universal broadband access and bridging the digital divide.

Conquering Vast Distances with a Unified Fiber Backbone: The core achievement of the NBN in the middle mile is the deployment of the NBN Transit Network (NTN). This is a vast fiber optic backbone stretching over 60,000 kilometers across the continent. This was not just extending existing networks, but also an ambitious project to create a single high-capacity digital network where the connections were inadequate and disparate previously. This comprehensive network effectively brought high-speed capacity closer to every community, a critical step in overcoming unique challenges posed by the economy's expansive geography and sparse population distribution.

Strategic Points of Interconnect for Widespread Access: The NTN strategically connects to over 120 Points of Interconnect across the economy. These POIs are vital aggregation points, acting as regional digital gateways. By extending fiber backbone to many geographically distributed POIs, NBN Co significantly reduced the need for individual retail service providers to build their own long-haul infrastructure. This decentralized approach has created a more competitive retail market, as more service providers are able to access the network and offer services in regional areas with lower barriers to entry.

Wholesale-Only Model as Enabler for Competition: NBN Co's operation as a wholesale-only network provider was a strategic choice. This model mandates that the multi-billion-dollar investment in the middle mile backbone be made available on a non-discriminatory basis to all retail service providers. This policy directly addressed the challenge of fostering competition in geographically challenging areas by preventing infrastructure monopolies.

Laying the Groundwork for Regional Transformation: The successful deployment of the NBN's middle mile fundamentally changed the landscape of regional and remote Australia. By extending high-capacity fiber closer to communities, it created the necessary digital infrastructure to enable better last mile solutions and unlock economic and social opportunities.

Source: (1) NBN Co flicks switch on transit capacity upgrade | nbn. (2020). Nbnco.com.au. https://www.nbnco.com.au/corporate-information/media-centre/media-statements/nbn-co-flicks-switch-on-transit-capacity-upgrade
(2) The network explained. (2025). Nbnco.com.au. https://www.nbnco.com.au/learn/how-the-network-comes-together
(3) National Broadband Network - Transition from Construction to Operation | Australian National Audit Office (ANAO). (2024). Anao.gov.au. https://www.anao.gov.au/work/performance-audit/national-broadband-network-transition-construction-to-operation-2024

Cluster A Policy Success Case

Russia's policy-driven broadband expansion shows how state intervention can overcome extreme geographic barriers. By combining a domestic fiber backbone, universal service mandates, and satellite programs under its "Digital Economy" agenda, show how large-landmass economies can extend connectivity where commercial incentives fall short.

Russia's Remote Connectivity Policy Success

Russia's vast geography, extreme climate conditions, and dispersed population across Siberia and the Far East created some of the most formidable barriers to broadband access among large-landmass economies. Commercial providers had little incentive to invest in settlements with only a few hundred people, while the absence of a unified backbone limited capacity in remote regions. To address this, it was state-led policy intervention that enabled the expansion of broadband across Russia's remotest areas.

LocalPolicy Driving Fiber Expansion: the government's support for a domestic fiber backbone, implemented through state-linked operators like Rostelecom and TransTelekom. Leveraging railway corridors, TransTelekom deployed more than 45,000 km of fiber, connecting nearly 1,000 settlements across seventy-one regions. Rostelecom complemented this with targeted builds such as the 1,056 km Tynda-Yakutsk line, delivering 80 Gbps (expandable to 3.2 Tbps) to the East.

Universal Service Obligation for Rural Inclusion: In 2014, amendments to Russia's communications law required Rostelecom to provide at least 10 Mbps broadband to settlements with fewer than 250 residents. This universal service mandate ensured digital inclusion for sparsely populated areas traditionally excluded from modernization due to low commercial returns. By mandating minimum service standards, the government guaranteed that rural Russia was not left behind in the digital economy.

Satellite Policy under the Digital Economy Program: recognizing the limits of terrestrial fiber in a landmass spanning eleven time zones, the government launched the Sfera satellite constellation under the domestic "Digital Economy" program. With a planned 640 satellites by 2030, Sfera aims to provide broadband and IoT coverage across Arctic territories, island settlements, and deep Siberia. In parallel, regulatory support through eased licensing and spectrum allocation for experimental satellite projects allowed private players like MegaFon to invest in low-earth orbit (LEO) R&D without the usual bottlenecks.

Policy-Led Impact:. According to ITU's data, the number of internet users in Russia increased from 80.9% in 2018 to 94.4% in 2024, accounting for over 18 million additional individuals using the internet in the 7 year period. By combining policy mandates, state-led infrastructure, and targeted subsidies, Russia created a hybrid digital infrastructure strategy-high-capacity fiber where feasible, satellite coverage for the most inaccessible areas, ensuring that broadband expansion was not left solely to market forces.

Source: (1) Maria Rossotto, C., Gelvanovska, N., Hohlov, Dr. Y., Shaposhnik, S., & Mačiulė, Dr. V. (2016, August 30). A Sector Assessment: Broadband in Russia. World Bank; World Bank Group. https://www.worldbank.org/en/country/russia/publication/broadband-in-russia
(2) Developing Broadband Network for the Socially Critical Infrastructure and Rural Areas in the Russian Federation. (2019). https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2019/Aug-MIIT/1.3Developing%20Broadband%20Network%20for%20the%20Socially%20Critical%20Infrastructure%20and%20Rural%20Areas%20in%20the%20Russian%20Federation.pdf
(3) Russia's MegaFon invests in satellite network to provide internet access from space. (2020, November 5). RUSSOFT. https://russoft.org/en/news/english-russia-s-megafon-invests-in-satellite-network-to-provide-internet-access-from-space
(4) *Russia Individuals using the Internet - ITU DataHub*. (2025). ITU. https://datahub.itu.int/data/?e=RUS&c=701&i=11624&v=chart

Cluster A Digital Readiness Success Case

Canada's Qiniq Network in Nunavut illustrates how targeted public investment, hybrid infrastructure, and community-driven delivery can overcome vast distances and extreme conditions to achieve real digital inclusion.

Canada - Qiniq Affordable Network in Nunavut (Underserved Arctic Communities)

Nunavut's vast distances, harsh climate, and dispersed communities made it one of the least connected regions in the developed world. Traditional operators had little incentive to invest, leaving residents facing excessive costs and limited access. The Qiniq Network, backed by the Canadian Government and operated by SSi Canada since 2005, changed this by making broadband both affordable and accessible across all 25 Nunavut communities.

Hybrid Models as a Cost-Efficient Path to Access: Qiniq's hybrid model, satellite backhaul paired with local LTE and Wi-Fi, allowed connectivity in regions where no terrestrial fiber existed. This significantly reduced costs compared to large-scale fiber builds and made broadband available to households that otherwise would have remained excluded.

Building Digital Literacy and Local Capacity: a distinctive feature of the Qiniq model is its reliance on local "Community Service Providers." These individuals support residents in accessing and using broadband services, troubleshoot issues, and provide digital training. By embedding support locally, Qiniq ensured that improved infrastructure translated into real inclusion, enabling participation in education, healthcare, and entrepreneurship.

Public investment to Make Access Affordable: affordability was made possible by federal policy. Programs like the Universal Broadband Fund and CRTC subsidies bridged commercial gaps that would otherwise have left Nunavut disconnected. In 2023, the CRTC allocated ~ USD 19.4 million over five years to expand high-speed satellite internet across Nunavut's 25

communities. Qiniq's entry-level plan at CAD 20/month is cheaper than Canada's average of CAD 65, while its premium CAD 120/month plan is comparable to high-end urban packages. This shows that even in remote Nunavut, pricing remains within local ranges, supporting digital inclusion despite extreme geography. The results were striking household availability of 5 Mbps broadband increased from 49.7% in 2018 to 99.6% in 2019, clear proof of uptake and success.

Interim Solutions for Arctic Connectivity: In late 2024, the Kativik Regional Government partnered with SpaceX and Starlink to deploy high-capacity gateway terminals across Nunavik as a short-term solution while awaiting completion of the Eastern Arctic Underwater Fibre Optic Network (EAUFON) by 2026. These terminals, delivered via air cargo to communities like Kuujjuaq, boosted bandwidth from 300 Mbps to 5 Gbps, bridging the digital divide until full fiber infrastructure is in place. This interim approach mirrors Qiniq's hybrid model by leveraging satellite connectivity to complement future fiber deployments, enhancing reliability, and accelerating access in remote Arctic regions.

Source: (1) Northern firm gets up to nearly $27M to speed up Nunavut's internet. (2023, December 22). Nunatsiaq News. https://nunatsiaq.com/stories/article/northern-firm-gets-up-to-nearly-27m-to-speed-up-nunavuts-internet/
(2) SSI Canada. (2025). *SSi Canada and QINIQ Broadband 2024 Progress Report for the Accessibility Plan*. https://www.ssicanada.com/wp-content/uploads/2025/05/2025-05-30-SSi-Canada-Accessibility-Plan-2024-Progress-Report.pdf
(3) Nunatsiaq News (2025). *Nunavut ISP offers new way to go mobile*. Nunatsiaq News. https://nunatsiaq.com/stories/article/65674nunavut_isp_offers_new_way_to_go_mobile/

(2) Qiniq website https://www.qiniq.com/shop/

3.4.2 Cluster B: Economies with Large Archipelagic

Cluster B economies (Indonesia; The Republic of the Philippines; Papua New Guinea) face unique barriers to broadband deployment due to geographical fragmentation, dependence on undersea cables, and the excessive cost of serving dispersed islands. Success cases in this cluster, Japan's mandate-driven infrastructure resilience, New Zealand's Ultra-Fast Broadband initiative, and the Republic of the Philippines' Free Wi-Fi for All and domestic Broadband Program, demonstrate how strong policy, innovative engineering, and government-backed initiatives can overcome archipelagic challenges to expand digital connectivity.

Cluster B Technology Success Case

Japan demonstrates how disaster-prone economies can achieve telecom resilience through technology. By embedding seismic engineering into facilities, undergrounding fiber to protect backbone networks, and enforcing redundancy across core systems, Japan set a global benchmark for resilient infrastructure.

Japan's Mandate-Driven Infrastructure Resilience and Engineering Evolution

Japan, characterized by high seismic activity and frequent exposure to extreme weather, such as typhoons, has established itself as a global leader in designing highly resilient telecommunications infrastructure. This achievement is primarily driven by proactive government mandates and rigorous engineering standards that compel network operators to build networks capable of withstanding severe natural forces. The 1995 Great Hanshin-Awaji

(Kobe) Earthquake served as a critical turning point, exposing significant vulnerabilities and prompting a local commitment to infrastructure resilience and hardening.

Legislated Resilience Standards: Following the 1995 Kobe earthquake, Japan implemented thorough revisions to its building codes and disaster readiness legislation, greatly impacting telecommunications infrastructure. The Building Standard Law (BSL) was significantly strengthened to include some of the world's most tightened seismic design requirements, especially for critical infrastructure, such as telecommunications facilities. Complementing this, the Disaster Countermeasures Basic Act designates major telecommunications operators as "public institutions," explicitly mandating them to formulate and regularly review the Business Continuity Plans (BCPs). These legal frameworks impose strict obligations on operators ensuring physical assets and constructed and maintained to high benchmarks for disaster resilience.

Such example of a public institution implementing a BCP, following the government mandate under the Disaster Countermeasures Basic Act, is KDDI.

- Its BCP covers all stages from initial response to full-scale restoration and relief activities, reflecting the Act's comprehensive approach to disaster management.
- KDDI assesses the effectiveness of its BCP through twice-yearly disaster preparedness drills and applies an annual PDCA (Plan-Do-Check-Act) cycle to continuously strengthen its emergency response structure.
- Disaster Response Headquarters are established during crises to lead rapid restoration efforts and coordinate closely with local offices.
- KDDI invests in robust and automated networks (such as in Tokyo and Osaka) to ensure operational continuity even if sites are affected. Furthermore, KDDI Cableships & Subsea Engineering Inc. operates ships equipped with mobile stations capable of recovering mobile networks in damaged seashore areas and transporting relief supplies, providing direct on-site support in line with local disaster response. This level of preparedness directly reflects the mandated responsibility to ensure continuous service.

Mandated Advanced Seismic Engineering in Facilities: Japan's strengthened Building Standard Law (BSL) directly mandates advanced seismic engineering in critical facilities, compelling operators to integrate innovative seismic isolation and damping technologies. The BSL requires buildings to ensure structural strength through technical standards for structural methods of construction and structural calculations. This legal framework effectively forces operators to ensure structures protect sensitive internal equipment from malfunction and prevent communication blackouts. For instance, NTT's Nexcenter data centers are designed with seismically isolated structures that can reduce seismic shocks by 80% and the impact on equipment by up to one third, preventing malfunction. Structures built or retrofitted to these enhanced post-Kobe standards have since demonstrated significantly superior performance in subsequent seismic events, directly validating the effectiveness of these mandated engineering practices.

Strategic Extensive Undergrounding: As part of their comprehensive BCPs and adherence to infrastructure resilience goals, a substantial portion of Japan's fiber optic backbone network and crucial feeder cables are buried deep underground. This strategic placement offers increased protection against surface-level threats, such as typhoons, high winds, falling debris, ice storms, and direct impacts from seismic shifts and ground movement. While it was costly initially, this approach delivers increased resilience against numerous common disasters,

reducing physical damage. The physical hardening proved critical during the 2011 Great East Japan Earthquake (magnitude 9.0). The underground nature of major backbone infrastructure was largely resistant to direct forces of seismic activity and surface disruption, allowing a remarkably small number of network prefixes (about 100 out of 6,000 Japanese prefixes on the global routing table) to be temporarily withdrawn from service post-earthquake.

Enhanced Network Redundancy and Diversity: The widespread congestion and localized communication blackouts experienced during the 1995 earthquake further highlighted the significance for more network redundancy, a solution that is a critical component of the mandated BCP. Japan's domestic telecommunications backbone is now designed with extensive redundancy and geographically diverse routing paths. This engineering approach ensures that if a segment of the network or a cable route is compromised by a disaster, traffic can be automatically rerouted through unaffected alternative paths, therefore minimizing service interruption. The effectiveness of these post-1995 design concepts was greatly demonstrated by the core network's ability to maintain connectivity and quickly reroute traffic during the magnitude 9.0 Great East Japan Earthquake and Tsunami in 2011. Even as multiple submarine cables were damaged, essential international connectivity was largely maintained, with most users experiencing no disruption, due to preexisting redundancy measures and the ability to reroute traffic through backup cables. Furthermore, the rapid activation of redundant pathways allowed most core backbone links to be restored within days.

Source: (1) The Secrets Behind Japan's World-Class Infrastructure. (2025, March 18). Wakoku. https://wakokujp.com/japanese-infrastructure/
(2) Seismic Evaluation Technology for Underground Communications Facilities. (2025). NTT Technical Review. https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr200801le1.html
(3) Analysis: Japan's telecoms infrastructure proves resilient in face of devastating earthquake. (2011, March 31). Capacity Media. https://www.capacitymedia.com/article/29ot42ikril15nmg62lzj/news/analysis-japans-telecoms-infrastructure-proves-resilient-in-face-of-devastating-earthquake
(4) Nexcenter – Data Center Service. (2025). NTT DOCOMO BUSINESS Global ICT Services Provider. https://www.ntt.com/en/services/data-center/nexcenter/data-center/tokyo5.html
(5) Disaster Preparedness. (2021). KDDI CORPORATION. https://www.kddi.com/english/corporate/sustainability/network/01/
(6) KDDI's Material Sustainability Issues: Safer and More Resilient Connected World. (2018). KDDI CORPORATION. https://www.kddi.com/english/corporate/ir/ir-library/annual-report/2018-selected/esg/network/
(7) Disaster Countermeasures. (2020). KCS. https://www.kkcs.co.jp/english/about/saigai.html#:~:text=In%20case%20of%20large%2Dsized,seashore%20areas%2C%20and%20recover%20mobile
(8) Building Standards Law. (2025). CAO. https://www8.cao.go.jp/kisei-kaikaku/oto/otodb/english/houseido/hou/lh_06010.html
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(10) Kaneko, K. (2025, June 16). The underlying risks to Japan's undersea cables. The Japan Times. https://www.japantimes.co.jp/news/2025/06/16/japan/explainer-japan-undersea-cables/
(11) Takemoto, S., Shibuya, N., & Sakoda, K. (2021, March 11). Learning from Megadisasters: A Decade of Lessons from the Great East Japan Earthquake. World Bank Group. https://www.worldbank.org/en/news/feature/2021/03/11/learning-from-megadisasters-a-decade-of-lessons-from-the-great-east-japan-earthquake-drmhubtokyo

Cluster B Policy Success Case

New Zealand's Ultra-Fast Broadband (UFB) initiative demonstrates how strong government legislation, public-private partnerships, and a fiber-first strategy can deliver economy-wide high-speed connectivity on time and within budget.

New Zealand's Ultra-Fast Broadband (UFB) Initiative

New Zealand's Ultra-Fast Broadband (UFB) initiative stands as an excellent model for effective execution in bridging the digital divide and delivering high-speed connectivity across an economy. Launched in 2009, this program aimed to bring fiber-to-the-premises (FTTP) to the vast majority of New Zealanders, highlighting how strategic planning, strong public-private partnerships, and disciplined project management can translate a domestic vision into a successfully deployed project.

Strong Central Government Management and Funding: The government established Crown Fibre Holdings (CFH), later renamed Crown Infrastructure Partners (CIP), as a dedicated entity to manage its significant investment and oversee the UFB rollout. The government's direct investment amounted to approximately ~ USD 1.1 billion, provided primarily as interest-free loans to partners. This investment formed part of the total project cost of over ~ USD 3.2 billion, which included co-funding from private sector partners. CFH was responsible for selecting commercial partners, managing contractual arrangements, and ensuring project milestones were met on time and within budget.

Public-Private Partnership: The UFB initiative was built on a co-investment model where the government partnered with four key commercial entities, designated as Local Fiber Companies (LFCs): Chorus, Enable Networks, Northpower Fiber, and Tuatahi First Fiber (formerly Ultrafast Fiber). These LFCs were established as wholesale-only providers, each responsible for building and operating the FTTP network in specific geographic areas. For instance, Chorus, as the largest LFC, was responsible for the majority of the UFB deployment areas across numerous cities and towns. The other LFCs covered distinct regions: Enable Networks managed the rollout in Christchurch and surrounding areas, Northpower Fiber deployed in Whangarei, and Tuatahi First Fiber covered several cities and towns across the central North Island.

Phased and Targeted Rollout: The UFB rollout was strategically phased, starting with the clear objective to connect 75% of the population by the end of 2019, a challenging goal that was successfully met ahead of schedule and under budget. This phase prioritized areas that would yield the greatest economic and social benefits initially, including businesses, schools, and health facilities, before expanding to residential areas. This targeted approach helped to manage immense logistical complexity and ensure early benefits were covered.

Focus on Fiber-to-the-Premises (FTTP): Unlike some other large-scale local broadband projects that opted for mixed technologies, New Zealand committed mainly to FTTP. While more expensive and complex to deploy upfront, this decision provided a network with superior speed and reliability, minimizing the need for costly upgrades later. The execution strategy successfully managed the challenge of laying fiber directly to premises across urban and rural environments.

Regular Audits and Reviews by Independent Bodies: The Office of the Auditor-General (OAG) for New Zealand played a critical role in providing independent assurance regarding the project's fiscal management and progress. The OAG explicitly stated that they looked at

how well Crown Fiber managed the first phase of the network, and that it was "on time and within budget." Their reports provided public accountability and verification that funds were being managed appropriately. These independent reviews helped assure the public and the government that the significant investment was delivering value for money.

Successful Completion and Impact: The entire Ultra-Fiber Broadband (UFB) rollout, with its expanded goal of reaching 87% of the population, was successfully completed in December 2022, on time and under budget. As a result, 87% of New Zealanders in 412 cities and towns gained access to the UFB fiber. The widespread high-speed connectivity has greatly impacted the economy and society.

Source: (1) Celebrating the UFB Network Completion. (2024, April). Fiber Network Council APAC. https://fibernetworkap.org/wp-content/uploads/2024/04/CIP-UFB-Completion-and-NZ-Map.pdf
(2) Ultra-Fast Broadband roll-out now complete. (2016). Ministry of Business, Innovation & Employment. https://www.mbie.govt.nz/about/news/ultra-fast-broadband-roll-out-now-complete
(3) Auditor-General's overview. (2016). Office of the Auditor-General New Zealand. https://oag.parliament.nz/2016/ufb
(4) National Infrastructure Funding and Financing . (2025, August 12). National Infrastructure Agency. https://nationalinfrastructure.govt.nz/about-us/
(5) Ultra-fast broadband (UFB - UFB2/2+) roll out. (2020, September). Chorus Service Providers. https://sp.chorus.co.nz/stories/ultra-fast-broadband-ufb-ufb22-roll-out
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(7) UFB Programme | New Zealand. (2025, March 14). National Infrastructure Funding and Financing. https://nationalinfrastructure.govt.nz/our_project/ufb-programme/

Cluster B Digital Readiness Success Case

The Republic of the Philippines' Free Wi-Fi for All and National Broadband Program illustrate how archipelagic economies can overcome geographic fragmentation through government-led investment, satellite-enabled rapid deployment, and fiber backbone expansion, bringing reliable broadband to thousands of remote islands and underserved communities.

The Republic of the Philippines' Free Wi-Fi for All and National Broadband Program

The Republic of the Philippines' Free Wi-Fi for All initiative and the National Broadband Program (NBP) represent one of the most ambitious broadband revitalization efforts across a large archipelagic economy. Launched by the Department of Information and Communications Technology (DICT), these programs directly address the challenge of connecting thousands of geographically isolated and disadvantaged areas (GIDAs) scattered across more than 7,600 islands. By combining satellite, fiber, and public-private partnerships, the initiative demonstrates how targeted government action can rapidly expand coverage, reduce digital inequality, and establish long-term local broadband capacity.

Strong Government Leadership and Investment: DICT positioned broadband as a domestic development priority, backed by substantial government funding and international partnerships. As of 2025, DICT reported more than 18,800 active free Wi-Fi sites across 9,700 locations, including over 6,100 sites in GIDAs. The government also advanced the construction

of the National Fiber Backbone, laying over 3,000 km of fiber infrastructure to strengthen middle-mile capacity and link underserved provinces to the local network.

Satellite-Enabled Rapid Deployment: Recognizing the geographical barriers of remote islands and mountain communities, DICT leveraged satellite technology to accelerate deployment. Through its partnership with Kacific and other providers, DICT executed the economy's largest satellite rollout, installing 438 VSAT sites across Northern Luzon in just 30 days. This rapid deployment model ensured that even the most remote communities could immediately access broadband services while waiting for terrestrial fiber to arrive.

Phased rollout with Clear Priorities: The initiative's success stemmed from strong partnerships between government, satellite operators, and local providers, which reduced costs and accelerated rollout. By prioritizing high-impact sites such as schools, health centers, and government offices in underserved islands, the program quickly delivered visible social and economic benefits. As a result, 92% of users could reliably connect to the internet.

Source: (1) The Philippines: Connectivity and Digital Skills for Inclusive Growth. (2025, July). OpenGov Asia. https://opengovasia.com/the-philippines-connectivity-and-digital-skills-for-inclusive-growth/?c=th
(2) Perez, N. (2025, April 16). Free Public Internet Program Reaches New Milestone with 17,966 Sites Activated. Free Wi-Fi for All. https://freepublicwifi.gov.ph/free-public-internet-program-reaches-new-milestone-with-17966-sites-activated/
(3) DICT-UNDP CoRe FW4A Project Launches 900 Free Wi-Fi Access Points in Public Health Facilities, IP communities, and GIDA sites nationwide. (2024). UNDP. https://www.undp.org/philippines/press-releases/dict-undp-core-fw4a-project-launches-900-free-wi-fi-access-points-public-health-facilities-ip-communities-and-gida-sites
(4) 19K free WiFi sites, 3K km. fiber laid under nat'l broadband program. (2025, June). Philippine News Agency. https://www.pna.gov.ph/articles/1252281
(5) Department of Information and Communications Technology Final Report . (2023). Philippine Statistical Research and Training Institute . https://ictstatistics.dict.gov.ph/wp-content/uploads/2023/06/Pipol-Konek-Technical-Report.pdf

3.4.3 Cluster C: Economies with Mountainous / Dense Forest Landscape

Cluster C includes APEC members (Brunei Darussalam; Chile; Republic of Korea; Malaysia; Mexico; Peru; Thailand; and Viet Nam) where rugged mountains and dense forests make broadband rollout especially difficult. These environments raise costs for backbone construction and slow last-mile access, often leaving rural and highland communities underserved. Despite these obstacles, success cases in this cluster, such as Korea's fiber-to-the-home expansion, Viet Nam's accelerated broadband penetration, and international partnerships supporting Papua New Guinea's digital readiness, show how tailored policies, infrastructure strategies, and capacity-building can overcome terrain-driven barriers.

Cluster C Technology Success Case

Republic of Korea's last mile strategy highlights how dense, urbanized economies can achieve near-universal fiber-to-the-home by combining large-scale fiber investment, government programs like KII and Cyber Korea 21, and strong retail competition that keeps broadband both fast and affordable.

Republic of Korea's Last Mile Success

Republic of Korea is globally recognized as a pioneer and leader in high-speed broadband, particularly for its success in deploying and achieving widespread adoption of Fiber-to-the-Home/Premises. Its strategic, multi-faceted approach to the last mile has resulted in one of the highest broadband penetration rates, fastest average speeds, and most competitive markets worldwide.

Aggressive Rollout of Fiber Infrastructure: Korea has prioritized fully fiber rollout over copper unlike other economies. The large-scale fiber rollout was targeted towards homes and businesses, ensuring even densely populated areas are served with high-speed broadband.

Government's Early Vision for Broadband: Strategic initiatives since the 1990s contributed to Korea's last mile success. Programs such as KII and Cyber Korea 21 incentivized private operators to expand their fiber networks to underserved areas through tax incentives and subsidies.

Open and Competitive Broadband Market: The government has maintained a competitive environment regarding retail broadband services through fair, unrestricted access policies that prevent monopolistic players. This resulted in lower subscription costs, widespread coverage, and innovations.

Digital Ecosystems and Literacy: Korea has invested in various initiatives to promote digital literacy, digital government services, and local content online. Consequently, the internet is deeply ingrained in citizens' day-to-day lives, from public services to commerce.

Local Competitive and Innovative Landscape: Their last mile strategy has turned broadband into Korea's strategic enabler. Technology firms could thrive in Korea, including digital content and gaming. For households, affordable and widespread high-speed broadband has transformed their daily lives, making Republic of Korea one of the most digitally connected societies globally.

Source: (1) Buchholz, K. (2023, October 23). Infographic: South Korea Leads the World in Fiber Adoption. Statista Daily Data; Statista. https://www.statista.com/chart/17211/share-of-fiber-connections-in-total-fixed-broadband-subscriptions
(2) National Policies and Projects Driving Fiber Expansion in APAC. (2024, October). Telecom Review Asia. https://www.telecomreviewasia.com/news/featured-articles/4601-national-policies-and-projects-driving-fiber-expansion-in-apac
(3) Reciprocity of Government Restructuring/Policy Changes and the Convergent Environment in South Korea | Telsoc. (2016, November). Telsoc.org. https://telsoc.org/journal/ajtde-v4-n4/a74
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Cluster C Policy Success Case

Republic of Korea's local broadband strategy demonstrates how long-term state leadership can deliver near-universal high-speed access by combining USD 24 billion in early public backbone investment, phased broadband initiatives since the 1990s, and public-private partnerships that tied infrastructure rollout to affordability incentives.

Republic of Korea's Strategic Domestic Broadband Model

Republic of Korea's remarkable achievement of near-ubiquitous, ultra high-speed broadband access stems from a long-term and consistent domestic strategy that began in the mid-1990s. Their approach was characterized by strong government leadership, substantial financial incentives, a mix of public and private investment (a sophisticated Public-Private Partnership (PPP) model that evolved over time), and a focus on both supply (infrastructure) and demand (usage).

Government as the Visionary and Initial Investor (Top-Down Approach): Republic of Korea's government's success began with its proactive and strategic leadership from the very beginning, establishing a clear domestic vision and providing critical initial investments.

- Early Planning and Economy-wide Informatization: The government recognized the strategic importance of information technology early on. With the enactment of the "Framework Act on Informatization Promotion" in 1995, it institutionalized its informatization efforts. The National Information Society Agency (NIA), originally established in 1987 as the National Computerization Agency (NCA), was designated to oversee network construction and promote IT utilization. This commitment was further solidified by the Korean Information Infrastructure (KII) initiative launched in 1994.
- Public Backbone Construction: In the initial phase, the government directly invested USD 24 billion to build a domestic high-speed public backbone fiber optic network. This critical middle mile infrastructure provided a foundation that private service providers could utilize and significantly lowering their initial investment barriers to reach end users. This removed a major hurdle for private sector entry, effectively acting as an initial SOE-like investment in core infrastructure.
- Long-term Vision and Implementation: The economy's domestic broadband planning spanned over 20 years, divided into phases like Cyber Korea 21, e-Korea, and U-Korea. Each phase had specific targets for access technologies and speeds (such as from DSL to 10 Giga - Internet and 5G), ensuring continuous upgrades and pushing technological boundaries.

Strategic Public-Private Partnerships (PPP) and Private Sector Incentives:

- Blended Funding Model: The government utilized a blend of public and private capital. For instance, the informatization fund included 39% government capital, 46% private capital, and 15% other capital, demonstrating a significant role for both and a strong PPP financial model.
- Targeted Financial Support: The government provided various incentives to encourage private investment. This included significantly lowering interest rates on loans and offering interest-free loans for network construction in remote areas during the KII-P (Private) phase. High-tech companies also benefited from local tax relief for 10 years and local tax relief for 15 years. For later phases, like 5G deployment, the government offered a 3% tax credit for 5G investments, with an additional 3% for increased investment over previous years, actively encouraging mobile network operators to build out networks for their coverage obligations.
- USO with Support: As part of the privatization of Korea Telecom (KT), the government mandated that KT provide broadband access (1Mbps or higher) to all homes in villages. To offset some costs for providers reaching harder-to-reach areas, the government provided loans (USD 926 million from 2001 to 2005) through its Digital Divide

Closing Plan. Recent studies also demonstrate the success of PPP-based projects for rural broadband via fiber networks as an effective measure alongside USO.

Effective Management and Demand Stimulation:

- Competition as Driver: While government-led, Republic of Korea encouraged fierce competition among internet service providers. This competitive environment drove down prices and improved service quality, making broadband highly affordable and attractive to consumers. This demonstrates the effectiveness of market-driven (private sector) element within a government-guided framework.

