A MULTI-STAKEHOLDER ROADMAP FOR 5G DEPLOYMENT IN SRI LANKA: REGULATORY, OPERATOR, AND ENTERPRISE USER PERSPECTIVES

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DECLARATION

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Name of Supervisor: Prof.(Mrs) Dileeka Dias

Signature of the Supervisor: Date: 2/7/2026

DEDICATION

This thesis is dedicated with deepest love and gratitude to my family members, whose unwavering support, encouragement, and sacrifices have been the foundation of my journey.

It is also dedicated to all those striving towards the advancement of Sri Lanka's digital future, to researchers, policy makers, and industry leaders who inspire innovation, and to the next generation of students and professionals who will carry this vision forward.

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ABSTRACT

The fifth generation of mobile technology (5G) is widely recognized as a transformative platform for digital economies, offering ultra-low latency, high device density, and enhanced mobile broadband. While early adopters such as South Korea, China, and the United States have demonstrated significant socio-economic benefits, developing nations continue to face barriers related to spectrum scarcity, infrastructure costs, and regulatory uncertainty. Sri Lanka represents a case where national digital ambitions, outlined in strategies for 2030, are not yet matched by an operational roadmap for 5G deployment.

This study examines Sri Lanka's readiness to adopt 5G through a multi-stakeholder lens, focusing on regulators, operators, infrastructure providers, and industry users. Using a qualitative-dominant mixed-methods design, the research combines expert interviews with global benchmarks and secondary data. The analysis is organized around five key themes: spectrum allocation, NSA to SA migration strategies, infrastructure and power cost challenges, policy and regulatory incentives, and enterprise adoption models.

Findings indicate that while operators are technically prepared to launch NSA 5G, progress is constrained by fragmented spectrum, limited fiber backhaul, high energy tariffs, and unclear regulatory processes. Industry adoption is further slowed by device affordability issues and weak enterprise demand. At the same time, lessons from regional peers highlight the importance of phased strategies, transparent spectrum frameworks, and coordinated infrastructure sharing.

Drawing on these insights, the thesis proposes a four-phase roadmap of Enablement, Optimization, Innovation, and Reinvention, designed to align technical, regulatory, and market priorities. The roadmap emphasizes spectrum harmonization, infrastructure cost-sharing, regulatory reform, and targeted enterprise pilots as prerequisites for sustainable rollout.

The study contributes by offering a context-specific model for 5G deployment in a developing economy, balancing international best practices with local constraints. Its outcomes are intended to guide policymakers, operators, and industry stakeholders in ensuring that 5G supports national goals of economic resilience, digital inclusion, and long-term competitiveness.

Keywords: 5G Deployment, Spectrum Management, NSA–SA Migration, Regulatory Framework, Multi-stakeholder roadmap, industry use cases, Sri Lanka

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CHAPTER 1

INTRODUCTION

1.1 Background

The arrival of fifth-generation (5G) mobile technology is widely regarded as a pivotal shift in global communications. Unlike previous generations that primarily emphasized higher data rates, 5G is designed as a foundational platform for digital economies, enabling ultra-low latency, massive device connectivity, and enhanced mobile broadband. These capabilities support transformative applications across strategic sectors such as smart manufacturing, intelligent transport and logistics, connected healthcare, digital public services, and advanced agriculture, positioning 5G as a critical enabler of national competitiveness rather than merely an incremental upgrade in mobile services.

Early adopters including South Korea, China, and the United States demonstrate how coordinated 5G strategies can strengthen industrial productivity, enable new enterprise ecosystems, and support broader digital transformation agendas. In contrast, many developing countries continue to experience slower progress due to persistent challenges related to spectrum availability, infrastructure costs, and regulatory uncertainty. Figure 1.1 illustrates the core technical capabilities of 5G and the range of applications they are expected to support across different sectors.

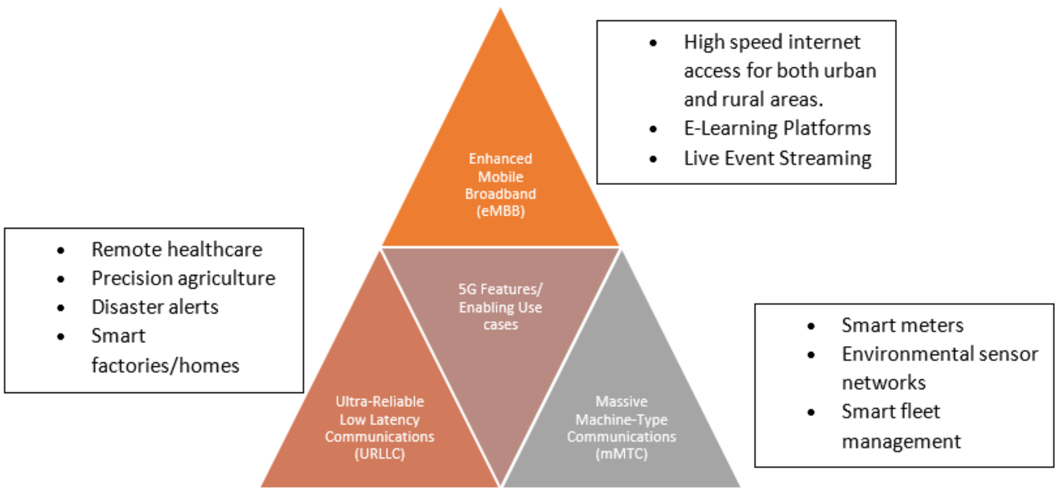

Fig. 1.1: Anticipated 5G Use Cases

In Sri Lanka, operators including Dialog Axiata, SLT-Mobitel and Hutch have already run pilot trials and upgraded their networks elements to prepare for 5G. However, nationwide deployment is still pending. Sri Lanka holds significant opportunities to leverage 5G for national priorities such as port and logistics modernization, export-oriented manufacturing, smart grid and energy management, and digital public services that improve efficiency and resilience. Realizing these high-impact outcomes, however, requires coordinated action among multiple stakeholders. Effective deployment depends on alignment between government institutions, the telecommunications regulator, mobile network operators, infrastructure providers, and industry users. Without such coordination, isolated investments risk remaining urban-centric, fragmented, and misaligned with broader digital economy objectives.

These considerations highlight why 5G is important for Sri Lanka's digital future. Yet, the hype around 5G has also created unrealistic expectations. While enhanced broadband services are already possible, the full set of advanced applications will only be realized through well-coordinated investment strategies, adequate supporting infrastructure, and a stable regulatory framework that enables long-term planning.

1.2 Problem Statement

Globally, organizations such as the GSMA, ITU, and World Bank emphasize that effective 5G deployment depends on three interrelated pillars: efficient spectrum management, robust infrastructure, and clear regulatory strategies. Experience from countries such as China, South Korea, and India demonstrates that these pillars cannot be addressed in isolation. Instead, they require coordination through phased, multi-stakeholder roadmaps that align policy decisions, investment priorities, and market readiness.

Sri Lanka has not yet developed such an integrated roadmap. While the 2024 TRCSL spectrum plan outlines auction timelines for mid- and high-band frequencies, several critical issues remain unresolved. These include the clearance of low-band spectrum, the establishment of mechanisms to extend coverage beyond urban centers, the development of a coordinated infrastructure sharing ecosystem, and the definition of a structured pathway for migration from Non-Standalone (NSA) to Standalone (SA) architecture. Infrastructure readiness is further constrained by limited fiber backhaul, high power costs for base stations, and delays in site approvals, while spectrum fragmentation and the absence of technology-neutral licensing add to deployment uncertainty.

Operators indicate that they are technically prepared to initiate NSA 5G rollouts in selected zones. However, in the absence of coordinated planning, such deployments risk being fragmented, predominantly urban-focused, and weakly aligned with national digital economy objectives. On the demand side, industry adoption remains constrained by low device penetration, affordability concerns, and the lack of enabling policies for sector-specific applications such as smart ports, logistics, and advanced manufacturing.

Together, these challenges can be summarized across four strategic dimensions: spectrum, infrastructure, regulation, and adoption, which is illustrated in Figure 1.2. While distinct, these dimensions are closely interconnected and collectively shape Sri Lanka's readiness for 5G deployment. The absence of a unified, multi-stakeholder roadmap that integrates regulator, operator, infrastructure provider, and industry user perspectives therefore represents a strategic risk. Without such a framework, Sri Lanka

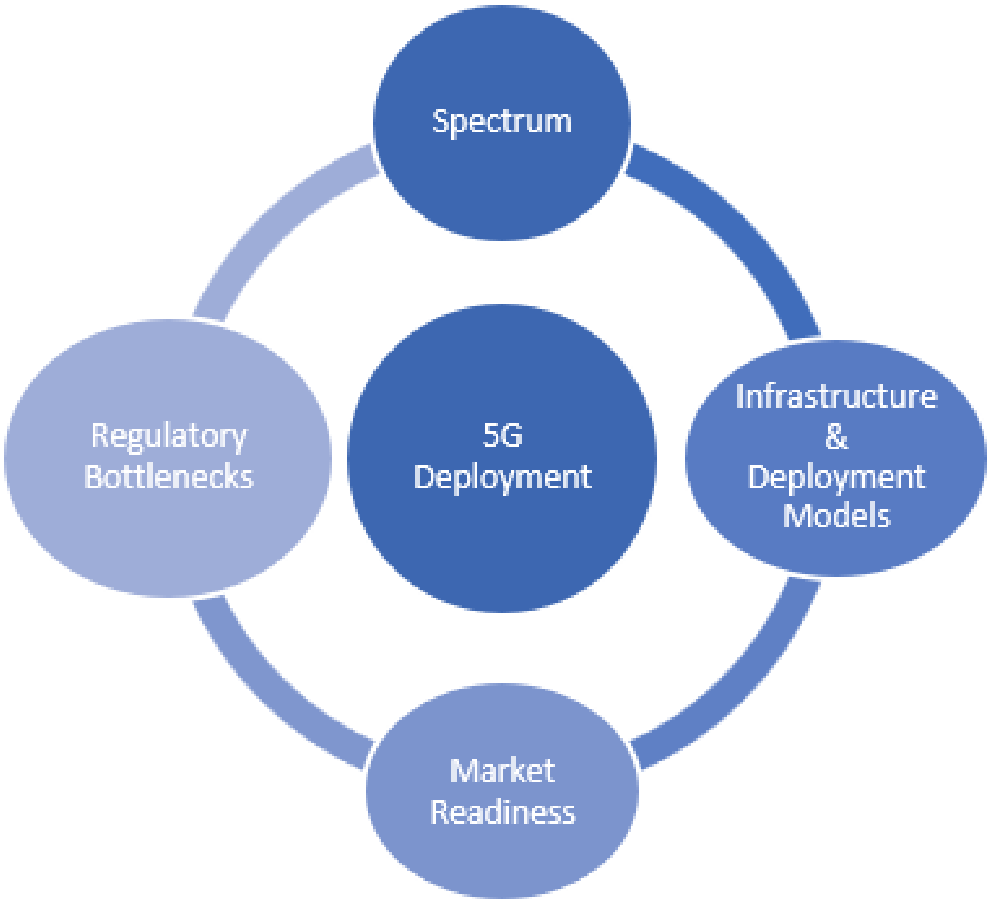

Fig. 1.2: Core Strategic Dimensions Influencing 5G Deployment in Sri Lanka

faces the possibility of delayed rural expansion, missed opportunities in enterprise adoption, and limited preparedness for advanced 5G services that depend on Standalone architecture. This thesis addresses this gap by combining global best practices with local stakeholder insights to propose a phased and actionable 5G roadmap for Sri Lanka.

1.3 Motivation and Importance

Sri Lanka has articulated ambitious digital transformation objectives through national development initiatives such as the Digital Economy Strategy 2030 and the National AI Strategy, both of which emphasize innovation-driven growth, digital public services, and the modernization of key economic sectors [1], [2]. In addition, broader development and connectivity-oriented policy frameworks highlight the role of digital infrastructure as a foundational enabler for productivity, regional integration, and inclusive economic growth in developing economies [3]. Together, these policy directions underscore the importance of strengthening advanced digital infrastructure as part of Sri Lanka's long-term development agenda.

To support these national ambitions, a reliable and future-ready connectivity foundation is essential. In this context, 5G is expected to play a decisive role in enabling the following outcomes:

- Industrial productivity and competitiveness: High-capacity and low-latency connectivity can support advanced manufacturing, automation, and real-time monitoring, which are increasingly important for export-oriented industries and participation in regional value chains.
- Modernization of ports, logistics, and transport systems: Enhanced connectivity can improve operational efficiency, asset tracking, and coordination in ports and logistics hubs, which are critical to Sri Lanka's role as a regional trade and transshipment center.
- Digital public services and infrastructure management: Next-generation networks can enable data-intensive public services, smart infrastructure management, and improved coordination across sectors such as energy, transport, and urban services.
- Integration of emerging digital technologies: Technologies such as IoT, automation, and data-driven platforms increasingly depend on low-latency and high-reliability networks, positioning 5G as a foundational layer rather than a standalone upgrade.

The motivation for this study arises from the gap between Sri Lanka's national digital ambitions and the practical realities of its telecommunications sector. Despite policy emphasis on digital transformation, progress toward 5G deployment remains constrained by spectrum fragmentation, infrastructure bottlenecks, regulatory delays, and limited readiness for adoption. These four dimensions of spectrum, infrastructure, regulation, and adoption collectively define the central challenges that must be addressed for 5G to move beyond isolated pilots and meaningfully support the digital economy.

By aligning 5G deployment strategies with Sri Lanka's broader digital development objectives, this research seeks to demonstrate how a phased, multi-stakeholder roadmap can address these constraints in a coordinated manner. The study aims to show that such an approach can reduce implementation uncertainty, support more effective investment planning, and enable 5G to contribute directly to economic resilience, inclusion, and long-term national competitiveness.

1.4 Objectives and Scope

1.4.1 Objectives

The main objective of this thesis is to propose a Multi-stakeholder roadmap for 5G deployment in Sri Lanka that reflects the needs and constraints of key stakeholders. The specific objectives are,

- **Technical:** Assess spectrum availability, evaluate infrastructure readiness, and outline NSA to SA migration options.

- **Regulatory and Policy:** Identify gaps in spectrum clearance, licensing, and site approvals, compare local policies with international practices, and recommend incentive models.
- **Strategic and Adoption:** Understand operator and industry views on adoption barriers, identify promising use cases, and develop phased recommendations for rollout.

1.4.2 Scope

This study is bounded by three levels of scope.

- **Geographic Scope**
  The primary focus is Sri Lanka, reflecting the country's unique institutional, regulatory, and market conditions. To strengthen the analysis, regional peers such as India, Malaysia, and South Korea are examined. These countries were selected because they represent diverse approaches to spectrum management, NSA→SA migration, and industry adoption that can provide transferable lessons for Sri Lanka.
- **Stakeholder Scope**
  The study examines the perspectives of the main stakeholder groups involved in Sri Lanka's 5G deployment ecosystem:
  - The regulator (TRCSL)
  - Major operators (Dialog Axiata, SLT-Mobitel, Hutch)
  - Vendors and infrastructure providers (e.g., Huawei, EDOTCO)
  - Industry users from sectors such as apparel, manufacturing, finance & Banking, IT services and automation-driven enterprises, and Airport & Aviation.