As a result of these government efforts, Republic of Korea has seen some great achievements. By 2020, 96.8% of households had access to fixed broadband internet, one of the highest rates globally.

As of January 2023, the economy boasted an average fixed broadband download speed of 195.93 Mbps, consistently ranking among the fastest in the world. Republic of Korea was the first economy to launch commercial 5G services in April 2019, demonstrating its leadership in deploying innovative mobile broadband technology and achieving rapid adoption.

Republic of Korea's domestic broadband concept was not just about constructing infrastructure, but about strategically integrating government investment, regulatory incentives, and demand-side policies within a competitive market to achieve digital transformation.

Source: (1) Falch, M., & Henten, A. (2010). Public private partnerships as a tool for stimulating investments in broadband. *Telecommunications Policy*, *34*(9), 496–504. https://doi.org/10.1016/j.telpol.2010.07.010
(2) Cho Mu-Hyun. (2018, March 19). South Korea to fund 10Gb internet push. ZDNET. https://www.zdnet.com/article/south-korea-to-fund-10gb-internet-push/
(3) Yajun, L. (n.d.). *Government Is Indispensable for National Informatization and Broadbandization Government Is Indispensable for National Informatization and Broadbandization*. Retrieved September 19, 2025, from https://carrier.huawei.com/~/media/CNBG/Downloads/Spotlight/national-broadband-network/Government%20is%20indispensable%20for%20national%20informatization%20and%20broadbandization.pdf
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(6) *Overview ITIF Rank: 1 Subscribers per Household 1, Appendix F: South Korea*. The Information Technology and Innovation Foundation (ITIF). Retrieved September 19, 2025, from https://d1bcsfjk95uj19.cloudfront.net/files/2008BBAppendixF.pdf

Cluster C Digital Readiness Success Case

Some APEC economies, particularly those where broadband deployment and digital adoption remain at earlier stages, have advanced with the support of international development partners. Limited fiscal resources and low commercial incentives have made external assistance valuable, with organizations such as the World Bank and the Asian Development Bank (ADB) helping to establish domestic broadband strategies, liberalize telecommunications markets, and fund the deployment of critical first-mile and middle-mile infrastructure in less commercially viable areas. Complementing these efforts, UN-affiliated programs have emphasized digital skills, inclusive digital services (such as e-health and e-learning platforms), and local capacity-

building for network maintenance and governance. In some cases, these initiatives are reinforced by multilateral partnerships involving advanced APEC economies, which contribute financing, expertise, and technology transfer to support their lower-income counterparts.

Papua New Guinea illustrates how digital readiness can advance even in resource-constrained, geographically challenging contexts. Initiatives such as the EU-STREIT program, the Australia-backed Coral Sea Cable, and ITU's Digital Transformation Centers combine infrastructure investment, skills training, and institutional support to ensure broadband adoption translates into meaningful inclusion.

Multiple Economies' Efforts on Papua New Guinea Broadband Improvement

Papua New Guinea (PNG) demonstrates how international organizations and development partners can play a pivotal role in advancing digital readiness in economies with limited resources and difficult geography. The success of these initiatives comes from their ability to combine infrastructure investment with skills development, institutional strengthening, and community-based approaches that ensure connectivity translates into meaningful digital use.

Leveraging Digital Tools for Economic Empowerment: The EU-STREIT PNG program, jointly implemented by multiple UN agencies, highlights how digital readiness can be built by embedding technology into local economic priorities. Although its main goal is agricultural development, the program integrates digital tools for financial inclusion, e-commerce, and value-chain improvement for smallholder farmers. This approach made digital adoption directly relevant to livelihoods, ensuring strong local uptake.

Infrastructure Plus Institutional Support from Australia: Australia's contribution to PNG's digital transformation shows the importance of pairing infrastructure with governance and capacity-building. By co-financing the Coral Sea Cable System, Australia increased PNG's international bandwidth nearly 1,000-fold. But equally important was its Official Development Assistance (ODA), which supported digital government reforms, cybersecurity frameworks, and digital service delivery to marginalized groups. This dual focus ensured that infrastructure gains were reinforced by strong institutions and human capital.

Grassroots Capacity-Building through ITU and Partners: The Digital Transformation Centers Initiative (ITU, Cisco, PNG University of Technology, and RMIT) addressed PNG's shortage of ICT skills through a train-the-trainers model. Local instructors were equipped with essential digital literacy and cybersecurity skills, then tasked with cascading this knowledge across rural communities. This community-driven multiplier effect built a sustainable pool of local digital educators, ensuring long-term resilience and reducing dependency on external experts.

Collectively, these international collaborations illustrate a comprehensive approach to broadband development in PNG. Rather than focusing solely on infrastructure deployment, these initiatives aim to create an enabling environment where broadband access translates into meaningful digital participation. They promote economic empowerment through digital entrepreneurship, improve access to essential services like e-health and e-education, and help build the digital resilience of PNG's institutions and communities. This approach acknowledges that in contexts like PNG, where literacy rates, affordability, and infrastructure gaps remain serious challenges. Achieving digital inclusion requires coordinated efforts across infrastructure, skills development, regulatory reform, and community empowerment.

Source: (1) ADB Approves $25 Million Cornerstone Investment to Improve Telecom Services in PNG. (2020, September 3). Asian Development Bank. https://www.adb.org/news/adb-approves-25-million-cornerstone-investment-improve-telecom-services-png
(2) Aid Investment Plan Papua New Guinea. (2015). Australian Government. https://www.dfat.gov.au/sites/default/files/papua-new-guinea-aid-investment-plan-2015-18.pdf
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3.4.4 Cluster D: Urban/Compact Economies

APEC's Cluster D economies (Hong Kong, China; Singapore; and Chinese Taipei) demonstrate how compact urban settings can enable digital success. Their achievements from Singapore's first-mile connectivity and regulatory model, Hong Kong, China's dense broadband adoption, and Chinese Taipei's alternative connectivity strategies, show how urban advantages can be maximized through targeted policies and technologies.

Cluster D Technology Success Case

Singapore exemplifies how compact economies can lead in technology by building one of the world's densest submarine cable networks, resilient internet exchanges, and advanced data center ecosystems to secure global first-mile connectivity.

Singapore's First Mile Success

Singapore's leading position as a global digital hub is largely attributed to its strategic first mile connectivity. This encompasses the critical infrastructure that links the economy to the global internet backbone, primarily through submarine cable systems and international internet exchange points. Singapore's success in this area is a testament to its forward-thinking government policies, strategic investments, and unique geographical advantages, often leveraging its small size as an asset.

Strategic Geographical Location: Singapore is situated at the crossroads of major international shipping and aviation routes in Southeast Asia, allowing it to be the hub for global data traffic. Its location positions it as a gateway to the Asia-Pacific region, making it an ideal interconnection point for data flowing between East Asia, South Asia, Europe, and the Americas.

Extensive and Resilient Submarine Cable Network: Singapore is one of the most connected economies globally in terms of submarine cable systems, serving as a major submarine cable landing hub with numerous international subsea cables terminating at its shores. As of June 2023, Singapore had twenty-six submarine cables landed across three designated landing sites with plans to double this capacity and add three new landing sites over the next decade to further enhance resilience and capacity for future demands. A vast and redundant network of cables provides enormous bandwidth, ensuring high capacity, diverse routes, and resilience against potential cable faults, thus minimizing disruptions to international connectivity.

Thriving Internet Exchange Points (IXPs) and Data Center Ecosystem: Singapore hosts key internet exchange points like the Singapore Internet Exchange (SGIX), which facilitate efficient and cost-effective traffic exchange among local and international carriers, internet service providers, and content providers. SGIX, established by IMDA, plays a crucial role in strengthening Singapore's position as an infocomm hub by encouraging international carriers

to locate in Singapore. This environment has fostered a dense ecosystem of world-class data centers, attracting global corporations, cloud service providers, and content delivery networks to host infrastructure and content in Singapore.

Proactive Government Policy and Investment: The government, with agencies like IMDA, has consistently adopted a proactive and forward-looking approach to digital infrastructure. It has made strategic investments to cater to demand, recognizing the fundamental role of digital connectivity in the growth of digital economy. The Digital Connectivity Blueprint, initiated in 2023, outlines ambitious plans to further strengthen international connectivity, including doubling subsea cable landing capacity and enhancing domestic network speeds.

Source: (1) Subsea Cable Installation | Subsea Cable Laying Services. (2025). Apollo Engineering. https://apollo.engineer/subsea-cable-installation/
(2) S Runde, D. F., Murphy, E. L., & Bryja, T. (2024, August). Safeguarding Subsea Cables: Protecting Cyber Infrastructure amid Great Power Competition. Center for Strategic and International Studies. https://www.csis.org/analysis/safeguarding-subsea-cables-protecting-cyber-infrastructure-amid-great-power-competition
(3) Sherman, J. (2021, September 13). Cyber defense across the ocean floor: The geopolitics of submarine cable security. Atlantic Council. https://www.atlanticcouncil.org/in-depth-research-reports/report/cyber-defense-across-the-ocean-floor-the-geopolitics-of-submarine-cable-security/
(4) Unlocking Global Markets: How Singapore's Strategic Location Fuels Business, Paul Hype, February 2025, https://www.paulhypepage.com/unlocking-global-markets-how-singapores-strategic-location-fuels-business/
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(7) Judge, P. (2023, June 8). Singapore plans to double submarine cable capacity. Data Center Dynamics. https://www.datacenterdynamics.com/en/news/singapore-plans-to-double-submarine-cable-capacity/

Cluster D Policy Success Case

Singapore's NGNBN, completed in 2012, shows how enforcing structural separation and strict open-access rules can transform broadband into a neutral utility, driving competition, lowering prices, and sustaining one of the fastest fixed networks worldwide.

Singapore's Next Generation Nationwide Broadband Network Regulatory Framework

Singapore stands as a leading example of how a visionary regulatory framework can successfully drive the development of a competitive and innovative local broadband network. Recognizing the critical role of expansive high-speed connectivity for its economy, Singapore implemented a bold regulatory model for its Next Generation Nationwide Broadband Network completed in 2012. This framework was primarily spearheaded by the Infocomm Development Authority (IDA) and later by the Info-communications Media Development Authority (IMDA). It was designed to fundamentally change market dynamics, ensuring unrestricted access, fostering fierce competition among service providers, ultimately benefiting end consumers and businesses with quality and affordable services.

Mandatory Structural Separation: At the core of Singapore's strategy was the initiation of structural separation on the NGNBN. This created a three-layered industry structure to eliminate any incentive for the network owner to discriminate against retail competitors.

- NetCo (Network Company): This layer owns and manages the fiber infrastructure. OpenNet (later acquired by Netlink Trust) was initially appointed as the NetCo. It is prohibited from offering retail services or active wholesale services. This ensures that the fundamental infrastructure is a neutral utility.
- OpCo (Operating Company): This layer provides active wholesale services over NetCo's fiber to retail service providers. Nucleus Connect was selected as the OpCo. While operating separately, OpCos could affiliate with retail players, but under non-discrimination rules.
- RSPs (Retail Service Providers): These companies lease services from the OpCo and offer a wide range of broadband services directly to end users.

This structural separation levels the playing field, ensuring that all RSPs, regardless of their size or whether they had legacy infrastructure, have non-discriminatory access to high-speed fiber network.

Effective Open Access Mandates: Complementing structural separation, IMDA enforced stringent effective unrestricted access regulations. This included:

- Non-discriminatory access: NetCo and OpCo were mandated to provide their services to all RSPs on equal terms, conditions, and prices. This prevented bottleneck issues and ensured new entrants could compete fairly.
- Standard interconnection offers: IDA/IMDA prescribed detailed interconnection offers, setting out the terms and conditions, and pricing for wholesale services. This reduced transaction costs for RSPs and provided regulatory standards.
- Quality of service standards: Strict QoS standards were imposed on wholesale providers to ensure reliability and performance, with regular monitoring and enforcement by IMDA. For instance, ISPs must maintain at least 99.9% network availability each month.

Proactive Regulatory Role of IDA/IMDA:
The regulator played an active and facilitative role:

- Policy formulation: IDA/IMDA formulated comprehensive competition codes, such as Telecom and Media Competition Code), that included ex-ante obligations and ex-post provision to manage market conduct and prevent anti-competitive practices.
- Procurement process: The government managed a competitive RFP process to select the NetCo and OpCo, ensuring cost-effectiveness and alignment with unrestricted access principles from the beginning.
- Dispute resolution: IMDA acted as an independent entity for disputes between different layers of the NGNBN ecosystem.
- Forward-looking policy: The regulator continuously reviewed and updated policies to adapt to technological advancements and market evolution, often investing to ensure future readiness.

Incentives for Innovation and Investment: The regulatory framework, combined with government support, stimulated innovation at the services layer:

- Service-based competition: By removing the burden of infrastructure ownership, RSPs were free to focus on developing innovative services, competitive pricing plans, and superior customer experiences.
- Government grants and programs: IDA/IMDA launched initiatives like the Next Generation Services Innovation Program (NGSIP) and facilitated Next Generation Innovation Centers (NGICs). These programs provided funding opportunities for RSPs

and application developers to create new products and business models using high-speed network.
- Affordable access: The competitive environment led to highly affordable broadband prices for end users, encouraging widespread adoption and further stimulating demand for services. Singapore currently has some of the fastest fixed broadband speeds globally.

Source: (1) OpenNet consortium has been selected as NetCo. (2008, September). Singtel. https://www.singtel.com/about-us/media-centre/news-releases/opennet-consortium-has-been-selected-netco
(2) Marcin Frąckiewicz. (2025b, May 15). Internet Access in Singapore: A Comprehensive Overview. TS2 Space. https://ts2.tech/en/internet-access-in-singapore-a-comprehensive-overview/
(3) Nationwide Broadband Network. (2023, December). Infocomm Media Development Authority. https://www.imda.gov.sg/regulations-and-licensing-listing/nationwide-broadband-network
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Cluster D Digital Readiness Success Case

Chinese Taipei's digital readiness success lies in its proactive diversification of connectivity leveraging satellites, HAPS, roaming protocols, and microwave systems to build resilience against frequent undersea cable disruptions.

Chinese Taipei's Alternative Connectivity Strategies

With a clear understanding of the need for genuinely independent and alternative communication pathways, Chinese Taipei has emerged as a leading example in strategically developing solutions that go beyond traditional network restoration. Utilizing its unique geographical challenges, Chinese Taipei is proactively investing in diverse technologies and protocols to ensure digital resilience.

Satellite Communications for Redundancy: With its vulnerability of undersea cables, which are critical for international connectivity and susceptible to natural disasters or damages, Chinese Taipei is making significant investments in satellite internet. The Ministry of Digital Affairs (MoDA) is driving a digital resilience enhancement program that includes establishing a satellite internet network as an essential backup. MoDA aimed to set up 700 satellite communication hotspots across the economy by 2024. The approach involves two parts:
- Partnerships with international satellite operators: MoDA is working with commercial Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellite constellations. For example, drills have been simulated switching to MEO satellite networks to maintain communication between major cities like Taipei and Kaohsiung during fiber optic disruptions. Chunghwa Telecom, a key player, is investing in acquiring a franchise for OneWeb (a LEO satellite operator) and plans to apply for licenses to provide LEO satellite services.
- Indigenous Satellite Development: Chinese Taipei also plans to develop its own B5G (beyond fifth generation) communication satellite under its National Space Technology Long-Term Development Program, aiming for an independent satellite communication system ready for testing by 2028. This domestic capability would reduce reliance on international providers.

In recent events, such as the April 2024 Hualien earthquake, MoDA dispatched seven trucks equipped with LEO and MEO satellite links to facilitate mobile communications among rescuers and residents, demonstrating the practical application and effectiveness of this alternative connectivity in affected areas. Plans are also ongoing to upgrade existing mobile service trucks to enable non-stationary satellite connectivity.

High-Altitude Platform Stations (HAPS): Beyond satellites in orbit, Chinese Taipei is actively developing and testing High-Altitude Platform Stations (HAPS), typically utilizing balloons or drones, as a localized alternative for connection. The Telecom Technology Center (TTC), under the guidance of MoDA, has highlighted a high-altitude communication platform using hydrogen fuel cells that can remain airborne for over 14 days at an altitude of 800 meters, providing network coverage with a radius of eleven kilometers. This technology is designed to restore signals in impacted areas even if ground communication facilities are damaged and can be used to bridge the digital divide in remote areas.

Cross-Network Roaming for Immediate Redundancy: Chinese Taipei has implemented disaster roaming capabilities, allowing users to automatically switch to any operational base station of another carrier if their primary network becomes inaccessible during an emergency or disaster. In September 2023, MoDA conducted the first drill, testing whether the three main wireless carriers (Chunghwa Telecom, FarEasTone Telecommunications, and Taiwan Mobile) could identify each other's customers and support VoIP communication across networks. A ~ USD 200 million budget has been allocated for this initiative, highlighting its strategic importance for digital resilience.

Microwave Internet Systems: For specific scenarios, particularly in outlying islands or geographically challenging underserved areas, microwave systems as a crucial alternative to undersea cables. During recent incidents, such as repeated undersea cable breaks affecting the Matsu Islands (due to factors like natural deterioration or fishing activity), Chunghwa Telecom immediately switched to microwave backup systems to maintain internet and telephone services. The system provided 12.6 Gbps of bandwidth, which significantly exceeded Matsu's usual peak traffic of 9.5 Gbps.

Source: (1) Fulco, M. (2024, February 15). Boosting Digital Infrastructure Resilience . Chinese Taipei Business TOPICS. https://topics.amcham.com.tw/2024/02/boosting-digital-infrastructure-resilience/
(2) Satellites touted in quake response. (2024, April 10). Taiwan Times. https://www.taipeitimes.com/News/taiwan/archives/2024/04/11/2003816266
(3) News - TELECOM TECHNOLOGY CENTER. (2024, October). News - TELECOM TECHNOLOGY CENTER. https://www.ttc.org.tw/eng/News/more?id=d1d05e3dfa2749b2a90737cf7932f9ae
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(5) Chinese Taipei tests disaster roaming capabilities for first time | Taiwan News | Sep. 22, 2023 10:42. (2023, September 22). Taiwan News. https://taiwannews.com.tw/news/5005306
(6) Backups used as cables to Matsu fail. (2025, January 22). Taipei Times. https://www.taipeitimes.com/News/front/archives/2025/01/23/2003830680
(7) Kaczmarek, M. (2025, June 29). Chinese Taipei's Internet Access – Fiber Power, 5G Expansion, and Satellite Horizons. Tech Space 2.0. https://ts2.tech/en/taiwans-internet-access-fiber-power-5g-expansion-and-satellite-horizons/

3.4.5 Conclusion

This chapter provided a comprehensive view of the key enablers for broadband development and analyzed the challenges that economies face in turning these enablers into effective outcomes. Three dimensions emerged as decisive: technology, policy, and digital inclusion.

From a technology perspective, the study confirmed that broadband deployment in underserved areas is constrained by the high cost and complexity of establishing first-, middle-, and last-mile infrastructure. The first mile faces challenges such as large upfront investments for subsea cables, environmental and geopolitical risks, and lengthy regulatory approvals. Middle-mile networks must cover vast, low-density areas or cross challenging terrain, requiring substantial backbone investment and better redundancy to avoid outages. The last mile remains the most expensive part of the network, demanding innovative, cost-efficient solutions such as hybrid fiber-wireless deployments and, where necessary, satellite access. The success case of Australia's NBN shows that a mix of technologies, combined with an open-access wholesale model, can achieve economy-wide reach even in a sparsely populated, large landmass economy.

The policy dimension plays a critical role in providing the right market conditions and incentives. The chapter highlighted the importance of clearly defined domestic broadband concepts, effective governance, and regulatory frameworks that encourage competition and investment. Challenges such as bureaucratic delays, inter-agency coordination gaps, and weak monitoring mechanisms often slow progress. Economies like Korea demonstrated how a phased, long-term local broadband plan backed by public investment and private participation can achieve near-universal fiber coverage and lead to global 5G adoption. These examples confirm that well-structured policies and strong regulatory oversight are key levers for broadband expansion.

The third enabler, digital inclusion, reminded us that connectivity is only meaningful if people can afford and know how to use it. Low adoption in some areas is driven more by socio-economic barriers than by lack of infrastructure. Successful initiatives like in Papua New Guinea show that combining infrastructure rollout with digital literacy programs, community internet centers, and affordability schemes leads to higher uptake and more equitable outcomes. This dimension is therefore best analyzed by differentiating between developed and developing economies rather than by geography.

A major result of this chapter is that while the enabler challenges are universal, their intensity and impact differ depending on economic, geographic, and social context. The success cases discussed illustrate that there is no "one-size-fits-all" solution, but there are transferable models - such as open-access infrastructure, PPPs, and resilience strategies - that can inspire other economies facing similar barriers.

Achieving universal and meaningful broadband access requires a coordinated approach that addresses technology, policy, and inclusion simultaneously. Infrastructure investment must be paired with strong governance and with programs that enable adoption and trust in digital services.

Building on these findings and real-world success stories, the next chapter moves from analysis to practical solutions. Chapter 4 outlines strategic options, policy-service models, and a KPI-

based implementation toolkit that helps economies translate these lessons into action and accelerate broadband vitalization in underserved areas.

4. PROPOSAL FOR BROADBAND VITALIZATION BY CLUSTER TYPE OF BROADBAND UNDERSERVED AREAS

4.1 INTRODUCTION: STRATEGIC FRAMEWORK FOR TAILORED BROADBAND VITALIZATION

Building on the analytical foundation of the previous chapter, this section shifts from understanding the challenges to designing practical solutions. Rather than describing why connectivity gaps persist, Chapter 4 focuses on how they can be closed through structured strategies, clear governance models, and measurable outcomes.

The chapter introduces a Policy-Service Model that serves as a blueprint for decision-makers to design targeted interventions. It links technology choices, policy instruments, and inclusion measures into a single, integrated framework that ensures that infrastructure expansion is matched by effective adoption and long-term sustainability.

A key feature of this chapter is its cluster-specific approach, which tailors strategies to the different conditions found across APEC economies - from large landmass areas to archipelagic, mountainous, and urban settings. By aligning policies, financing mechanisms, and technology solutions with geographic and economic realities, the proposed strategies aim to maximize impact and cost-effectiveness.

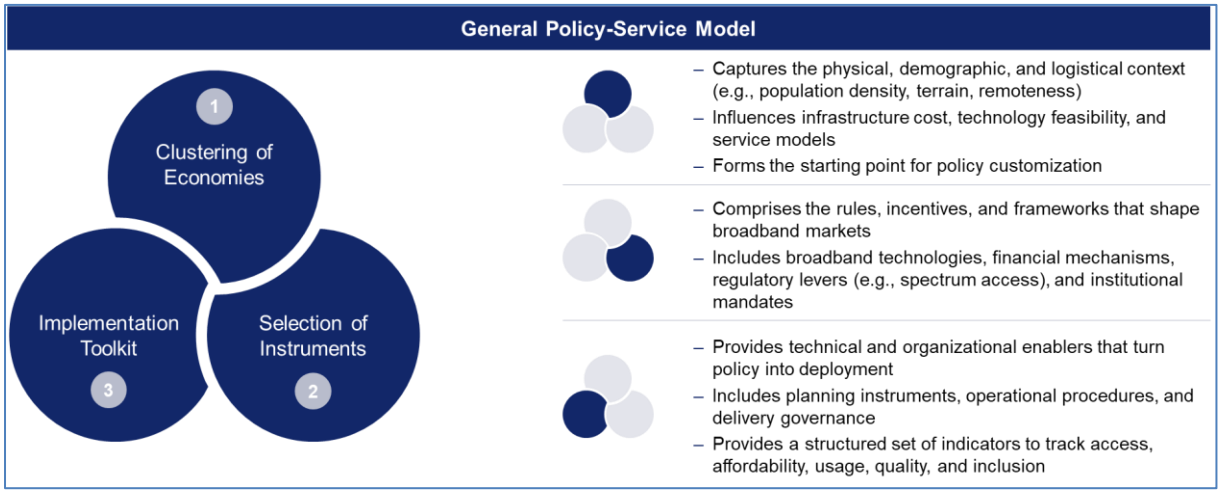
This approach allows policymakers to benchmark progress, ensure accountability, and adjust measures over time so that investments yield equitable, high-quality broadband access for everyone. The chapter begins by outlining a general Policy-Service Model that policymakers can use as a blueprint for designing interventions (Section 4.2). The chapter then details an integrated strategy that combines policy instruments, technology tools, and digital inclusion measures in a cohesive manner (Section 4.3), ensuring that supply-side infrastructure expansion goes hand-in-hand with demand-side adoption. Next, this integrated framework is applied in tailored strategies for each underserved area cluster (Section 4.4), with concrete proposals suited to the geographic and economic realities of each cluster type. The chapter then proposes a Policy-Service Model Implementation Toolkit (Section 4.5), including a decision-making framework from readiness assessment to funding model, and a Key Performance Indicator (KPI) -based monitoring and evaluation framework to guide execution and track progress. The chapter concludes with summary and recommendations (Section 4.6), synthesizing key findings and actionable recommendations.

4.2 GENERAL POLICY-SERVICE MODEL FOR SUSTAINABLE BROADBAND

Successful broadband extension in various settings needs a Policy-Service Model with complementary technological solutions, facilitative policies, and service enablers on the ground. The underlying assumption is that all underserved locations are not equal - a highland village is different from a sprawling desert settlement or a city slum. Hence, differing by location type and integrating the fundamental pillars of technology, policy, and inclusion, the model stresses differentiation and integration. We set out the model's pillars and foundations below:

- **Clustering of Areas/Economies:** Policymakers first cluster economies or regions by shared physical and structural characteristics, for example, huge landmasses, island archipelagos, mountainous or forested terrains, or densely populated city-states. Within each cluster, a further classification distinguishes developed vs. developing contexts and assesses the state of broadband supply (technology-driven factors) and demand (economic and social factors). This two-layer approach ensures strategies consider both the broad cluster type and each economy's specific market maturity and infrastructure conditions. The methodology accounts for remoteness, terrain difficulty, population density, and economic conditions - variables that directly influence deployment costs, infrastructure viability, and business models. As part of tailoring, policymakers should diagnose the precise gaps or market failures in each context. For example, in remote rural areas, the combination of excessive costs and low potential revenues may deter private investment, indicating a supply-side gap that necessitates public funding or subsidies. In crowded low-income urban areas, basic infrastructure might exist, but many residents cannot afford devices or monthly plans - an affordability gap requiring demand-side interventions (subsidies, community networks, etc.). By starting with a clear-eyed analysis of each economy's situation, policymakers can avoid "blanket" solutions and instead implement practical, context-sensitive broadband plans. Clustering underserved areas in this way allows governments to apply the appropriate policy tools where they will do the greatest good.

Figure 4.1 Pillars of General Policy-service Model



- **Selection of Instruments (Technology, Policy, and Services)**: For each clustered context, the model calls for selecting a mix of supply-side and demand-side instruments spanning technology, policy, and services. On the technological side, this means choosing infrastructure solutions that are scalable and resilient for the given area (e.g., fiber backbones where feasible vs. satellite or wireless in extremely remote regions) and optimizing technical designs (such as modular network kits or spectrum strategies) for cost-effective deployment. On the policy side, governments should craft supportive regulatory and financial measures - for instance, streamlined permits and rights-of-way, incentives for rural investment, open-access rules for shared infrastructure, and public-private partnership frameworks - to lower barriers and encourage investment. Policy measures also include aligning public funding with impact through data-driven or performance-based subsidies, so that funds flow to areas of greatest need or to projects that meet defined targets. The service instruments refer to programs that drive adoption

and inclusion: for example, bundling broadband rollout with e-government services or community Wi-Fi, promoting digital literacy and local content to stimulate usage, and implementing affordability schemes (subsidies, vouchers) for low-income users. The core idea is that infrastructure alone is not enough. True success requires that people can access and meaningfully use connectivity. By selecting a balanced set of technology, policy, and inclusion instruments, policymakers create synergies (for instance, deploying a new rural fiber link combined with subsidized internet access at schools and a digital skills program will yield far greater impact than the network alone).

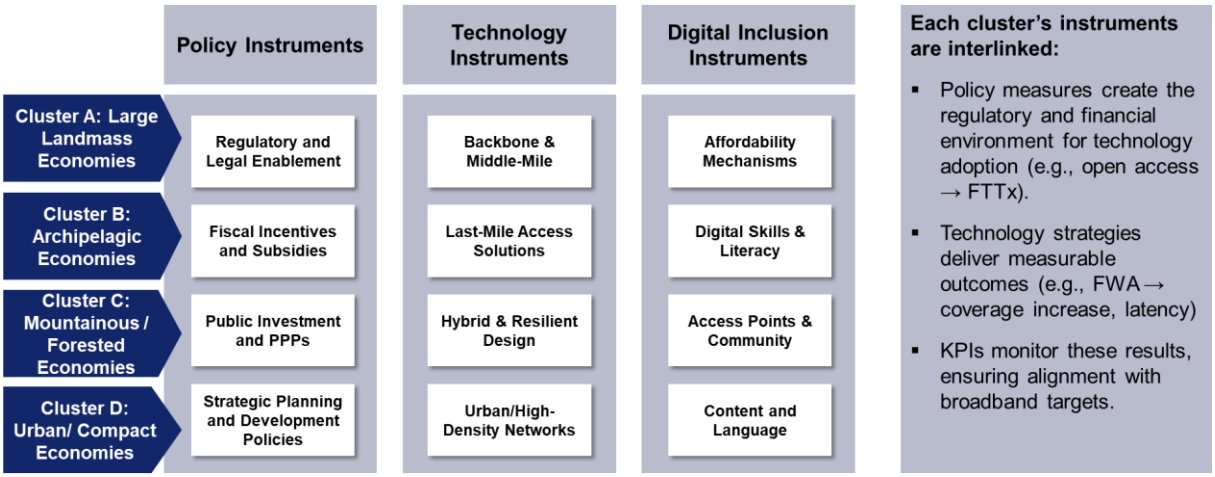
- **Implementation Toolkit (Decision and Monitoring):** Even well-chosen instruments can falter without effective implementation. Thus, the third pillar of the model is an implementation toolkit that provides the *"how"*- guiding policymakers through execution and ensuring accountability. This toolkit includes planning and operational instruments (such as Geographic Information System (GIS) mapping tools, standardized procedures for project rollout, templates for public-private contracts, etc.) that turn policy ideas into on-the-ground projects. It also incorporates an institutional governance strategy - for instance, defining which agency leads the effort, how inter-agency coordination is managed, and how private and community stakeholders are engaged in delivery. Crucially, the toolkit features a monitoring and evaluation framework with a structured set of Key Performance Indicators (KPIs) to track outcomes. This allows continuous tracking of progress on access, affordability, usage, quality, and socio-economic impact, so that policy adjustments can be made based on evidence. (The KPI framework is detailed in a later section of this chapter.)

Importantly, the Policy-Service Model is differentiated for developed vs. developing contexts and for supply vs. demand interventions. Developed economies may focus more on demand-side measures (like stimulating uptake in the few pockets still uncovered or upgrading quality), whereas developing economies may prioritize supply-side infrastructure expansion in unserved areas. Likewise, some clusters will need heavier public investment (where market returns are too low), while others might leverage market competition if the basic policy enablers are in place. The model is flexible to these differences. It essentially provides a menu of instruments and a framework to apply them appropriately. In summary, this general model ensures that when designing broadband strategies, policymakers concurrently address the physical infrastructure, the enabling policy environment, and the end-user adoption, rather than tackling these in isolation. This integrated, context-aware approach sets the stage for the specific cluster-based proposals that follow.

4.3 INTEGRATED STRATEGY APPROACH: COMBINING POLICY, TECHNOLOGY, AND INCLUSION

Effective broadband expansion in underserved areas requires an integrated approach that unites the technical rollout with enabling policies and inclusive practices. Rather than treating these as separate workstreams, the approach emphasizes their convergence: policy and regulatory measures create the conditions for infrastructure deployment; technology solutions deliver connectivity on the ground; and digital inclusion initiatives ensure that connectivity translates into actual socio-economic benefits. All three components must work in concert for broadband vitalization to be sustainable.

Figure 4.2 Policy, Technology and Digital Inclusions Instruments



Policy Instruments: A robust policy framework is the backbone that supports all other efforts. Key policy instruments include:

- *Regulatory and Legal Enablement:* Adopting laws/regulations that lower barriers to broadband deployment. For example, implementing unrestricted access policies for critical infrastructure (so that multiple service providers can use shared fiber backbones or submarine cable landing stations) is vital for large, capital-intensive networks. Open access regimes encourage competition and avoid duplication, particularly important in high-cost rural and remote areas. Streamlined permits and rights-of-way for laying fiber or building towers also fall under this category, as do policies that facilitate spectrum access for wireless broadband (e.g., affordable rural spectrum licensing or unlicensed spectrum for community networks).

- *Fiscal Incentives and Subsidies:* Governments can offer targeted financial incentives to entice investment in underserved areas. This includes subsidies or viability gap funding for network rollout in areas that are not commercially viable on their own, as well as tax credits, reduced license fees, or low-interest loan programs for operators expanding coverage. For instance, Republic of Korea provided extensive incentives (tax relief, concessional financing) to operators for rural broadband build-out, which was instrumental in achieving economy-widefiber coverage. Another example is direct subsidy of backbone infrastructure in sparsely populated zones - effectively treating rural broadband as a public good. Many APEC economies use universal service funds (USF) to channel such subsidies; the integrated strategy ensures USF programs are aligned with broader plans and focused on the most underserved clusters (e.g., remote villages, outer islands). Demand-side subsidies are also relevant, such as broadband voucher programs for low-income households or device subsidies, which are tied into inclusion goals.

- *Public Investment and PPPs:* Public–Private Partnerships (PPPs) are a key mechanism for expanding broadband access in areas where private investment alone is insufficient. They represent a structured collaboration in which governments and private operators share risks, responsibilities, and resources to achieve connectivity outcomes that neither side could efficiently deliver on its own. In broadband, PPPs can take different forms depending on domestic priorities, institutional capacity, and market maturity.

At their core, PPPs balance two objectives: ensuring long-term financial sustainability and safeguarding public interest. Governments contribute through financial support (e.g., subsidies, tax incentives, or access to universal service funds), regulatory facilitation (e.g., streamlined permits, rights-of-way, or guaranteed demand), and in some cases co-investment. The private sector, in turn, provides technical expertise, efficiency in project execution, innovation in service delivery, and ongoing network operations.

Well-designed PPPs also help optimize the use of scarce public resources. Instead of fully funding infrastructure projects, governments can strategically deploy limited subsidies to "crowd in" private capital and extend networks to high-cost or low-demand areas. This is particularly relevant in broadband, where deployment costs in rural or remote regions may be three to five times higher than in urban areas. PPPs allow such costs to be shared, making large-scale connectivity projects feasible without placing the entire financial burden on either the public or private side.

Critically, PPPs should be guided by principles of transparency, competitive procurement, and accountability. Successful models include clear service-level obligations, measurable coverage and quality targets, and independent monitoring mechanisms to ensure that public funds are used efficiently. Without these safeguards, PPPs risk becoming subsidies without results, or locking governments into long-term contracts with limited flexibility.

International experience shows that PPPs are highly adaptable. They can range from small-scale local access initiatives - such as municipalities partnering with ISPs for community Wi-Fi - to domestic backbone projects where governments provide capital subsidies, while private partners build, operate, and maintain the infrastructure under availability-payment schemes. Development banks and multilateral agencies increasingly support PPP models in the digital sector, recognizing their potential to combine efficiency, innovation, and inclusivity.

In sum, PPPs are not a one-size-fits-all solution but rather a versatile instrument that, when professionally designed, can bridge the investment gap, accelerate broadband deployment, and ensure long-term sustainability of services. Within an integrated broadband strategy, PPPs complement other instruments - technology, policy, and inclusion measures -by aligning incentives between the public and private sectors toward the shared goal of universal connectivity.

- *Strategic Planning and Coordination:* Policies must also ensure strong institutional coordination and planning. This involves establishing a clear local broadband plan (or "digital connectivity strategy") as noted in Chapter 3 and setting up effective governance structures such as an inter-agency broadband task force or a dedicated implementation agency. Strategic planning might designate priority zones (e.g., identifying clusters of villages or islands for connectivity focus over the next five years) and coordinate complementary efforts like electrification, fiber deployment, and community training in those areas simultaneously. It also includes planning for network resilience, mandating climate-resilient designs and emergency restoration procedures, which are especially relevant for disaster-prone mountainous or island regions. Overall, the policy instrument set creates an enabling environment for technology deployment and ensures investments are channeled in a goal-oriented, equitable way.

Technology Tools: On the supply side, the approach tailors technology choices to the geography and needs of each underserved cluster:

- *Backbone and Middle-Mile Solutions:* Extending high-capacity backbone networks into underserved regions is often the toughest challenge. The approach advocates innovative backbone solutions that leverage non-traditional infrastructure and multi-technology combinations. For example, in large landmass economies, using existing utility infrastructure (power transmission lines, railway corridors) to lay fiber can reduce costs and accelerate deployment. Some economies have successfully implemented "fiber along the rails" or along electricity grids to reach remote towns. In archipelagic settings, submarine fiber-optic cables form the backbone connecting main islands, but for smaller or widely scattered islands a mix of satellite links and microwave relays may serve as the middle-mile. For instance, Papua New Guinea and other Pacific economies increasingly rely on satellite backhaul to connect islands lacking undersea cables. The Coral Sea Cable (completed 2019) now links Papua New Guinea and Solomon Islands to Australia. According to World Bank research, enhanced internet access and connectivity could generate over USD 5 billion in additional GDP and create nearly 300,000 new jobs across the Pacific by 2040[80]. Newer low-Earth orbit (LEO) satellites with lower latency can also play a role in archipelagos and deep rural interiors (use cases are discussed in cluster sections). The toolkit also includes establishing regional network hubs - such as local Internet exchange points or data centers in provincial cities - to improve traffic flow and cache content closer to users, which is especially beneficial in large economies (reducing dependence on long-haul or international links).
- *Last-Mile Access Solutions:* The last-mile requires choosing the right access technology for each context. In dense urban or town centers (even within underserved clusters), fiber-to-the-home or 5G mobile networks may be viable. But in sparsely populated rural and remote areas, Fixed Wireless Access (FWA) and satellite connectivity are often the most practical. The integrated approach promotes "hybrid" last-mile solutions. For example, FWA networks (4G/5G or Wi-Fi) can beam internet from a village base station to households over several kilometers, significantly cheaper and faster to deploy than running fiber to each home. Governments can facilitate this by providing or subsidizing standardized FWA kits (towers, antennas, solar power units) for use by local Internet Service Providers (ISPs) or communities. In extremely remote settlements - deep in forests, high in the mountains, or isolated by water - community Very-small-aperture terminal (VSAT) terminals (satellite dishes) may be the only immediate option; these can provide a village Wi-Fi hotspot or connect key institutions (schools, clinics) as an interim solution. Notably, the Philippines recently deployed 438 satellite VSAT sites in geographically isolated areas, delivering 10–30 Mbps links to communities as part of its National Broadband Plan.[81] Such examples show that multi-pronged last-mile approaches (fiber where feasible, wireless and satellite elsewhere) can collectively push connectivity outward. Additionally, network design should emphasize resilience and redundancy - e.g., using ring topologies or backup links for vulnerable stretches - so that service is not easily knocked out by single points of failure (like a fiber cut in a remote valley).

[80] *Coral Sea Cable System*. (n.d.). Coral Sea Cable Company. https://coralseacablecompany.com/the-system
[81] Onag, G. (2023). *Southeast Asia looks to satellite Internet to bridge digital divide*. Lightreading.com. https://www.lightreading.com/satellite/southeast-asia-looks-to-satellite-internet-to-bridge-digital-divide divide

- *Emerging Technologies and Innovations:* The approach also keeps an eye on emerging solutions that could be game changers for underserved areas. This includes High-Altitude Platforms (HAPS) - essentially communications payloads on balloons or drones in the stratosphere, which can blanket remote areas with signal (some APEC members are testing these). Community mesh networks that auto-connect via long-range Wi-Fi or TV White Space frequencies are another innovation allowing communities to self-provision coverage at low cost. While not yet mainstream, these tech innovations are part of the toolkit for difficult areas, and policy frameworks should remain flexible to incorporate them (for instance, allowing pilots and removing regulatory roadblocks to new tech adoption). The integrated approach thus remains technology-neutral in principle - encouraging any solution that achieves the connectivity objective - but technology-aware in practice by recommending the best fit for each scenario (e.g., fiber plus 5G for suburban areas, versus satellite plus Wi-Fi for remote islands).

Digital Inclusion Mechanisms: Infrastructure alone is insufficient; broadband strategies must also ensure affordability, accessibility, and meaningful use:

- *Affordability Programs:* Cost is a major barrier in low-income and remote areas, so targeted programs are needed to make broadband financially accessible. One mechanism is subsidized service plans or broadband vouchers for qualifying users (such as rural students, low-income households, or small businesses in isolated areas). For example, some economies have introduced vouchers that rural households can apply toward a discount on monthly internet bills or the upfront cost of customer equipment. Another approach is community Wi-Fi or tele centers where a government or sponsor provides free or low-cost internet at a public site (like a village library, post office, or community center). This model has been effective in economies from Mexico to Malaysia for getting people online where home access is scarce. The integrated plan would align such initiatives with infrastructure rollout (e.g., as soon as a new network node is live in a village, ensure there is a free Wi-Fi hotspot or community access point and promote its use). On the device side, affordability is also crucial - programs that provide discounted smartphones or computers to people in remote communities can be transformative, since owning an internet-capable device is a prerequisite for meaningful use. In sum, inclusion instruments must ensure that broadband services are affordable relative to incomes, aiming to meet the global target of entry-level broadband costing <2% of monthly GNI per capita[82].
- *Digital Skills and Literacy:* Building digital literacy and skills is another critical inclusion pillar, so that new users can confidently use the Internet. The strategy calls for training programs in underserved areas, for instance, community-based digital literacy workshops, integrating digital skills into school curricula, and leveraging NGOs or volunteer networks to teach basic Information, Communication, Telecommunication (ICT) skills (e.g. how to use email, e-banking, e-commerce,). Particular focus is given to marginalized groups: for example, special programs for elderly citizens in rural areas who may be intimidated by technology, or for women and girls in communities where gender gaps in internet use persist. Some economies have deployed mobile tech training units (e.g., “digital buses” that travel to villages with

[82] Broadband Advocacy Target 2. Broadband Commission. (2023, December 18). https://www.broadbandcommission.org/advocacy-targets/2-affordability/

trainers and devices[83]). The model encourages knowledge-sharing of best practices among economies for such outreach. Building local digital skills not only increases adoption but also helps create local digital entrepreneurs who can sustain the broadband ecosystem (for instance, a youth trained in IT could start a small ISP or ICT business in their town, multiplying the impact). In the cluster strategies below, we include examples like community training centers and school partnerships to drive digital inclusion

- *Local Content and Services:* For broadband to be valuable, content must be relevant to the local population. Thus, an integrated approach promotes the development of local-language content, e-government services, and applications tailored to rural users. Governments can spearhead this by digitizing public services (health consultations, e-learning, e-agriculture advisories) that address the immediate needs of remote communities. Where literacy is a challenge, content in audio/visual formats or local dialects should be provided. Community radio and mobile apps can be leveraged to disseminate information over broadband networks in culturally appropriate ways. One successful example is the use of localized agricultural market info services delivered via mobile internet to farmers in rural Thailand and Viet Nam, which has improved farmers' incomes by bridging information gaps[84]. Encouraging local content creation - e.g., through grants or competitions for local developers/ Small and Medium Size Enterprises (SMEs) - can also enrich the ecosystem and drive demand. The inclusion strategy ultimately aims for *universal participation*: ensuring that once an area is connected, all segments of the population (regardless of income, gender, age, or language) can actively use the internet in ways that improve their lives.

In summary, this integrated approach is about synchronizing the "supply push" of networks with the "demand pull" of adoption. It reflects the clustering framework of Chapter 2 by recognizing that different areas need different mixes of these tools. Crucially, it avoids past mistakes such as building networks without users or distributing devices without connectivity or training. Instead, it emphasizes coordination across ministries and stakeholders - e.g., telecom ministries working with education, finance, local governments, and the private sector - so that policy, technology, and inclusion measures reinforce each other. The following sections apply this approach to specific clusters of underserved areas, detailing how each cluster's unique challenges can be met with a calibrated set of interventions.

4.4 TAILORED STRATEGIES BY UNDERSERVED AREA CLUSTER

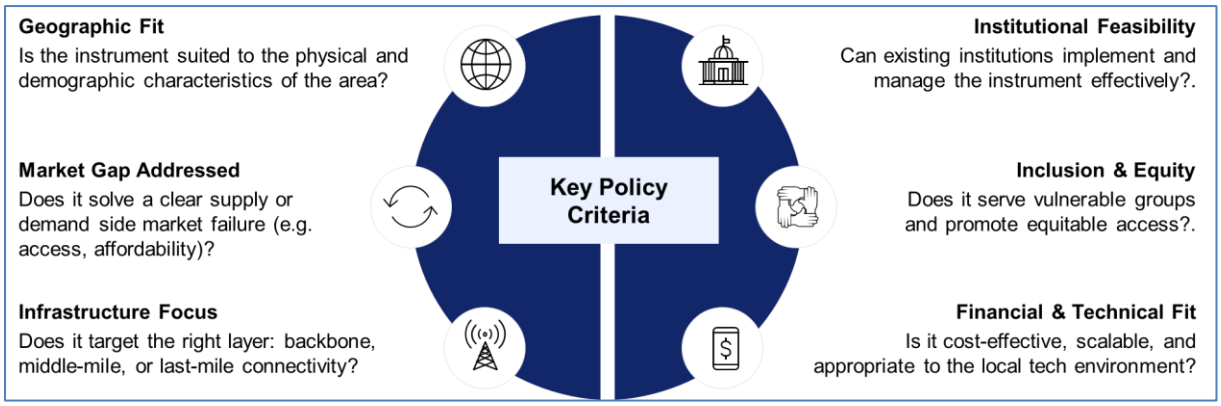
Chapter 4.4 presents tailored broadband vitalization strategies for each underserved area cluster identified in Chapter 2. As defined earlier, the clusters are: (A) Large Landmass Economies, (B) Archipelagic Economies, (C) Mountainous/Forested Economies, and (D) Urban/Compact Economies. While there is some overlap among clusters (for instance, a large landmass economy may also have mountainous regions or remote islands internally), each cluster's strategy emphasizes the distinct challenges and opportunities that characterize it. The proposals below integrate relevant policy instruments, technology solutions, and inclusion measures for

[83] *MMMUT's "Wisdom on Wheels" to boost digital literacy*. (2025, July 25). The Times of India. https://timesofindia.indiatimes.com/city/varanasi/mmmuts-wisdom-on-wheels-to-boost-digital-literacy/articleshow/122909119.cms

[84] Nguyen, T., Trung Thanh Nguyen, & Grote, U. (2023). Internet use and agricultural productivity in rural Vietnam. Review of Development Economics, 27(3). https://doi.org/10.1111/rode.12990

each cluster, providing a cohesive strategy. We also include examples from APEC economies (and beyond) to illustrate feasible interventions.

Figure 4.3 Key Policy Criteria for Well Targeted and Sustainable Interventions



Before designing cluster-specific broadband strategies, policymakers should apply a consistent set of decision criteria to ensure interventions are well-targeted and sustainable. The Key Policy Criteria framework provides a structured approach to evaluating potential instruments based on six dimensions[85]:

- Geographic Fit - Alignment with the physical and demographic characteristics of the area.
- Market Gap Addressed - Clear resolution of supply- or demand-side market failures such as affordability or access barriers.
- Infrastructure Focus - Targeting the right connectivity layer (backbone, middle-mile, or last-mile) to achieve maximum impact.
- Institutional Feasibility - Ability of existing institutions to implement and manage the intervention effectively.
- Inclusion and Equity - Ensuring that vulnerable groups are served and equitable access is promoted.
- Financial and Technical Fit - Cost-effectiveness, scalability, and appropriateness to the local technology environment.

Applying these criteria enables policymakers to balance policy measures, technology choices, and inclusion programs in a way that is context-specific yet comparable across clusters. This ensures that the strategies outlined in the following sections are not only technically sound but also economically viable, socially equitable, and institutionally executable.

4.4.1: Strategic Options for Large Landmass Economies (Cluster A)

Large landmass economies, e.g., Australia; Canada; People's Republic of China; Russia; and the United States, face the "tyranny of distance" in connecting vast rural and interior regions with low population density. Chapter 3 noted that even economically advanced economies

[85] Adapted from: Alliance for Affordable Internet. (2020, March). *Rural Broadband Policy Framework: Connecting the unconnected*.

struggle to serve far-flung communities due to high costs per user and weak commercial incentives. These economies often have remote Indigenous or minority populations with significant digital divides. The imperative, therefore, is to treat broadband as essential domestic infrastructure (like highways or power grids) that must reach all regions despite distance[86].

For large landmass economies, the overarching strategy is an economy-wide, state-supported backbone rollout combined with last-mile wireless solutions, underpinned by targeted public subsidies and pro-competitive policies. Governments should take a leading role in planning and funding expansive fiber backbones to connect every province/state, while incentivizing private operators to extend coverage to sparsely populated areas. Market mechanisms (like rural coverage obligations and open-access requirements) are paired with public funding (universal service funds, PPP subsidies) to ensure no region is left behind. Key components include:

- **Domestic Fiber Backbone**: Develop a local fiber-optic backbone plan mapping links to all regions and border areas. Given the enormous distances and capital expenditure, upfront public investment is often required for backbone deployment. A recommended model is for the government or a public–private consortium to build an open-access fiber network reaching every major district, allowing all ISPs and mobile operators to lease capacity instead of duplicating infrastructure. This reduces overall costs and encourages competition even in remote markets. For example, Peru's National Fiber Backbone (Red Dorsal Nacional), along with complementary regional PPP projects, is extending fiber deep into the Andes and Amazon. By 2025–26, Peru plans to activate eight new regional fiber networks connecting about 3,070 villages and 5,171 public institutions across rural provinces[87]. Such backbones should utilize existing rights-of-way (along highways, railways, power lines) to lower deployment costs and be built with redundancy (ring topologies or parallel routes) so that a single fiber cut does not isolate entire areas - a critical resilience measure for vast networks[88]. Where fiber is infeasible in the near term, high-capacity microwave radio links can be deployed as interim backhaul to reach remote communities

- **Public Funding and PPPs:** Because private-sector incentives rarely suffice to reach the "last mile" in sparsely populated, expansive regions, governments must mobilize public funding mechanisms - and often partner with the private sector via PPPs -to expand broadband in large landmass economies. This can include dedicated broadband infrastructure funds, universal service funds, and regional development grants. For example:

    - In Canada, the Eastern Ontario Regional Network (EORN) embraced a public–private partnership model: with over USD 175 million in public and private investment, the project extended broadband access to 89% of residents across thirteen counties comprising more than 50,000 km². Regional collaboration among municipalities, provincial and federal governments, and private

[86] News, I. (2021, December 1). Strengthening ties for affordable connectivity worldwide. https://www.itu.int/hub/2021/04/strengthening-ties-for-affordable-connectivity-worldwide/
[87] Kaczmarek, M. (2025, August 25). Internet access in Peru: A comprehensive overview. Tech Space 2.0. https://ts2.tech/en/internet-access-in-peru-a-comprehensive-overview/

operators exemplifies how PPPs can bring cost-effective service to vast, rural territories.[89]

- The Broadband for Rural Nova Scotia Initiative demonstrates a successful provincial-level PPP. The Government of Nova Scotia co-funded the project with federal and private partners - deploying Motorola Canopy wireless technology to deliver broadband service to rural addresses that had previously lacked connectivity.[90]

These examples show that governments can share both financial support and risk with private or community partners to extend broadband across remote or low-density zones. A Universal Service Fund - commonly financed through small levies on telecom operators - can underwrite such partnerships if operated transparently and directed toward underserved areas.

- **Coverage Obligations and Spectrum Policy**: Regulators in large economies should leverage spectrum licensing to compel rural coverage, while lowering barriers for smaller players in underserved areas. Regulators should attach coverage obligations to low-band spectrum (e.g., requiring 4G/5G licensees in 700 MHz or 850 MHz bands to reach rural populations). Coverage obligations attached to 4G/5G spectrum have proven effective in extending rural mobile broadband in many economies. For example, a spectrum auction might require licensees to cover at least, say, 90% of rural population within a few years of network launch (with affordable reserve prices and realistic deadlines to make it feasible). In parallel, regulators can designate unused spectrum for community networks or local ISPs (e.g., via "use-it-or-share-it" rules). The United States FCC, for instance, in 2020 opened a Rural Tribal Priority Window that granted Indigenous communities licenses in the 2.5 GHz band to build their own broadband networks[91]. As of 2024, the FCC had issued over 300 such licenses to tribal entities, helping them provide connectivity on their lands. Canada is piloting a similar Indigenous spectrum priority initiative: Innovation, Science and Economic Development Canada (ISED) are developing an "Indigenous Priority Window" to reduce barriers and allow First Nations and Inuit communities priority access to spectrum licenses in rural areas[92]. These measures empower local providers and ensure even the most isolated settlements can get wireless coverage, either from mainstream operators or community-led networks.

- **Last-Mile Technology Mix** Large landmass economies need a multi-technology mix for last-mile access, given diverse terrains, and settlement patterns. The principle is fiber where economically feasible, and wireless or satellite for the rest. Fixed Wireless Access (FWA) using 4G/5G is a primary tool to reach farms and villages where laying fiber to every premise is impractical. Low-frequency bands (e.g., 700 MHz) are crucial for wide-area rural 4G/5G coverage due to their longer range; regulators should ensure sufficient low-band spectrum is allocated for rural broadband and consider spectrum sharing or affordable licenses so that smaller Wireless ISPs (WISPs) can serve sparsely

[89] *Eastern Ontario Heads of Council Urge Support for EORN Gig Project*. (2021, May 19). Eorn.ca. https://www.eorn.ca/en/news/eastern-ontario-heads-of-council-urge-support-for-eorn-gig-project.aspx
[90] Closing Broadband Connectivity Divides for All. (2025). OECD. https://www.oecd.org/en/publications/closing-broadband-connectivity-divides-for-all_d5ea99b2-en.html
[91] *2.5 GHz Rural Tribal Window*. (2025). Fcc.gov. https://www.fcc.gov/25-ghz-rural-tribal-window
[92] *Spectrum and the Indigenous Priority Window*. (2024, October 25). Canada.ca. https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/spectrum-allocation/spectrum-and-indigenous-priority-window

populated areas. In the U.S. and Canada, for example, dozens of small rural ISPs have used unlicensed TV White Space frequencies to provide internet service to remote farms and hamlets[93]. In extremely remote areas (e.g., settlements dozens of kilometers from any grid), satellite broadband is increasingly viable. New low-earth orbit satellite (LEO) constellations (e.g., Starlink, OneWeb) can offer ~100 Mbps with latency under 50 ms: a major improvement over older satellite system. The LEO network architecture can be categorized into two types:

- Direct-to-Premises: where CPEs at homes/schools/clinics connect directly to LEO satellites, typically delivering ~100 Mbps with 25-60 ms latency.
- Wireless Backhaul: where rural base stations or community Wi-Fi hotspots are backhauled via LEO, and the last mile is served via 4G/5G or Wi-Fi.

Large economies are beginning to partner with LEO satellite providers to connect remote schools and clinics; for instance, Canadian federal and provincial programs have subsidized consumer equipment and subscriptions for LEO satellite service in far-northern Indigenous communities. While per-user costs for satellites are higher than terrestrial networks, they can be justified as a last resort to achieve universal coverage where land-based infrastructure is prohibitively expensive.

- **Financing and Business Models:** Covering vast, sparsely populated areas entails high capital expenditure (CAPEX) and ongoing operating costs (OPEX) that private operators alone often struggle to recover. Policymakers should conduct cost studies to quantify the funding needed for universal broadband. Many APEC economies have set targets (e.g., 100% broadband coverage by 2030) and evaluated the investment gap to reach them. Strategies must address not only construction costs but also maintenance. For example, maintaining a single remote cellular tower site (with off-grid power and satellite backhaul) can cost about USD 30,000 per year in fuel, maintenance, and bandwidth - a recurring burden after deployment[94]. Governments may therefore need to subsidize operational expenses (OPEX) in uneconomic zones - for instance, covering part of the backhaul bandwidth or diesel generator costs for base stations serving very low-density areas. Another approach is cross-subsidization: urban users effectively subsidize rural networks either internally (through an operator's tariff structure) or via industry-wide mechanisms. Australia's Regional Broadband Scheme (RBS) exemplifies the latter - it imposes a levy (approximately AUD 8 per month) on broadband providers outside the local network, to fund NBN Co's loss-making rural fixed-wireless and satellite services[95]. This transparent industry levy shares the cost of rural service across all providers and treats broadband access as a basic entitlement. Such cost-sharing ensures no single operator is unfairly burdened and reflects the notion that broadband has good public characteristics.

- **Governance and Coordination:** Large federated economies must synchronize efforts across economy, state/provincial, and local governments. A central broadband coordinating unit (or task force) can align federal funding with regional initiatives and prevent overlapping. For instance, if a province plans its own fiber ring, it should

[93] Closing Broadband Connectivity Divides for All. (2025). OECD. https://www.oecd.org/en/publications/closing-broadband-connectivity-divides-for-all_d5ea99b2-en.html

[94] Calculation based on internal benchmarks

[95] Jones, T. (2024, November 18). *Broadband tax review: What it means for rural and regional businesses*. SmartCompany. https://www.smartcompany.com.au/tax/broadband-tax-review-means-rural-regional-businesses/

interconnect seamlessly with the local backbone - coordination that a joint planning body can facilitate. Domestic agencies can set technical standards and share best practices, while local authorities contribute on-the-ground knowledge (e.g., identifying which villages lack connectivity or where to locate community Wi-Fi hubs). Clear governance also helps involve non-government stakeholders: utilities (for rights-of-way agreements), cooperatives and community groups (for local access networks), and academia (for digital literacy programs) should all have channels to inform the broadband strategy. Transparency in how projects are selected and funds allocated builds public trust and investor confidence.

In summary, large landmass economies must deploy comprehensive "first-mile to last-mile" solutions: the first mile (local backbone) built with public leadership and open access, and the last mile delivered via a mix of fiber, wireless, and satellite technologies supported by smart subsidies and pro-competition rules. These interventions, coupled with training and local inclusion programs (to ensure rural users can afford and effectively use the new networks), will help close the urban-rural digital gap across vast territories.

4.4.2: Strategic Options for Archipelagic Economies (Cluster B)

Archipelagic economies (e.g., Indonesia; the Philippines) consist of many islands separated by sea, making broadband expansion uniquely challenging. Chapter 3 highlighted issues such as the high cost of undersea cables, difficulties maintaining infrastructure across dispersed islands, and unequal connectivity, main islands often have decent service while remote islands lag far behind. These economies have historically relied on legacy satellite systems or aging microwave relays for inter-island links, resulting in slower speeds and higher prices. The goal for archipelagos is to integrate all islands into the economy (and global) information grid, ensuring even small or remote island communities can get online.

For archipelagic areas, the strategy centers on connecting islands in a phased manner: first linking major population centers via high-capacity submarine cables or terrestrial fiber (where applicable), then extending coverage to smaller and outlying islands using a mix of technologies (microwave relays, community LTE/5G, and satellites for the very remote). Public policy plays a big role in financing submarine cable systems and incentivizing operators to serve sparsely populated islands, while market-driven competition can be fostered on the core infrastructure (for instance, open-access cable landing stations that allow multiple ISPs to operate). Key strategic measures include:

- **Submarine Cable Infrastructure**: A robust domestic fiber-optic cable network is the backbone of connectivity in archipelagic economies. Governments should prioritize connecting all major islands or island groups with high-capacity submarine cables (or terrestrial fiber across connected islands). These undersea cables drastically reduce per-bit data costs and latency compared to satellites, enabling broadband speeds and prices closer to those on continental network[96]. Given the high CAPEX and long payback periods for such cables - especially routes serving small, remote islands - public co-financing is often needed. PPPs can be effective: for instance, the Philippines is

[96] Sea, C. (2023, December 22). *Coral Sea Cable Company*. Coral Sea Cable Company. https://coralseacablecompany.com/media-releases/press-release-coral-sea-cable-company-pty-ltd-december-2023

implementing a "BroadBand ng Masa" program wherein the government invests in a National Fiber Backbone linking the major islands (Luzon, Visayas, Mindanao) and provincial capitals, with private telcos then lighting and operating these fibers[97]. In very small island economies, multilateral donors (World Bank, ADB) have funded regional cable systems - e.g. the proposed East Micronesia Cable will connect the Federated States of Micronesia, Nauru, and Kiribati by the late 2020s. Open access is crucial - cable landing stations built with public funds should offer wholesale bandwidth at regulated, cost-based prices to any licensed operator. This prevents monopolies around critical undersea infrastructure and encourages multiple ISPs on each island, driving down retail prices. In practice, establishing an independent "CableCo" or consortium to run the submarine network (selling capacity to all comers) can promote competition in island markets that could otherwise only support one vertically integrated provider.