  These stakeholders were chosen because they directly influence both supply-side deployment decisions and demand-side adoption.
- **Thematic Scope**
  The analysis is structured around six cross-cutting themes selected based on their recurring prominence in global 5G deployment frameworks and their relevance to Sri Lanka's institutional and market context. These themes provide a coherent lens for evaluating readiness, constraints, and strategic trade-offs relevant to roadmap design.
  - Multi-stakeholder roadmaps and 5G readiness frameworks
  - Spectrum scarcity and allocation strategies
  - Non-Standalone (NSA) to Standalone (SA) migration trade-offs
  - Infrastructure and power-cost barriers
  - Policy and regulatory incentive models
  - Industry use cases and adoption readiness

  Together, these themes enable a structured assessment of how technical, regulatory, and market factors interact to shape feasible 5G deployment pathways in

Sri Lanka.

- **Exclusions**
  Areas outside the study's scope include vendor-specific cost models, network engineering designs, and emerging 6G considerations. These are beyond the objectives of this research and require separate technical or financial analysis.

1.5 Originality and Novelty

Most global 5G readiness frameworks assume environments with high investment levels and strong institutional capacity. Sri Lanka presents a different case, with a fragmented spectrum, high power costs, and relatively weak industry demand. This research adds value by,

- Developing a readiness assessment framework tailored to Sri Lanka.
- Proposing a multi-stakeholder roadmap that integrates regulator, operator, and industry perspectives.
- Offering insights that may be relevant to other developing economies facing similar challenges.

1.6 Thesis Outline

This thesis is organized into five chapters.

- **Chapter 1 – Introduction:**Sets the background, problem statement, motivation, objectives, scope, and originality of the study.
- **Chapter 2 – Literature Review:**Examines international and regional frameworks, spectrum strategies, NSA to SA migration, infrastructure challenges, regulatory incentives, and industry use cases, while identifying gaps in the Sri Lankan context.
- **Chapter 3 – Methodology:**Describes the qualitative-dominant mixed-methods approach, including interviews and secondary data analysis.
- **Chapter 4 – Findings and Discussion:**Presents stakeholder perspectives, global comparisons, gap analysis, and the proposed Multi-stakeholder roadmap.
- **Chapter 5 – Conclusions and Future Work:**Summarizes findings, highlights policy and industry implications, provides recommendations, and identifies directions for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The transition to fifth-generation (5G) wireless technology is regarded as a pivotal milestone in global digital transformation. Unlike previous generations, 5G is designed not only to deliver ultra-fast speeds but also to provide low latency, high reliability, and massive device connectivity, enabling applications such as industrial automation, autonomous vehicles, and smart healthcare [4]. Economic studies forecast that by 2035, 5G will contribute up to USD 12.3 trillion in global economic output and support more than 22 million jobs, positioning it as a general-purpose technology with transformative impact across industries [5].

Recognizing these benefits, governments and regulators have developed structured strategies and roadmaps to facilitate timely rollout. In India, the Department of Telecommunications outlined a 5G roadmap in 2018, emphasizing spectrum allocation, trials, and ecosystem development [6]. More recent industry studies reinforce that India's multi-tiered approach combining spectrum reforms, infrastructure readiness, and enterprise use-case pilots is central to unlocking digital-economy dividends [7]. Similarly, the GSMA's global guidance highlights that successful 5G deployment requires coordinated action across spectrum policy, regulatory incentives, and investment frameworks, rather than focusing solely on technical readiness [8].

However, such models often assume advanced digital maturity, strong government support, and high investment capacity. In lower- and middle-income contexts, including Sri Lanka, these enabling conditions are less robust. National policy documents such as the Digital Sri Lanka 2030 Strategy and the National AI Strategy 2028 underscore the importance of digital transformation but do not provide an operational 5G roadmap [1], [2]. Moreover, sector challenges persist, including high spectrum fees, limited infrastructure investment, and regulatory uncertainty. While operators have modernized core networks and expressed readiness for commercial deployment, broader gaps remain in spectrum availability, policy alignment, and rural use-case development [9], [10].

Against this backdrop, this literature review aims to draw lessons from international frameworks and regional experiences to inform a contextualized 5G roadmap for Sri Lanka. It focuses on six cross-cutting themes critical for roadmap design:

1. Multi-stakeholder roadmaps and 5G Readiness Frameworks
2. Spectrum scarcity and allocation strategies
3. Non-Standalone (NSA) to Standalone (SA) migration trade-offs
4. Infrastructure and power-cost barriers

5. Policy and regulatory incentive models

6. Industry use cases, including private 5G networks

By systematically benchmarking global best practices against Sri Lanka's institutional and technical realities, supported by preliminary insights from operator and industry interviews, the review establishes the rationale for a national Multi-stakeholder roadmap. Integrating perspectives from regulators, operators, and enterprises is essential to ensure feasibility, sustainable investment, and long-term digital dividends for the country.

2.2 Multi-stakeholder roadmaps and 5G Readiness Frameworks

Multi-stakeholder roadmaps are essential tools that help align the deployment of 5G technologies with national development goals, especially in developing economies where challenges such as limited infrastructure, regulatory bottlenecks, and affordability concerns exist. In environments characterized by infrastructural gaps, affordability barriers, and regulatory fragmentation, roadmaps serve to align multiple stakeholders toward common technological and socio-economic goals. They provide phased pathways that sequence national decisions around spectrum allocation, infrastructure investment, regulatory policy, and innovation ecosystems.

2.2.1 Global and Regional Frameworks

Multi-stakeholder roadmaps have become a central tool for guiding 5G deployment, particularly in developing regions where limited infrastructure, affordability challenges, and regulatory fragmentation hinder progress. Among the most widely adopted models is the GSMA's four-phase framework—Spectrum → Infrastructure → Ecosystem → Innovation—which emphasizes sequential development while recognizing interdependencies across spectrum policy, infrastructure readiness, market conditions, and innovation capacity. This model has informed many national strategies by stressing the importance of early spectrum reform and coordinated infrastructure planning [11].

Complementing industry-led guidance, the International Telecommunication Union (ITU) has highlighted regulatory enablers for low- and middle-income countries (LMICs). These include flexible spectrum licensing, public–private partnerships, and digital inclusion mandates, all of which are positioned as prerequisites for effective roadmap design [12]. Similarly, the World Bank identifies five readiness pillars—digital infrastructure, institutional capacity, market liberalization, affordability and inclusion, and demand-side innovation—arguing that effective 5G strategies must extend beyond technical feasibility to incorporate governance and equity considerations [13].

At the regional level, the African Telecommunications Union (ATU) has conducted multi-country assessments to benchmark 5G readiness across its member states. While not offering a maturity model, its reports highlight persistent systemic challenges in spectrum planning, stakeholder coordination, and stimulating industry demand. These findings underscore the importance of tailoring roadmap design to the financial and institutional realities of resource-constrained environments [14].

Together, these global and regional frameworks provide a layered foundation for national 5G strategies. They stress that effective roadmaps must integrate technical, regulatory, and socio-economic dimensions, ensuring that spectrum policy, infrastructure investment, and innovation ecosystems evolve in parallel [11] [14].

2.2.2 Case Studies – India, Vietnam, Nigeria, and Others

Several countries have localized global 5G frameworks to reflect their own policy and market conditions. India has followed a structured, phased approach led by the Telecom Regulatory Authority of India (TRAI) and the Department of Telecommunications (DoT). The 2018 national roadmap outlined three stages—Enablement, Optimization, and Reinvention—covering spectrum reform, trials, domestic manufacturing, and eventual industry-scale adoption [15]. This was reinforced through task forces and readiness indices that sought to capture state-level variations in digital preparedness [6]. More recent analyses highlight India's emphasis on spectrum affordability, indigenous equipment development, and cross-sector partnerships to drive digital inclusion [7].

Vietnam has taken a government-led but industry-supported route, working closely with the GSMA to design a phased roadmap. This strategy has included proactive spectrum planning, multiple trial deployments across frequency bands, and a focus on affordability and ecosystem engagement. Public–private partnerships have been central to Vietnam's model, helping reduce costs for early adoption and broadening use-case experimentation [16].

Malaysia adopted a distinctive single wholesale network model through Digital Nasional Berhad (DNB). While designed to minimize duplication and accelerate nationwide rollout, this centralized structure also prompted governance and investment concerns. A 2021 policy review recommended safeguarding the roadmap by strengthening transparency, aligning investments, and encouraging infrastructure sharing to improve coverage in rural areas [17].

Nigeria, representing a lower-income LMIC context, adopted a cautious phased roadmap. Its strategy centered on hybrid Non-Standalone (NSA) and Standalone (SA) deployments while encouraging passive infrastructure sharing to reduce costs [18]. Constraints such as limited device affordability, financial barriers, and spectrum fragmentation shaped a more gradual migration path.

Across these case studies, common elements emerge: spectrum harmonization, pilot projects for aligning technology with business models, stakeholder collaboration through infrastructure sharing, and regulatory capacity building to support new licensing and vertical applications. These patterns highlight how global frameworks are adapted to local realities, balancing ambition with practical constraints.

2.2.3 Roadmap Gaps and Context in Sri Lanka

Sri Lanka's digital policy landscape emphasizes broad transformation objectives but lacks a dedicated, phased national 5G roadmap. The National Digital Economy Strategy 2030 outlines high-level digitalization targets without specifying sequencing across spectrum policy, infrastructure development, or regulatory reform [1]. Similarly, the National AI Strategy 2028 reflects ambition in emerging technologies but does not explicitly position 5G as a foundational enabler.

The Telecommunications Regulatory Commission of Sri Lanka (TRCSL) has initiated spectrum planning through its 2024–2029 Spectrum Roadmap, which presents timelines for auctions, refarming, and allocation across low-, mid-, and high-frequency bands [19]. While this document improves transparency regarding spectrum availability and band intentions, it does not define implementation stages, inter-operator coordination mechanisms, or a phased migration framework aligned with Non-Standalone (NSA) and Standalone (SA) deployment pathways.

Regional and international literature highlights the importance of inclusive policymaking in national broadband and 5G strategies. The African Telecommunications Union (ATU) emphasizes lowering spectrum costs, strengthening industry consultation, and incorporating public feedback into roadmap development [14]. Complementary regional studies similarly underline the role of regulatory flexibility, infrastructure sharing, and tailored incentive mechanisms in supporting affordability and sustainable rollout.

Collectively, the literature indicates that effective national roadmaps typically integrate spectrum policy, infrastructure planning, regulatory alignment, and stakeholder engagement within a coordinated framework. In the Sri Lankan context, publicly documented constraints—including elevated energy costs, limited fiber penetration, fragmented spectrum holdings, and institutional coordination challenges—underscore the relevance of structured national planning approaches observed in comparable developing markets.

2.3 Spectrum Scarcity and Allocation Strategies

Effective spectrum allocation is a critical enabler of 5G deployment, especially in developing economies where legacy systems and institutional inertia present significant constraints. As spectrum is a finite and high-value national resource, regulators must ensure that allocation frameworks promote efficiency, innovation, and equitable access. Countries transitioning to 5G face competing demands: balancing affordable access for operators, encouraging investment, and aligning with long-term digital transformation goals. Strategic spectrum management through well-structured auctions, dynamic access models, and spectrum refarming, therefore becomes a cornerstone of national 5G strategies.

2.3.1 Global Spectrum Bands: Coverage vs. Capacity Trade-offs

The availability of spectrum across low-, mid-, and high-frequency ranges is fundamental to the performance and scalability of 5G networks. Each range offers unique trade-offs between coverage and capacity that shape deployment strategies.

Low-band frequencies below 1 GHz, such as the 700 MHz band, are valued for their wide-area and indoor coverage due to strong propagation characteristics. However, their narrower bandwidth limits capacity, making them most suitable for rural coverage and basic mobile broadband expansion [20]. In contrast, high-band millimeter wave (mmWave) frequencies above 24 GHz, particularly the 26–28 GHz range, can deliver ultra-high throughput and very low latency but suffer from limited propagation and weak indoor penetration. As a result, they require dense infrastructure and are currently deployed primarily in hotspot environments and specialized industrial use cases [21].

Mid-band spectrum, especially the 3.3–3.8 GHz range (C-band), is widely recognized as the optimal balance between capacity and coverage. International studies highlight that at least 100 MHz of contiguous mid-band spectrum per operator is necessary to support efficient nationwide 5G rollout and to enable advanced services such as massive IoT and immersive applications [20]. Countries such as South Korea, India, and the United Kingdom have prioritized mid-band allocations as the backbone of their national 5G strategies, while layering low-band for broad coverage and high-band for capacity-intensive use cases [22], [20].

This three-tier spectrum strategy demonstrates that effective 5G deployment requires harmonization across bands. Ensuring a balanced mix allows regulators and operators to meet both national coverage objectives and capacity requirements for advanced digital services [22], [20].

2.3.2 Dynamic Spectrum Sharing, Auctions, and Refarming

Efficient spectrum management requires flexible approaches that maximize utilization while balancing affordability and investment incentives. One such tool is Dynamic Spectrum Sharing (DSS), which allows operators to deploy both 4G and 5G within the same frequency band by dynamically allocating resources. While DSS accelerates 5G rollout without requiring new spectrum, studies indicate that it may reduce overall performance due to interference and limited capacity gains [23].

Spectrum refarming has also become a practical strategy. South Korea, for example, refarmed existing 1.8 GHz and 2.1 GHz holdings to complement new allocations in the 3.5 GHz and 28 GHz bands, enabling faster deployment and reducing infrastructure duplication [22]. This phased strategy allowed operators to leverage legacy assets while aligning with long-term 5G goals.

Globally, auctions remain the dominant mechanism for assigning 5G spectrum. The United Kingdom's model, built around regional licensing, spectrum caps, and shared access licences, has promoted competitive fairness while ensuring efficient utilization [24]. In India, reforms included lowering reserve prices, bundling spectrum blocks, and offering trial spectrum to encourage operator participation [25]. At the same time, some regulators have experimented with administrative or hybrid approaches. In Germany, 100 MHz of the 3.5 GHz band was set aside for private industrial networks and licensed administratively. While this supported vertical industries, it also reduced auction supply, driving prices higher and leaving parts of the reserved band underutilized [26]. In Finland, instead of large set-asides, licence holders in the 3.5 GHz band were required to either provide private networks on demand or sub-license spectrum to enterprises. This compromise encouraged nationwide 5G rollout while still enabling local innovation [27].

In Sri Lanka, the Telecommunications Regulatory Commission (TRCSL) considered multiple allocation mechanisms in its 2024 consultation, including (i) auctions, (ii) administrative assignment to a wholesale operator, and (iii) direct assignment with spectrum-sharing obligations [28]. During expert interviews, the regulator confirmed that under the Sri Lanka Telecommunications Act (1991, amended 1996; consolidated 2024), TRCSL has the legal discretion to assign frequencies either administratively or through auctions. According to the interview feedback from the regulator, for high value and competitive 5G bands such as 3.5 GHz and 26 GHz are decided to allocate through an auction and the regulator has opted for a clock auction format, citing international best practice and lessons from previous allocations.