- **Inter-Island Backhaul and Middle-Mile** Even after main islands are connected to fiber, extending that capacity to every inhabited island is a challenge. A mix of microwave radio links and additional small submarine cables is used for the middle-mile. Microwave towers can beam high-bandwidth signals tens of kilometers over water (suitable for island clusters that are relatively close together). However, microwaves have capacity limits and can be vulnerable to weather interference over long spans, so it is often a steppingstone until traffic demand justifies a dedicated fiber link. Policymakers should map out island clusters and prioritize fiber vs. microwave vs. satellite[98]. A general sequencing is connecting the largest and most populous islands first with submarine fiber, then progressively link secondary islands - either via spur cables branching off the main backbone or via terrestrial fiber if islands are connected by bridges. For extremely remote small islands (e.g., hundreds of kilometers from the main island group), satellite connectivity may be the only feasible option in the near term. In such cases, governments can deploy ground stations or VSAT hubs on those islands to provide backhaul for local mobile networks or Wi-Fi hotspots. LEO satellite services (Starlink, OneWeb, etc.) can now deliver 50 - 150 Mbps to small islands that previously had only dial-up or very slow VSAT (very-small-aperture terminal), vastly improving connectivity for residents. Some archipelagic economies have started subsidizing satellite terminals for their most isolated islands as an interim solution until fiber reaches them. Notably, satellite providers now complement traditional telcos across the Pacific, connecting schools and clinics on atolls not yet reached by cables. Domestic plans should also incorporate LEO/MEO satellite options for resiliency, serving as backup paths when undersea cables occasionally break (due to earthquakes, ship anchors, etc.).

- **Last Mile Connectivity for Small Island**: Reaching the "last mile" on small islands requires a mix of complementary technologies tailored to local conditions. On larger or more developed islands (e.g. Bali or Bohol), fiber-to-the-premises (FTTP) can deliver high-speed access in towns and tourism centers, especially now that undersea fiber cables connect these islands to the economy backbone[99]. However, for smaller villages

[97] Presidential Communication Office, President of the Philippines (2023): "BroadBand ng Masa" program
[98] Strategies and policies for the deployment of broadband in developing countries. (2021). International Telecommunication Union (ITU). https://www.itu.int/dms_pub/itu-d/opb/stg/D-STG-SG01.01.2-2021-PDF-E.pdf
[99] Telco Eastern Communications arrives in Bohol to boost internet services. (2024, July 24). BOHOL ISLAND NEWS. https://boholislandnews.com/2024/07/24/telco-eastern-communications-arrives-in-bohol-to-boost-internet-services

or outer islands, 4G/5G mobile networks and fixed wireless access (FWA) are often the primary last-mile solution due to their quicker deployment and lower cost relative to extensive fiber laying. Governments are actively extending mobile coverage to remote islands. For example, Indonesia's universal service agency (BAKTI) is building 630 new cell towers in far-flung areas by 2024 to bring 4G signal to previously isolated communities[100]. In practice, operators in the region also use 5G FWA to reach homes as a substitute for wired broadband, even launching 5G FWA services before mobile 5G in some cases (as seen with new providers in the Philippines and Indonesia)[101].

For extremely remote or sparsely inhabited islands, satellite broadband has become a vital option. Modern high-throughput satellites can now beam connectivity at decent speeds (50–150 Mbps) to places once reachable only by slow VSAT. Indonesia's recently launched SATRIA-1 satellite, for instance, is designed to provide internet service across the economy's 18,000 islands, connecting schools, clinics and other public facilities in the outermost regions[102]. Likewise, low-earth orbit services are being tapped: the Philippines began using SpaceX Starlink to connect dozens of remote island schools to the internet in 2023-2025. These satellite links can serve as backhaul for local Wi-Fi or cellular hotspots, rapidly expanding coverage while more permanent fiber or microwave links are underway. In fact, the Philippines' government has already rolled out over 8,800 free public Wi-Fi sites in isolated barangays (villages) using a combination of satellite and terrestrial backhaul [103] .

Community networks and innovative spectrum use can further fill connectivity gaps on small islands. In areas where neither commercial fiber nor mobile coverage reaches, local cooperatives or small ISPs can distribute bandwidth from a satellite or microwave backhaul to end-users. Such community-based models have been piloted in rural Indonesia, where small Wi-Fi or even LTE networks operated by local organizations deliver internet to village[104]. Regulatory support is crucial here: authorities should allow flexible use of spectrum (including license-exempt use or shared access in unused bands) so that community networks can operate legally. One promising approach is TV White Space (TVWS) technology, which uses unused TV broadcast frequencies to provide wireless internet links. Trials in Indonesia showed that TVWS equipment could affordably extend broadband connectivity across 30 km of water or rugged terrain to reach island villages. With enabling regulations, TVWS-based links (or other

[100] Lipscombe, P. (2024b, July 27). BAKTI to build 630 new cell towers in remote parts of Indonesia. Datacenterdynamics. https://www.datacenterdynamics.com/en/news/bakti-to-build-630-new-cell-towers-in-remote-parts-of-indonesia

[101] Osio, J. (2022). Telecoms World Asia 2022: Opportunities for FWA in Asia-Pacific. S&P Global Market Intelligence. https://www.spglobal.com/market-intelligence/en/news-insights/research/telecoms-world-asia-2022-opportunities-for-fwa-in-asia-pacific

[102] Dobberstein, L. (2023, October 23). Indonesia grounds second broadband satellite to free up digital inclusion funds. Theregister.com; The Register. https://www.theregister.com/2023/10/23/indonesia_ditches_backup_broadband_satellite

[103] Dela Cruz, R. C. (2025). DICT connects 17 far-flung schools via Starlink. Pna.gov.ph. https://www.pna.gov.ph/index.php/articles/1252645

[104] Local Community-based Internet Infrastructure Development And Internet Utilization In Rural Indonesia. (2025). Apnic.foundation. https://apnic.foundation/projects/local-community-based-internet-infrastructure-development-and-internet-utilisation-in-rural-indonesia/technicalreport/

unlicensed band solutions) can be scaled up as a viable last-mile tool[105]. Several APEC economies are now expanding innovative solutions. For example, a recent initiative with Microsoft's Airband program and Kacific satellites is bringing high-speed internet to 750 rural schools and clinics across archipelagic areas of PNG, the Philippines and Pacific islands - each site uses a satellite backhaul combined with local Wi-Fi to connect the surrounding community[106]. By combining fiber in urban hubs, 4G/5G and FWA for widespread coverage, satellite links for the most remote spots, and supportive policies (targeted subsidies, spectrum sharing, and community-run networks), small islands can achieve sustainable last-mile connectivity that leaves no community behind in the digital age.

- **Financing and Business Models:** Broadband projects in archipelagos are highly capital-intensive and often not immediately profitable, so creative financing is needed. Governments should tap international development funds - many multilateral programs (World Bank, ADB, ITU) support digital infrastructure in island and remote regions as part of development and climate resilience initiatives. Public- private models are valuable: for example, an undersea cable system could be funded by a consortium of government, the incumbent operator, and possibly a regional infrastructure fund, each taking on part of the cost and risk. In the Pacific, there are examples of cooperative ownership of cables (several island economies jointly owning segments of a regional cable). Subsidy auctions can also engage the private sector: a government can tender out the task of connecting a set of islands, where bidders compete on the lowest subsidy needed. Another tactic is leveraging existing assets (e.g., utility company infrastructure). If an economy has inter-island power transmission lines or undersea power cables, fiber can often piggyback on those. Where relevant, governments should coordinate telecom plans with power and transport ministries to exploit such synergies. Once backbone links are in place, operational sustainability must be planned: small island networks have high OPEX (maintenance of undersea cable landings, satellite bandwidth costs, etc.). Pooling maintenance at a regional level (e.g., a single entity maintaining multiple island cables) can save costs. Also, cross-subsidies from profitable routes (e.g., the busy cable segment between the capital island and a major city) can support uneconomical routes to tiny outer islands. Regulators might allow a modest "access deficit charge" or similar mechanism, where a fraction of revenues from lucrative markets is set aside to fund connectivity in peripheral islands.

- **Governance and Coordination**: To foster a healthy telecom market across islands, liberalization and strong regulation are key. Many archipelagic economies historically had telecom monopolies (often state-owned) that under-invested in outlying areas. Recent reforms in the Pacific have opened markets and set up independent regulators. A robust regulator should ensure new submarine cables or satellite services are not locked into exclusive arrangements that limit competition. For example, if the government subsidizes a cable, it should mandate open access and cost-oriented wholesale pricing on that cable. Similarly, landing rights for international operators (submarine cable consortia or satellite firms) should be simplified to attract multiple

[105] Ammachchi, N. (2020, April 26). Indonesia Rural Broadband TV White Space Pilot – Integra LLC. Integrallc.com. https://www.integrallc.com/portfolio-item/indonesia-rural-broadband-tv-white-space-pilot
[106] Rokotuiveikau, W. (2024, April 11). Kacific and Microsoft Partner to Reach 10 Million People in the Asia Pacific with Internet Access Initiative. Islands Business. https://islandsbusiness.com/partner-news/kacific-and-microsoft-partner-to-reach-10-million-people-in-the-asia-pacific-with-internet-access-initiative

providers. The arrival of new satellite players is injecting competition. Regulators should welcome LEO constellations by streamlining user terminal licensing (while ensuring they meet local security and interference standards). Several archipelagic economies have fast-tracked licenses for SpaceX Starlink, Kacific, OneWeb, etc., which in turn has quickly provided service to remote islands that previously had no broadband. Another regulatory focus is retail pricing and quality of service given the tendency for high consumer prices on remote islands (due to monopoly or small scale). Regulators might choose to set basic broadband price caps or offer targeted subsidies/vouchers to low-income island residents. For instance, a regulator could mandate that a baseline 10 Mbps plan be offered below a certain price per month, with the USF or government compensating the operator for the shortfall. In governance, establishing a Local Broadband Steering Committee including telecom officials, local island governments, and even military/coast guard (for logistical support in remote deployments) can improve coordination. Archipelagos often face logistical delays (equipment must be shipped by boat, etc.), so high-level coordination helps prioritize and fast-track critical projects to isolated communities.

- **Spectrum Policy**: Focus on spectrum for backhaul and satellite connectivity. Island economies often rely on microwave links (which use high-frequency bands like 6-11 GHz) - regulators should coordinate those assignments and protect inter-island link frequencies from interference. More critically, streamline the licensing for new satellite services: many archipelagic economies have moved quickly to permit LEO satellite user terminals and gateways by simplifying procedures and regulations (as noted in the section above. In Cluster B, the spectrum strategy is about flexibility: allowing multiple satellite operators to operate (through blanket licensing of terminals) and possibly adopting spectrum sharing where islands are too small to auction exclusive licenses (for instance, using Wi-Fi 6E in remote island communities for local access). This ensures that spectrum is not a bottleneck in connecting each island.

In summary, archipelagic broadband strategies require connecting the dots across the sea - building a web of undersea cables and microwave links that progressively reaches every island, bolstered by satellite overlays for the most remote gaps. It is a sequential process: fiberize the big islands, use interim wireless links for smaller ones, and ensure no inhabited island is too remote to at least get a satellite connection. Public investment is often the linchpin, but once core infrastructure exists, market forces can be leveraged to expand services and drive innovation (e.g., new ISPs or community initiatives utilizing the backbone). By learning from successful cases (e.g. Indonesia's backbone, Pacific regional cables).), archipelagic APEC members can accelerate progress toward universal island connectivity.

4.4.3: Strategic Options for Mountainous/Forested Economies (Cluster C)

This cluster refers to economies with extensive mountainous terrain or dense forests/jungles, where dispersed settlements are hard to reach. Parts of economies like Peru (Andes and Amazon); Thailand; Viet Nam; and others in APEC fall into this category. As noted in Chapter 3 these areas often have some of the lowest connectivity rates and highest costs to serve.

In mountainous and forested areas, flexibility and creativity in technology choices are paramount. The strategy emphasizes wireless and community-based solutions for last-mile connectivity, with fiber deployed opportunistically along reachable corridors. Governments

should subsidize infrastructure in high-cost zones and facilitate community networks and small operators, since big carriers may not prioritize tiny, hard-to-reach villages. A combination of terrestrial wireless (using terrain-aware planning), satellites for isolated spots, and innovative spectrum use can progressively extend broadband. Key strategic elements include:

- **Incremental Fiber and Backhaul Expansion**: While rugged topography makes fiber deployment expensive, it is still vital to extend fiber backhaul as close as possible to rural clusters (for capacity and quality). Governments can piggyback on any existing infrastructure: for example, running optical fiber along roads, power lines, or pipelines that penetrate into mountain valleys or forest interiors. If a new highway or electricity grid extension is planned into an under-served region, coordinating it with fiber installation greatly reduces cost. Another tactic is building microwave relay chains: tall towers on mountaintops can relay internet signals deep into valleys. Microwave backhaul has been the workhorse in many developing economies' mountainous regions. Policymakers should identify key mountaintop sites (perhaps leveraging broadcasting towers or even installing relays on solar-powered masts) to connect remote communities below. Though it has a lower capacity than fiber, modern IP microwave can deliver hundreds of Mbps over tens of kilometers, enough to serve villages until demand grows. Additionally, planners must consider redundancy because landslides, storms or wildfires can take out towers or cables. Where feasible, create loop routes (a fiber or microwave ring connecting villages from two directions) so that connectivity is not lost due to a single break. Backup satellite links at critical hubs (like a district center) can also provide emergency connectivity if terrestrial links fail.

- **Community Networks and Local ISPs:** Mountainous/forested regions often benefit from bottom-up broadband initiatives, since large operators may not see profit in a small, isolated village. Enabling and supporting community-based networks is a key strategy. This can involve local cooperatives, NGOs, or even municipalities building and operating their own small-scale networks. For example, in remote areas community Wi-Fi and mesh networks have successfully connected villages using low-cost point-to-point wireless links and shared satellite backhaul. Governments can assist by providing grants or equipment for such community initiatives and by simplifying licensing requirements. Access to license-exempt spectrum (like Wi-Fi bands or TV White Space) is crucial. It allows communities to deploy connectivity without waiting for a telecom operator. Another model is partnering with local entrepreneurs or micro-ISPs: for instance, small ISPs use long-distance Wi-Fi links to bring internet from towns to remote villages, charging affordable fees. Policymakers can create rural ISP licensing categories with low fees and provide capacity-building support for these entrepreneurs. By devolving some responsibility to local actors who have the on-the-ground knowledge and incentive to serve their community, broadband reach can extend beyond where large carriers stop. It is also worth directing universal service funds to finance community networks (e.g. a USF could run a tender where a community organization is selected and funded to provide connectivity to an underserved district). Evidence from Organisation for Economic Co-operation and Development (OECD) economies shows that municipal and community networks can deliver high-quality service: some rural electric cooperatives in the U.S. have deployed fiber-to-the-home[107], and utility-

[107] *Cooperatives Fiberize Rural America: A Trusted Model For The Internet Era*. (2017, November). https://communitynetworks.org/sites/default/files/Cooperatives-Fiberize-Rural-America.pdf

led networks in Europe offer gigabit speeds in small towns. Such successes can be replicated in APEC's hard-to-reach areas with the right support.

- **Rural Mobile Coverage and Innovative Technologies**: Extending mobile networks into mountains and forests is challenging. Governments should work with mobile operators to eliminate remaining "black spots" on coverage maps. Coverage obligations (as discussed for cluster A) can mandate operators to cover 90% of rural or specific remote areas by certain timelines (e.g., Chile's 5G licenses require 90% domestic coverage within three years)[108]. However, meeting these obligations in rugged terrain might need additional support: for example, capital subsidies for tower construction at locations where traffic (and revenue) will be extremely low. Some economies provide "tower subsidies" or cost-sharing - the state helps build the tower and the operator only needs to install its base station equipment. Infrastructure sharing is also critical as having each operator build separate towers is wasteful and often impractical. Regulators can encourage or require tower sharing and even active network sharing in such areas to lower costs. An example is the UK's Shared Rural Network[109], where operators jointly extend coverage to black spot with government co-investment. New technology can help, too. For instance, small-cell networks backhauled by satellite or long-distance Wi-Fi can cover a village at lower cost than a traditional tall tower. High-altitude platforms (HAPS) -balloons or drones - were tested (e.g., Google's Loon project in the Andes[110]) to beam LTE signals into hard-to-reach valleys. Policymakers should stay abreast of such innovations and be ready to facilitate pilots (as some did with Loon trials in mountainous areas). Direct-to-user satellite connectivity is another tool: in the most isolated hamlets providing satellite broadband terminals to a school or community center might be the only viable option in the short term. Local programs can subsidize the equipment and monthly fees for such communities.

- **Power and Resilience Considerations**: A unique challenge in deep rural and forested zones is powering the telecom equipment (this applies also to parts of Cluster A and B with remote sites) - many broadband projects face the lack of electrical grid power in rural locales. The key approach is integrating off-grid renewable energy systems - chiefly solar panels with battery storage - to run base stations and relay towers in isolated areas. This is already a proven strategy: mobile operators have widely adopted solar for rural cell sites, finding that modern base stations can operate entirely on solar power (with batteries for night-time) and drastically cut reliance on diesel generators. (For example, Huawei's "RuralStar" sites deployed by Safaricom in Kenya use solar-only power, reducing OPEX and maintenance needs while connecting villages.) Many remote towers lack grid electricity, so the broadband plan funds solar-powered base stations with batteries, as piloted in economies like Thailand and PNG. This not only ensures sustainable power supply but also reduces operating costs and emissions. Local teams will be trained for upkeep of these systems to ensure reliability.

[108] Errazquin, I., & Andrés Schwerter. (2025, March 3). *5G regulation and law in Chile*. CMS Law. https://cms.law/en/int/expert-guides/cms-expert-guide-to-5g-regulation-and-law/chile

[109] *Shared Rural Network (SRN)*. (2020, June 22). Department for the Economy. https://www.economy-ni.gov.uk/articles/shared-rural-network-srn

[110] Lee, D. (2017, May 17). Google owner Alphabet balloons connect flood-hit Peru. *BBC News*. https://www.bbc.com/news/technology-39944929

- **Financing and Business Models:** The cost per broadband user in rugged areas can be extremely high. Studies show an exponential rise in cost for the last few percent of population in difficult terrain. Policymakers need to identify sustainable funding. Blended finance (combining public subsidies, community contributions, and maybe revenue from other services like TV or cellular where possible) is often the solution. For instance, a community may contribute labor or land for a tower site, while the government provides equipment and an operator provides a discounted service - sharing the burden. Another consideration is that in forested areas, demand might initially be low (due to low digital literacy or income). So, pairing connectivity with digital inclusion programs is important: providing local language content, training villagers, and ensuring devices (like community tablets or PCs in tele centers) are available. Otherwise, even if a network is built, usage may lag (which in turn hurts the business case to sustain the network).

- **Spectrum Policy**: Promote license-exempt and shared spectrum use for rural innovators. Given difficult terrain, community Wi-Fi and small ISPs play a big role (as noted). Policymakers should open up bands like the TV White Spaces (unused TV channels) for broadband use, as well as standard Wi-Fi bands, on a license-exempt basis. This lets local providers deploy inexpensive equipment without waiting for formal spectrum licenses. Additionally, encourage infrastructure and spectrum sharing among mobile operators in hard-to-reach areas. In practical terms, this could mean allowing two carriers to jointly use one assigned band or tower in a mountain valley (since duplicative networks there would be inefficient). Some economies have implemented active network sharing or local roaming in rural zones to maximize coverage - those ideas should be mentioned as a policy tool for Cluster C. The overall spectrum approach is to lower barriers for any entity that is willing to serve remote pockets - whether by unlicensed spectrum for community networks or rural roaming agreements for commercial operators.

Overall, mountainous, and forested economy strategies boil down to "connecting the hardest last miles" through a blend of supportive policy (subsidies, spectrum access, community empowerment) and appropriate tech (wireless, satellite, small cells) tailored to the landscape. The approach is often granular (village by village solutions) unlike the broad strokes of laying a single domestic fiber. This implies strong local involvement and iterative planning, but it is essential to reach universal connectivity.

4.4.4: Strategic Options for Urban/Compact Economies (Cluster D)

Urban/compact economies include city-states or highly urbanized regions (e.g., Hong Kong, China; Chinese Taipei; and Singapore). These places have little geographic barrier to infrastructure and often enjoy near-universal coverage, but they face high demand for innovative broadband and challenges like network congestion, upgrading legacy infrastructure, and pockets of underserved urban poor. Chapter 3 noted that while basic connectivity is high in cities, issues remain in ensuring ultra-fast speeds everywhere, affordability for lower-income groups, and keeping up with technological evolution (e.g., dense 5G rollout, fiber-to-the-home ubiquity).

In urban and compact economies, the focus shifts from "availability" to capacity, quality, and inclusiveness. Strategies revolve around staying ahead of demand by upgrading networks (to gigabit fiber, pervasive 5G, etc.), fostering intense competition to keep prices low, and addressing any remaining digital divide in marginalized urban communities. Public policy

should facilitate rapid deployment of new tech (through streamlined regulations and possibly public facilitation of infrastructure like ducts or poles), while leveraging market competition and private investment which is usually ample in cities. Key actions include:

- **Gigabit Infrastructure Everywhere:** Densely populated economies should aim for fiber to every home and business and 5G (and future 6G) coverage in every corner. This often requires removing bottlenecks in deployment. One strategy is dig-once and shared infrastructure policies - city governments can provide common conduit infrastructure or maps of existing ducts to avoid repetitive street digging. For example, in Singapore's Next Generation Nationwide Broadband Network (NGNBN), the government structured the market in layers and invested in passive infrastructure, resulting in pervasive fiber coverage (95%+ of premises) within a few years. Singapore achieved gigabit speeds throughout the city by 2012 under this open-access fiber PPP model[111]. Other dense cities can adopt similar models: coordinate with utility or transportation projects to lay fiber, require building developers to include fiber-ready cabling in new buildings, and mandate open access to building wiring (so multiple ISPs can serve apartments competitively). 5G deployment in urban areas requires many small cells. Policies can help by granting easier access to street furniture (lampposts, traffic lights) for small cell installation, at reasonable fees. APEC city administrations could similarly streamline permitting and possibly provide public facilities (buildings, public fiber) for operators to use, expediting network densification.

- **Competition and Market Innovation:** Urban markets often have multiple broadband providers. This competition should be maintained and enhanced, as it provides better services and pricing. Policymakers must ensure no single operator can dominate crucial urban infrastructure. If incumbents still control legacy last-mile networks (like copper telephone lines or coaxial cable TV networks), regulators might need to mandate open access or unbundling until new entrants build their own fiber. The entry of an additional mobile operator or a new fiber ISP could lead to significant price drops and innovation in services. For example, the introduction of a challenger broadband provider in France caused broadband prices to plummet and subscriptions to soar[112]. Thus, policies that lower entry barriers - such as number portability, easier wholesale leasing of capacity, and even support for municipal broadband in niche areas - help keep competitive pressure on incumbents. In some compact economies, the government itself facilitated a neutral wholesale network (as Singapore did with its NetLink Trust for fiber). These approaches ensure multiple retail service providers can use one infrastructure, creating retail competition even if duplicating networks city-wide would be inefficient.

- **Upgrading Legacy Networks:** In certain dense economies, there may still be pockets of legacy infrastructure (e.g., DSL on copper, older cable systems) in some neighborhoods or buildings. A strategy is to incentivize upgrades: possibly through time-bound targets or subsidies for upgrading in less profitable areas. For example, a regulator might set a policy that copper networks in urban areas must be phased out by a target date, with operators required to migrate customers to fiber or equivalent high-speed solutions by then. If some low-income or older apartment blocks are not upgraded due to cost, the government could provide a one-time subsidy or public-private co-

[111] Singapore's Next Generation Nationwide Broadband Network (IMDA, Govt. of Singapore, 2012), as referenced in Light Reading (2023)
[112] Closing Broadband Connectivity Divides for All. (2025). OECD. https://www.oecd.org/en/publications/closing-broadband-connectivity-divides-for-all_d5ea99b2-en.html

investment to wire those buildings). This is analogous to urban renewal programs - just as cities invest in upgrading roads and utilities in aging districts, they can invest in modern broadband infrastructure in those districts, often in partnership with ISPs. Public Wi-Fi initiatives are another tool: while mobile and fixed networks are primary, free, or low-cost Wi-Fi in public spaces (parks, libraries, transit hubs) can complement them and ensure that those who cannot afford high data bills still have connectivity options.

- **Inclusion and Closing Urban Gaps:** Even in wealthy cities, affordability and digital skills can be issues for certain groups (e.g., the elderly, low-income households, migrant workers.). Strategies should include targeted urban inclusion programs. For instance, some economies have subsidized broadband plans or devices for low-income urban families. The U.S. Affordable Connectivity Program (ACP) offered eligible consumers a monthly discount of up to USD 30 on their broadband service. For households located on qualifying tribal lands, the support was enhanced to up to USD 75 per month. In addition, the program included a one-time device subsidy of up to USD 100 toward the purchase of a laptop, desktop computer, or tablet through participating providers[113]. Governments can negotiate with ISPs to offer a "social tariff" (a discounted basic internet plan for qualifying households) in exchange for regulatory goodwill or support. Digital literacy campaigns in city community centers can help late adopters (like seniors) to come online confidently. Policymakers should track metrics like broadband adoption rate among the lowest-income quintile in the city, or usage rates among senior citizens, to identify remaining gaps. If those metrics lag, more aggressive inclusion measures may be warranted (e.g., expanding community IT centers, one-on-one digital ambassador programs for seniors, etc.). The principle is that no population group in a city should be left offline or stuck with sub-par connectivity simply due to income or social factors.

- **Smart City Synergies:** Urban broadband strategy can tie into smart city initiatives. As cities invest in smart infrastructure (Internet of Things (IoT) sensors, intelligent transport systems, etc.), they often deploy fiber and wireless networks that can have dual-use for public broadband. For example, a city installing fiber for smart traffic lights could possibly make some fiber strands available for commercial ISP use. Likewise, a municipal LTE/5G network for utilities or public safety might share capacity or infrastructure (towers, fiber) with mobile operators. Exploring such synergies can reduce overall costs and expand coverage. At a minimum, coordinating urban broadband plans with smart city projects avoids duplication and fosters a more cohesive digital ecosystem.

- **Governance and Regulation in Compact Economies**: Given their small size, these economies often have more centralized governance over telecom which can be an advantage for swift decision-making. But inclusive stakeholder engagement is still key: working closely with industry on standards (e.g., uniform standards for fiber installations or 5G antenna siting), with city planners (to include telecom ducts in urban planning), and with consumer groups (to ensure services remain affordable and accessible). Urban regulators also need to monitor service quality as networks become heavily loaded. They may enforce quality-of-service (QoS) minima (like minimum broadband speeds, latency, or maximum contention ratios) to guarantee that advertised

[113] *Affordable Connectivity Program*. Universal Service Administrative Company. https://www.usac.org/about/affordable-connectivity-program/

"gigabit" or "5G" actually delivers in practice. Additionally, as networks densify, coordination to minimize interference and aesthetic clutter (especially for 5G small cells in dense neighborhoods) might be necessary. This could involve technical guidelines or facilitated infrastructure sharing to avoid every carrier mounting separate antennas on the same street block.

- **Spectrum Policy**: Allocate high-capacity bands to relieve urban congestion. Densely populated cities need large blocks of mid-band and high-band spectrum for 5G/6G. The report should note that regulators are releasing, for example, the 26 GHz and 28 GHz mmWave bands to mobile operators in many economies, enabling multi-gigabit wireless service in cities. Ensuring ample mid-band (e.g. 3.5 GHz) spectrum is available and not over-constrained by legacy uses is also key for urban areas (many APEC members are moving to free up 3.3-4.2 GHz for 5G). In addition, policy can support dense urban networks by making spectrum licensing more flexible - e.g. micro licensing or unlicensed use in mmWave for indoor/outdoor small cells, so that building owners or city agencies themselves can deploy local 5G hot-spots. The Cluster D spectrum strategy thus focuses on capacity: releasing new bands and enabling innovative usage (while coordinating with satellite services, WiGig, etc., to manage interference in high bands).

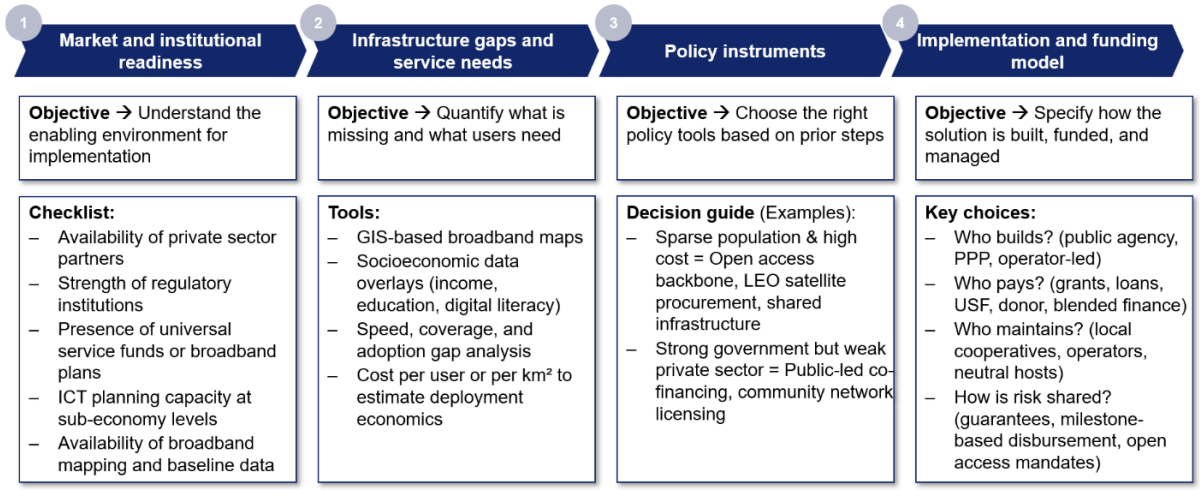
In summary, strategies for urban/compact economies aim to future-proof the digital infrastructure and ensure equity. These areas are usually ahead of others in connectivity, so the task is to maintain that edge (by rolling out next-gen tech early and ubiquitously) and to solve any remaining pockets of unmet need. Public policy levers are often about enabling and fine-tuning the market: removing red tape, setting ground rules for fair competition, and directly supporting any segments the market does not naturally serve (like low-income households or challenging locations such as subway tunnels or old public housing estates).

4.5 POLICY-SERVICE MODEL IMPLEMENTATION TOOLKIT

4.5.1 Decision Framework: From Readiness Assessment to Funding Model

Designing broadband vitalization strategies requires a systematic framework guiding policymakers seamlessly from initial readiness assessment through to implementation and financing. We propose a framework comprising four interconnected steps: (1) assessing market and institutional readiness, (2) identifying infrastructure gaps and service needs, (3) selecting appropriate policy instruments, and (4) defining the implementation and funding model.

Figure 4.4 Decision Framework and Process Steps



Step 1: Assess Market and Institutional Readiness

Before committing significant resources, governments must determine if the environment is conducive to implementation. Key considerations include regulatory preparedness, whether agencies have experience with PPPs, spectrum management, and infrastructure-sharing, and market readiness, namely whether private service providers are willing to invest if incentivized.

Readiness Assessment Toolkit

1. Regulatory Preparedness
Is there a clear and predictable regulatory framework in place? Do regulatory agencies have the experience and authority to manage complex arrangements such as PPPs, open-access obligations, or spectrum allocations for new technologies? Strong regulators can lower investor risk by enforcing transparency, safeguarding competition, and ensuring fair access to infrastructure.

2. Market Interest and Private-Sector Readiness
Broadband expansion requires the involvement of service providers and operators. Assessing market interest involves identifying whether private firms are willing to invest if appropriate incentives are provided. This includes evaluating:

- The presence of established ISPs or mobile operators active in underserved areas.
- The viability of business models under current demand levels.
- The extent to which incentives (e.g., tax breaks, spectrum pricing reforms, or infrastructure-sharing rules) could stimulate investment.
- Where no credible operator interest exists, public-led or community-driven solutions may need to take precedence until the market matures.

3. Institutional Capacity at Economy-wide and Local Levels
Even with strong regulations and interested operators, the ability of institutions to design, coordinate, and monitor projects can vary widely. A readiness assessment should consider whether:

- Sub-economy governments (states/provinces or municipalities) have the capacity to plan and manage ICT projects.
- There are local "digital champions" (e.g., engaged municipalities, cooperatives, or anchor institutions like universities) that can drive adoption on the ground.

4. Decision Criteria for Policymakers
At this stage, several criteria guide the strategic direction of broadband interventions:

- **Geographic suitability:** Are there physical barriers (mountains, islands, sparsely populated areas) that increase deployment costs?
- **Market attractiveness:** Can private investment be expected, or is full public funding necessary?
- **Institutional feasibility:** Are existing agencies equipped to manage and enforce new initiatives?
- **Demand drivers:** Are there anchor institutions (schools, hospitals, government offices) or clear community demand that justify investment?
- **Resilience needs:** Is the area prone to disasters, requiring more robust and redundant infrastructure designs?

5. Low-Readiness Pathways
If readiness is limited - such as the absence of operator interest, weak institutions, or a lack of baseline planning - strategies should initially focus on building capacity. This could involve strengthening regulatory agencies, developing broadband maps, piloting smaller-scale projects, or introducing universal service fund mechanisms. In such cases, early interventions are often publicly led, with the private sector gradually integrated as market conditions improve.

Institutional capacity also matters: are domestic broadband plans in place? Does a universal service fund exist? Are there local champions? The OECD highlights that sound institutional frameworks and evidence-based diagnostics are foundational to effective broadband deployment strategies OECD[114]. Where readiness is low, due to weak market interest or institutional gaps, strategies may need to begin with capacity-building or public-led models before private-sector engagement can be scaled.

Step 2: Identify Infrastructure Gaps and Service Needs

Once readiness is established, policymakers must quantify the "distance to target: What specific connectivity gaps exist? For example, how many villages are underserved? What coverage levels, such as only 2G mobile service, prevail? Are fiber backbones distant or absent? Is existing infrastructure underused due to cost or lack of digital awareness?

Community consultations should uncover local priorities, for instance, whether rural schools need broadband or farming communities value mobile services. Technical tools such as coverage mapping, speed tests, and cost models (e.g., cost per user or per km²) help set baseline

[114] Closing Broadband Connectivity Divides for All. (2025). OECD. https://www.oecd.org/en/publications/closing-broadband-connectivity-divides-for-all_d5ea99b2-en.html

metrics and inform resource estimates. This step establishes clear, measurable objectives such as "connect 20 villages with 4G, reaching 10,000 residents," and lays the foundation for subsequent monitoring.

Gap and Needs Analysis Toolkit

1. Gap Analysis of Infrastructure and Services
A structured assessment should identify:

- Villages or communities without any form of connectivity.
- Areas with only limited or legacy services (e.g., 2G or 3G coverage instead of 4G/5G).
- Regions lacking high-capacity backbones, such as fiber within feasible distance.
- Locations where networks exist but adoption is low due to affordability, lack of digital literacy, or lack of relevant content.

2. Tools for Evidence-Based Assessment
Policymakers should rely on a combination of technical and socioeconomic tools to define needs precisely:

- GIS-based broadband coverage maps to identify unserved or underserved pockets.
- Speed tests and quality-of-service measurements to determine whether existing connections meet minimum standards.
- Socioeconomic data overlays (income, education, digital literacy) to anticipate demand potential.
- Cost models estimating deployment economics, such as cost per user or per km^2, which highlight whether a given solution is affordable and sustainable.

3. Community and Stakeholder Engagement
Quantitative data should be complemented with community consultations. These reveal user priorities and help policymakers design demand-driven solutions. For example, farming communities may prioritize mobile access for agricultural services, while schools and clinics may require high-capacity internet for e-learning and telemedicine.

4. Defining Baseline Metrics and Targets
By combining infrastructure mapping, cost analysis, and user insights, policymakers can set clear baseline metrics for intervention. This includes defining:

- The number of villages to be connected.
- The quality of service to be achieved (e.g., minimum 4G coverage).
- The expected number of new users or institutions brought online.
- The approximate resources required to meet these objectives.

Step 3: Select Appropriate Policy Instruments

With gaps identified, policymakers must choose instruments tailored to the context. The key is to select interventions that respond directly to identified needs: for remote, sparsely populated

areas, satellite or backbone-sharing may be most effective; in moderate contexts with active private sector, demand-side incentives might deliver better results.

Instrument Selection Toolkit

1. Criteria for Instrument Selection

Policy instruments should be assessed against several key dimensions:

- Geographic fit: Does the instrument work with the physical and demographic conditions (e.g., remote mountains vs. dense sub-urban)?
- Market gap addressed: Does it resolve a clear supply- or demand-side failure (e.g., affordability, lack of incentives for private operators)?
- Infrastructure layer targeted: Is the intervention aimed at the right layer (backbone, middle-mile, last-mile)?
- Institutional feasibility: Do existing institutions have the capacity to implement it?
- Inclusion and equity: Does it address the needs of marginalized groups?
- Financial and technical fit: Is it scalable and appropriate to the local context?

2. Examples of Instruments

- Supply-side interventions: open-access backbone networks, spectrum allocation for rural use, low-Earth orbit (LEO) satellite procurement, shared towers, or wholesale models.
- Demand-side interventions: device subsidies, vouchers for low-income households, local content promotion, and digital literacy programs.
- Institutional measures: public–private partnerships (PPPs), community-based networks, or regulatory reforms (e.g., streamlined licensing, infrastructure sharing rules).

3. Decision Guidance

Different conditions call for different approaches. For instance:

- In areas with sparse populations and high costs, shared infrastructure models and satellite backhaul may be more viable.
- In contexts where the government is strong, but the private sector is weak, publicly led models, cooperative financing, or community networks may be required.
- In middle-income regions with active private ISPs, demand-side subsidies may be more effective than supply-side interventions.

Step 4: Define the Implementation and Funding Model

The final step translates strategy into practice by specifying how the solution is built, funded, and sustained over time. Without a realistic implementation and financing plan, well-designed policies risk remaining aspirational.

To safeguard sustainability, financing models should incorporate risk-sharing arrangements, milestone-based disbursement, and open-access clauses to prevent monopolization. In addition, involving local communities in maintenance enhances ownership and cost efficiency. By the

end of this step, policymakers have a clear operational plan: the responsible entities, the financing structure, and the risk-sharing mechanisms. This ensures interventions can move rapidly from planning to execution and, ultimately, deliver sustainable impact

Implementation and Financing Design Toolkit

1. Key Questions
Policymakers must resolve four central questions:

- Who builds the infrastructure? (public agency, PPP, private operator, or community initiative)
- Who pays? (government grants, universal service funds, donor financing, blended finance models, or end-user contributions)
- Who operates and maintains it? (incumbents, local cooperatives, private ISPs, or neutral hosts)
- How is risk shared? (e.g., guarantees, milestone-based disbursement, revenue-sharing models, or open-access obligations)

2. Funding Models

- Public funding - fully government-financed, common where private interest is minimal.
- Private-led models - incentivized through subsidies, tax breaks, or spectrum conditions.
- Blended finance - combinations of grants, loans, and equity, often with donor or development bank support.
- Universal Service Funds (USFs) – increasingly used for targeted last-mile projects.

3. Risk Mitigation and Sustainability
Implementation planning should include safeguards to ensure resilience and sustainability. Examples include:

- Mandating open-access provisions to avoid monopolies.
- Using milestone-based disbursements to ensure performance before funds are released.
- Encouraging local participation in maintenance to strengthen ownership and reduce operating costs.

4.5.2 KPI-Based Monitoring and Evaluation Framework

To ensure that the strategies and projects are delivering the intended outcomes, a robust Monitoring & Evaluation (M&E) framework with Key Performance Indicators (KPIs) is indispensable. We propose a framework with five key dimensions of metrics, as identified in APEC discussions and aligned with international best practices:

1. **Access and Coverage:** Indicators measuring the reach of infrastructure and networks, essentially, availability of connectivity. For example:
    - Percentage of population covered by broadband networks (mobile or fixed)
    - Number of previously unserved communities now connected

- Backbone capacity metrics like international internet bandwidth per capita (to ensure macro-capacity keeps up)

These KPIs answer: Is the infrastructure reaching the people who lacked it? A baseline might be, say, 85% 4G coverage domestically and only 50% in rural areas, target could be 95% rural coverage, and the KPI tracks progress towards that. Network uptime is another relevant metric in remote areas, measuring reliability (e.g., average network availability or downtime frequency, as resilience indicator).

2. **Affordability:** Indicators of the cost of broadband access relative to income levels. Common metrics are:

    - Price of a baseline broadband package as % of monthly income or GNI per capita (the UN 2% target is an example benchmark)
    - Cost of 1 GB of mobile data as % of income; and possibly device affordability (cost of an entry-level smartphone as % of monthly income).
    - Availability of free/low-cost access options, e.g., number of free public Wi-Fi hotspots per 10,000 people.

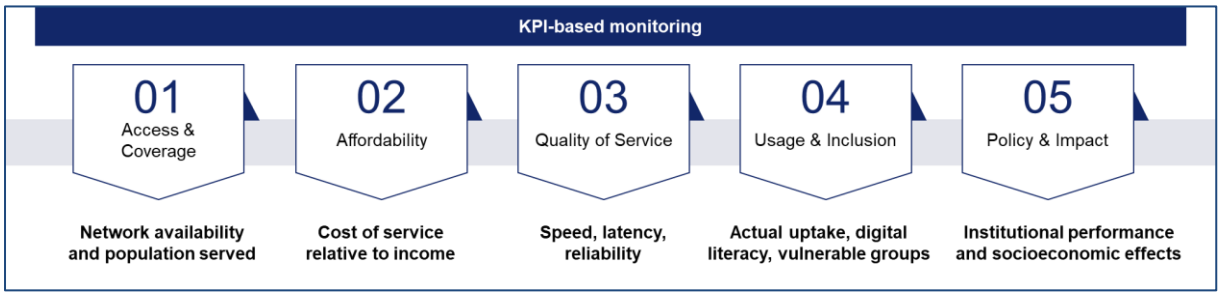
These metrics show whether broadband is becoming more economically accessible to the population. We would expect to see, for instance, the price of 5 GB mobile data for rural users drops from 5% of monthly income to under 2% after intervention (subsidies, competition, etc.), and we would track that over time.

3. **Quality of Service (QoS):** Indicators of network performance and quality. This includes:

    - Average broadband speeds (download/upload) are often measured via local speed test data and ideally segmented by urban vs rural to ensure the gap is closing.
    - Latency, especially important if satellites are involved; we could track average latency in areas served by different technology (if LEO satellites are introduced, latency should drop significantly compared to Geostationary or, traditional satellite system)
    - Network reliability - average downtime per user per month, or frequency of outages in a given area.
    - Infrastructure resilience, like % uptime of broadband infrastructure in disaster-prone areas
    - User-reported satisfaction can be a QoS indicator, e.g., via surveys, what % of users are satisfied with their internet service quality.

    Improved QoS indicators would reflect the effect of projects like backbone upgrades (increasing speeds) or network redundancy (reducing outages).

Figure 4.5 KPI Dimension to Measure Broadband Deployment Impact



4. **Usage and Inclusion:** Indicators focusing on adoption rates and the inclusion of target groups. Primary metrics are:

    - Internet penetration rate (e.g., % of households with internet access, % of individuals using the internet). These should be broken down by region (urban vs rural) and demographic groups (e.g., gender) to ensure disparities are narrowing. For example, the rural internet usage rate should rise and the urban-rural gap in usage should decrease over time, if initially urban usage is 80% vs rural 40%, perhaps target rural 60% and gap less than 20 points.

    - Gender gap in internet use is also key - measured as the difference in internet usage rates between women and men. If inclusion programs for women work, that gap should shrink (e.g., from 10% to 5%).

    Other inclusion metrics:

    - Institutional connectivity: e.g., % of schools connected, % of clinics connected, since many programs aim to connect public facilities (UNICEF/ITU's GIGA initiative target is all schools online).
    - Digital skills training delivered: such as number of people trained in digital literacy, especially from target groups (women, elderly, Indigenous).
    - e-government uptake (e.g. number of e-government transactions per capita)
    - % of small businesses selling online

    Those metrics show that beyond connectivity, people are actually using digital services. These can be proxies for the impact of inclusion efforts (though crossing into impact domain).

5. **Policy and Socio-Economic Impact:** Indicators to measure whether policy efforts are being implemented and the broader economic/social impacts. This can include:

    - Progress of policy implementation: e.g., number of reforms or actions completed out of those planned. For instance, if the broadband plan lists ten major actions (e.g. new law, spectrum auction, USF reform), track how many are done.

    - Budget execution rate: what percentage of the allocated broadband funds were effectively spent each year. If money is left unused (like USF funds often are), that may indicate a delivery bottleneck.

    - Macro-level impact indicators: a common one is broadband's contribution to GDP or productivity growth (World Bank studies showed a 10% increase in broadband penetration can correlate with ~1% GDP growth in developing economies). While

attributing causality can be risky, tracking indicators like broadband penetration vs. GDP or employment can provide evidence of impact.

- SME digitalization rate (% of SMEs online or using digital tools) as a socio-economic impact indicator (showing accrued benefits to small and medium enterprises)
- Digital inequality indices (urban-rural gap, gender gap, etc., some of which we covered in usage metrics) could be repeated here to underscore improvement in equality.

The KPI framework should be used for regular monitoring and adaptive management. The plan is to collect data on these indicators continuously (some annually, some quarterly) and publish them transparently, for example, via an online dashboard or in annual reports to stakeholders. This fosters accountability: parliament, media, and the public can see if targets are being met. For example, if by Year 3 only 50 villages have been connected out of 500 planned, that is a red flag to investigate and adjust course. The data also allows mid-course corrections: suppose KPIs show that affordability is not improving (prices still >5% of income), policymakers might respond by enhancing subsidy schemes or mandating a social tariff. Or if internet use by women remains low despite coverage, the digital literacy program may need expansion or redesign for women. Essentially, "what gets measured gets managed." APEC's workshops emphasized that the KPI model enables benchmarking and evidence-based policymaking. Economies can also benchmark internationally, e.g., compare their rural coverage or broadband prices with peers to gauge relative progress.

Implementing the KPI framework requires some practical steps: clearly define each KPI (so it's measured consistently), assign data collection responsibilities (operators might be required to report coverage and speed data; domestic statistical offices might gather household survey data on usage and income; etc.), and invest in measurement tools (like drive-test kits for mobile coverage or subscriptions to speed measurement services). Capacity-building may be needed for regulatory staff to analyze and visualize the data. It is also advisable to set intermediate targets on the way to final goals, to check trajectory.

By maintaining this comprehensive KPI framework, policymakers can ensure the broadband vitalization strategy stays on track and delivers actual results in terms of increased connectivity, greater affordability, better quality, higher usage, and positive socio-economic impact. If something is not working, the KPIs will highlight it, prompting timely adjustments, far better than realizing at the end that targets were missed. In sum, the KPI-based monitoring approach turns the strategy into a "living plan", one that learns and evolves through data feedback, aligning with modern principles of evidence-based policy and continuous improvement.

4.6 CONCLUSION AND RECOMMENDATION

4.6.1 Conclusion

In this chapter, we presented a comprehensive set of proposals and tools aimed at broadband vitalization in APEC's underserved areas, tailored to the diversity of challenges across large landmass, archipelagic, mountainous, and urban/ compact contexts. The overarching message is that bridging the digital divide in these areas requires integrated, smartly differentiated models - combining technology solutions with enabling policies and targeted inclusion efforts.

No single intervention will suffice on its own; success comes from the orchestration of multiple instruments within a coherent framework.

We outlined a general Policy-Service Model that serves as a blueprint for such orchestration, emphasizing clustering (to customize to context), a mix of policy/technology/service levers, and an implementation toolkit to drive execution and track progress. By applying this model, policymakers can move beyond ad-hoc projects to strategic programs that address both supply and demand side of broadband. The importance of this integrated approach cannot be overstated: as summarized in the workshop findings, effective broadband expansion requires integration of technology, policy, and services.

Each cluster section provided concrete and cluster-specific measures, from open-access fiber backbones across vast interiors, to submarine cables and satellites for islands, to microwave relays over mountains, to empowering community networks in isolated villages. While varied, these proposals all share a focus on sustainability - financially (through cost-sharing and PPPs), technically (choosing appropriate resilient tech), and socially (building local capacity and inclusion).

Finally, we introduced a Policy-Service Model Implementation Toolkit that provides a pathway to implementation and evaluation. The four-step decision framework ensures that interventions are well-planned, evidence-based, and tailored; the KPI-based monitoring model ensures that we keep our eyes on outcomes (like coverage, quality, usage, affordability) and not just inputs. This toolkit addresses the common pitfalls identified earlier - such as fragmentation and weak monitoring - by promoting coordination (via clear roles and decision criteria) and accountability (via KPI tracking and benchmarking).

In moving forward, APEC economies can utilize these insights to craft their own action plans. Given the collaborative spirit of APEC, economies could also benefit from sharing this toolkit and best practices regionally (e.g., through policy workshops, pilot projects, or even joint investment in cross-border infrastructure for remote regions). The recommendations here provide a menu, but each economy will need to prioritize and sequence actions according to its circumstances (e.g., some might focus first on backbone investment, others on immediate connectivity for schools, etc.).

Importantly, the chapter's proposals align with the APEC Putrajaya Vision's goal of inclusive and sustainable growth - recognizing that digital inclusion underpins economic inclusion in the modern era. By ensuring that people in the most remote and challenging environments gain access to broadband and the opportunities it brings, APEC economies will not only foster greater equality but also unlock new economic potential (through e-commerce, tele-health, e-learning, smart agriculture, and more) in those communities. As our KPI framework will help demonstrate, the dividends of broadband - from higher GDP growth to improved SME performance - can be substantial when connectivity reaches everyone.

In conclusion, tailored broadband models with clear tools, smart policies, and KPI-based tracking will drive effective connectivity across APEC. By customizing strategies to local conditions, integrating efforts across sectors, and diligently monitoring progress, member economies can make significant strides toward closing the digital divide. The result will be a more connected, innovative, and inclusive APEC region, where all communities - no matter how remote - can participate in and benefit from the digital economy. The next and final chapter

will summarize key recommendations and present a roadmap for implementation, building upon the detailed proposals outlined here.

4.6.2 Recommendations

Drawing on the above findings, we outline key recommendations for policymakers, telecom regulators, and development partners to accelerate broadband vitalization in underserved areas:

1. Establish a Customized Domestic Broadband Plan: Every economy should update or develop a broadband plan that includes cluster-specific strategies - differentiating rural and urban targets, and sub-programs for islands versus highlands - backed by political endorsement at the highest government level. Evidence shows OECD economies set domestic broadband targets specifying gigabit-ready fixed broadband coverage for both households and critical public services by specific deadlines (e.g., 100% of households with 100 Mbps, upgradeable to 1 Gbps by 2025)[115].

2. Create a Central Coordination Mechanism: Governments should establish a Broadband Steering Committee including ministries of ICT, finance, education, utilities, and local authorities to coordinate implementation, fast-track approvals, and resolve barriers such as right-of-way and funding delays. Regional development frameworks stress that multi-level coordination and coherent governance accelerate digital infrastructure rollout, connecting urban and rural areas effectively.

3. Fully Leverage Universal Service Funds (USF) and Innovative Financing: Many economies have large USF reserves that remain underutilized; prioritizing their use for underserved clusters - combined with blended financing (e.g., combining USF grants, development bank loans, and private equity)- can mobilize resources effectively. The OECD emphasizes matching public support with strategic deployment, and GSMA highlights that while many USFs underperform due to inefficiencies, reforming them toward transparency and community inclusion unlocks their potential.[116]

4. Implement Open Access and Infrastructure Sharing Rules: Policy should mandate open access to critical infrastructure (fiber backbones, subsea landing stations) and require operators to share towers, ducts, and poles, especially in rural zones, to reduce duplication and lower costs. Infrastructure-sharing in rural regions is a proven method in OECD contexts, helping make remote-area networks economically viable[117].

5. Utilize Spectrum as a Public Good for Inclusion: Regulatory frameworks should be revised to release low-frequency spectrum bands (e.g., TV White Spaces) for rural broadband, include coverage obligations in spectrum allocations, and offer incentives like bonus spectrum or fee discounts for operators expanding into underserved areas. Such spectrum management approaches are recognized as essential enablers of rural coverage and competition in OECD member.

[115] Closing Broadband Connectivity Divides for All. (2025). OECD. https://www.oecd.org/en/publications/closing-broadband-connectivity-divides-for-all_d5ea99b2-en.html
[116] Closing Broadband Connectivity Divides for All. (2025). OECD. https://www.oecd.org/en/publications/closing-broadband-connectivity-divides-for-all_d5ea99b2-en.html
[117] Closing Broadband Connectivity Divides for All. (2025). OECD. https://www.oecd.org/en/publications/closing-broadband-connectivity-divides-for-all_d5ea99b2-en.html

6. Invest in Backbone and Middle-Mile Infrastructure: Public investment should focus on local fiber backbones and regional links where markets fail to deliver. Development agencies often co-finance these high-impact infrastructures through low-cost funding models. Ensuring these networks are open access enhances competition and drives retail affordability.[118]

7. Extend Last-Mile Coverage through Smart Subsidies and PPPs: Use competitive subsidy auctions to deliver rural coverage - selected providers bid on the lowest subsidy required - as seen in economies like Brazil and the U.S., encouraging cost-efficient delivery. When auctions are not viable, direct contracting with milestone obligations remains an effective alternative. Mini-grants for community networks also serve as an efficient and lower-cost complement.

8. Address Affordability: Even where networks are available, ensure people can afford to connect. Implement an affordable broadband program domestically: this could be a voucher scheme for low-income households or students to get discounted or free internet (similar to the USA's ACP or Europe's social tariffs). Set a goal aligned with the UN 2%-of-income affordability target[119]. For example, "Within 3 years, entry-level broadband (e.g. 5–10 Mbps) will cost no more than 2% of household income for the bottom 40% of the population." Use a combination of subsidies, market pressure, or cross-subsidy (like Australia's NBN uniform pricing where urban users indirectly subsidize rural costs) to achieve that. Additionally, consider removing consumer taxes (VAT, etc.) on basic telecom services or devices for a period or for designated poor regions, evidence from some economies suggests this can boost adoption with minimal revenue loss.

9. Boost Digital Literacy and Local Content Initiatives: Allocate resources for mass digital literacy campaigns targeting rural communities, the elderly, and micro-SMEs. This could involve train-the-trainer programs (e.g., youth teaching seniors, or agricultural extension workers teaching farmers to use smartphone apps). Set tangible targets like "Train 100,000 rural citizens in basic internet use by 2026" and monitor it. At the same time, invest in local content and services that make the internet valuable to underserved populations: e-government in local languages, digital agriculture marketplaces, telemedicine platforms for remote clinics, etc. Partner with the private sector and NGOs to create and promote such content. For example, support development of local-language educational content and work with mobile operators to zero-rate it (make it data-free for users) - tackling relevance and affordability in one stroke.

10. Implement the KPI Monitoring and Public Dashboard: As projects roll out, begin collecting KPI data across the five dimensions outlined (Access, Affordability, Quality, Usage, Policy impact). Assign the telecom regulator or local statistics office to gather and publish these KPIs annually (if not more frequently). Ideally, launch a "Broadband Dashboard" website where anyone can see progress: e.g., how many new villages connected this quarter, current internet prices vs. target, speeds achieved, number of female users, etc. This transparency will maintain momentum and pressure to achieve results. It also helps catch issues early: for instance, if after a year the percentage of women online has not increased, then the digital inclusion programs for women may need to be re-evaluated. Use the KPIs to also benchmark

[118] *Strengthening Regional Policy for Resilient Places*. (2025). Business at OECD (BIAC). https://www.businessatoecd.org/hubfs/Strengthening%20Regional%20Policy%20for%20Resilient%20Places.pdf?hsLang=en

[119] *Broadband Advocacy Target 2: Make Broadband Affordable*. (2025). Broadband Commission for Sustainable Development. https://www.broadbandcommission.org/advocacy-targets/2-affordability/

internationally (APEC could consider agreeing on a common set of indicators for members to compare, fostering healthy competition and knowledge sharing).

11. Strengthen Regional Cooperation and Knowledge Sharing: APEC should continue facilitating exchange of best practices, case studies, and even resources. Economies can collaborate on cross-border connectivity projects (like shared satellite capacity, regional internet exchange points, or joint regulatory training programs). Development agencies can be urged to support multi-economy initiatives (e.g., a regional fund for Pacific connectivity, or an ASEAN digital inclusion program focusing on women and rural youth). The knowledge compiled - e.g., how Indonesia handled its islands, how Peru tackled fiber in the Andes - should be disseminated so others can adapt those models.

12. Integrate Sustainability and Resilience into Broadband Planning: Broadband expansion should be designed not only for coverage and speed but also for long-term environmental sustainability and network resilience. Governments and regulators should adopt "green ICT" principles - promoting the use of energy-efficient equipment, renewable-powered base stations, and shared passive infrastructure to reduce the carbon footprint of broadband networks. In climate-vulnerable regions (e.g., archipelagic and mountainous economies), network resilience must be strengthened through redundant links, disaster-resistant design standards, and emergency connectivity protocols to ensure continuity of communication during natural disasters. Development banks and donors increasingly prioritize climate-aligned digital investments; integrating these criteria early will attract sustainable financing and future-proof domestic broadband programs.

13. Promote Equipment Standards and Interoperability: Governments and regulators should adopt and enforce open technology standards to ensure interoperability across vendors and network layers. This allows service providers to mix and match components without being locked into proprietary ecosystems, reducing costs and increasing flexibility. For example, local fiber backbones should use standard ITU-T interfaces to enable seamless interconnection with various optical equipment, and community Wi-Fi networks should adhere to mainstream IEEE standards for universal device compatibility. Initiatives such as the Broadband Forum's multi-vendor PON interoperability and the global Open RAN movement illustrate how open standards accelerate innovation, competition, and ease of integration. By prioritizing interoperability, economies can future-proof their broadband infrastructure, simplify upgrades, and expand connectivity through a diverse supplier ecosystem

14. Apply Cost–Performance Trade-off Principles in Broadband Investment: Policymakers should explicitly consider the balance between performance and cost when planning broadband deployment in underserved areas. The goal is to achieve reliable, affordable connectivity for the greatest number of people, rather than pursuing the most advanced technology everywhere. While fiber remains the benchmark for speed and scalability, in many rural or remote areas a hybrid approach- combining fiber backbones with wireless or satellite last-mile solutions - can deliver comparable service quality at a fraction of the cost and time. For example, instead of spending tens of thousands of dollars per household on fiber in sparsely populated regions, a 5G fixed wireless or satellite setup costing around USD 1,000 could provide 50–100 Mbps within weeks. Policymakers should therefore adopt pragmatic, cost-efficient strategies that stretch limited resources, prioritize early impact, and reserve high-capacity fiber extensions for areas where demand and density justify the investment.

15. Ensure Political and Financial Sustainability: Finally, treat broadband vitalization as a long-term development priority, not a one-off project. Secure multi-year funding commitments

(e.g., incorporate broadband into domestic development plans and budgets). Build broad political consensus (across parties, across levels of government) that digital inclusion is foundational for economic competitiveness and social well-being. This helps protect programs from political shifts. Embed accountability for broadband targets into officials' performance evaluations. Encourage not just economy-level but also local government involvement. Provinces and cities should have their own digital inclusion plans feeding into the economy-wide one. And maintain flexibility: as technology evolves (say satellite costs plummet or 6G emerges), be ready to integrate new solutions, guided by the same principles of inclusion and context fit.

By implementing these recommendations, economies will make significant strides toward closing the digital divide. The benefits will be far-reaching: more vibrant economies as SMEs and entrepreneurs come online; improved education and health outcomes through connected schools and clinics; empowerment of marginalized groups (women, rural and indigenous communities) by giving them a voice and opportunities in the digital sphere; and greater resilience in times of crisis (as seen during COVID-19, connectivity is a lifeline). Moreover, investing in broadband can have a substantial economic multiplier effect.

In conclusion, tailored broadband vitalization, executed with smart policies, innovative technologies, and inclusive services, and tracked by clear KPIs, can drive effective connectivity across APEC and beyond. By following the structured approach outlined in this report, policymakers and partners can ensure that no area and no population is left behind in the digital age. The time to act is now, to turn these proposals into concrete programs that deliver affordable, reliable, and inclusive broadband for all.

5. CAPACITY BUILDING WORKSHOP AND SURVEY RESULTS

As an important final step of this study, a capacity building workshop was conducted with Asia-Pacific Economic Cooperation Telecommunications and Information Working Group (APEC TELWG) member economies to validate findings, exchange experiences, and strengthen regional collaboration on broadband development. The workshop served two main purposes:

- **Knowledge Sharing**: Experts presented insights on broadband trends, domestic broadband plan design, and digital inclusion strategies, followed by a discussion of the study's preliminary results.