Country wise spectrum allocation approaches will be illustrated in the Table 2.1.

2.3.3 Country-Specific Lessons

Experiences from different regions demonstrate the diversity of spectrum allocation approaches and provide valuable lessons for developing economies. These cases highlight how regulatory choices on pricing, licensing, and assignment models influence both the pace and inclusivity of 5G deployment.

Asia

In India, early 5G spectrum policy was hindered by high reserve prices and fragmented holdings, which limited operator participation. Over time, the Department of Telecommunications (DoT) and the Telecom Regulatory Authority of India (TRAI) reformed the process by lowering reserve prices, bundling spectrum blocks, and releasing low-band (700 MHz) and mid-band (3300–3670 MHz) spectrum for trials [6], [7], [25]. Additional measures, such as spectrum-sharing guidelines and incentives for domestic equipment production, aligned spectrum policy with industrial policy goals.

Vietnam, with GSMA support, adopted a phased approach emphasizing proactive spectrum planning, 5G trials across multiple bands, and public–private partnerships. This model not only supported operator readiness but also emphasized affordability and ecosystem development [16].

Malaysia represents a different model, having allocated spectrum administratively to a single wholesale network operator, Digital Nasional Berhad (DNB). While this

TABLE 2.1: SPECTRUM ALLOCATION APPROACHES

Country	**Allocation Method**	**Frequencies Involved**	**Key Features**
UK	Auction + Shared Access Licensing	700 MHz, 3.6–3.8 GHz auctioned; 26 GHz licensed for trials; 3.8–4.2 GHz/1800/2300 MHz available under Shared Access licences	Auctions with spectrum caps; enterprises can apply for local shared access licences [24]
India	Auction (reformed)	700 MHz,800,900 MHz etc, 3300–3670 MHz (mid-band), 26 GHz (mmWave)	Lower reserve prices, bundled blocks, and trial spectrum allocations [25]
South Korea	Auction + Refarming	1.8 and 2.1 GHz refarmed; 3.5 GHz and 28 GHz auctioned	Early licensing and extensive backhaul; phased spectrum release [22]
Germany	Auction + Administrative (Set-aside)	3.4–3.7 GHz auctioned; 100 MHz at 3.7–3.8 GHz set aside for industrial/private use (administrative application)	Industrial set-aside inflated auction prices and led to underutilization of reserved band [26]
Finland	Auction (with obligations)	3.41–3.8 GHz auctioned to 3 MNOs	No administrative awards; licence obligations required operators to enable private 5G through service provision or sub-licensing [27]
Malaysia	Administrative (Single Wholesale Network)	700 MHz, 3.5 GHz, 26/28 GHz assigned to DNB (not auctioned)	All key 5G bands administratively allocated to a single wholesale operator [17]
Nigeria	Hybrid	3.5 GHz auctioned (100 MHz in 2021); other bands phased; infrastructure sharing mandated	Auction combined with policy for NSA/SA and sharing due to affordability barriers [18]
Sri Lanka	Auction (planned)	3.5 GHz and 26 GHz confirmed for auction (clock method)	TRCSL policy: 5G bands via auction

Note. Comparison of spectrum allocation globally

approach was intended to reduce duplication and accelerate rollout, it raised concerns regarding governance, competition, and investment incentives [17].

South Korea pursued a first-mover strategy, prioritizing the 3.5 GHz band for nationwide coverage and the 28 GHz band for capacity-intensive services [22]. Refarming of 1.8 GHz and 2.1 GHz spectrum complemented new allocations, while strong investment in fiber backhaul enabled rapid rollout. However, mmWave adoption has been limited, highlighting the risks of overestimating demand for high-frequency bands [22].

Europe

The United Kingdom implemented a balanced spectrum policy combining auctions with innovation-enabling licences. Major allocations included the 700 MHz and 3.6–3.8 GHz bands, while Ofcom's Shared Access Licensing framework opened underutilized spectrum (3.8–4.2 GHz, 1800 MHz, 2300 MHz) for enterprises and localized 5G deployment [24].

In Germany, regulators auctioned the 3.4–3.7 GHz band but set aside 100 MHz at 3.7–3.8 GHz for private industrial networks, allocated administratively. Although this supported vertical industries, it reduced auction supply, raising spectrum costs by nearly 3 billion euros and leaving parts of the set-aside underutilized [26].

Finland avoided administrative set-asides, instead auctioning the 3.41–3.8 GHz band to three MNOs, while imposing licence obligations requiring operators to either provide private 5G services or sub-license spectrum. This ensured nationwide rollout while supporting industrial demand without spectrum fragmentation [27].

Africa

In Nigeria, a lower-income context, regulators adopted a hybrid strategy combining auctions and infrastructure-sharing mandates. The 3.5 GHz band was auctioned in 2021, but affordability challenges and ecosystem immaturity necessitated gradual deployment and a strong emphasis on NSA-to-SA migration [18].

At the regional level, the African Telecommunications Union (ATU) has documented persistent challenges, including spectrum scarcity, weak cross-stakeholder collaboration, and limited demand stimulation [14]. These highlight the importance of flexible assignment frameworks and cost-reduction strategies tailored to resource-constrained environments.

Key Takeaways

These country experiences underscore several important lessons:

- Affordability reforms (India) and phased allocation (Vietnam, Nigeria) are essential in markets with financial and adoption barriers.
- Administrative models (Malaysia, Germany) can stimulate private or wholesale deployment but risk governance challenges or inefficiency if not carefully designed.
- Hybrid approaches (Finland, UK) show that auctions combined with licence obligations or shared access frameworks can balance nationwide rollout with innovation needs.
- First-mover strategies (South Korea) demonstrate the benefits of early spectrum planning but also warn against overestimating short-term demand for mmWave

bands.

- Regional experiences, particularly in Africa, stress the importance of stakeholder consultation, spectrum cost rationalization, and infrastructure sharing as prerequisites for sustainable 5G roadmaps.

Together, these lessons provide a comparative foundation for shaping a context-specific spectrum strategy in Sri Lanka.

2.3.4 Challenges and Constraints in the Sri Lankan Context

Sri Lanka's spectrum allocation process for 5G is shaped by several documented institutional and structural constraints. Mid-band spectrum, particularly within the 3.4–3.7 GHz range, remains congested due to legacy license holdings, limiting the availability of sufficiently large contiguous blocks. International benchmarks indicate that approximately 100 MHz per operator is required for efficient 5G deployment [29]. The TRCSL Spectrum Roadmap 2024–2029 acknowledges this limitation, noting that ongoing refarming and clearance activities are necessary prior to assigning large mid-band allocations [19].

International literature highlights the financial implications of spectrum charging regimes during 5G transitions. In India, spectrum usage charges (SUC), calculated as a percentage of adjusted gross revenue (AGR), were identified as a legacy regulatory burden that constrained operator liquidity and reduced investment capacity. In response, the Telecom Regulatory Authority of India recommended the removal of SUC on newly auctioned spectrum, a position subsequently adopted by the Department of Telecommunications as part of broader sector reforms. Regulatory assessments indicated that SUC had reduced operator cash flow by approximately 2–3% of AGR, affecting long-term network investment capacity [30].

In contrast, Sri Lanka's emerging 5G framework relies primarily on upfront auction payments combined with annual radio frequency licence fees, without an explicit AGR-linked SUC mechanism. Publicly available regulatory documents indicate that long-term licence fee trajectories, renewal conditions, and future spectrum pricing policies remain under development, contributing to uncertainty in forward-looking investment planning.

Comparative international cases further illustrate institutional challenges associated with spectrum governance. Malaysia's single wholesale network model, administratively assigned to Digital Nasional Berhad, experienced delays in operator participation due to governance concerns [17]. Similarly, Germany's industrial spectrum set-aside approach resulted in inefficiencies linked to reduced spectrum availability in public auctions [26].

Based on regulatory publications and international case studies, key spectrum-related challenges documented in the Sri Lankan context include:

- Mid-band spectrum scarcity and fragmentation (3.4–3.7 GHz).
- Absence of long-term, publicly defined spectrum release timelines.

- Limited transparency in auction design and pricing frameworks.
- Evolving approaches to spectrum refarming and private network provisioning.
- Elevated energy costs and constrained backhaul capacity, which interact with spectrum availability to affect nationwide deployment potential.

2.4 NSA to SA Migration Trade-offs

The migration from Non-Standalone (NSA) to Standalone (SA) architectures represents one of the most critical transitions in the global 5G journey. While NSA has enabled operators to leverage existing 4G assets for rapid deployment, SA introduces a cloud-native 5G Core (5GC) capable of unlocking the full range of IMT-2020 features, including ultra-reliable low-latency communication (URLLC), massive machine-type communications (mMTC), and network slicing [11], [31]. This transition is not uniform across regions; instead, it reflects market maturity, spectrum readiness, device ecosystem evolution, and policy direction.

Globally, NSA was the preferred launch architecture due to its cost efficiency, operational simplicity, and compatibility with existing LTE coverage. Reports confirm that NSA networks began commercial rollouts as early as 2019, relying on dual connectivity options such as 3/3x where the LTE Evolved Packet Core (EPC) handled control signaling while 5G New Radio (NR) delivered user data [31]. This allowed operators to showcase enhanced mobile broadband (eMBB) capabilities without waiting for full 5GC deployment.

By contrast, SA deployment is emerging as the strategic end-state for 5G. It eliminates reliance on LTE, introduces service-based architecture, and supports differentiated quality of service through features like flexible user plane function (UPF) placement and cloud-native orchestration [32]. As of late 2024, over 60 operators had launched commercial SA networks, with Asia–Pacific and advanced European markets leading adoption [33]. The pace of migration, however, is influenced by investment priorities, spectrum availability, and device readiness, with some markets planning dual NSA–SA coexistence until the late 2020s [32].

For developing countries such as Sri Lanka, the NSA-to-SA migration poses unique challenges. Limited fiber backhaul, spectrum congestion, and high power costs make NSA a pragmatic entry point, while SA represents a longer-term ambition tied to enterprise applications and digital economy objectives. Interviews with local operators confirm this phased approach: NSA for initial rollouts, followed by gradual SA adoption as spectrum, devices, and regulatory frameworks align.

2.4.1 Understanding NSA and SA Architectures

The evolution of 5G has been shaped by two distinct deployment architectures: Non-Standalone (NSA) and Standalone (SA). Each model presents unique technical characteristics and strategic implications for operators, regulators, and national digital agendas.

Non-Standalone (NSA)
NSA architecture integrates 5G New Radio (NR) with the existing 4G Evolved Packet Core (EPC). In this configuration, control-plane signaling remains anchored in LTE, while user-plane data traffic is delivered via 5G NR [11], [31]. The most common deployment variant is Option 3 and its derivatives (3a/3x), which enable dual connectivity between LTE eNodeBs and 5G gNodeBs [31]. This approach allows operators to launch 5G services quickly by reusing existing LTE infrastructure, making it particularly attractive in markets with strong 4G coverage but limited readiness for a full 5G Core. NSA's primary contribution has been to deliver enhanced mobile broadband (eMBB), improving peak data rates and user experience without requiring immediate large-scale investment in backend transformation [31]. Early deployments in Europe, Southeast Asia, and Latin America largely followed the NSA-first model [33].

Standalone (SA)
In contrast, SA deployment eliminates LTE dependency and introduces a cloud-native 5G Core (5GC), defined under 3GPP's Option 2 architecture [32]. The SA model leverages a service-based architecture (SBA), network slicing, and native support for edge computing. These enable the full scope of IMT-2020 requirements—eMBB, ultra-reliable low-latency communication (URLLC), and massive machine-type communication (mMTC) [41]. SA also allows flexible user plane function (UPF) placement, dynamic orchestration through software-defined networking (SDN) and network function virtualization (NFV), and differentiated quality of service (QoS) for advanced enterprise and vertical applications [32]. Industrial automation, remote healthcare, and autonomous transport are among the key domains where SA is indispensable [33].

Comparative Positioning

From a technical perspective, NSA is primarily a transitional architecture, offering speed and cost efficiency while relying on LTE EPC. Its limitations include increased signaling overhead, higher energy consumption, and restricted support for advanced 5G-native services [31]. SA, on the other hand, represents the target end-state of 5G networks, enabling scalability, low latency, and innovation potential. However, SA requires substantial investment in backhaul, distributed cloud infrastructure, and workforce reskilling, making its adoption more challenging in developing contexts [32].

For countries like Sri Lanka, NSA provides a pragmatic entry point into 5G deployment, but long-term strategic alignment with SA will be essential if the nation is to harness 5G for industrial transformation and digital economy growth.

2.4.2 NSA vs SA: Pros and Cons

The choice between Non-Standalone (NSA) and Standalone (SA) deployment models presents operators with a set of trade-offs that affect cost, performance, deployment timelines, and long-term innovation capacity. These trade-offs are especially relevant for developing economies, where affordability and ecosystem maturity significantly shape network strategies.

Advantages of NSA Deployment

NSA has been widely adopted as the initial pathway to 5G, as it anchors 5G New Radio (NR) on the existing LTE Evolved Packet Core (EPC). By leveraging already deployed 4G infrastructure, NSA enables rapid time-to-market while minimizing capital expenditure (CAPEX) [11], [31]. This is particularly advantageous in urban areas with dense LTE networks, where operators can launch 5G services by upgrading base stations with 5G NR. NSA also ensures continuity with legacy devices, supports carrier aggregation to boost throughput, and reduces operational complexity by retaining LTE-based control plane functions [31]. These features explain why NSA has been the dominant architecture in early rollouts across Europe, Southeast Asia, and Latin America [8].

Limitations of NSA

Despite its cost and time benefits, NSA is constrained by its dependence on the LTE EPC. Because signaling continues to run on a 4G core, NSA networks cannot deliver advanced 5G-native capabilities, including ultra-reliable low-latency communication (URLLC), massive machine-type communications (mMTC), and true end-to-end network slicing [12]. Operational inefficiencies also arise: dual connectivity introduces signaling overhead, increases energy consumption, and limits performance optimization in higher frequency bands such as millimeter wave (mmWave) [31]. For long-term strategies centered on industrial applications and digital transformation, NSA therefore represents only a temporary solution.

Benefits of SA Architecture

SA deployment, in contrast, enables the full scope of IMT-2020 requirements by operating independently of LTE and introducing a cloud-native 5G Core (5GC) [32]. With its service-based architecture (SBA), SA supports dynamic network slicing, differentiated quality of service (QoS), and user plane function (UPF) placement at the network edge. These features are critical for vertical-specific deployments such as smart manufacturing, healthcare, transport, and mission-critical communications [33]. SA also enhances spectral efficiency and reduces latency through local breakout and optimized radio-resource management [31].

Challenges with SA Deployment

The shift to SA, however, comes with significant challenges. SA networks require large-scale CAPEX for core modernization, distributed data centers, and orchestration platforms [32]. Deployment timelines are longer due to the need for reskilling engineering teams, building cloud-native capabilities, and validating end-to-end SA devices [34]. The ecosystem for pure SA devices remains immature in many markets, which slows operator adoption and can limit customer uptake [32]. Furthermore, reliance on containerized functions and vendor-specific orchestration may expose operators to interoperability and vendor lock-in risks [12].