- **Interactive Exchange**: Participants engaged in structured breakout sessions to identify key challenges in broadband deployment and propose the most promising solutions for underserved areas, providing valuable real-world input for the final recommendations.

Complementing the workshop, a targeted survey was distributed to APEC TELWG members to systematically verify the study's data, refine the cluster analysis, and ensure that policy recommendations reflect the priorities of member economies.

Together, the workshop and survey created a feedback loop that ensured the study's outputs are evidence-based, regionally relevant, and endorsed by key stakeholders, strengthening the practical applicability of the proposed policy-service models and toolkits.

5.1 Agenda and Participation

The three-day capacity building workshop was attended by delegates and speakers from the following economies:

1. Australia
2. Indonesia
3. Republic of Korea
4. Malaysia
5. Papua New Guinea
6. Russia
7. Singapore
8. Chinese Taipei
9. Thailand
10. The United States

The official agenda of the workshop follows a chronological order: Day 1's focus is on hearing different perspectives from various presenters and speakers hailing from various economies. Day 2's focus is on presenting the initial key findings from this report, along with hosting interactive exchanges between groups of economies. Lastly, Day 3's focus is on a field trip for participants to gain hands-on knowledge from the field.

Figure 5.1 Capacity Building Workshop Agenda

Workshop Schedule, Day1

7.28.(MON)	Program	Speaker
10:00~10:10	Project Introduction	June Lee Principal Manager, Global Digital Planning Team of NIA)
10:10~10:20	Opening Speech	Hye-Jeong Lim (Director, Global Digital Planning Team of NIA)
10:20~10:40	(Topic Presentation) Korean Broadband Policy and Service (Early Stage of Broadband History)	Hyun-Je Park (Hallym University)
10:40~11:00	(Topic Presentation) Fixed Broadband Access Ne twork Trends	HyungJin Park (KT)
11:00~11:20	(Topic Presentation3) An Inclusive and Multilingual Internet	Angela Wibawa (ICANN)
11:20~11:50	(Panel Discussion with topic presenters) Bridging the Digital Divide: Strategies for Enhancing Broadband C onnectivity in Underserved Regions.	Presenters
11:50~13:30	Lunch	-
13:30~14:30	(APEC Economy) Status Update (1): Broadband Network in APEC. - Indonesia, Malaysia, Papua New Guinea, Peru, Australia	Each Economy
14:30~15:00	Issue Discussion	-
15:00~15:30	Workshop Survey	-

Workshop Schedule, Day 2&3

7.29.(TUE)	Program	Speaker
10:00~10:10	Project Overview	DETECON
10:10~10:40	(Project Progress) Analysis of Broadband Status by Economy Type	DETECON
10:40~11:10	(Project Progress) Analysis of Best Practices in Broadband Networks	DETECON
11:10~11:40	(Project Progress) Sharing of Customized Broadband Technology-Policy-Service Models by Economy Type	DETECON
11:40~13:30	Lunch	-
13:30~14:30	Clustering and Prioritization of Broadband Vitalization Measures for Underserved Areas.	DETECON
14:30~15:00	Identifying key implementation challenges	DETECON
15:00~15:10	Closing Session	-
15:10~15:30	Workshop Survey	-
8. 3. (SUN)	**Program**	
14:00~18:00	[Field Trip] SEOUL ROBOT & AI MUSEUM	

5.2 Day 1: Key Results of Status and Trends of Broadband Supply and Demand

On Day 1, various speakers were invited to present relevant topics in broadband. This includes topic presenters from prestigious domains such as Hallym University, Korean Telecom (KT), and the Internet Corporation for Assigned Names and Numbers (ICANN). Furthermore, delegates from four different economies (Australia; Indonesia; Malaysia; and Papua New Guinea) presented their perspectives on their economy's current broadband statuses and challenges.

5.2.1 Korean Broadband Policy and Service (Early Stage of Broadband History) by Hyun-Je Park, Hallym University

The presentation offers valuable strategic insights on state–market coordination, infrastructure reuse, and content-driven adoption. It highlights how private investment and regulatory openness enabled rapid broadband rollout, providing lessons for market-led growth today. It also shows how education, youth engagement, and local content such as games and e-learning spurred demand, underscoring the point that infrastructure deployment must go hand in hand with user adoption and digital literacy.

The key messages from the presentation:

- **Strong Government Leadership:** Korea's early broadband success was driven by the KII strategy, massive infrastructure investments, and widespread education and public access initiatives.
- **Market Liberalization:** Deregulation and fair competition enabled new entrants like Thrunet and Hanaro, fostering rapid deployment and innovation.
- **Affordable and Diverse Services:** Early flat-rate pricing, broadband bundling, and multimedia applications boosted demand and made access widely affordable.
- **Digital Literacy and Demand:** High urban density, a strong education culture, and eager netizens (especially youth and parents) drove adoption.
- **Holistic Ecosystem:** Korea combined public policy, private investment, infrastructure reuse, and digital content (e.g., games, education) into a coherent, scalable broadband model.

5.2.2 Fixed Broadband Access Network Trends by HyungJin Park, KT

The presentation lays out a clear technology roadmap, showing the evolution from copper to multi-gigabit PON solutions (e.g., GPON to 50G-PON to 100G-CPON), while also being forward-looking by covering long-term trends to 2050 and future use cases such as AI, XR, and cloud. Its scope is comprehensive, extending beyond fiber rollout to include FTTR, FWA, and cloud-network convergence. The content is data-driven and highly visual, drawing on global sources like Omdia and WBBA to support key messages. A strong focus is placed on AI, emphasizing its role in accessing network operations and enhancing user experience. Scalability and coexistence are addressed through Multi-PON Modules that allow legacy and next-generation technologies to operate together. The material is vendor-neutral and globally relevant, not confined to Korea or KT, and is well aligned with broader digital goals, linking broadband to smart homes, Industry 4.0, and digital transformation.

The key messages from the presentation:

- **Broadband is a critical enabler of digital transformation**
    - Transition from dial-up to gigabit+ broadband has been exponential.

    - Future networks must support bandwidth-hungry applications (AI, XR, cloud, etc.).
- **Fiber is the dominant and future-proof technology**
    - "Fiber for everything" is the global trend.
    - Gigabit-class broadband adoption is rising worldwide.
- **Passive Optical Network (PON) technology is rapidly evolving**
    - GPON to XGS-PON to 50G-PON/100G-PON.
    - Multi-PON coexistence is a practical path to support legacy and future needs.
- **Customer premises network (FTTR) is increasingly important**
    - FTTR helps eliminate indoor Wi-Fi dead zones and supports smart home use cases.
- **Cloud-network convergence shifts computing power**
    - AI and device functionalities are increasingly offloaded to the cloud.
- **Fixed Wireless Access (FWA) is viable for underserved areas**
    - 5G FWA can deliver fiber-like speeds where fiber rollout is not feasible.
- **Network architecture is becoming more disaggregated and software-defined**
    - Transition from hardware-defined, monolithic networks to AI-enhanced, cloud-native designs.
- **AI is a core enabler of smart, scalable, and efficient broadband networks.**

5.2.3 An Inclusive and Multilingual Internet by Angela Wibawa, ICANN

The presentation places strong emphasis on inclusivity by highlighting the importance of creating a multilingual internet, aligning with the broader goal of expanding access to broadband. It effectively uses visual aids and examples, such as IDNs, EAIs, and illustrations of Universal Acceptance challenges, to simplify complex technical concepts. The discussion is framed within global governance contexts like WSIS and MSM, reinforcing its international relevance. Finally, it provides a clear call to action by outlining specific roles for governments, technology businesses, civil society, and academia, offering a concrete roadmap for advancing Universal Acceptance.

The key messages from the presentation:

- **ICANN's Mission:** Ensures the stable and secure operation of the Internet's unique identifier systems.
- **Multistakeholder Model:** The Internet's governance is driven by a bottom-up, community-based approach.

- **Need for Multilingual Internet:** Addresses global language diversity beyond English through Internationalized Domain Names (IDNs) and Email Addresses (EAIs).
- **Universal Acceptance (UA):** Promotes the equal treatment of all domain names and email addresses across all systems.
- **Call to Action:** Urges collaboration among governments, tech, civil society, and academia to implement UA for inclusive internet access.

5.2.4 Broadband Status in Indonesia: Insights on Growth, Challenges, and Strategic Outlook by Siti Desfira Utami, BAKTI KOMDIGI

The presentation lays out the current status of broadband connectivity in Indonesia; acknowledging that digital divide still persists due to infrastructure deployment challenges, spectrum auction delays, and regulatory disputes.

The key messages from the presentation:

- **Core Infrastructure:** Palapa Ring, extensive fiber optics, critical submarine cables, advanced satellite networks, growing data center capacity.
- **Broadband Coverage and Penetration Rates:** 79.5% (~225 million users) are online; only 27.4% have fixed broadband access, while 95% has access to at least 4G.
    - It is projected that satellite broadband users could reach three million in the future, crucial for remote areas.
- **Fixed Broadband Trends:** 1.7% growth in 2024. The high cost is the significant barrier, ranging from IDR 400,000 to IDR 500,000
- **Market Structure:** IndiHome (Telkom) takes up 75% market share. Key competitors such as Biznet, First Media, MyRepublic, and XLHome
- **Internet Speed in Comparison:** Indonesia's average speed is 30 Mbps (urban) and >10 Mbps (rural), significantly lower than regional leaders such as Singapore (336 Mbps) and Malaysia (129 Mbps)
- **Government Strategies:** Accelerate spectrum allocation, large-scale infrastructure projects, and promotion of technology convergence for inclusivity.
    - Spectrum roadmap is 2025: 700 MHz Allocation, 2026: 1.4 GHz Planning, 2027: 5G Deployment, and 2029: Satellite Broadband
- **Key Challenges:** High deployment costs, limited private investment, digital divide, and spectrum and regulation
- **Opportunities:** Bundled Services, Government Incentives, Public-Private Partnerships, Digital Transformation Roadmap

5.2.5 Malaysia's Broadband Status by Malaysian Communications and Multimedia Commissions (MCMC)

The presentation highlights Malaysia's broadband progress and digital inclusion efforts, covering local initiatives like the National Broadband Initiative and JENDELA, key achievements in fiber rollout and mobile broadband, rural connectivity programs, and community initiatives such as NADI to enhance digital literacy and access.

The key messages from the presentation:

- **Broadband Status (Q4 2024):** Fiber to the premise: 9.03 million premises passed, Internet coverage in populated areas: 98.66% coverage, Fixed broadband subscription: 4.87 million, and Mobile broadband subscription: 44.7 million
- **Convergence Framework:**
    - Local broadband initiative (2010 – 2020): Public-Private Partnership (PPP), accessibility and affordability, and expansion
    - JENDELA (2020 – 2025): Improve the coverage and quality for broadband and digital service especially in rural areas. Currently Phase 2: FWA-focused
- **JENDELA Target and Progress:**
    - **Premises Passes with Fiber Connectivity:** Exceeded target (9.03/9 million premises)
    - **Mobile Broadband Speed:** Exceeded target (105.36/100 Mbps)
    - **Internet Coverage in Populated Areas:** In progress (98.66/100 per cent)
- **Broadband Expansion to Rural Areas:**
    - Sarawak government funding SMART600 capital expenditures (CAPEX) and joint OPEX funding between government and telcos
    - 600 towers deliver 4G mobile services to <1,000 rural sites benefiting <180,000 residents
- **National Information Dissemination Centre (NADI):**
    - Universal Service Provision (USP) initiative to provide collective internet access, help communities with digital literacy, and provide a government-to-citizens platform.
- **Industry Guideline for Network Infrastructure Sharing:** Resource Optimisation, Inclusive Connectivity, Economic Resilience, and Quality Service and Coverage.

5.2.6 Papua New Guinea by Roa Velekiri, National Information and Communications Technology Authority (NICTA)

The presentation underscores broadband's role in digital transformation, with mobile as the main access but low penetration and high rural costs. Despite UAS initiatives, challenges include limited infrastructure, tough terrain, and affordability issues. The way forward calls for expanded coverage, spectrum and infrastructure sharing, LEO satellites, and regional cooperation.

The key messages from the presentation:

- **Overview:** Driven by government policies, regulatory frameworks, and market competition. The sector plays a critical role in domestic development, enabling digital transformation, improving connectivity, and enhancing service delivery across various industries.
- **Broadband Status:** Mobile is the primary connectivity at 76% 4G coverage but penetration is >0.3%, satellite is the primary means of fixed broadband connectivity with >1% penetration rate, and mobile prices consume <30% of household income while rural prices are 4 to 5 times higher than urban areas.
- **Universal Access and Service:** UAS levy charged on operators focused on broadband, broadcasting, and meaningful connectivity initiatives, e.g., smart farming and MSMEs support
- **Challenges:**
    - **Limited Network Infrastructure**
    - **Geographical Barriers:** Mostly mountainous areas increase the deployment costs by 300%
    - **Limited Accessibility:** 11% of the population lacks basic mobile coverage
    - **Affordability Constraints:** 80% of the population is low-income in the rural areas.
    - **Lack of Reliable Grid Power**
- **Way Forward:** Expand current coverage, implement market-based spectrum assignments and infrastructure sharing, deploy LEO satellite services and Mobile Number Portability frameworks, and leverage relationships within the region and APEC.

5.2.7 Australia: Broadband in Underserved Areas by Ellie Barclay

The presentation outlines Australia's broadband landscape, with NBN delivering fixed services via mixed technologies, 84% high-speed access, and a legislation guarantees of 25 Mbps economy-wide. Mobile 5G covers 91%, while satellite and emerging LEO services expand remote access. Rural and First Nations programs further enhance connectivity through targeted funding and community Wi-Fi initiatives.

The key messages from the presentation:

- Fixed broadband services in Australia are primarily delivered over the NBN using a mix of fixed-line, fixed wireless and satellite technologies.
    - Eighty-four percent of population have high-speed internet access of close to 1 Gbps
    - Statutory Infrastructure Provider (SIP) legislation ensures at least 25 Mbps speed all over the economy
- Ninety-one percent of the population has mobile 5G coverage
- Satellite services have been expanding since 2016 for remote areas. Furthermore, LEO satellite services are ramping up with Starlink and Amazon Kuiper
- Better Connectivity Plan for Regional and Rural Australia provide funding for rural regions, including 'Mobile Black Spot' and 'Regional Connectivity' programs
- First Nations Digital Inclusion Budget Measures include NBN community wide Wi-Fi services serving twenty-three remote First Nations communities across Australia and Open competitive First Nations Community Wi-Fi program delivering additional free Wi-Fi services will help remote communities.

5.3 Day 2: Key Results of Project Progress of Broadband Study

On Day 2, the workshop centered on presenting the initial findings outlined in earlier chapters, including the Broadband Status by Economy Type, Best Practices in Broadband Networks, and Broadband Technology-Policy-Service Models segmented by Economy Type. Following the presentations, an interactive capacity-building session was held, bringing together participants from APEC economies to collaboratively explore each economy's perspectives on broadband gaps, relevant best practices, and essential instruments for revitalizing broadband access in underserved areas.

To reinforce understanding and ensure effective knowledge transfer, various interactive tools, such as online quizzes, were incorporated throughout the day. These activities helped validate participants' grasp of the broadband concepts and recommendations discussed, which the results will be displayed in this chapter as well.

5.3.1 Broadband Status by Economy Type

This presentation provides a comprehensive overview of broadband infrastructure and adoption across APEC economies. It highlights the disparity between high-income and low-income economies in terms of fixed and mobile broadband penetration. While economies like Japan; Korea; and Singapore lead with near-universal fiber and 5G coverage, others such as Indonesia and Papua New Guinea rely heavily on mobile networks due to limited fixed infrastructure.

The analysis shows that mobile broadband penetration averages 133%, significantly higher than fixed broadband at 81.5%. However, affordability, population density, and digital literacy remain key factors influencing adoption. Economies with high population density and lower broadband costs tend to have higher penetration rates. The presentation also emphasizes the

need to balance supply-side infrastructure with demand-side measures like affordability programs and digital literacy initiatives.

Regulatory frameworks vary across economies, with advanced economies focusing on infrastructure modernization and emerging ones relying on public investment and universal service obligations. The conclusion stresses that infrastructure alone is not enough, adoption and meaningful use must be supported through inclusive policies and digital ecosystems.

5.3.2 Best practices in Broadband networks

This presentation explores successful broadband strategies across APEC economies, categorized by geographic and socioeconomic clusters. It identifies four key enablers for meaningful connectivity: infrastructure deployment, regulatory frameworks, resilience to natural disasters, and digital readiness.

Examples include:

1. Australia's NBN model, which uses a wholesale-only approach and extensive local backbone to connect remote areas.
2. Korea's strategic domestic plan, combining public investment and private sector incentives to achieve near-universal high-speed broadband.
3. Chinese Taipei's disaster-resilient infrastructure, including satellite redundancy and cross-network roaming.
4. Papua New Guinea's EU-STREIT initiative, integrating broadband with agriculture, finance, and education to promote rural development.

The presentation emphasizes that tailored approaches are essential. Economies must consider terrain, population distribution, and digital inclusion needs. It concludes that effective broadband policies require a balance of infrastructure, governance, and community engagement.

5.3.3 Broadband Technology-Policy-Service Models by Economy Type

This presentation introduces a framework for designing broadband policies tailored to different economy types. It proposes a three-pillar model: clustering of economies, selection of policy instruments, and an implementation toolkit.

Economies are grouped into four clusters:

1. Large landmass economies (e.g., Australia; Canada)
2. Archipelagic economies (e.g., Indonesia; The Philippines)
3. Mountainous/forested economies (e.g., Peru; Thailand)
4. Compact urban economies (e.g., Hong Kong, China; Singapore)

Each cluster faces unique challenges, such as high infrastructure costs, geographic isolation, or digital inclusion gaps. The policy instruments include regulatory reforms, fiscal incentives, public-private partnerships, and digital inclusion programs. The implementation toolkit helps assess readiness, identify service gaps, and monitor progress using KPIs across access, affordability, quality, and inclusion.

The presentation concludes that successful broadband expansion depends on strategic policy design, institutional capacity, and continuous monitoring. Tailored models with clear tools and inclusive strategies are key to bridging the digital divide across APEC.

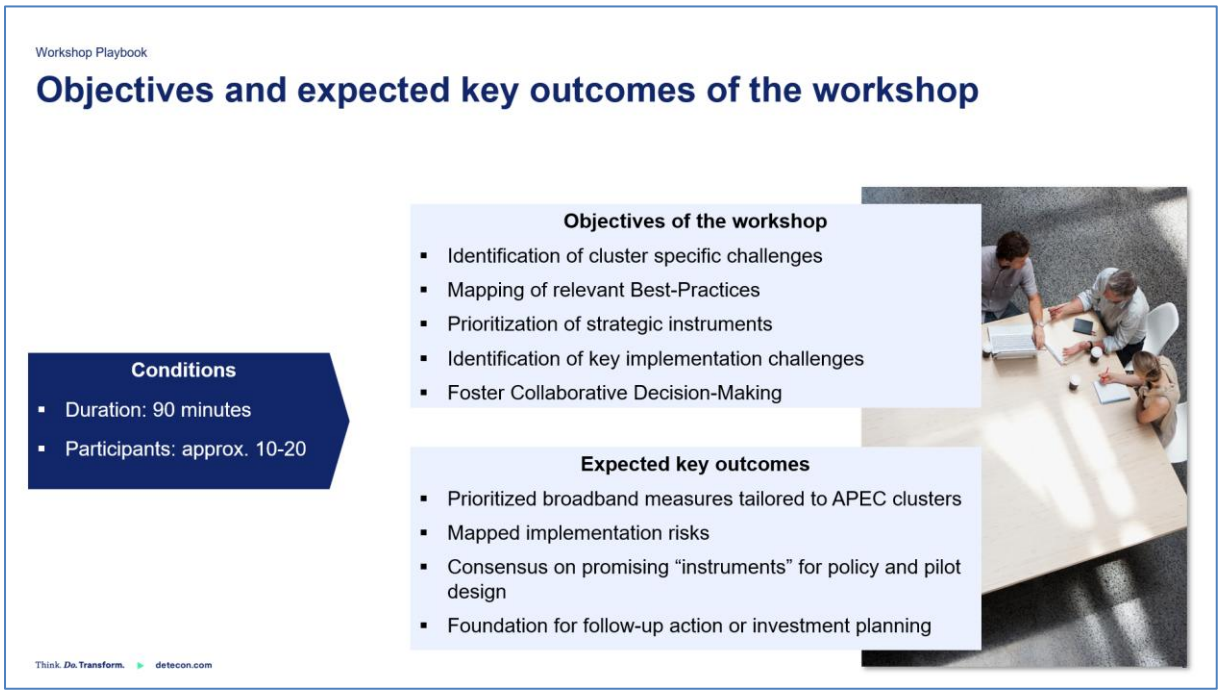
5.3.4 Interactive Session: Current situation and challenges for Broadband in APEC

The workshops revealed that despite differences in geography, income levels, and regulatory traditions, APEC economies face many similar challenges in extending broadband to underserved areas. Participants frequently emphasized that rural and remote regions continue to lag urban centers due to the high cost of infrastructure deployment, the difficulties of connecting sparsely populated communities, and the lack of immediate commercial incentives for operators. Even when infrastructure exists, affordability remains a critical barrier, particularly for low-income users who may struggle with recurring subscription costs or the purchase of devices. This dual challenge of supply and demand, expanding networks while ensuring people can afford to use them, was a recurring theme throughout the discussions.

Another key insight from the workshops concerned the role of policy and regulation. Economies have experimented with a variety of tools, including universal service funds, spectrum obligations, and infrastructure-sharing mandates. Some of these mechanisms have helped reduce deployment costs and create incentives for private sector investment, but participants noted that results are uneven. Effectiveness often depends on how policies are implemented, the transparency of funding mechanisms, and whether there are clear enforcement mechanisms. Importantly, participants highlighted that policies must evolve as technology changes, pointing to the growing role of satellite services, wireless technologies, and new partnership models.

Workshops also provided space for participants to share examples of innovation. Some economies described pilot projects involving community-managed networks, partnerships between local governments and operators, and novel financing schemes that pooled resources across different stakeholders. These initiatives demonstrate that creative approaches, adapted to local conditions, can make a difference in bridging connectivity gaps. At the same time, participants stressed the importance of regional cooperation, with several economies expressing strong interest in platforms for knowledge exchange and capacity building. The consensus was clear: while each economy faces unique conditions, APEC members can learn much from each other’s successes and failures.

Figure 5.2 Interactive Session Methodology Used



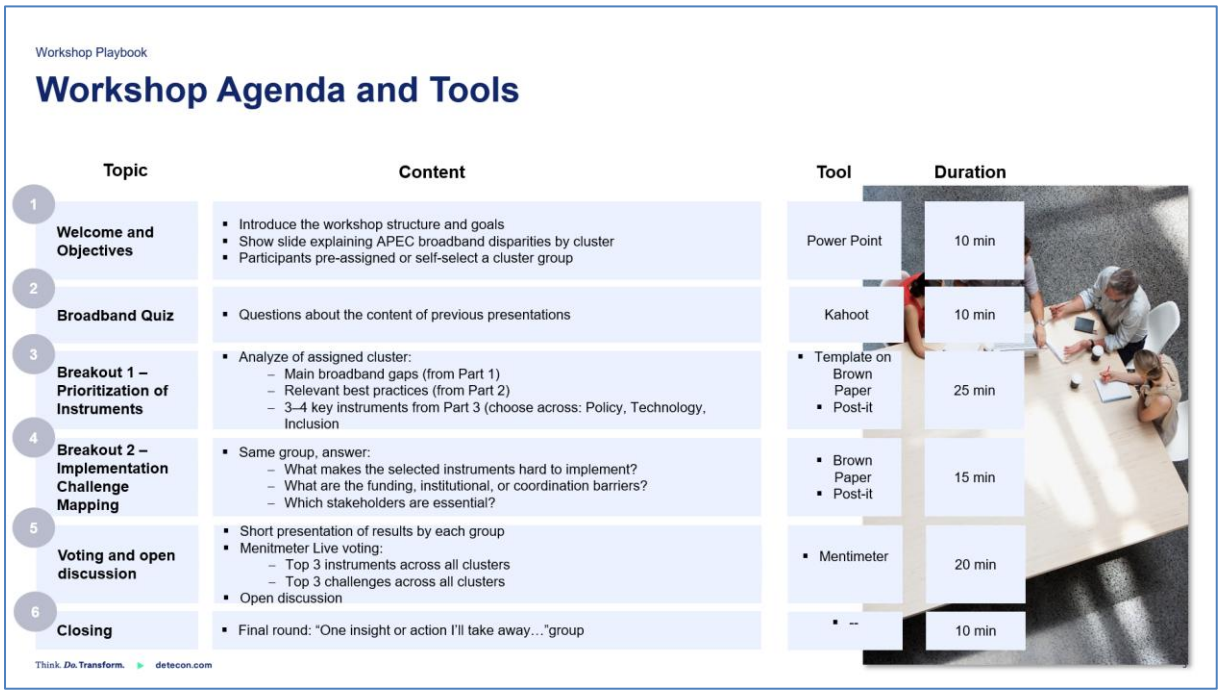
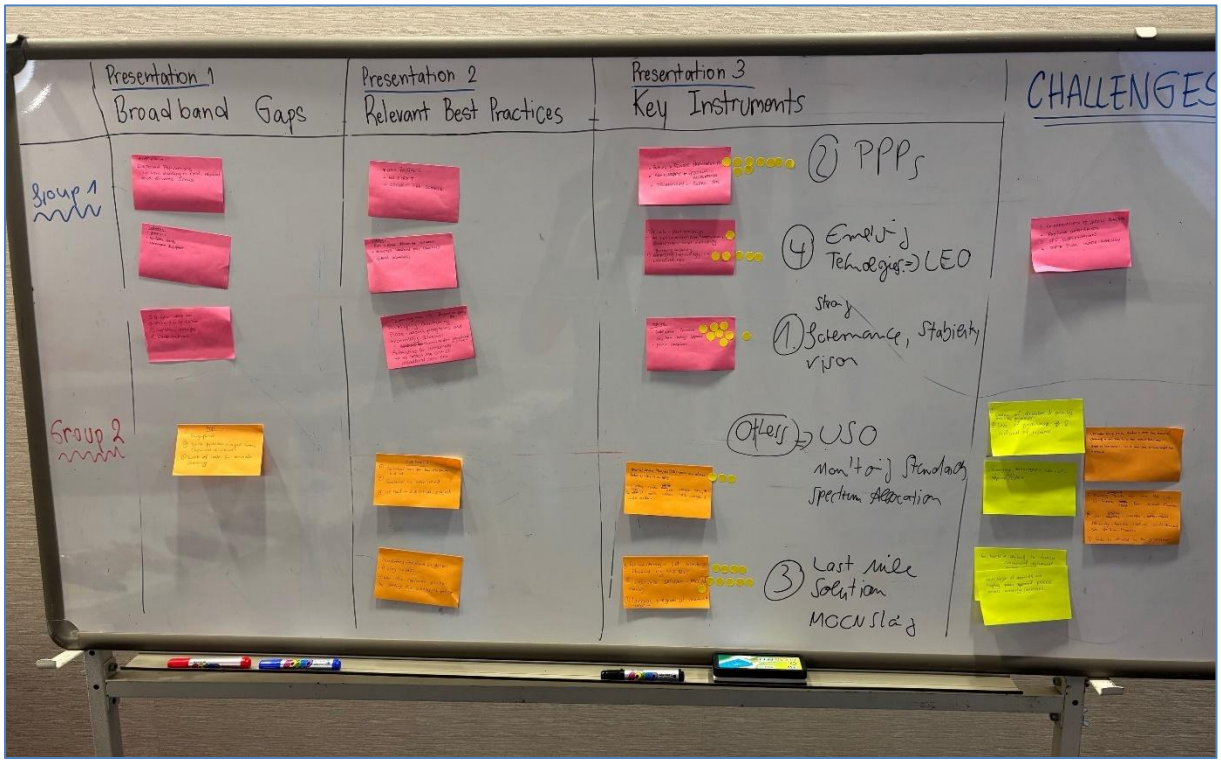


Figure 5.3 Results from the Interactive Session



Workshop Results: Policy Measures to Promote Broadband Infrastructure and Services in Underserved Areas

	Presentation 1 Broadband Gaps	Presentation 2 Relevant Best Practice	Presentation 3 Key Instruments	Challenges for Key Instruments	
Group 1	Australia Dispersed populations - Low density in rural, regional and remote areas	UAS Projects - EU – STREIT - Connect the schools	- Public & private partnerships - Regulatory – spectrum allocations - Technology – rural BTS	1. Co-ordination of various players 2. Funding constraints 3. PPP Coordination 4. Data flow inter-agency	
	Indonesia - Geographics - Population density - Infrastructure development	Indonesia - Public & private collaboration investments - Discounted broadband price (subsidies) - Updated technologies	- Public & private partnerships - Co-investment between government and industry - Emerging technology i.e., LEO satellites		
	1. Population density 2. Infrastructure 3. Geographical challenges 4. Funding constraints	"Community free wifi" "Regional connectivity Plan" Developing community Place-based programs and technology solutions "School student broadband Initiative" Subsidies for consumers - To lessen the cost of broadband services	Indonesia - Stabilization government - Long term policy approach - Private commitment		
Group 2	1. Geographical 2. Sparse populations in rugged terrains 3. Lack of data for accurate planning	1. Technical code for infrastructure roll out 2. Guidelines on infra roll out 3. USP Fund – subsidized project	1. Universal Service Obligations (USO) center in rural area funded by xxx NBTC	1. Change of direction & priority from the government 2. Lack of governance & inefficient of resource - Emerging technologies like LEO require high OPEX	1. USO center set up process slow down in some area because of community in rural area is in the reserved forest area 2. Return on investment is low in some area, operator might not be interested
		Mandatory standard of Access Pricing (MSAP) Lower the consumer price by setting the wholesale price	1. For monitoring – set monitoring standard e.g., MS QoS 2. Last mile solution – MOCN sharing 3. Literacy program at community center	1. Promoting coverage of remote area have high costs. CT Frequency usage fee discount program 2. Use satellite coverage may be difficult because of spectrum coordination and get spectrum Licenses 3. Should be promoted by government	Multi layer of approval and lengthy xx approval process across authority / agencies For MOCN → Difficult to finalize commercial agreement across…

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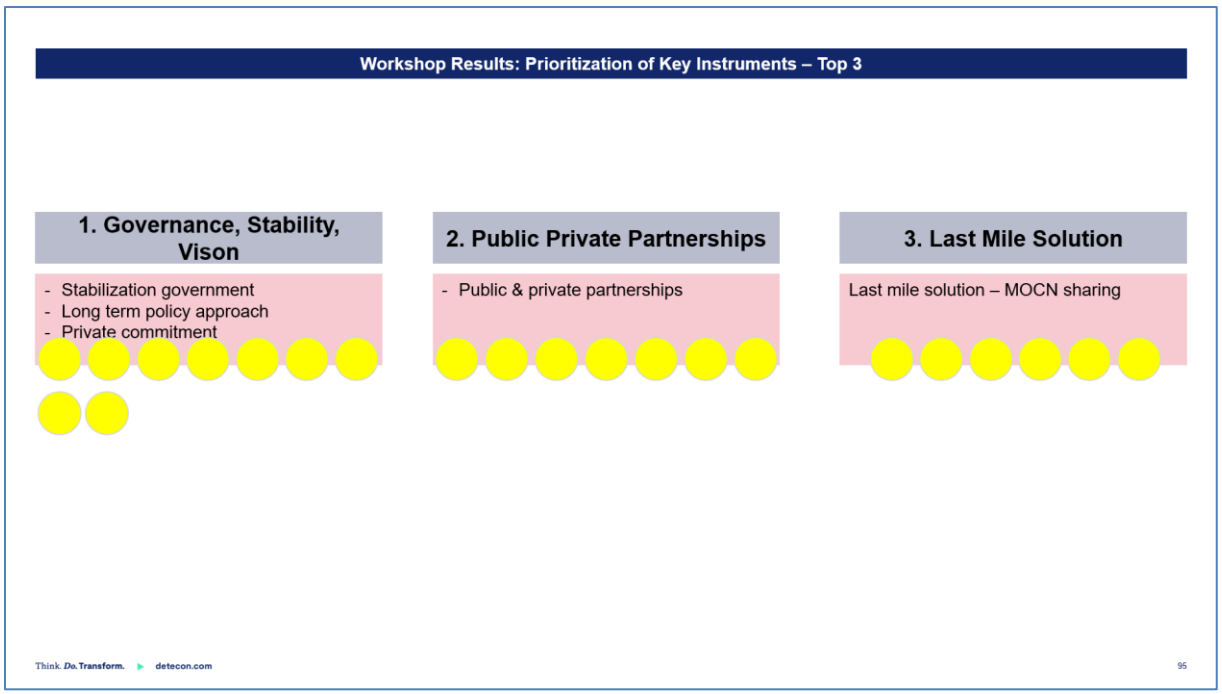


5.3.5 Mentimeter Results

Mentimeter is an online synchronous polling platform used during the workshop after each Day 2 presentation, aimed to gather immediate insights from member economies on the challenges, barriers, and opportunities surrounding broadband infrastructure and adoption in underserved areas seen within the presentations. Through interactive polling, participants shared their perspectives on current infrastructure status, policy effectiveness, and strategic priorities. The following analysis summarizes key themes and findings across the three workshop segments.