Comparative Perspectives

Global experiences illustrate these trade-offs. In the United States, India, and Brazil, NSA provided a pragmatic first step to demonstrate 5G services quickly, while in China, South Korea, and the UAE, operators rapidly migrated to SA to meet industrial demand and national digital strategies [33]. Hybrid approaches are also emerging, where NSA supports consumer eMBB while SA is introduced in enterprise or industrial zones, balancing affordability with advanced capabilities [32]. For Sri Lanka, NSA offers a practical entry point, aligning with existing infrastructure readiness and financial constraints. Yet, to achieve long-term objectives such as smart manufacturing, digital healthcare, and public-sector digitization, transitioning to SA will be indispensable.

2.4.3 Global Adoption Trends

The migration from NSA to SA is progressing unevenly across regions, reflecting variations in spectrum availability, investment priorities, and device ecosystem maturity. While NSA remains dominant in early deployments, SA adoption is steadily increasing, especially in markets with strong policy support and enterprise demand.

Global Status

According to GSMA Mobile Economy 2025, more than 245 commercial 5G networks had launched worldwide by early 2025, but only a fraction had transitioned to SA [33]. By the end of 2024, 60 operators in 35 countries had launched commercial SA services, with Asia–Pacific leading adoption, followed by Europe and North America [35]. This figure underscores a growing but gradual shift toward SA, as many operators continue to rely on NSA for coverage while introducing SA selectively in high-value markets.

Asia–Pacific

China and South Korea remain the most advanced in SA migration. China had deployed over 500,000 SA base stations by 2022, representing a deliberate pivot to support differentiated enterprise services [33]. South Korea, supported by extensive fiber backhaul and aggressive spectrum policies, was among the first to commercialize SA, enabling nationwide industrial and consumer services [22]. Vietnam has also adopted a phased approach, combining NSA for consumer rollout with SA pilots in enterprise and industrial zones, reflecting its affordability-driven strategy [16].

Europe

European markets have moved cautiously. The United Kingdom continues to rely primarily on NSA for consumer services, while operators experiment with SA in enterprise contexts such as manufacturing and logistics [24]. Finland and Germany illustrate different policy strategies: Finland promoted SA indirectly through licence obligations requiring operators to sub-license spectrum for private networks, while Germany created dedicated industrial spectrum blocks (3.7–3.8 GHz) to enable enterprise-driven SA deployments [26], [27].

Americas

In North America, operators such as T-Mobile US have already launched nationwide SA networks, positioning SA as a differentiator for low-latency and private network services [33]. Latin American operators, however, remain largely NSA-focused due to investment and device ecosystem barriers. For instance, early deployments in Brazil and Mexico centered on NSA to accelerate coverage, with SA expected to follow gradually as ecosystem maturity improves [36].

Africa

African markets continue to focus on NSA rollouts, constrained by spectrum costs and infrastructure readiness. Nigeria, one of the region's early movers, adopted a phased approach that began with NSA before introducing hybrid NSA/SA strategies supported by infrastructure sharing [18]. Regional studies by the African Telecommunications Union (ATU) confirm that while SA is recognized as the long-term goal, affordability and ecosystem gaps will extend NSA reliance in the near term [14]

Sri Lanka in Context

For Sri Lanka, the global migration trend reinforces the logic of an NSA-first strategy, as confirmed during local operator interviews. However, international evidence shows that timely transition to SA is critical for unlocking advanced 5G use cases in manufacturing, healthcare, and logistics. Without a structured roadmap for SA, Sri Lanka risks lagging behind regional peers that are already piloting SA in enterprise zones.

The country wise NSA and SA adoption trends will be summerized in the Table 2.2.

The comparative evidence highlights clear regional patterns in NSA–SA migration. Asia–Pacific markets such as China, South Korea, and Vietnam have taken the lead in SA deployment, driven by strong government coordination and enterprise demand. Europe has pursued a more cautious approach, combining NSA consumer rollouts with targeted SA initiatives through licence obligations (Finland) or set-asides (Germany). In the Americas, the United States stands out for nationwide SA launches, while most Latin American operators remain reliant on NSA due to ecosystem constraints. In Africa, NSA dominates, with SA limited to pilot projects given cost and infrastructure barriers. For Sri Lanka, these patterns underscore the feasibility of an NSA-first strategy, but also demonstrate the need for a clear timeline and policy support for eventual SA migration to remain competitive regionally.

TABLE 2.2: NSA VS SA ADOPTION TRENDS BY REGION

Country	Deployment Model	Frequencies Used	Status and Adoption	Key Lessons	Sources
China	SA-first (Option 2)	3.5 GHz, 2.6 GHz, 700 MHz	>500,000 SA base stations deployed by 2022; rapid enterprise adoption	State-led policies and spectrum planning accelerate SA migration	[33]
South Korea	Early SA + Refarming	3.5 GHz, 28 GHz, refarmed 1.8/2.1 GHz	One of first to commercialize SA; nationwide coverage	Early licensing + strong fiber backhaul enabled smooth SA rollout	[22]
Vietnam	Hybrid (NSA + SA pilots)	2.6 GHz, 3.5 GHz	NSA for consumer rollout; SA pilots in enterprise zones	Phased approach balances affordability and industrial demand	[16]
India	NSA-first, SA trials	700 MHz, 3300–3670 MHz, 26 GHz	Large-scale NSA rollout; SA under testing	Pricing reforms + spectrum bundling are critical for faster SA migration	[6], [30]
UK	NSA with SA pilots	700 MHz, 3.6–3.8 GHz; Shared Access (3.8–4.2 GHz)	NSA dominates consumer services; SA used in enterprise contexts	Shared access licensing fosters private SA deployment	[24]
Germany	NSA + Admin set-aside	3.4–3.7 GHz auctioned; 3.7–3.8 GHz set aside for industry	NSA for coverage; SA used by enterprises in reserved spectrum	Set-asides enabled industrial SA but raised auction prices	[26]
Africa (regional)	NSA-dominant	3.5 GHz, 700 MHz	Few SA pilots; affordability and ecosystem barriers persist	Regional harmonization + cost reductions required	[14]
Sri Lanka	NSA-first (planned)	3.5 GHz, 26 GHz (future auctions)	Operators plan NSA initially; SA to follow with spectrum clearance	Clear roadmap and investment support critical for SA transition	[37], [38]

2.5 Infrastructure and Power Cost Barriers

The rollout of 5G is closely tied to infrastructure readiness and the ability of operators to manage rising capital and operational costs. Unlike previous generations, 5G requires denser site grids, resilient energy systems, and extensive high-capacity backhaul. These requirements drive up both deployment and operating expenditure, creating financial pressures particularly acute in low-ARPU markets. Industry assessments consistently show that network densification, escalating energy demand, and limited fiber penetration represent the most significant hurdles to sustainable 5G deployment [8], [10], [35].

In Sri Lanka, these constraints are further compounded by high electricity tariffs, uneven fiberization rates, and the capital expenditure limitations faced by operators. Recent annual reports from Dialog Axiata and SLT-Mobitel highlight concerns over energy costs, backup power provisioning, and the need for accelerated national fiber expansion to prepare for 5G [39], [40]. Addressing these challenges will be essential if 5G is to contribute effectively to the country's digital transformation objectives.

2.5.1 Site Densification, Power Redundancy, and Fiber Backhaul Challenges

One of the defining shifts from 4G to 5G is the requirement for a much denser network of sites. The shorter propagation characteristics of mid-band and high-band spectrum necessitate the addition of small cells alongside macro sites to maintain service continuity. Ericsson's network evolution analyses indicate that higher frequencies require significantly more sites, while GSMA highlights that densification increases site acquisition complexity and rollout timelines [8], [10]. Case studies from China further demonstrate that Massive MIMO and functional splits between Distributed Units (DU) and Centralized Units (CU) have been instrumental in optimizing dense deployments [41].

The increase in site density brings corresponding challenges in energy demand. Huawei's 5G Power White Paper reports that a 5G macro site equipped with 64T64R antennas may require over 10 kW of power—nearly three times the consumption of a comparable 4G LTE site [42]. GSMA's Mobile Net Zero report further indicates that energy accounts for between 15% and 40% of operator operating expenditure in many markets, underscoring the significance of power consumption in sustainable 5G expansion [43].

Regulatory experience from India further illustrates the complexity of addressing telecom energy costs through electricity tariff reclassification. A Working Group convened under the Forum of Regulators assessed industry requests to move telecom towers from commercial to industrial electricity tariffs, citing their designation as national infrastructure and their role in enabling digital connectivity. While acknowledging that telecom towers are formally recognised as infrastructure assets, the review found that most states continue to classify towers under commercial tariff categories, with only limited exceptions. The Working Group concluded that introducing preferential or industrial tariffs for telecom towers would increase cross-subsidisation, place additional financial pressure on distribution utilities, and conflict with cost-reflective pricing principles under the Electricity Act. Instead, it recommended that any support to telecom infrastructure be delivered through explicit government subsidies rather than electricity tariff restructuring. This case highlights that, although telecom networks are widely viewed as critical infrastructure, regulators often favour targeted policy support and operational efficiency measures over direct tariff concessions when managing rising network energy costs during 5G deployment [44]. Consequently, backup systems such as dual power feeds, hybrid renewable–battery solutions, and site-level energy optimization are increasingly recognised as important elements in maintaining network resilience and operational stability.

Equally critical is the availability of robust backhaul infrastructure. Fiber connectivity is widely recognised as the most effective solution to meet 5G's ultra-low latency and high-throughput requirements. However, Ericsson and GSMA report that in many markets fewer than half of base stations are fiberized, resulting in continued reliance on microwave backhaul, which constrains performance [8], [35]. The Mobile Economy Asia-Pacific 2024 report identifies low fiberization rates as a major barrier to advanced 5G services across the region [45], while Nokia Bell Labs emphasizes that without accelerated fiber densification, nationwide Standalone 5G deployment remains challenging [46].

Public disclosures from Sri Lankan operators similarly reference the importance of expanding national fiber infrastructure to support future 5G services [39], [40].

2.5.2 Open RAN and Green Telecom Practices

Open Radio Access Networks (Open RAN) represent a reconfiguration of mobile network architecture, disaggregating vendor-specific solutions into interoperable components. The O-RAN Alliance defines standardized open interfaces among the radio unit (O-RU), distributed unit (O-DU), and centralized unit (O-CU), coordinated through a Service Management and Orchestration (SMO) framework [47]. This architecture enables operators to combine hardware and software from multiple suppliers, supporting vendor diversity, potential cost efficiencies, and faster innovation cycles [48], [49].

Despite these potential benefits, Open RAN deployments introduce technical complexity. Existing studies highlight stringent fronthaul latency and synchronization requirements, challenges associated with multi-vendor interoperability, and expanded security considerations arising from open interfaces [50], [51]. At the same time, the modular and software-driven design of Open RAN aligns with global sustainability objectives, enabling energy-saving capabilities such as carrier sleep modes, dynamic load management, and AI-driven orchestration [47], [52].

For developing countries, Open RAN is frequently discussed as a means to lower capital intensity, extend rural coverage, and engage local system integrators. However, reported outcomes indicate that potential gains depend on addressing energy consumption, achieving interoperability across heterogeneous vendor environments, and operating within supportive regulatory frameworks [48], [49].

Global Deployment Landscape

Global adoption of Open RAN shows a spectrum of approaches, from nationwide greenfield rollouts to incremental trials in brownfield networks. Selected deployments between 2020 and 2025 are summarized in the Table 2.3.

TABLE 2.3: SELECTED GLOBAL OPEN RAN DEPLOYMENTS

Country	Operator(s)	Vendors/Partners	Deployment Status	Source
Japan	Rakuten Mobile	Rakuten Symphony, NEC, Altiostar, Nokia	First nationwide cloud-native Open RAN 5G deployment	[48], [49]
USA	DISH Wireless	Samsung, Mavenir, Fujitsu; Dell, Intel	Greenfield 5G SA Open RAN; NTIA-funded integration	[49]
UK / Europe	Vodafone	Samsung, NEC, Dell, Capgemini, Wind River	2,500 sites by 2027; 30% of European footprint by 2030	[48]
India	Bharti Airtel, others	Rakuten Symphony, Mavenir	Multiple trials; staged adoption across circles	[49]
South Korea	KT, SKT (ORIA)	Local and global vendors	PlugFests/testbeds; limited commercial rollout	[50]
Malaysia	Axiata	Mavenir, Parallel Wireless, Infosys (SI)	Commercial pilots underway	[49]
Sri Lanka	Dialog Axiata, Mobitel, Hutch	Mavenir, Parallel Wireless	Early trials and pilots	[49]

Note. OpenRAN trend analysis

These examples highlight different strategic directions.

- **Greenfield leaders:** Japan (Rakuten) and the USA (DISH) demonstrate rapid scaling of Open RAN in environments without legacy integration constraints.
- **Incremental adoption:** Europe, India, and Malaysia illustrate how incumbent operators combine trials and partial rollouts with system integrator partnerships.
- **Collaborative testing:** South Korea's PlugFests demonstrate the role of shared testbeds in addressing interoperability challenges.
- **Emerging market pilots:** Sri Lanka and several Asian markets are exploring

Open RAN primarily as a cost-optimization approach for rural coverage.

Two consistent observations emerge across deployments:

1. Ecosystem maturity remains critical, with large-scale rollouts requiring advanced cloud platforms and strong system integration capabilities.

2. Developing markets exhibit cautious adoption, with most implementations remaining at pilot stage due to financial constraints, vendor ecosystem readiness, and regulatory conditions.

Role of System Integrators in Open RAN

Open RAN's multi-vendor architecture increases flexibility but also creates integration challenges that operators cannot easily manage alone. This has made system integrators (SIs) an important part of the ecosystem, particularly in brownfield environments where legacy LTE and early 5G infrastructure must coexist with new Open RAN deployments.

Case studies show the diversity of SI involvement:

- Infosys acted as SI in Axiata's Malaysia and Sri Lanka pilots, working with Mavenir and Parallel Wireless to coordinate rural coverage trials [51].
- In the UK, Capgemini supported Vodafone's Open RAN rollout, focusing on interoperability and lifecycle management [49].]
- In Japan, Rakuten Symphony serves as both vendor and SI, overseeing end-to-end deployment and integration for its nationwide Open RAN network [52].

Industry assessments further indicate that in brownfield markets, SIs play a central role in managing multi-vendor testing, fronthaul synchronization, and long-term automation [53]. Overall, while Open RAN expands the vendor ecosystem, deployment outcomes are closely linked to the availability of integration expertise and coordination capabilities across participating stakeholders.

2.5.3 CAPEX Pressure in Low-Revenue Environments

The deployment of 5G requires extensive investment in spectrum, sites, and supporting infrastructure, yet these costs are particularly challenging in low-revenue environments where average revenue per user (ARPU) remains among the lowest globally. The World Bank highlights that operators in emerging markets often face higher capital intensity ratios (CAPEX relative to revenue) compared to advanced economies, as they must expand networks into less profitable rural and semi-urban areas while contending with limited financing options [54].

The OECD further notes that competitive pricing pressures exacerbate this issue, reducing margins and slowing investment cycles [55]. In such contexts, operators frequently adopt phased rollouts or rely on vendor financing arrangements to spread costs over longer horizons [56]. The International Finance Corporation (IFC) emphasizes the role of blended financing mechanisms and public–private partnerships (PPPs) in enabling broadband expansion under constrained revenue models, citing cases where PPPs facilitated infrastructure sharing and reduced duplication of capital costs [57].

Global industry studies also link ARPU levels directly to 5G deployment pace. GSMA analysis shows that countries with ARPU below USD 5 per month tend to experience delayed or incremental rollouts, as operators struggle to justify nationwide coverage without regulatory support or cost-sharing mechanisms [8], [45]. In these markets, infrastructure sharing and innovative financing are critical to sustaining investment momentum.

Sri Lanka reflects many of these challenges. Dialog Axiata's 2024 Annual Report indicates that significant portions of capital expenditure are directed towards maintaining LTE capacity while selectively investing in 5G pilot zones, largely due to spectrum uncertainty and revenue constraints [40]. Similarly, SLT-Mobitel highlights that limited capital budgets and high energy costs constrain the feasibility of nationwide deployment, with infrastructure sharing and phased expansion considered as strategies to optimize expenditure [39]. Both operators identify spectrum fees and electricity tariffs as material barriers to scaling 5G, further underscoring the sensitivity of CAPEX efficiency to regulatory and macroeconomic conditions.

International literature further documents the use of regulatory incentives, including reduced spectrum reserve prices, tax relief, and promotion of active and passive infrastructure sharing, alongside innovative financing instruments such as vendor credit, green bonds, and multilateral development support, as mechanisms adopted to mitigate financial constraints associated with large-scale 5G deployment [54], [56], [57].

2.5.4 Market-Led Shared Infrastructure Models (Tower Sharing, Active Sharing, and Neutral-Host Fiber)

Shared infrastructure has become a cornerstone of cost-efficient 5G deployment, particularly in developing economies where capital expenditure constraints and affordability pressures are acute. Market-led sharing models broadly fall into two categories: passive sharing, which includes towers, sites, power systems, and backhaul; and active sharing, which extends to radio access network (RAN) equipment and, in some cases, spectrum resources. Both approaches are widely recognised as mechanisms to reduce deployment costs, accelerate rollout timelines, and improve coverage in rural or commercially less attractive areas [58].

The ITU/CRASA Guidelines on Infrastructure Sharing highlight that passive sharing alone can reduce site-related CAPEX by up to 40%, while active sharing provides further efficiencies in rural deployments [59]. Similarly, the GSMA Mobile Policy Handbook (2024) underscores that tower and fiber sharing frameworks, supported by clear regulation and transparent access pricing, are instrumental in achieving nationwide broadband coverage [58]. Together, these models enable operators to mitigate duplication of physical assets while maintaining service competition at the retail level.

Passive Infrastructure Sharing and Towerco Models

Global experience demonstrates the impact of large-scale tower sharing in emerging markets. Tower companies such as Indus Towers in India and EDOTCO in Southeast Asia have achieved high tenancy ratios, enabling operators to reduce site costs while expanding rural footprints [60]. The TowerXchange Asia Guide further documents how towercos across the region are evolving toward neutral-host 5G models, preparing infrastructure for small cells, lamp poles, and edge facilities [60]. Roland Berger's Towering Above report estimates that tower companies in Asia could generate up to USD 10 billion in cumulative capital expenditure savings by 2025, while avoiding 5–17 million tonnes of carbon emissions through shared deployments [61].

EDOTCO in Sri Lanka

In Sri Lanka, EDOTCO is the primary towerco operating under a neutral-host model, managing approximately 1,300 towers as of 2022 [62]. The company collaborates with operators such as Dialog Axiata and Hutch, with Mobitel expected to colocate under the same model. EDOTCO has also rolled out around 800 lamp poles in Colombo and other urban centers, positioning itself as a key enabler of 5G densification [62].

From an energy perspective, EDOTCO emphasizes efficiency through shared grid connections and hybrid solar pilot projects, reducing duplication of three-phase electricity lines and lowering OPEX burdens for colocated operators [62]. This approach mirrors broader towerco strategies across Asia, where shared infrastructure directly supports both cost reduction and sustainability objectives [61].

Active Infrastructure Sharing Models

Beyond passive infrastructure, active sharing has emerged as a critical mechanism for improving network economics in dense and low-revenue environments. Active sharing typically involves joint deployment of radio access network components through configurations such as Multi-Operator Radio Access Network (MORAN) and Multi-Operator Core Network (MOCN), enabling operators to share baseband and radio equipment while retaining service differentiation at higher network layers. Engineering studies indicate that such arrangements can significantly reduce incremental deployment costs and improve spectrum utilization, particularly in rural and semi-urban areas where standalone rollout is commercially challenging [63, 64].

Quantitative assessments further demonstrate that infrastructure reuse plays a decisive role in managing 5G densification costs. Kumar and Oughton show that coordinated RAN sharing and physical infrastructure reuse can materially reduce capital expenditure while maintaining coverage targets, especially as site density increases under 5G architectures [64]. Regional regulatory guidance from the Asia-Pacific Telecommunity similarly recognises active sharing as a viable approach to accelerate rollout, provided that governance frameworks preserve competitive neutrality and service quality [65]. Complementary policy recommendations from SAP VIII emphasise the importance of clear operational boundaries, dispute resolution mechanisms, and regulator oversight to ensure that shared deployments translate into tangible coverage gains without undermining market competition [66].

Industry evidence also supports the role of active sharing in expanding coverage while containing investment intensity. GSMA reports highlight that operator-led RAN sharing has enabled faster rural deployment and reduced network duplication across multiple markets, reinforcing the view that active sharing acts as a practical extension of passive tower models in high-cost environments [67]. As 5G networks require substantially higher site density than previous generations, active infrastructure sharing is expected to play an increasingly important role in sustaining rollout momentum while limiting capital intensity.

Neutral-Host Fibre, Dark Fibre, and PPP-Based Backhaul

Beyond tower sharing, the use of government-owned dark fiber has proven critical in extending high-capacity backhaul. The National Digital Economy Strategy 2030 outlines plans to leverage state-owned fiber assets in Sri Lanka, while the Successful PPPs Report documents cases where public–private collaboration in backbone deployment lowered investment barriers for operators [68], [69].

The TRCSL Consultation Paper (2024) also emphasizes the need for competitive neutrality in infrastructure sharing, suggesting neutral-host and PPP-based backhaul expansion as tools to overcome rural connectivity gaps [70]. Moreover, regulatory instruments such as the Extraordinary Gazette No. 2396-32 (2024) establish the legal framework for shared telecom infrastructure, mandating nondiscriminatory access and encouraging co-build models [71].

Challenges and Opportunities

Despite these frameworks, two persistent challenges remain. First, macro tower approvals can take between six and twelve months due to fragmented clearance processes involving agencies such as the RDA, BOI, and local authorities [70]. Second, public resistance driven by health-related concerns has slowed deployments in certain regions, underscoring the need for structured awareness campaigns led by local institutions [71].

Nevertheless, the convergence of Sri Lanka's regulatory reforms, EDOTCO's neutral-host model, and expanding fiber-sharing initiatives provides a strong foundation to reduce costs, accelerate 5G rollouts, and extend coverage beyond profitable urban centers. However, while market-led infrastructure sharing through tower companies, active RAN models, and PPP-based fiber expansion delivers measurable efficiency gains, these mechanisms alone cannot resolve structural bottlenecks related to rights-of-way access, public land availability, and cross-sector coordination. A significant share of deployment delays and cost escalation continues to originate from fragmented approvals and limited access to government-controlled physical infrastructure. Consequently, international experience increasingly points to the need for government-enabled infrastructure access strategies to complement operator- and towerco-led delivery models—a theme examined in the following section.

2.5.5 Government-Enabled Infrastructure Sharing Strategies

While market-led sharing models address cost efficiencies within the telecommunications sector, international experience increasingly highlights the importance of government-enabled infrastructure access in overcoming structural deployment barriers. A substantial share of network rollout costs arises from civil works and access to physical corridors rather than radio equipment alone. Global studies show that coordinated use of public infrastructure such as road reserves, ducts, poles, municipal buildings, and utility corridors can significantly reduce duplication of trenching, accelerate deployment timelines, and improve the economic feasibility of extending fiber connectivity beyond dense urban centers [72],[63],[73],[64],[74].

From a policy perspective, government-enabled infrastructure access focuses on facilitating use of public rights-of-way and physical assets, rather than on commercial network operations. The World Bank and IFC emphasise that broadband networks depend heavily on ducts and poles to connect access nodes to backbone infrastructure, and that sharing opportunities extend across multiple sectors including transport, power, and municipal services [72],[73]. Integrating telecommunications infrastructure into these existing corridors—often described as dig-once approaches—allows fiber to be deployed alongside road construction or rehabilitation at marginal incremental cost, substantially improving rollout efficiency [72],[75].

Government Role in Passive Infrastructure Enablement

Across both advanced and emerging markets, governments increasingly act as facilitators and coordinators, enabling operators to reuse public assets and simplifying approval processes. Typical mechanisms include access to public rights-of-way, street furniture and government buildings, standardised permitting frameworks, and cross-agency coordination for infrastructure deployment.

In the United Kingdom, planning reforms permit mast strengthening and height extensions without full planning approval, alongside simplified development rights designed to maximise reuse of existing infrastructure and accelerate coverage expansion, particularly in rural areas [75]. Australia's 5G readiness assessments similarly identify lengthy approval processes for Crown and council land as a material barrier to deployment, recommending consolidated approval pathways and regulatory streamlining to reduce cost and uncertainty for fiber and small-cell rollouts [76],[77].

Singapore's regulatory consultations further highlight the importance of coordinated access to buildings and public infrastructure to support dense urban deployments, reinforcing the role of government agencies in aligning planning frameworks with connectivity objectives [78]. Collectively, these examples illustrate a common policy direction: governments prioritise regulatory simplification and public-asset access to support private investment, rather than acting as network operators.

India provides a further example of government-enabled infrastructure access through its BharatNet programme. Special Right-of-Way guidelines issued by the Ministry of Road Transport and Highways grant preferential access for optical fiber deployment along national highways, including waiver of license fees and performance guarantees, establishment of utility corridors, and expedited approvals targeted within seven days. The framework also mandates non-exclusive use of rights-of-way and prioritizes reuse of existing ducts where available, illustrating how coordinated public-asset access can materially accelerate fiber rollout while minimizing civil works duplication [79].

Governance Considerations and Public Asset Coordination

Although government-enabled access can substantially accelerate deployment, international experience also highlights governance challenges. Without clear institutional responsibilities, coordinated planning mechanisms, and transparent access conditions, deployment efforts can be delayed by fragmented approvals and inter-agency misalignment. The literature therefore emphasises the need for standardised access rules, predictable permitting timelines, and clearly defined roles between public authorities and network operators to ensure that infrastructure access frameworks deliver their intended outcomes [72],[73],[64],[74].The Table 2.4 summarizes selected international examples of government-enabled infrastructure access, highlighting common public-asset mechanisms and policy objectives adopted across different regulatory contexts.

Implications for Sri Lanka

For Sri Lanka, these international lessons suggest that government-enabled infrastructure access should be treated as a foundational enabler of 5G deployment. Priorities include formalising access to RDA ducts, utility poles, and public buildings; integrating fiber deployment into national road and urban development projects; strengthening cross-sector coordination; and establishing unified approval processes to reduce inter-agency delays. When combined with market-led infrastructure delivery models, these measures provide a practical pathway to reduce capital intensity, accelerate densification, and support more equitable expansion of 5G beyond commercially attractive urban cores.

2.6 Policy and Regulatory Incentive Models

The success of 5G deployment depends not only on spectrum allocation and infrastructure readiness but also on enabling policy and regulatory incentives. Globally, governments and regulators have adopted measures such as spectrum pricing discounts, tax incentives, regulatory sandboxes, and infrastructure-sharing mandates to ease capital burdens and accelerate rollout. For developing markets such as Sri Lanka, these incen-

TABLE 2.4: GOVERNMENT-ENABLED INFRASTRUCTURE ACCESS MECHANISMS AND POLICY OBJECTIVES

Country/Region	**Public Asset / Mechanism**	**Policy Objective**	**Key Sources**
United Kingdom	Planning reform, mast upgrades, rights-of-way access	Accelerate roll-out and reduce new site construction	[75]
Australia	Streamlined Crown land approvals, regulatory reform	Reduce approval delays and deployment uncertainty	[76],[77]
Singapore	Coordinated access to buildings and public infrastructure	Support dense urban fiber and small-cell deployment	[78]
India	BharatNet RoW reform, highway utility corridors, fee waivers	Accelerate fiber rollout via public corridors	[79]
Global (World Bank case studies)	Road corridors, ducts, poles, municipal assets	Lower civil works costs and improve rollout efficiency	[72], [73]

Note. Passive infrastructure sharing mechanisms tives are crucial in balancing affordability with investment sustainability.

2.6.1 Incentives: Spectrum Pricing Discounts, Tax Holidays, and Fast-Track Approvals

Spectrum pricing directly shapes both the pace and quality of network deployment. Excessive spectrum fees are known to divert funds away from infrastructure expansion, resulting in delayed rollouts and higher consumer prices [54], [55]. In developing markets, spectrum prices as a share of operator revenue are on average three times higher than in advanced economies, constraining long-term investment [57].

Global guidelines emphasize cost-based approaches. The ITU recommends phased fee structures and administrative flexibility to avoid overburdening operators [12]. The GSMA has also highlighted how discounted reserve prices and deferred payment models in countries such as India, Malaysia, and several African markets have enabled faster broadband reach [8], [16], [17], [57]. The OECD and IFC further note that targeted incentives such as tax holidays and spectrum fee rebates tied to rural rollout obligations have proven effective in encouraging investment in low-revenue environments [55], [56].

2.6.2 Regulatory Sandboxes and National 5G Councils

Regulatory sandboxes provide a framework for testing innovative technologies under controlled conditions, reducing compliance risks for operators while enabling regulators to monitor outcomes. International case studies show that sandboxes have been instrumental in piloting dynamic spectrum sharing, network slicing, and early 5G services in countries such as the UK, Singapore, and Bahrain [12], [80].

In South Asia, India's "Making India 5G Ready" initiative recommended a national steering body to coordinate spectrum allocation, Research and Development, and pilot projects [6]. Similarly, Korea's national 5G council aligned regulatory approvals and operator investment timelines, enabling rapid SA deployment [22]. More recently, Japan and Spain have introduced expanded governance frameworks for telecom sandboxes, including eligibility criteria, performance evaluation, and fast-track licensing [80].

Sri Lanka can draw lessons from these examples. A telecom-specific regulatory sandbox, modeled on the Central Bank of Sri Lanka's sandbox in fintech, could accelerate innovation by enabling controlled pilots in private 5G, dynamic spectrum access, and enterprise use cases [19]. Establishing a multi-stakeholder 5G council would further align spectrum roadmaps, infrastructure policy, and industry needs.