Part I: Current Status and Adoption Barriers

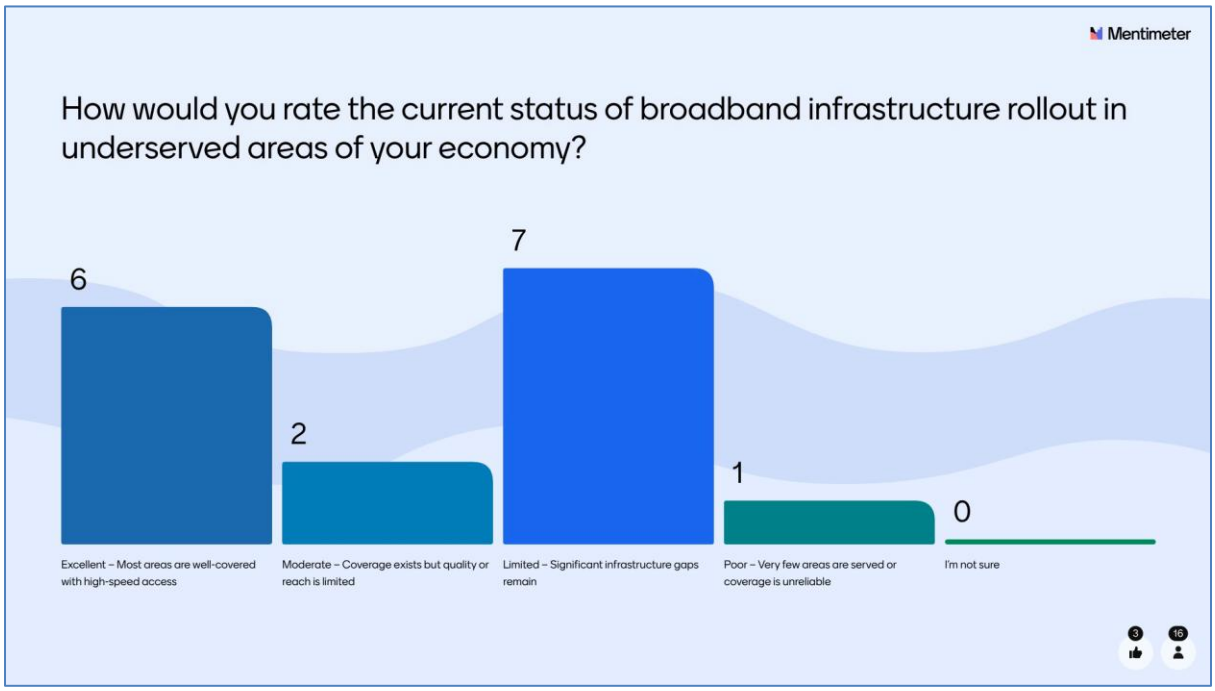
Participants rated the status of broadband infrastructure in underserved areas as predominantly moderate to limited, indicating that while some coverage exists, quality and reach remain problematic. Only a few respondents considered the infrastructure excellent, and a notable number were unsure, suggesting a lack of comprehensive data or visibility.

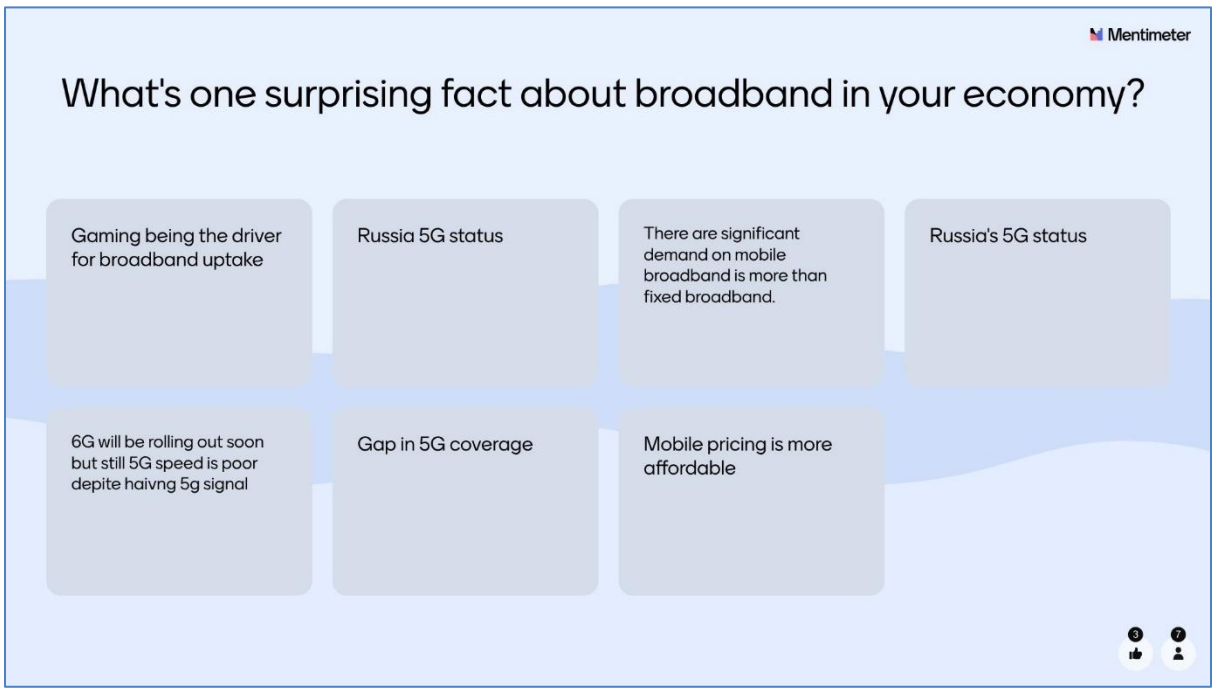
The main barriers to broadband adoption were identified as:

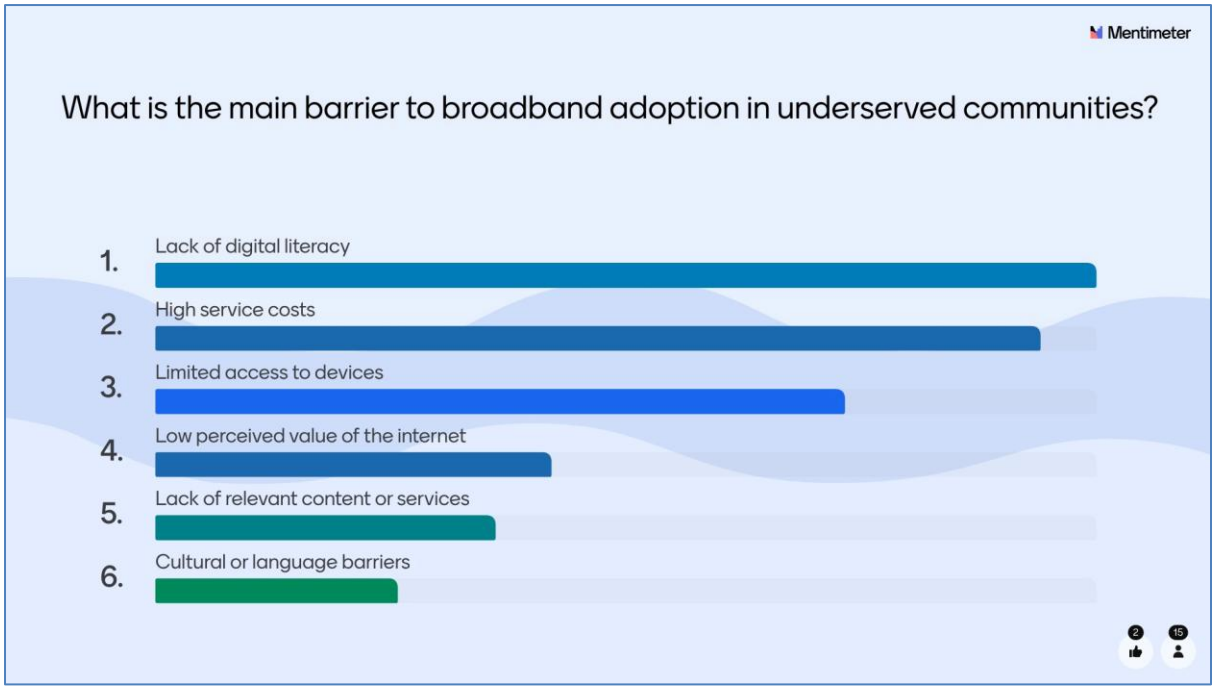
- High service costs
- Limited access to devices
- Lack of digital literacy
- Cultural or language barriers

Interestingly, some participants highlighted unexpected drivers of broadband uptake, such as gaming and mobile broadband demand surpassing fixed broadband, especially in economies like Russia. This suggests that consumer behavior and entertainment trends can significantly influence infrastructure development.

Figure 5.4 Results from Part I: Current Status and Adoption Barriers







Part II: Critical Challenges and Successful Initiatives

The most critical broadband challenges cited included:

- High infrastructure costs
- Digital inclusion gaps
- Regulatory and coordination issues
- Climate and disaster resilience

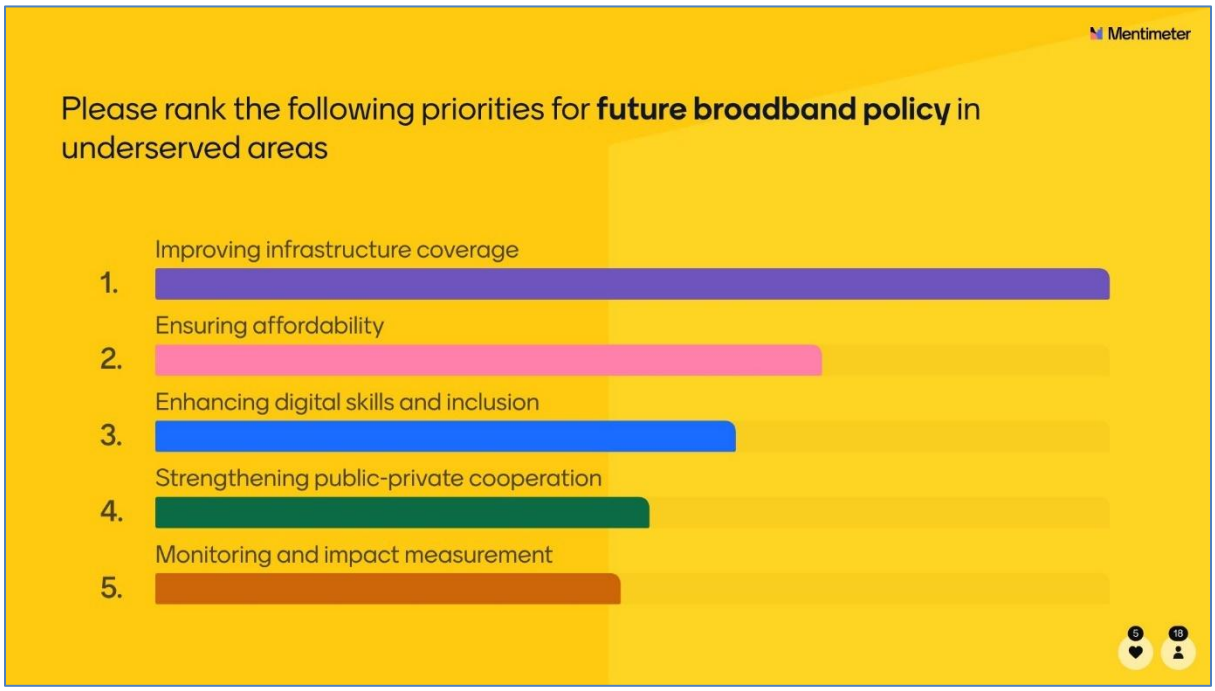
Best-practice examples from economies such as Australia; Republic of Korea; Papua New Guinea; and Chinese Taipei were considered highly relevant, displaying diverse approaches to broadband expansion.

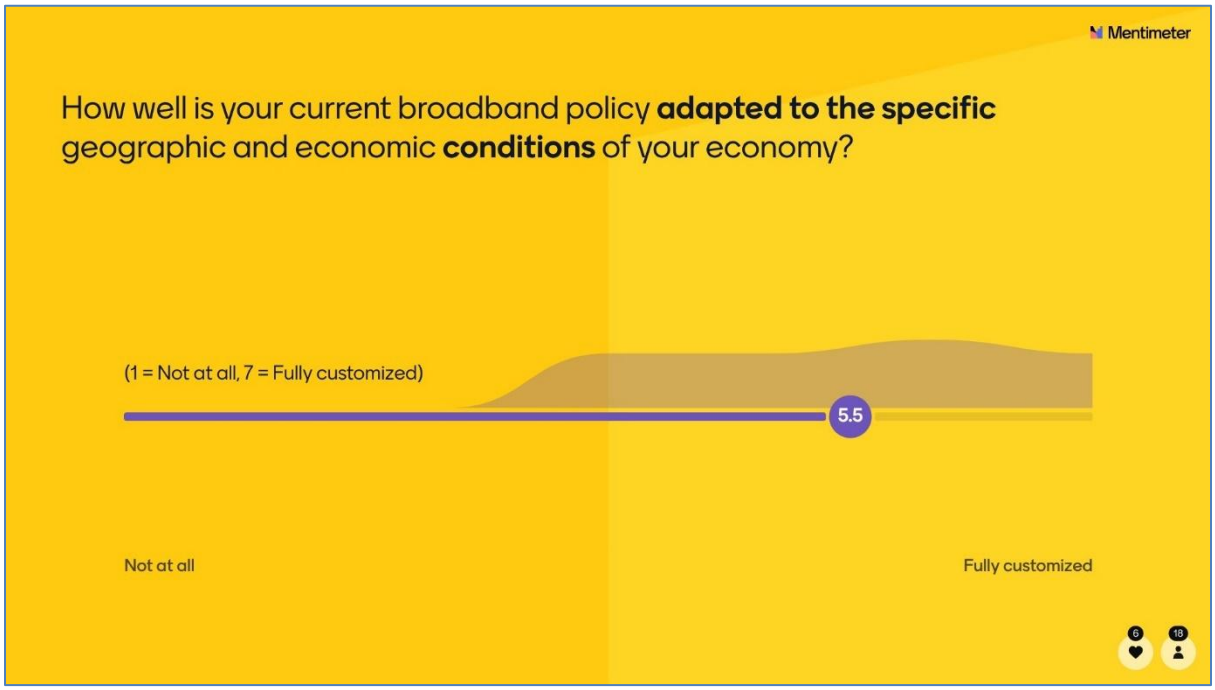
Successful initiatives shared by participants included:

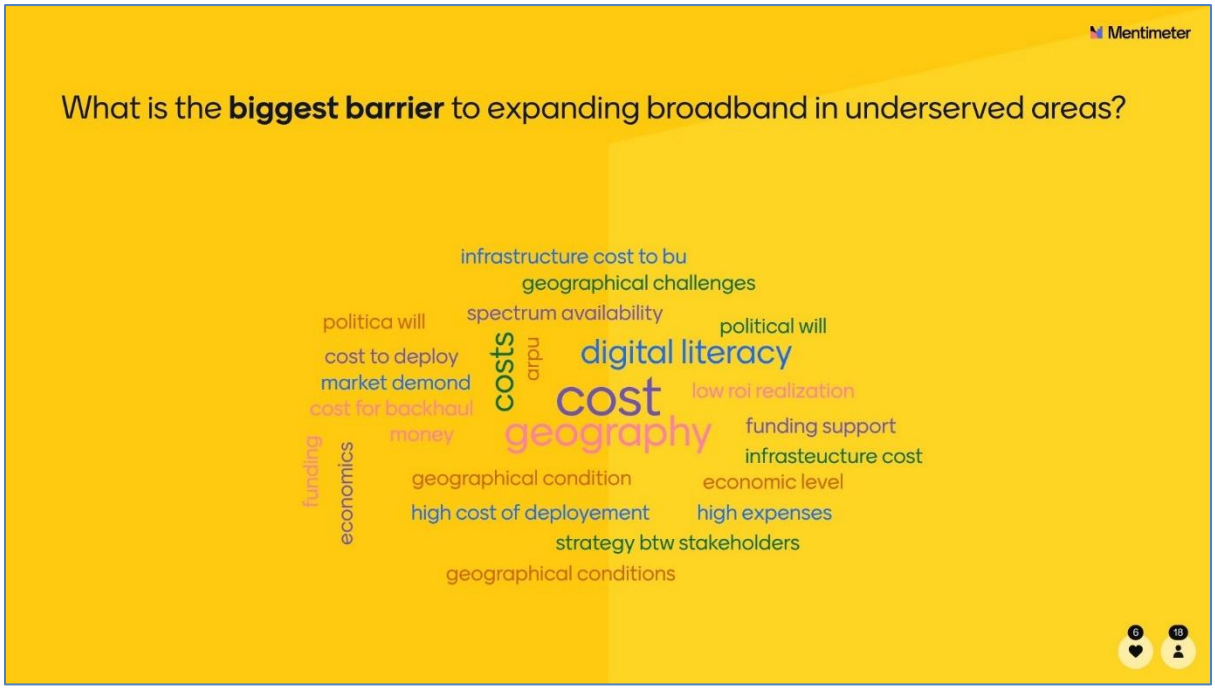
- Infrastructure sharing frameworks
- Public-private partnerships (PPP)
- Universal Service Obligations (USO)
- Long-term policy planning
- Government-led market liberalization

These examples reflect a strong emphasis on collaboration, cost reduction, and inclusive policy design.

Figure 5.5 Results from Part II: Critical Challenges and Successful Initiatives







Part III: Policy Adaptation and Future Priorities

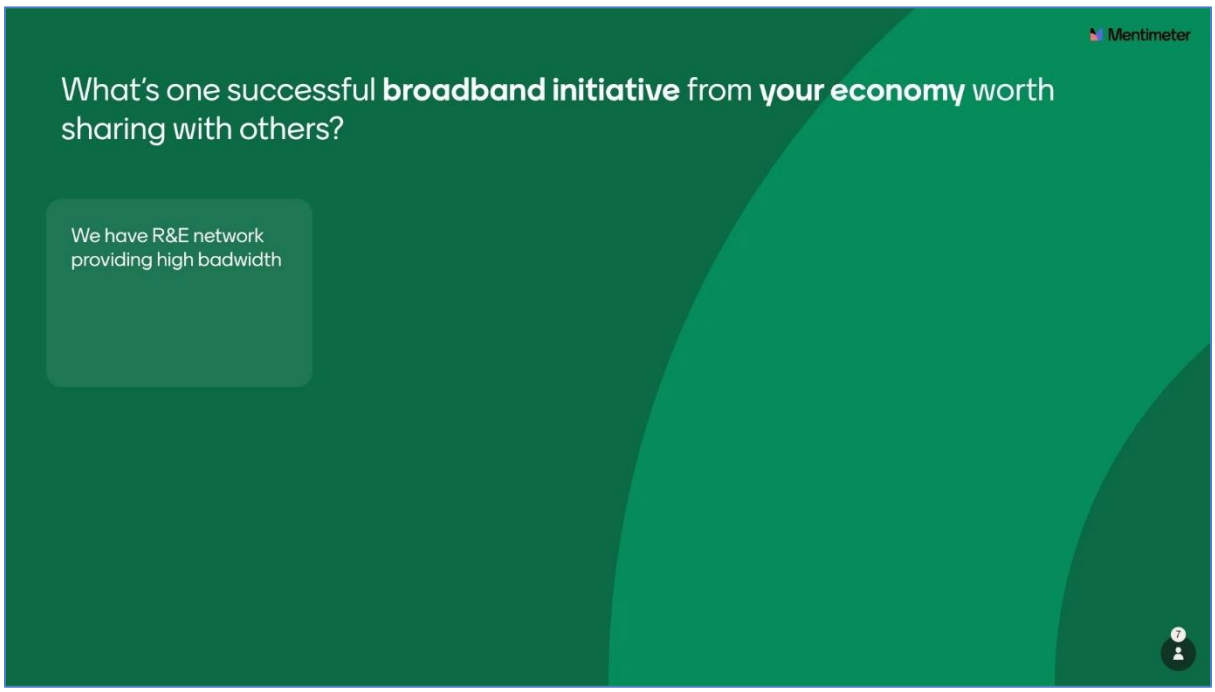
When asked about the adaptability of current broadband policies to local geographic and economic conditions, the average rating was 5.5 out of 7, indicating moderate customization but room for improvement.

Top priorities for future broadband policy in underserved areas were:

- Improving infrastructure coverage
- Ensuring affordability
- Enhancing digital skills and inclusion
- Strengthening public-private cooperation
- Monitoring and impact measurement

The responses underscore a comprehensive approach, balancing physical infrastructure with affordability, education, and governance.

Figure 5.6 Results from Part III: Policy Adaptation and Future Priorities



5.4 Survey Results

This survey was conducted to gather insights from APEC economies on how they define, assess, and address broadband infrastructure challenges in underserved areas. The goal was to identify common barriers, successful policy interventions, and opportunities for regional collaboration. By analyzing responses from government agencies and telecom authorities, the survey aims to support evidence-based policymaking and foster inclusive digital development across the region.

The survey collected responses from multiple APEC economies, revealing diverse definitions of underserved areas, most based on low broadband coverage, high service costs, and low

adoption rates. Coverage in these regions varies significantly, with some economies reporting less than 20% household access, while others exceed 80%. Download speeds range from below 2 Mbps to over 25 Mbps, and adoption rates span from under ten to above 50 subscriptions per 100 inhabitants.

Key barriers to broadband deployment include geographic isolation, low population density, lack of infrastructure, economic constraints, and limited private sector interest. Many governments have responded with domestic programs, universal service funds, tax incentives, and regulatory mandates to stimulate investment and improve connectivity.

There is strong interest in regional learning, with economies looking to adapt successful models from Indonesia; Korea; and Malaysia. Top priorities for the next 3–5 years include expanding fiber-optic networks, enhancing affordability, boosting digital literacy, and improving data collection and mapping.

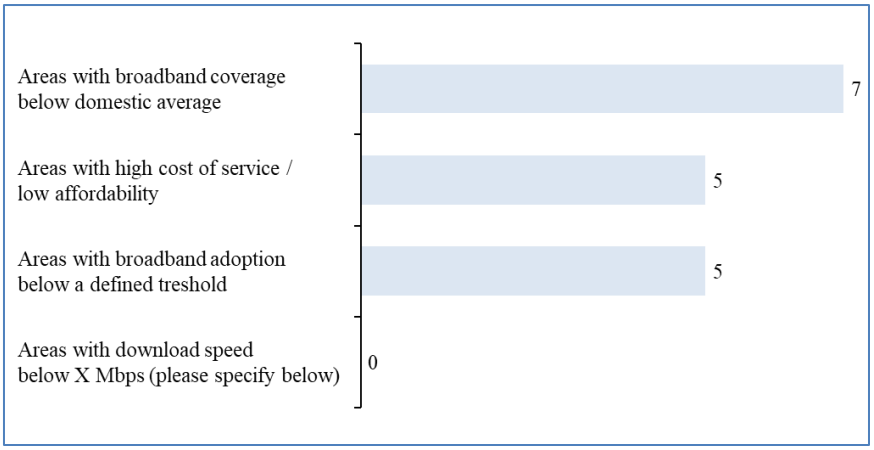
This survey highlights both the shared challenges and innovative strategies being pursued to close the digital divide and ensure equitable access to broadband services across the Asia-Pacific region.

5.4.1 Defining Underserved Areas

Survey responses revealed that economies tend to define underserved areas in broadly similar ways, though with some important nuances. The most common criteria included areas with broadband coverage or adoption rates below the economy's average, as well as places where service quality, particularly download speeds, remains inadequate. For some economies, underserved areas are primarily rural and remote communities, while others highlighted border regions, small islands, or low-income urban districts. This indicates that "underserved" is not a uniform category but rather a context-specific designation shaped by geography, infrastructure, and socio-economic conditions. The diversity of definitions suggests that policy solutions must be tailored accordingly, even as economies share a common goal of expanding access.

Question Section 1: Defining and Locating Underserved Areas

Question 1.1: How does your economy define "underserved areas" for broadband infrastructure and services? (Select all that apply)



Question 1.2: Please describe the major underserved areas in your economy (Geographic regions/Demographic groups/Settlement types)

1.2 Summary of responses:

Seven out of the 9 participant economies identified rural and remote geographic regions as the main underserved areas, often citing mountainous terrain, dense forests, or limited electrification as key obstacles to infrastructure deployment.

Four economies highlighted border or peripheral regions, including outermost islands and underdeveloped border zones, as facing persistent connectivity gaps due to high deployment costs and difficult logistics.

Three economies noted that Indigenous or minority populations remain disproportionately affected, as these groups are more likely to live in isolated or hard-to-reach locations with minimal network coverage.

Six economies emphasized that rural communities continue to be the most vulnerable settlement types, reporting lower internet access and broadband speeds compared to urban centers.

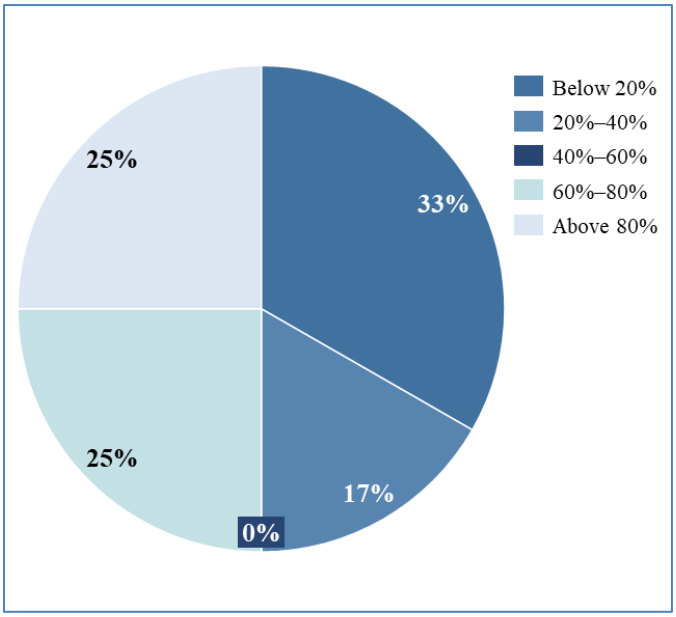
Several economies (at least four) referred to local ICT surveys or household data, indicating a consistent urban–rural digital divide, though most reported gradual annual improvements in broadband penetration between 2023 and 2024

5.4.2 Broadband Conditions in Underserved Areas

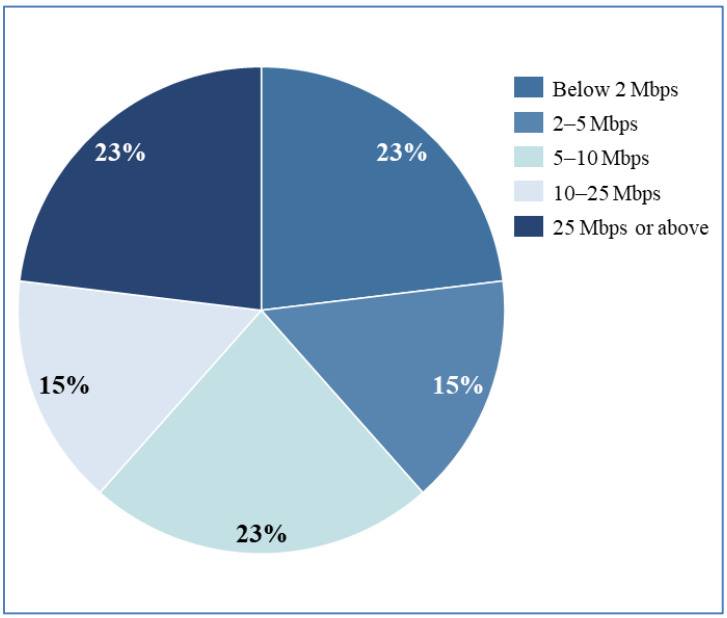
The survey also provided a snapshot of current broadband conditions in these underserved areas. Coverage estimates varied widely, with some economies reporting more than 80 percent of households connected, while others indicated coverage below 20 percent. This disparity illustrates the different stages of development across the region. Reported download speeds ranged from above 25 Mbps in some economies to less than 2 Mbps in others, underscoring that even where networks exist, quality can be a significant challenge. Adoption rates also varied, with some economies indicating subscription levels well above 50 per 100 inhabitants, while others reported figures below 25. These results confirm that while APEC economies share common challenges, the scale and severity of those challenges differ significantly, which in turn shapes the kinds of policy responses required.