2.6.3 Infrastructure Sharing Mandates and Regulatory Access Frameworks

Building on the market-led and government-enabled infrastructure sharing mechanisms discussed in Section 2.5, policy frameworks increasingly focus on mandating fair access, reducing approval delays, and ensuring competitive neutrality. Rather than defining technical sharing models, regulatory interventions aim to create enabling conditions that lower deployment costs and accelerate rollout while preserving service competition.

Global evidence shows that well-designed infrastructure sharing mandates can significantly improve deployment efficiency. Passive sharing arrangements, including rooftop access and power infrastructure, have been shown to reduce site-related capital expenditure by up to 40%, while active sharing frameworks further enhance cost efficiency in low-density and low-revenue environments [59]. The GSMA Mobile Policy Handbook emphasizes that transparent pricing mechanisms and nondiscriminatory access conditions are essential to prevent market distortion and ensure fair participation across operators [81].

Across South and Southeast Asia, regulatory measures supporting rooftop access, fiber pooling, and neutral-host arrangements have contributed to reduced rollout timelines and improved semi-urban connectivity [17], [60]. Tower companies such as Indus Towers in India and EDOTCO in Southeast Asia illustrate how high tenancy ratios, supported by regulatory clarity, translate into improved cost efficiency and accelerated 5G densification [60], [61].

In Sri Lanka, policy direction is reflected in the National Digital Economy Strategy 2030, which promotes the use of government-owned dark fiber through public–private partnership models to strengthen backhaul capacity [68]. Complementing this, the TRCSL Consultation Paper (2024) highlights competitive neutrality in tower and fiber sharing, while Extraordinary Gazette No. 2396–32 establishes the legal framework for nondiscriminatory access to shared telecommunications infrastructure [70], [71]. Together, these instruments signal a regulatory shift toward facilitating shared infrastructure as a means of reducing capital intensity and extending broadband reach.

A consolidated summary of international policy instruments supporting 5G deployment, including spectrum pricing reforms, fiscal incentives, regulatory sandboxes, governance models, and infrastructure access mandates—is presented in Table 2.5.

Overall, international experience indicates that infrastructure sharing mandates are most effective when combined with streamlined approval processes, clear access rules, and regulatory oversight mechanisms. Such policy frameworks play a critical role in translating technical sharing capabilities into practical deployment outcomes, particularly in markets facing affordability constraints and high civil works costs.

2.7 Industry Use Cases and Private 5G Readiness

2.7.1 Global Cases: Manufacturing, Ports, and Logistics

Global deployment of 5G in industry demonstrates its role in enabling automation, efficiency, and advanced connectivity. In Germany, the 5G Strategy for Germany and related research highlight the use of dedicated 5G campus networks in manufacturing, supporting machine vision, cyber-physical systems, and robotics within factory

TABLE 2.5: SELECTED POLICY AND REGULATORY INCENTIVES FOR 5G

Incentive Type	**Global Practice**	**Example Countries**	**Reported Impact**	**Source**
Spectrum pricing discounts and phased fees	Reduced reserve prices, deferred payments	India, Malaysia, Nigeria	Faster spectrum uptake; reduced CAPEX burden	[6], [16], [17], [55], [57]
Tax incentives	Tax holidays, reduced licence fees	Kenya, Malaysia	Encouraged rural broadband rollout	[55], [56]
Regulatory sandboxes	Pilots for spectrum sharing, slicing	UK, Singapore, Bahrain, Japan	Faster innovation; reduced compliance risk	[12], [80]
National 5G councils	Cross-government steering bodies	India, Korea	Coordinated policy; faster approvals	[6], [22]
Infrastructure sharing mandates	Rooftop access, fiber pooling, neutral-host models	India, Malaysia, Bangladesh	Reduced rollout delays; extended rural coverage	[81], [59], [60], [62]

Note. Insights from global practices

floors [82], [83]. In China, 5G is applied in port operations for remote-controlled cranes, automated guided vehicles (AGVs), and real-time high-definition video monitoring, reducing latency in logistics processes [84]. Singapore and Southeast Asian case studies show integration of 5G in logistics for connected forklifts, augmented reality (AR)-assisted inventory, and warehouse automation [85], [86]. These examples demonstrate how private and localized 5G deployments are driving transformation in critical sectors.

2.7.2 Private 5G Spectrum Models

Private 5G networks require flexible spectrum models. In Europe, dedicated local licensing schemes allow enterprises to operate campus networks using mid-band spectrum, tailored to industrial zones [87]. The United Kingdom provides localized spectrum through shared access and license-exempt allocations, enabling enterprise adoption without relying exclusively on operators [24]. In Asia-Pacific, regulatory models include direct enterprise licensing, operator-led leasing, and shared spectrum frameworks. For instance, the CBRS model in the United States provides dynamic spectrum access for private enterprises, while APAC markets have experimented with both leasing and administrative assignment [9], [88]. Research on spectrum sharing schemes shows that coexistence between public and private networks is possible with appropriate coordination technologies [89], while spectrum leasing arrangements provide enterprises with temporary or project-based access to frequencies [90].

2.7.3 User-Side Digital Maturity and Barriers

Enterprise adoption of 5G depends on digital maturity. Models developed for Industry 4.0 highlight technology readiness, organizational processes, and workforce capability as determinants of adoption [91], [92]. However, reports indicate that awareness of 5G's industrial benefits remains limited, and many firms face challenges in building strong business cases [8]. Cybersecurity risks are also significant; open interfaces and increased device connectivity in industrial environments expand potential attack surfaces [93]. Further studies emphasize barriers such as integration with legacy systems, high upfront costs, and limited device ecosystems as constraints to widespread enterprise uptake [94].

2.7.4 Sri Lanka and Regional Context

Within the Asia-Pacific region, private 5G readiness is progressing unevenly. The Mobile Economy Asia-Pacific 2024 notes that spectrum availability, supportive regulatory frameworks, and enterprise demand shape adoption trajectories [45]. The Private Networks in Asia-Pacific report highlights that countries in the region use diverse licensing models, ranging from direct enterprise spectrum to operator-led deployments [88]. The State of 5G 2024 confirms that South and Southeast Asian enterprises are piloting applications in manufacturing and logistics, though commercial-scale adoption remains limited due to cost and ecosystem challenges [8]. Regional digital transformation studies underscore that skills development, backhaul investment, and regulatory clarity are prerequisites for accelerating enterprise 5G adoption [95]. In Sri Lanka, operators and infrastructure providers are evaluating enterprise models, while reliance on microwave backhaul continues to complement fiber in rural and dispersed geographies [96].

2.8 Research Gaps

Despite extensive global and regional scholarship on 5G deployment, several critical gaps persist in the Sri Lankan context that warrant targeted investigation:

1. Absence of an Integrated Roadmap Combining Multi-Stakeholder Perspectives Global best practices stress coordinated planning between regulators, operators, infrastructure providers, and enterprise users to ensure harmonized deployment. For instance, countries such as Germany and South Korea have demonstrated success through national 5G councils that align technical standards, regulatory policy, and industry adoption strategies. In contrast, Sri Lanka's national policy documents (e.g., Digital Economy 2030) present ambitious digital economy targets but stop short of integrating these diverse perspectives into a sequenced and actionable 5G roadmap. This gap hinders the formulation of a coherent, phased rollout plan.

2. Mismatch Between Global Assumptions and Local Realities Many international analyses assume conditions such as high smartphone penetration, extensive nationwide fiber coverage, and stable energy infrastructure. These assumptions do not fully reflect Sri Lanka's context, where smartphone affordability, uneven backhaul availability, and elevated electricity tariffs remain key barriers. Without localized models that account for these realities, the direct transfer of global strategies risks inefficiency and misalignment with ground conditions.

3. Limited Consideration of Enterprise-Level Demand and Cost Recovery Models While policy reports often emphasize spectrum pricing, consumer adoption, and infrastructure readiness, less attention has been paid to enterprise-specific use cases and ROI mechanisms. In Sri Lanka, the readiness of manufacturing, logistics, and healthcare sectors to adopt private 5G networks—and their ability to justify investments—remains largely unexplored. This gap underscores the importance of demand-side analysis in complementing supply-side readiness.

4. Insufficient Integration of Global Learnings with Local Deployment Challenges Case studies from India, Vietnam, Nigeria, and Europe provide insights into spectrum frameworks, incentive schemes, and regulatory reforms. However, Sri Lanka has yet to systematically adapt these lessons to its unique policy environment, market size, and revenue constraints. The limited contextual integration highlights the need for systematic assessment of how international approaches translate into Sri Lanka's policy and market environment.

Positioning of This Study

This study addresses these gaps by integrating expert perspectives from Sri Lankan operators, regulators, and enterprise users with selected international benchmarks. It develops an evidence-based understanding of policy, infrastructure, energy, and enterprise readiness factors influencing 5G deployment. Through this approach, the research establishes an analytical foundation for evaluating Sri Lanka's preparedness and informing the development of a context-sensitive Multi-stakeholder roadmap in subsequent chapters.

2.9 Summary

This chapter has examined global, regional, and local perspectives on 5G deployment, organized across six thematic areas:

1. Multi-stakeholder roadmaps and 5G Readiness Frameworks – Reviewed international frameworks (GSMA, ITU, World Bank) and country case studies that localized 5G deployment strategies to align with national priorities.

2. Spectrum Scarcity and Allocation Strategies – Explored allocation models, coverage–capacity trade-offs, and Sri Lanka's specific spectrum challenges, including congestion in mid-bands and delays in refarming low-band frequencies.

3. NSA to SA Migration Trade-offs – Analyzed the technical and economic implications of transitioning from Non-Standalone (NSA) to Standalone (SA) architecture, with emphasis on ecosystem maturity and vendor dynamics.

4. Infrastructure and Power Cost Barriers – Assessed site densification requirements, fiber and microwave backhaul constraints, and energy cost burdens, particularly under Sri Lanka's elevated power tariff structure.

5. Policy and Regulatory Incentive Models – Evaluated incentive mechanisms such as spectrum fee discounts, regulatory sandboxes, and infrastructure-sharing frameworks.

6. Industry Use Cases and Adoption Readiness – Examined global and regional trends in private 5G networks across manufacturing, logistics, and port operations, while highlighting Sri Lanka's limited enterprise digital maturity and barriers to adoption.

The review demonstrates that while global best practices provide a wealth of guidance, Sri Lanka's readiness is constrained by infrastructure gaps, spectrum fragmentation, high operational costs, and low enterprise awareness. The absence of a coordinated, multi-stakeholder roadmap emerges as the most significant barrier to effective deployment. The research gaps identified in Section 2.8 directly shape the study's methodology in the next chapter. The forthcoming methodology chapter outlines how expert interviews, thematic analysis, and case benchmarking will be employed to bridge these gaps, ultimately producing an actionable Multi-stakeholder roadmap tailored to Sri Lanka's 5G future.

CHAPTER 3

METHODOLOGY

3.1 Research Design

This research adopts a qualitative-dominant mixed-methods design, combining semi-structured stakeholder interviews with secondary document analysis. A qualitative approach is well-suited to exploring perceptions, institutional barriers, and strategic decision-making processes surrounding 5G deployment, while secondary data provides context and validation. The design reflects the exploratory nature of the study, where the goal is not only to document readiness indicators but also to understand the dynamics between technical, regulatory, and market factors.

3.2 Data Sources

3.2.1 Primary Data

Primary data was collected through semi-structured interviews with representatives from key stakeholder groups, including:

- **Regulator** – TRCSL officials responsible for spectrum management and policy formulation.
- **Operators** – Dialog Axiata, SLT-Mobitel, Hutch.
- **Vendors and Infrastructure Providers** – EDOTCO, Huawei.
- **Industry Users** – organizations in logistics, manufacturing, and port operations.

The interview design ensured coverage of both supply-side (deployment) and demand-side (adoption) perspectives.

3.2.2 Secondary Data

Secondary data was obtained from regulatory publications, operator reports, GSMA and ITU studies, academic papers, and industry white papers. These sources provided global benchmarks and regional case studies (India, Malaysia, South Korea) for cross-comparison with Sri Lanka.

3.3 Sampling Strategy

A purposive sampling strategy was adopted to ensure that participants represented institutions with direct influence on 5G deployment. Within each stakeholder group, participants were selected based on their involvement in spectrum planning, infrastructure strategy, or technology adoption. In total, 25 interviews were conducted, covering diverse institutional perspectives.

3.4 Data Collection Methods

Data collection involved,

- **Semi-structured interviews** guided by questionnaires tailored to each stakeholder group. This allowed consistency across interviews while leaving space for participants to raise context-specific issues.
- **Document review**, including TRCSL consultation papers, national digital economy strategies, operator 5G roadmaps, and global benchmark reports.

Interviews were recorded with consent, transcribed, and anonymized to preserve confidentiality.

3.5 Questionnaire Design

To capture multi-stakeholder perspectives on 5G deployment in Sri Lanka, five structured questionnaires were prepared for telecom operators, the regulator, industry users, vendors, and infrastructure providers (TowerCos). The instruments were designed based on insights from the literature review, global benchmarks, and expert consultations, ensuring close alignment with the research objectives.

- Operator Questionnaire: Focused on organizational readiness, phased migration (NSA to SA), infrastructure gaps, priority use cases, spectrum and policy issues, and revenue expectations
- Regulator Questionnaire: Addressed strategic vision, spectrum allocation, infrastructure planning, regulatory barriers and enablers, stakeholder consultation, competition safeguards, and future policy frameworks
- Industry User Questionnaire: Assessed awareness of 5G, pilot initiatives, urgency of adoption, sector-specific use cases, adoption barriers, operator communication, and integration with digital strategies
- Vendor Questionnaire: Explored infrastructure readiness, spectrum-related challenges, NSA–SA migration pathways, energy efficiency, private 5G initiatives, enterprise solutions, and capacity-building partnerships
- Infrastructure Provider (TowerCo) Questionnaire: Concentrated on site acquisition and tower deployment, smart street furniture (e.g., lamp poles), indoor coverage solutions, energy and power cost management, infrastructure sharing, regulatory approvals, and Open RAN readiness.

Each questionnaire blended closed-ended questions (Likert scale, multiple-choice) for comparability with open-ended items to elicit qualitative insights. Draft versions were reviewed with academic supervisors and refined with expert feedback to ensure clarity, comprehensiveness, and contextual relevance.

The finalized questionnaires were administered electronically (via email and online survey tools) and through direct interviews, targeting purposively selected respondents across the stakeholder groups. This approach ensured both breadth and depth of perspectives, which were later triangulated with secondary sources and thematic analysis to enhance validity.

3.6 Pilot Testing and Instrument Refinement

The interview questionnaires were initially designed based on the key domains identified through the literature review, including spectrum strategy, NSA–SA migration, infrastructure readiness, regulatory frameworks, and industry adoption. This ensured that the instruments were theoretically grounded and aligned with the study objectives.

Prior to the main data collection, the questionnaires were pilot tested with telecom operators and selected industry users. The pilot phase focused on evaluating question clarity, logical sequencing, and relevance to practical deployment realities. Insights from these preliminary interviews informed several refinements, including rephrasing selected questions for clarity, removal of overlapping or less relevant items, and reordering of sections to improve conversational flow.

In addition, early responses highlighted the need to place greater emphasis on low-band spectrum availability, device ecosystem readiness, and coordination across public institutions, which were subsequently strengthened in the final interview guide. This iterative refinement process enhanced instrument reliability and ensured that the interviews captured both policy-level and operational perspectives in a balanced and context-sensitive manner.

3.7 Data Analysis

The interview transcripts were analyzed using thematic analysis, following Braun and Clarke's (2006) widely adopted six-step framework [97]. This method was chosen because it provides a structured yet flexible process for identifying patterns and insights in qualitative data, and is particularly well-suited to studies involving multiple stakeholder perspectives.

The six steps applied in this study were as follows.

1. Familiarization with the data: Interview transcripts were read several times to gain a thorough understanding of the content. During this stage, initial observations and recurring points were noted.

2. Generating initial codes: Relevant excerpts were highlighted and assigned short descriptive codes. For example, references to "spectrum auction delays" were coded as "spectrum barriers."

3. Searching for themes: Codes with similar meanings were grouped together to form broader themes. For instance, codes such as "spectrum delays," "fragmentation," and "pricing uncertainty" were combined under the theme of Spectrum Scarcity.

4. Reviewing themes: The provisional themes were checked against the data to ensure they accurately represented the interviews. At this stage, some themes were merged (e.g., “energy costs” and “site power challenges” were combined into Infrastructure Costs), while others were refined.

5. Defining and naming themes: Each theme was clearly defined and given a concise name that captured its central meaning. Examples included Regulatory Bottlenecks, Infrastructure Barriers, and Adoption Challenges.

6. Producing the report: The final themes were integrated into the findings chapter, supported by direct quotations from participants and cross-checked with secondary sources for validation.

To manage the data, Excel spreadsheets were used as a coding matrix, with columns for Interview ID, Question, Transcript Excerpt, Initial Code, Theme, and Notes. Although software such as NVivo is often employed for qualitative analysis, Excel was considered sufficient for this study given the dataset size. It allowed systematic organization and transparency in the coding process while maintaining flexibility for iterative refinement.

By following Braun and Clarke’s structured process, the analysis ensured that findings were grounded in the data, systematically derived, and aligned with the study’s six key themes as follows.

1. Multi-stakeholder roadmaps & Readiness Frameworks

2. Spectrum Scarcity & Allocation

3. NSA $\rightarrow$ SA Migration Trade-offs

4. Infrastructure & Power Costs

5. Policy & Regulatory Incentives

6. Industry Use Cases & Adoption Readiness

The overall research process is summarized in Figure 3.1. As shown, the study combined insights from the literature review and stakeholder interviews, which were analyzed using thematic coding. Triangulation between primary and secondary sources produced readiness assessment indicators, which in turn informed the development of a phased 5G deployment roadmap tailored to Sri Lanka.

3.8 Credibility, Reliability, and Triangulation

Several measures were adopted to enhance the credibility and reliability of the qualitative findings. Triangulation was applied by systematically cross-checking interview insights with secondary sources, including GSMA industry reports, TRCSL publications,

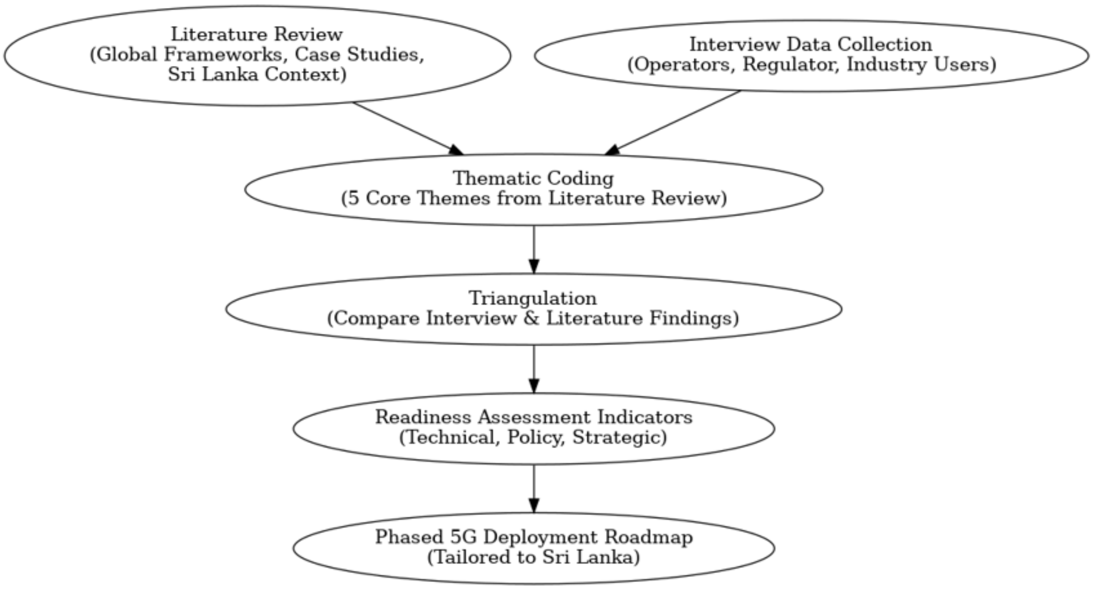

Fig. 3.1: Research Process Flow for Developing the Strategic 5G Roadmap

Note. the figure illustrates the summarized overall research process

policy documents, and relevant international case studies, particularly for themes related to spectrum availability, NSA–SA migration timelines, infrastructure constraints, and device adoption levels.

Triangulation was operationalized through the following mechanisms.

- **Data-source triangulation:** Interview findings from regulators, operators, infrastructure providers, and industry users were compared to identify convergent and divergent perspectives.
- **Method triangulation:** Qualitative insights were validated against secondary evidence drawn from GSMA publications, TRCSL reports, national policy documents, and global deployment case studies.
- **Metric-based cross-checking:** Quantitative indicators such as reported 5G penetration levels, spectrum allocations, infrastructure readiness metrics, and adoption benchmarks were used as reference points to support qualitative interpretations.
- **Thematic validation:** Core themes including spectrum scarcity, NSA–SA migration uncertainty, infrastructure and power-cost barriers, and device ecosystem readiness were corroborated across multiple evidence sources.
- **Thematic validation:** Insights from pilot testing informed iterative improvements to interview guides, strengthening construct validity and consistency of responses.

Cross-case comparison was employed across stakeholder groups, including regulators, operators, infrastructure providers, and industry users, to identify both shared priorities and contrasting viewpoints. Transparency in analysis was maintained through coding logs and documentation of analytical decisions, enabling traceability from interview transcripts to final themes. Participant validation was also applied where feasible, with summaries of interpretations shared with selected participants to confirm accuracy and minimize misrepresentation.

Finally, iterative theme review and refinements introduced during pilot testing further enhanced construct validity by ensuring that interview instruments captured both policy-level and operational dimensions.

3.9 Ethical Considerations

Ethical approval for the study was obtained in accordance with the university research guidelines. Participants were provided with an information sheet explaining the purpose of the study and gave informed consent before taking part in the interviews. Interviews were recorded with the participant's consent to support accurate transcription and analysis.

All interview data were anonymized and stored securely. To protect confidentiality, participant identities and organizational details were removed or generalized in the reporting of findings. Any sensitive information shared during interviews was treated with care to ensure that individual respondents and organizations could not be identified.

3.10 Limitations

The study acknowledges several limitations:

- A relatively small number of interviews may limit the ability to generalize.
- Stakeholder availability, particularly at the regulatory level, constrained the breadth of perspectives.
- The rapidly evolving policy environment may mean some findings reflect a specific temporal context.
- The study does not evaluate vendor financing models or device-level technical specifications, which fall outside its scope.

CHAPTER 4

FINDINGS AND DISCUSSION

4.1 Data Collection

Overview

Primary data was collected through semi-structured interviews with stakeholders across the 5G ecosystem in Sri Lanka. In total, 25 interviews were conducted, covering the regulator, operators, vendors, infrastructure providers, and industry users. The summary detail of the interview participants are shown in the Table 4.1. Each stakeholder group was selected for its direct role in shaping 5G deployment, either from a supply-side or demand-side perspective.

Secondary data sources included TRCSL consultation papers and spectrum roadmaps, operator annual reports, GSMA and ITU publications, and regional case studies (India, Malaysia, South Korea). These were used to benchmark Sri Lanka's readiness and validate findings from the interviews.

Data Handling

All interviews were recorded with consent, transcribed, and anonymized. Coding was conducted using Excel spreadsheets following Braun & Clarke's six-step thematic analysis framework, with excerpts tagged to initial codes and grouped into higher-order themes. Secondary sources were organized alongside primary data to ensure triangulation, allowing findings to be validated across multiple evidence streams.

4.2 Thematic Analysis of Interviews

4.2.1 Multi-stakeholder roadmaps & Readiness Frameworks

Findings

The interviews revealed that Sri Lanka lacks a unified, phased 5G roadmap that integrates regulator, operator, and industry perspectives. While TRCSL has published a spectrum roadmap (2024), it focuses mainly on auction timelines rather than long-term migration or adoption strategies.

- **Regulator perspective:** The regulator highlighted its role as an enabler of services, emphasizing spectrum assignment and auction design. However, rollout targets are still debated (site-based vs population-based), and the national strategy remains urban-first, with initial focus on municipal councils and smart cities before wider coverage.
- **Operator perspective:** Operators consistently noted the absence of a clear NSA→SA migration pathway and expressed concern that fragmented spectrum release prevents long-term planning.

TABLE 4.1: SUMMARY OF INTERVIEW PARTICIPANTS

Stakeholder Group	**Organization type / role**	**Seniority level / designation**	**Functional area / focus**
Regulator	Regulator	Senior management (spectrum)	Spectrum management
Operator	Wireless Operators	Assistant Vice President	Network strategy transformation
		Principal Architect	Transport network
		Senior management	Radio network planning
		Assistant Vice President	Network planning
		Senior Manager	Network strategy transformation
		Supervisory Engineer	Core network
		Engineer	Network planning
		Senior Manager	Technology development & rollout
Vendors & Infra Providers	Vendor	Director	Solution architecture
	TowerCo	Head of Operations	Tower operations
Industry Users	Manufacturing	Head of Remote Manufacturing and Third Party Manufacturing	Manufacturing operations / digitalization
		Head of IT	IT / enterprise systems
		Deputy General Manager	Operations / technology enablement
		Lead Digital Evangelist	Digital transformation
		Engineer	Automation / engineering
		Senior Manager IT	IT / infrastructure
	Aviation	Engineer	Aviation technology / operations
	IT	Director Engineering	Engineering leadership
		Engineer (2)	Engineering
		IT Executive	IT operations
		Executive – Infrastructure & System Support	Enterprise infrastructure
		Software Engineer	Software / platforms
	Finance & Banking	General Manager	Banking / technology strategy
	IT,Smart Cities & Utilities)	Chief Technology Officer	Technology leadership

- **Vendor perspective:** Vendors stressed that without a Multi-stakeholder roadmap, Sri Lanka risks falling further behind regional peers, particularly India and Malaysia, which have defined phased rollout targets and vertical-specific adoption strategies.
- **Industry user perspective:** Industry users expressed uncertainty, noting that without clarity on spectrum allocation and private 5G policies, sectors like ports and manufacturing cannot plan for digital adoption.

The summarised representation of the findings on the theme; Multi-stakeholder roadmaps & Readiness Frameworks is presented in the Table 4.2.

TABLE 4.2: SUMMARY TABLE OF THEME NO 1

Stakeholder	Key Point	Example Quote
Regulator	Spectrum roadmap published, urban-first rollout	“TRCSL is the regulator, and we are the enabler of services. We use different” (Regulator, Q1) "use strategy tools to enable services." “we cleared 3.5 GHz and 26 GHz for auction, but the 700 MHz band remains with broadcasting.” (Regulator, Q1)
Operator	No NSA→SA migration pathway	“We are technically ready for NSA (Operator, OpA01, Q1) “Already late. In the past 3G, 4G were launched here by 3 to 4 years from the global launches. We are left behind now. Earlier from the speed and experience perspective, SL was in a better rank than now. It is because we got late to launch 5G.” (Operator, OpA01, Q18) “Guideline issued. Their plan is very clear. Strategically completely aligned. Ecosystem readiness & spectrum issuing is the problem.” (Operator, OpA02, Q13)
Vendor	Fragmented spectrum release will hurt performance	“Sri Lanka is behind peers in spectrum release; fragmentation will hurt performance.” (Vendor, VnA01, Q2)
Industry	No clarity for private 5G adoption	“Without a clear roadmap, plan private 5G adoption.” (Industry User, InA01)

Note. Analysis on Multi-stakeholder roadmaps & Readiness Frameworks

4.2.2 Spectrum Scarcity & Allocation

Findings

Spectrum availability and allocation emerged as the most pressing concern across all stakeholders. While mid- and high-band frequencies (3.5 GHz and 26 GHz) have been cleared for auction, the critical low-band spectrum (700 MHz, Band 28) remains tied up in broadcasting, delaying rural coverage and slowing adoption.

- **Regulator perspective:** TRCSL emphasized its role in clearing 3.5 GHz and 26 GHz for auction and introduced rollout targets with bank guarantees to ensure operator compliance. However, the regulator acknowledged that clearance of the 700 MHz band remains unresolved.
- **Operator perspective:** Operators criticized the delays in spectrum auctions and the lack of clarity on pricing and refarming timelines. They stressed that NSA→SA migration and rural coverage expansion cannot proceed without low-band spectrum.
- **Vendor perspective** Vendors highlighted spectrum fragmentation and warned that performance and cost-efficiency would suffer if allocations were not harmonized. They also noted that Sri Lanka is already behind regional peers in the timely release of the spectrum.
- **Industry user perspective:** Industry players expressed concern that uncertainty in spectrum availability, particularly for private 5G or enterprise allocation, discourages early adoption and investment in digital transformation projects.

The summarised representation of the findings on the theme; Spectrum Scarcity & Allocation is presented in the Table 4.3.

TABLE 4.3: SUMMARY TABLE OF THEME NO 2

Stakeholder	**Key Point**	**Example Quote**
Regulator	Cleared 3.5/26 GHz, but 700 MHz clearance unresolved	"We cleared 3.5 and 26 GHz for auction, but the 700 MHz band is still used for broadcasting." (Regulator, Q1)
Operator	NSA→SA migration delayed by low-band unavailability	"NSA to SA migration is delayed because low-band spectrum is not yet released." (Operator, OpA01, Q3)
Vendor	Fragmentation risks poor performance, SL behind peers	"Sri Lanka is behind peers in spectrum release; fragmentation will hurt performance." (Vendor, VnA01, Q2)
Industry	Uncertainty blocks enterprise adoption planning	"Without clarity on spectrum, cannot plan their adoption strategies." (Industry User, InA01)

Note. Analysis on Spectrum Scarcity & Allocation

4.2.3 NSA to SA Migration Trade-offs

Findings

Stakeholders expressed mixed views on the migration from Non-Standalone (NSA) to Standalone (SA) 5G. Operators emphasized the practicality of launching NSA first, leveraging existing 4G cores to reduce costs. However, they also acknowledged that without a roadmap for SA, Sri Lanka risks being stuck in a transitional phase, unable to fully enable advanced use cases such as URLLC (ultra-reliable low latency communication) and massive IoT.