Question Section 1 (continued): Defining and Locating Underserved Areas

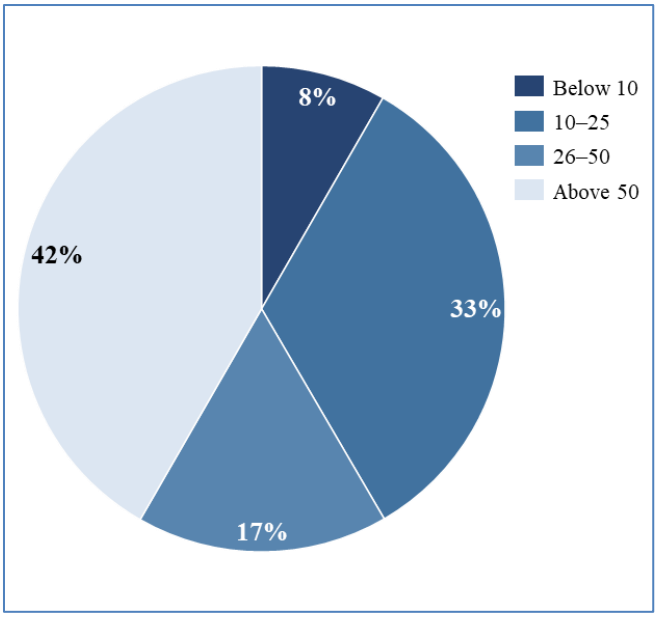
Question 1.3: Please indicate the estimated broadband coverage (% of households that have access to broadband services) in underserved areas



Question 1.3 (continued)**:** Please indicate average download speeds in underserved areas



Question 1.3 (continued): Please indicate broadband adoption rates (subscriptions per 100 inhabitants)



Question 1.4: Has your economy conducted any mapping or diagnostic studies to identify underserved areas? If yes, please describe the approach and share references

1.4 Summary of responses:

Several economies reported conducting GIS-based mapping and data integration exercises to identify underserved regions, often combining coverage data from operators with population or census information.

Some regulators have developed interactive platforms and databases to track broadband coverage and service availability, supporting data-driven policymaking and investment planning.

In certain cases, local surveys on ICT access and use were referenced as complementary sources for identifying connectivity gaps.

A few respondents indicated that mapping initiatives were led by telecommunications ministries or implementing agencies, often in collaboration with operators and other government bodies.

5.4.3 Key Challenges and Barriers

Survey results show that APEC economies face a common set of barriers that make broadband deployment in underserved areas particularly difficult. The most frequently cited issue is low population density, which translates into high cost per user and low return on investment (ROI) for private operators. Economies consistently reported that sparse populations make it difficult to justify network rollout on a commercial basis, requiring governments to provide incentives, subsidies, or universal service mechanisms to make projects viable.

A second recurring barrier is geographic constraints, including mountains, forests, remote islands, and areas with difficult terrain. These factors significantly increase the cost and

complexity of infrastructure deployment, particularly when they coincide with low-density populations. In such cases, economies noted that even when there is a recognized social benefit, private operators are unlikely to expand coverage without targeted public support.

Respondents also emphasized the importance of supporting infrastructure. In many underserved areas, broadband deployment is hindered by the lack of basic enablers such as reliable electricity, transport networks, or backhaul connectivity. Without these foundational elements, even subsidized broadband initiatives may struggle to succeed.

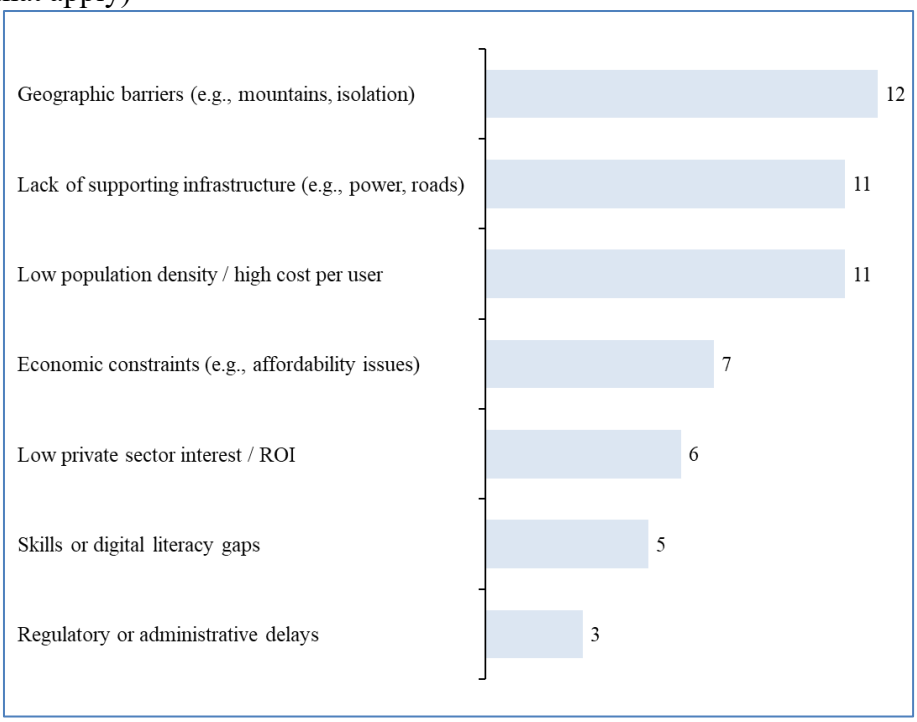
Another challenge highlighted was limited private sector interest, stemming from both the financial risks of low ROI and the long payback periods involved in rural broadband projects. Several economies linked this to the need for clearer regulatory frameworks, streamlined approval processes, and stronger government leadership to attract investment.

Finally, demand-side factors such as economic constraints (affordability issues) and skills or digital literacy gaps were also identified as barriers. Even where networks exist, households may lack the resources or knowledge to make meaningful use of broadband services. This underlines the importance of combining infrastructure investment with policies that improve affordability, provide devices, and build digital capacity within communities.

Taken together, these findings confirm that barriers to broadband deployment in underserved areas are both structural and systemic. They involve not only physical and geographic obstacles but also economic, institutional, and social challenges. Addressing them will require a comprehensive mix of supply-side measures (such as infrastructure subsidies and incentives) and demand-side interventions (such as affordability programs and digital literacy initiatives), along with stronger monitoring to ensure that resources are effectively deployed.

Question Section 2: Key Barriers and Challenges

Question 2.1: What are the primary barriers limiting broadband deployment in these areas? (Select all that apply)



Question 2.2: Which of these challenges is considered the most difficult to overcome and why?

2.2 Summary of responses:

Eight economies identified geographic barriers, such as mountainous terrain, dense forests, remote islands, and dispersed settlements, as the most significant challenge to expanding broadband connectivity.

Seven economies emphasized low population density as a critical factor, noting that sparse populations make it economically unviable for private operators to invest in network infrastructure.

Six economies pointed to low return on investment (ROI) and high cost per user as major deterrents for both public and private sector participation in rural connectivity projects.

Four economies highlighted limited supporting infrastructure (such as power supply and backhaul availability) as an additional structural constraint.

A few respondents also mentioned economic constraints, low private-sector interest, and digital literacy gaps as compounding factors that hinder long-term sustainability and inclusive connectivity.

Several economies stressed that government incentives or universal service funds are essential to offset the financial and operational risks of rural broadband expansion.

Question 2.3: Has your government conducted any cost-benefit analysis or feasibility studies for broadband expansion in these areas? If yes, please summarize the findings.

2.3 Summary of responses:

Several economies indicated that they have conducted or are in the process of conducting feasibility and cost-benefit analyses to assess broadband expansion in rural and underserved areas.

In terms of economic and financial feasibility, one economy reported undertaking an economy-wide study assessing the costs of deploying fiber networks at the municipal level. The findings suggested that broadband expansion is financially feasible in most regions when household telecommunications spending meets or exceeds economy's averages, though certain regions would still require additional support.

A few economies highlighted persistent gaps in socio-economic data and assessment capabilities for rural areas, noting reliance on mobile network operator (MNO) data such as subscriber counts and average revenue per user (ARPU) to guide subsidy allocations and investment priorities.

Some respondents mentioned using USO mechanisms to analyze broadband expansion needs and fund connectivity in rural and underserved regions, emphasizing government-led intervention as critical to project viability.

Policy and Market Viability:

Multiple economies stressed that broadband expansion in remote areas is not commercially viable without public funding or targeted subsidies. Long-term socio-economic benefits were cited as the main justification for such interventions.

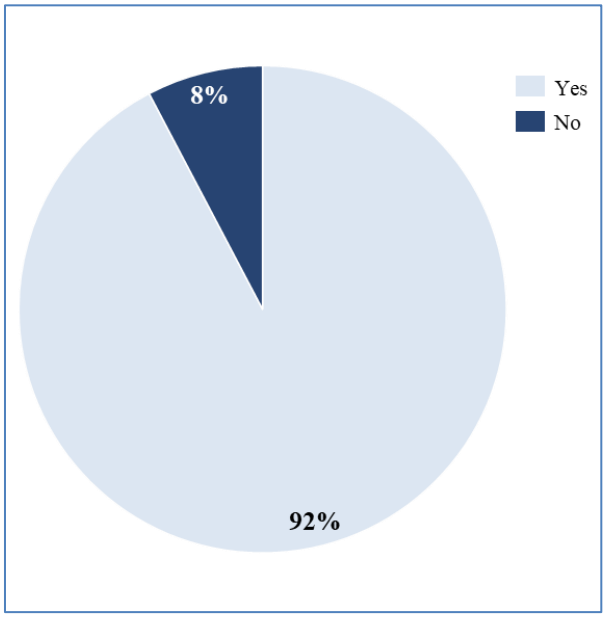
At least one economy conducted household surveys to identify user needs and prioritize broadband service types most in demand among rural populations.

5.4.4 Policy Tools and Incentives

Survey participants described a range of measures being used to improve connectivity in underserved areas. Common approaches included regulatory mandates such as coverage obligations tied to licensing or spectrum awards, financial support mechanisms like subsidies and co-funding arrangements, and incentives for operators such as tax breaks. Some economies rely heavily on universal service funds, while others are exploring infrastructure-sharing policies to lower costs. Despite these efforts, several respondents admitted there is limited clarity on how well such programs work. In many cases, key performance indicators are not systematically applied, and monitoring mechanisms remain weak. Without reliable measures of outcomes, it is difficult to assess whether resources are being used effectively or whether programs are delivering the intended impact.

Question Section 3: Domestic Policies and Programs

Question 3.1: Has your government implemented any domestic or sub-national programs or policies to improve broadband connectivity in underserved areas?



Question 3.2: (If yes) Describe the key initiatives:
- Name and launch year
- Target areas or population groups

- Delivery model
- Achievements to date

3.2 Summary of responses:

Several economies reported implementing economy-wide and sub-economy broadband programs launched between 2018 and 2025 targeting rural, remote, and marginalized populations to expand connectivity and reduce the digital divide. These initiatives typically combine government funding, regulatory reform, and public-private collaboration.

Governments have introduced large-scale broadband plans mapping unserved areas, prioritizing regions with high social or economic marginalization, and embedding universal and affordable internet access as a policy objective. New or updated telecommunications laws reinforce user protection, fair competition, and the recognition of connectivity as a universal right.

Broadband goals are often integrated into multi-year development plans that assign rollout targets to regional or provincial authorities. Reported outcomes include near-universal network presence across administrative districts and 4G coverage exceeding 70 percent of the population in several economies.

Funding and implementation rely heavily on Universal Service Obligations (USO) or Universal Access Secretariats (UAS) that finance rural internet centers and specialized accessibility services such as telecommunication relay systems for persons with disabilities.

Large-scale infrastructure projects under PPP models are expanding local fiber backbones and connecting remote areas previously deemed commercially unviable. Some governments are also refining digital resource fee systems and connectivity funds to sustain long-term investment.

Finally, a number of economies are emphasizing inclusive digital initiatives that address connectivity gaps for Indigenous and remote communities, supported by periodic telecommunications reviews and targeted budget allocations.

Question 3.3: (If yes) Are there incentives or obligations in place for telecom operators to extend service in underserved areas? (e.g., licensing conditions, spectrum obligations, tax incentives, buildout mandates)

3.3 Summary of responses:

Most respondents confirmed that incentives or obligations exist for telecom operators to expand service into underserved areas. These include a mix of tax incentives, spectrum obligations, and licensing conditions tied to Universal Access or Service (UAS/USO) frameworks.

Some economies noted that UAS-related projects receive tax incentives for equipment purchases, while others highlighted regulatory mandates requiring operators to contribute a fixed percentage of their annual revenue (around 1-1.25%) to a Universal

Service Fund (USF). Operators may also benefit from co-funding arrangements or levy contributions under UAS schemes.

A few respondents emphasized that obligations are embedded within licensing and statutory infrastructure provider regimes, ensuring operators invest in universal mobile and broadband coverage as part of their compliance requirements.

Question 3.4: (If yes) How is the effectiveness of these programs measured (KPIs, audits, user feedback)?

3.4 Summary of responses:

Most respondents indicated that the effectiveness of broadband expansion programs is assessed using KPIs, audits, and technical evaluations, though some noted limited data or familiarity with specific processes.

Common measurement tools include KPIs such as the number of cities, districts, or regencies connected, and the number of telecom operators leveraging domestic backbones for last-mile services. Several economies conduct financial audits, field inspections, and regulatory reviews to verify progress.

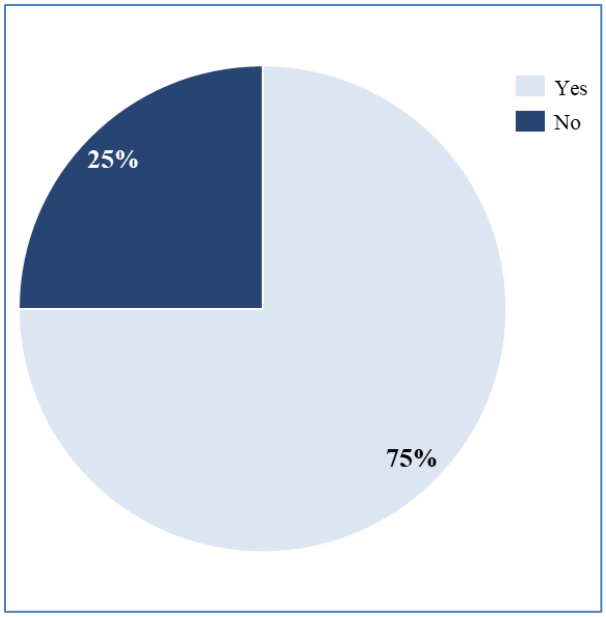
Some also rely on case studies, user feedback, and technical measurements. For example, tracking the number of newly connected households to assess program impact. A few noted that industry-driven network expansion continues with limited direct government intervention, though coverage gaps remain in remote regions.

5.4.5 Learning from Other APEC Economies

Encouragingly, the survey indicated that many economies are actively looking to learn from each other. Respondents cited examples of drawing lessons from public-private partnerships, community-based networks, and regulatory reforms tested in other APEC economies. Infrastructure sharing emerged as a particularly attractive model, as it allows operators to reduce costs while extending networks into less commercially viable areas. Several economies also expressed interest in adapting community-led models, where local stakeholders play a more active role in managing and sustaining broadband access. This appetite for cross-learning suggests strong potential for regional cooperation under the APEC framework.

Question Section 4: Learning from Regional Practices

Question 4.1: Have you reviewed or learned from successful broadband inclusion models in other APEC economies?



Question 4.2: (If yes) Which economies or initiatives were most relevant?

4.2 Summary of responses:

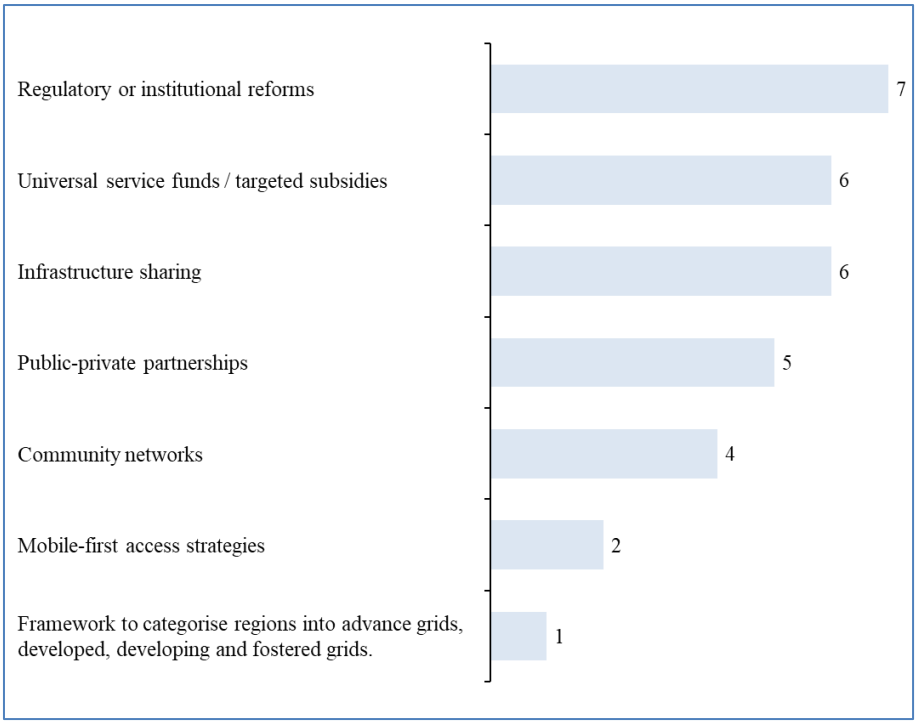
Most respondents identified the Republic of Korea (ROK) as the most relevant reference economy for broadband development, citing its advanced ICT systems, strong policy frameworks, and economy-wide connectivity achievements as models to learn from.

Malaysia's JENDELA initiative was also highlighted for its structured, government-led approach to expanding broadband infrastructure and coverage.

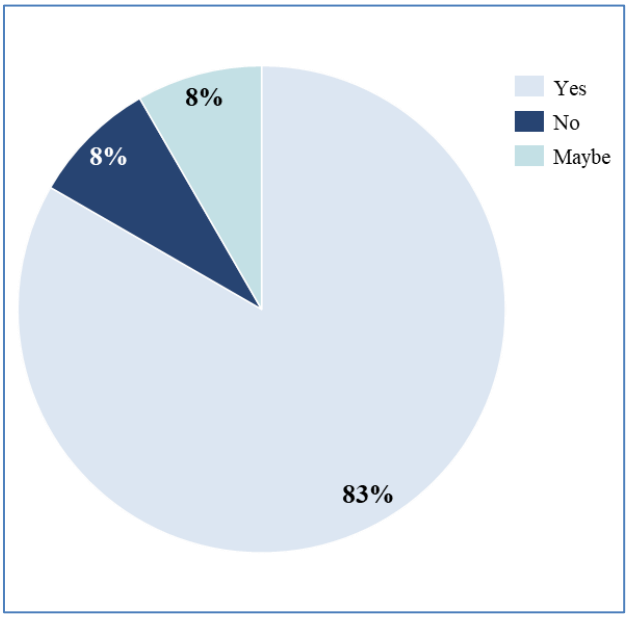
Other references included Indonesia and broader mentions of adopting best practices or models from developed economies, particularly those with effective rural broadband rollout programs.

A few respondents, such as Papua New Guinea, specifically emphasized the need to learn from Korea's digital transformation experience to strengthen their own ICT development strategies.

Question 4.3: (If yes) What elements of these models could be adapted to your context? (Check all that apply)



Question 4.3: (If no) Would your economy be interested in joining a regional knowledge-sharing platform or task force focused on broadband inclusion?



5.4.6 Future Priorities and Cooperation Needs

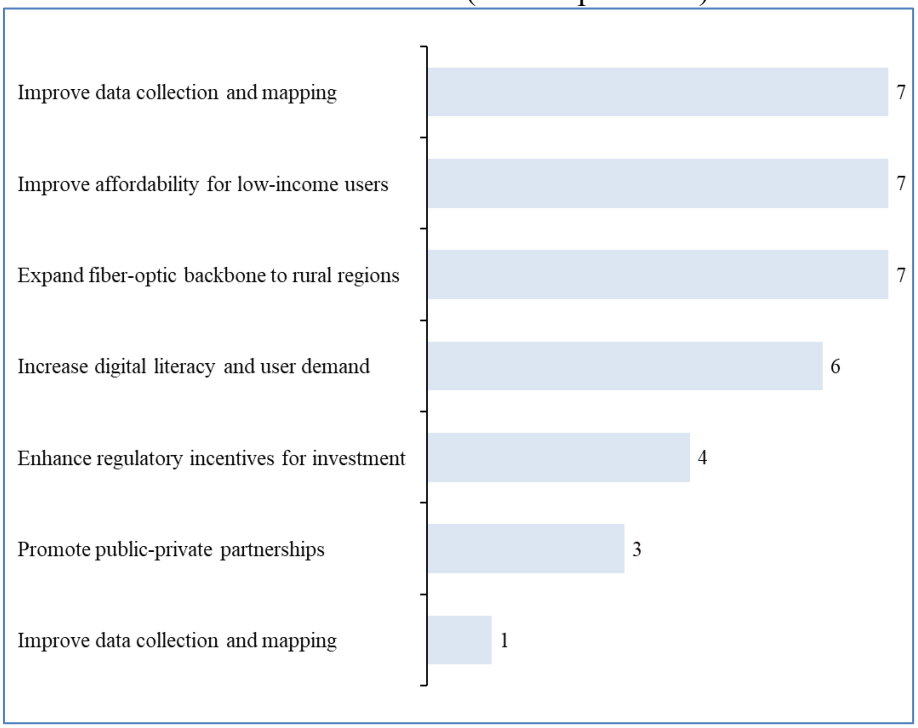
Looking ahead, economies identified several priorities for the next three to five years. Improving affordability for low-income households was mentioned frequently, reflecting the recognition that infrastructure expansion alone will not close the digital divide. Expanding backbone and last-mile networks in rural regions remains another central goal, alongside the creation of more effective regulatory incentives to stimulate investment. Several respondents also pointed to the need for stronger partnerships between government and industry,

particularly in mobilizing resources for large-scale infrastructure projects. Taken together, these priorities highlight the dual focus on both supply and demand measures, ensuring networks are built while also ensuring they are affordable and usable for the populations that need them most.

When asked about the role of regional cooperation, survey respondents expressed strong interest in more structured forms of collaboration. Technical assistance, joint projects, and funding mechanisms were identified as particularly valuable, as they can help share costs and expertise across economies. Capacity building for regulators and policymakers was also seen as a high priority, especially in designing effective strategies for broadband inclusion and in adapting lessons from successful models elsewhere. The responses underline the recognition that while domestic policies are essential, regional cooperation can amplify their impact by pooling resources, harmonizing practices, and accelerating the diffusion of innovation.

Question Section 5: Future Priorities and Cooperation Needs

Question 5.1: What are the top domestic priorities over the next 3–5 years to improve broadband infrastructure in underserved areas? (Select up to three)



Question 5.2: What forms of regional cooperation or support from APEC or other international partners would be most beneficial? (e.g., technical assistance, joint projects, funding mechanisms, capacity building)

5.2 Summary of responses:

Respondents consistently emphasized the importance of capacity building, technical assistance, and funding mechanisms as the most beneficial forms of regional cooperation and international support.

Many economies highlighted the need for capacity-building initiatives to share policy knowledge, update technical skills, and learn from international experiences in extending connectivity to remote areas.

Several responses underscored the value of technical assistance, particularly for technology transfer in advanced areas such as last-mile connectivity, satellite communications, and network optimization. Some also called for support in harmonizing technical and regulatory standards across the region to improve interoperability and enable cross-border connectivity.

Funding support and joint regional projects were also identified as priorities to help economies overcome financial and infrastructural barriers to broadband deployment.

Overall, respondents see collaborative learning, investment facilitation, and coordinated technical support as key drivers for accelerating broadband expansion and digital inclusion within APEC.

Question 5.3: Are there any pilot programs, policy innovations, or public-private partnerships in your economy that could be scaled or shared regionally?

5.3 Most respondents reported that no major pilot programs or policy innovations are currently being implemented that could be scaled or shared regionally. A few noted limited awareness at their respective ministries, indicating that such initiatives may be managed by specialized telecommunications agencies.

However, some economies identified specific infrastructure and connectivity programs with regional relevance. These include Network and Infrastructure Sharing Guidelines for mobile operators and the Smart 600 Tower project in Sarawak, which serves as a funding mechanism to expand rural tower infrastructure.

Another example mentioned was a Mobile Blackspot Program (as used in Australia) and a Regional Connectivity Plan, both designed to improve coverage in underserved or hard-to-reach areas through public-private collaboration.

Overall, while pilot initiatives exist in certain economies, their implementation remains limited, and respondents expressed interest in exploring how such programs could be scaled or replicated regionally under shared policy frameworks.

5.4 Cross-Analysis: Commonalities between Study, Workshop and Survey Results

The triangulation of the study's analytical results, the interactive workshop discussions, and the APEC TELWG member survey provides a robust and consistent picture of broadband challenges and opportunities across the region. All three sources converge on the same central message: underserved areas face a mix of supply-side and demand-side constraints that require holistic solutions.

Across the three inputs, several strong commonalities emerge:

- **Shared Understanding of Underserved Areas:** Whether remote islands, sparsely populated rural districts, or marginalized urban communities, participants emphasized

that underserved status is driven not only by geography but also by affordability gaps, low digital literacy, and socio-economic barriers.

- **Alignment on Barriers:** Low population density, geographic isolation, high infrastructure cost per user, and lack of supporting utilities (electricity, transport) were highlighted as core supply-side obstacles. On the demand side, low willingness, or ability to pay and limited awareness of the benefits of broadband were repeatedly cited.
- **Consistency on Policy Tools:** Universal service funds (USF), public–private partnerships (PPP), and infrastructure-sharing mandates were recognized as key enablers. However, both survey respondents and workshop participants voiced concerns about the effectiveness and governance of these tools, pointing to weak monitoring mechanisms, insufficient KPIs, and inconsistent implementation across economies.

The workshop sessions added additional depth and qualitative insights by highlighting success stories from Australia; Indonesia (Palapa Ring); Republic of Korea; and the Philippines (Free Wi-Fi for All), offering practical blueprints for other economies. The survey responses validated these insights by providing quantitative confirmation of the scale of the problem and demand for such interventions.

Whether it is a remote village, a mountainous region, or a low-income urban district, the core issues remain the same: limited infrastructure, high costs, and low adoption. Both the workshops and survey responses emphasize that underserved areas are not just defined by geography, but also by socioeconomic factors like affordability and digital literacy. This shared understanding reinforces the need for tailored solutions that reflect each economy's unique context.

One of the strongest points of agreement is around the barriers to broadband deployment. Across the board, economies cited low population density, geographic isolation, and lack of supporting infrastructure, like electricity and transport, as major hurdles. These supply-side challenges are compounded by demand-side issues, such as the inability to afford services or the lack of digital skills. The survey responses brought these issues to life with real-world examples and data, while the workshops added depth by highlighting successful strategies and policy models that have worked in similar conditions.

Policy tools like universal service funds, public-private partnerships, and infrastructure-sharing mandates were widely discussed in both the workshops and the survey. While many economies are using these tools, there is a shared concern about their effectiveness. Weak monitoring, unclear KPIs, and inconsistent implementation were common themes. The workshops proposed structured frameworks and best practices to address these gaps, while the survey highlighted the practical realities of trying to make these policies work on the ground.

What stood out in the workshops was the emphasis on regional learning. Presenters shared examples from Australia; Indonesia; Malaysia; and Papua New Guinea, showing how different economies have tackled similar problems in creative ways. The survey echoed this interest, with many respondents expressing a desire to adapt successful models to their own contexts. There is a clear appetite for collaboration, and both sources agree that APEC has a key role to play in facilitating knowledge exchange and joint initiatives.

Looking ahead, the priorities are clear and shared: expand backbone and last-mile networks, improve affordability, boost digital literacy, and strengthen regulatory incentives. Both the

workshops and survey responses stress that infrastructure alone is not enough, people need to be able to afford and use broadband meaningfully. There is also a growing recognition that better data and monitoring are essential to track progress and adjust strategies as needed.

In short, the study, workshops, and survey all point in the same direction. They tell a story of economies facing common challenges, trying different approaches, and learning from each other. The alignment between these sources provides a strong foundation for collective action, and a clear roadmap for making broadband more inclusive, affordable, and impactful across the APEC region.

5.5 Conclusion

The analysis revealed that no single solution fits all. Economies face distinct challenges based on their terrain, population distribution, and market maturity. Large landmass economies struggle with vast distances and sparse populations; archipelagic economies face logistical hurdles in connecting thousands of islands; mountainous and forested regions deal with difficult terrain and infrastructure fragility; and compact urban economies must focus on inclusion and resilience rather than coverage.

Despite these differences, common themes emerged. Infrastructure alone is not enough, adoption depends on affordability, digital skills, and relevant content. Successful economies have combined supply-side investments with demand-side measures, such as community hubs, digital literacy programs, and targeted subsidies. Public-private partnerships, open-access models, and universal service obligations have proven effective when tailored to local contexts.

The workshops and survey responses reinforced these findings, highlighting a shared desire among APEC economies to learn from each other, adapt best practices, and collaborate on regional solutions. Economies like Australia; Republic of Korea, and New Zealand have demonstrated that with strong leadership, inclusive policies, and strategic investment, even the most challenging environments can be connected.

Moving forward, APEC economies must continue to prioritize broadband as a strategic enabler, not just for economic growth, but for social equity and resilience. This means investing in infrastructure, but also in people, policies, and partnerships. By doing so, the region can close the digital divide and ensure that every community, no matter how remote, could thrive in the digital age.

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