- **Regulator perspective:** TRCSL indicated that technology-neutral licensing is being considered, allowing operators to reuse 4G spectrum for 5G. This suggests flexibility but does not provide a concrete NSA→SA migration timeline.
- **Operator perspective:** Operators highlighted that while NSA is technically feasible and already trialed, low-band spectrum gaps and high migration costs remain barriers to SA. They stressed the absence of an integrated national strategy for SA readiness.
- **Vendor perspective:** Vendors viewed NSA as a necessary stepping-stone but stressed that enterprise-grade adoption requires SA, especially for private networks, automation, and mission-critical communications.
- **Industry user perspective:** Industry stakeholders noted that most enterprises are not yet ready for advanced SA applications but expect clarity on when SA will become commercially available to plan investments.

The summarised representation of the findings on the theme; NSA to SA Migration Trade-offs is presented in the Table 4.4.

TABLE 4.4: SUMMARY TABLE OF THEME NO 3

Stakeholder	Key Point	Example Quote
Regulator	Technology-neutral licensing under review	"We are analyzing technology-neutral licensing… so 4G spectrum in rural could be reused for 5G in cities." (Regulator, Q6)
Operator	NSA trials feasible, SA blocked by spectrum & cost	"NSA to SA migration is delayed because low-band spectrum is not yet released." (Operator, OpA01, Q3)
Vendor	NSA is interim, SA essential for enterprise adoption	"NSA is a starting point, but SA is essential for private 5G and automation use cases." (Vendor, VnA01)

Note. Analysis on NSA to SA Migration Trade-offs

4.2.4 Infrastructure & Power Costs

Findings

Stakeholders identified infrastructure limitations and power costs as key challenges to 5G deployment.

- **Regulator perspective:** TRCSL noted that site acquisition approvals are delayed due to multiple local authorities and reported that a single-window system is being developed to address this. High electricity tariffs were also identified as a major barrier, with discussions initiated with the CEB.
- **Operator perspective:** Operators highlighted the need for extensive site densification in urban areas, but emphasized that high power costs and limited fiberization make deployment economically difficult. Concerns were also raised about the absence of active infrastructure sharing mandates.
- **Vendor perspective:** Vendors suggested that approaches such as Open RAN and green telecom practices could lower deployment costs, but stressed that without supportive policies, these innovations may not see wide adoption.
- **Infrastructure provider perspective (EDOTCO):** Infrastructure providers stated they are prepared to expand tower and fiber networks, but face regulatory hurdles in rooftop access and pricing disputes with operators. They welcomed efforts to formalize cost models for infrastructure sharing.
- **Industry user perspective:** Industry users reported coverage gaps in industrial zones and indicated that unreliable power and backhaul are limiting factors in planning digital transformation projects.

The summarised representation of the findings on the theme; Infrastructure & Power Costs is presented in the Table 4.5.

4.2.5 Policy & Regulatory Incentives

Findings

Policy and regulatory incentives were a recurring theme in the interviews, with stakeholders raising issues related to spectrum pricing, licensing frameworks, approvals, and regulatory flexibility.

- **Regulator perspective:** TRCSL reported that spectrum auctions are designed using the clock auction method to avoid inflated bids and allow staggered payments over five years, providing financial flexibility for operators. They also noted plans for technology-neutral licensing, regulatory sandboxes for pilots, and initiatives to involve academia and vendors in developing local 5G research capacity.
- **Operator perspective:** Operators emphasized that spectrum costs are high relative to revenue potential and requested longer payment windows and policy incentives to make investments viable. They also raised concerns about delays in approvals for site rollouts.

TABLE 4.5: SUMMARY TABLE OF THEME NO 4

Stakeholder	Key Point	Example Quote
Regulator	Delays in approvals, high electricity tariffs	“We are setting up a single-window system for site approvals, because currently operators face delays from multiple local authorities.” (Regulator, Q6) “Electricity tariffs for base stations are a concern, but discussions are ongoing with CEB.” (Regulator, Q10)
Operator	Densification critical but costs high	“Site densification is a major challenge — the cost of power is too high to expand rapidly.” (Operator, OpA02)
Vendor	Open RAN and green practices as cost solutions	“Open RAN and green practices can help, but without strong sharing policies adoption will remain slow.” (Vendor, VnA01)
Infra Provider	Rooftop disputes and need for cost models	“We face site acquisition problems, need to streamline the processes.” (Infrastructure Provider, InA01)

Note. Analysis on Infrastructure & Power Costs

- **Vendor perspective:** Vendors stressed the importance of supportive regulatory frameworks, particularly in reducing spectrum fees, promoting infrastructure sharing, and enabling industry pilots. They highlighted that regulatory incentives are key for ecosystem development.
- **Infrastructure provider perspective (EDOTCO):** Infrastructure providers pointed to the need for clear cost models to resolve pricing disputes and welcomed regulatory guidance on both passive and active infrastructure sharing.

The summarised representation of the findings on the theme; Policy & Regulatory Incentives is presented in the Table 4.6.

4.2.6 Industry Use Cases Adoption Readiness

Findings

Stakeholders highlighted that while there is strong interest in 5G use cases, adoption readiness in Sri Lanka remains limited due to low device penetration, lack of private 5G frameworks, and sector-specific constraints.

- **Regulator perspective:** TRCSL reported that demand is strongest in ports and logistics, with operators already requesting mmWave allocations for private networks. They noted that device penetration is only 6.5% and that private 5G licensing will be evaluated case by case. A three-year 2G shutdown plan has also been introduced to encourage digital adoption.
- **Operator perspective:** Operators confirmed low device penetration as a barrier and emphasized that enterprise adoption is limited without clear private 5G spectrum policies. They also noted that trial networks are helping to raise awareness

TABLE 4.6: SUMMARY TABLE OF THEME NO 5

Stakeholder	Key Point	Example Quote
Regulator	Clock auction, staggered payments, tech-neutral licensing	"We have chosen the clock auction method to avoid inflated bids, with staggered payments over 5 years." (Regulator, Q4)
Operator	High spectrum costs, need for incentives	"Spectrum costs are too high for the market size — long-term incentives are needed." (Operator, OpA02)
Vendor	Supportive policies needed for ecosystem growth	"Regulatory incentives are essential to promote enterprise adoption of 5G." (Vendor, $\mathrm{VnA}_0 1$)
Infra Provider	Cost models for infra sharing required	"We welcome regulatory cost models to resolve disputes over infra sharing." (Infrastructure Provider, InA01)

Note. Analysis on Policy & Regulatory Incentives

among enterprise users.

- **Vendor perspective:** Vendors indicated that sectors such as manufacturing, ports, and healthcare present strong opportunities, but stressed that adoption requires regulatory flexibility and industry-targeted support.
- **Infrastructure provider perspective (EDOTCO):** Infrastructure providers stated that they are ready to support private 5G deployments in industrial zones but require clear guidance from regulators and operators on spectrum and rollout priorities.
- **Industry user perspective:** Industry users expressed readiness in principle but highlighted gaps in digital maturity, unreliable infrastructure, and unclear policies as barriers to adoption. They emphasized that government and operators must drive early pilots to build confidence.

The summarised representation of the findings on the theme; Industry Use Cases & Adoption Readiness is presented in the Table 4.7.Device ecosystem readiness, particularly in relation to legacy 2G handsets, is further examined in Section 4.3.7 as a critical adoption and policy gap.

4.3 Major Gaps Identified Across Six Themes

4.3.1 Device Regulation and Early 2G Shutdown Readiness

The transition toward advanced mobile architectures is increasingly accompanied by the planned retirement of legacy 2G networks, enabling operators to refarm low-frequency spectrum for 4G and 5G services while reducing long-term operational expenditure. However, the feasibility of early 2G shutdown is strongly dependent on device ecosys-

TABLE 4.7: SUMMARY TABLE OF THEME NO 6

Stakeholder	Key Point	Example Quote
Regulator	Ports/logistics key sectors; low device penetration; case-by-case private 5G	"Highest demand observed in ports (SAGT, CICT) with automation; IoT awareness is there." (Regulator, Q11) "Private 5G not restricted... operators prefer slicing, low interest so far." (Regulator, Q12)
Operator	Low device penetration, unclear private 5G spectrum policies	"Trial networks are raising awareness, but device penetration is very low." (Operator, OpA01)
Vendor	Adoption requires regulatory flexibility and sector pilots	"Without regulatory clarity, industries will hesitate to adopt 5G solutions." (Vendor, VnA01)
Infra Provider	Ready for private 5G infra in industrial zones but need guidance	"We are ready to support private 5G deployments..."
Industry	Gaps in digital maturity; government must lead pilots	"Government-led pilots are needed to push adoption in manufacturing and logistics." (Industry User, InA01)

Note. Analysis on Industry Use Cases & Adoption Readiness

tem readiness. Continued inflow of legacy 2G-only or limited-capability devices can create a stranded user base, making network retirement socially and operationally infeasible and delaying spectrum refarming timelines.

In developing markets, this risk is amplified by the availability of low-cost handsets and informal import channels, which sustain demand for outdated technologies even as operators invest in next-generation infrastructure. Without strict regulatory controls on device imports, operators may be forced to maintain parallel networks for extended periods, diverting spectrum and capital away from 5G deployment. This undermines both coverage economics and migration toward standalone architectures. As such, device regulation must be treated as a core adoption-readiness measure rather than a peripheral technical issue.

International experience demonstrates that early 2G shutdown requires strong regulatory leadership and structured transition frameworks. In the United Kingdom, national switch-off plans are supported through coordinated operator outreach, device replacement programs for vulnerable users, and digital inclusion initiatives designed to prevent service disruption among low-income and elderly populations [98]. Korea's 2G termination process further illustrates the importance of regulator involvement, where service shutdown was permitted only after remaining subscribers fell below a defined threshold, accompanied by mandatory advance notice periods and compensation packages including free devices, tariff concessions, and refunds [99]. These cases highlight that device ecosystem readiness, subscriber migration support, and regulatory oversight are prerequisite conditions for successful spectrum refarming and legacy network retirement.

For Sri Lanka, early 2G shutdown represents a critical enabler of low-band refarming and nationwide 4G/5G coverage improvement. However, continued importation of 2G-only devices risks prolonging dependency on legacy networks and increasing the social cost of transition. Given that such devices are still entering the local market, immediate regulatory action is required to prevent further accumulation of incompatible handsets. This includes strengthening type-approval enforcement at the point of import, introducing minimum device capability requirements for market entry (for example, 4G/VoLTE support), and enhancing monitoring of grey-market channels. These measures should be complemented by operator-led customer migration programs and targeted affordability initiatives to support vulnerable user segments.

From a Multi-stakeholder roadmap perspective, device regulation must therefore be aligned with phased 2G retirement timelines. Proactively restricting legacy device inflows while supporting user migration enables regulators and operators to synchronise spectrum refarming, coverage expansion, and service continuity. Without such coordination, Sri Lanka risks facing a delayed 2G sunset, prolonged operational inefficiencies, and slower progress toward standalone 5G deployment. Accordingly, strict device regulation emerges as a foundational policy lever to avoid a disruptive shutdown scenario and to ensure an orderly transition toward next-generation mobile networks.

4.3.2 Impact of Low-Band Spectrum Assignment Delays on SA Migration

Low-band spectrum is fundamental for cost-efficient nationwide 5G coverage, particularly in rural and indoor environments. Delays in assigning sub-1 GHz bands such as 700 MHz therefore affect not only coverage expansion but also the technical and economic viability of migrating from Non-Standalone (NSA) to Standalone (SA) architectures. GSMA evidence indicates that countries deploying 600/700 MHz achieve significantly higher average 5G population coverage (73%) compared to those relying solely on mid-band spectrum (46%), underscoring the importance of low frequencies for nationwide availability.[100]. In current NSA deployments, operators extend coverage by anchoring mid-band 5G carriers to existing low-frequency LTE layers through dual connectivity and carrier aggregation. However, in SA environments this LTE anchor is removed, and equivalent coverage can only be achieved if low-band 5G spectrum is available. Without low-frequency NR carriers, SA deployments become limited to higher bands, requiring greater site density and higher capital expenditure.

Operator interviews conducted in this study confirmed that low-band spectrum is essential to support carrier aggregation and maintain coverage parity when transitioning to SA. In its absence, operators prioritise incremental NSA upgrades, delaying full SA deployment and associated 5G-native capabilities. Since advanced use cases such as network slicing, URLLC, private 5G, and massive IoT fundamentally require SA architecture, delays in SA transition also postpone enterprise adoption and socio-economic benefits.

For Sri Lanka, the Digital Terrestrial Television Broadcasting (DTTB) implementation timeline indicates that 700 MHz clearance may extend until 2029. This prolonged horizon represents a systemic risk to the national 5G roadmap, reinforcing continued NSA dependence and constraining investment in SA cores. Accordingly, immediate allocation of alternative low-band spectrum (e.g., 800/900 MHz refarming) becomes critical to avoid delayed SA migration and to enable scalable advanced 5G use cases within the phased deployment framework proposed in this thesis.

4.3.3 Technology-Neutral Licensing and Spectrum Refarming Considerations

Technology-neutral licensing enables operators to deploy evolving radio technologies within assigned spectrum bands without being constrained by service-specific licence categories. Academic studies highlight that such regulatory flexibility can improve spectrum efficiency and support innovation, provided it is accompanied by appropriate policy safeguards to manage transition risks [101]. Across South Asia, regulators are increasingly moving toward unified and technology-neutral licensing frameworks to support convergence and changing market structures. However, regional experience also shows that relicensing processes must be carefully designed to avoid unintended market distortions and uneven service availability [102].

Sri Lanka's Unified Licensing Roadmap similarly recognizes that while licence consolidation and technology neutrality can reduce regulatory complexity and enable more efficient spectrum use, implementation must be supported by regulatory protections, particularly to ensure fair competition and nationwide service coverage [38]. Interview findings reinforce this perspective, with operators noting that refarming existing spectrum could accelerate migration toward Standalone (SA) networks and improve coverage economics, especially in lower frequency bands.

A key concern relates to spectrum refarming without accompanying coverage obligations. In liberalized licensing environments, operators may prioritize commercially attractive urban areas, potentially delaying upgrades in rural and underserved regions. This highlights the importance of complementary regulatory mechanisms, including minimum coverage thresholds, structured refarming processes, and transparent monitoring of spectrum utilization. In Sri Lanka, the existing Notice of Assignment for 5G already incorporates rollout obligations for newly assigned bands, providing a regulatory precedent that can be extended to refarmed spectrum to support balanced national deployment outcomes [37].

Overall, these findings indicate that technology-neutral licensing can play a constructive role in Sri Lanka's 5G evolution when embedded within a broader spectrum strategy that integrates NSA–SA migration planning, low-band availability, and infrastructure readiness. Without coordinated policy guidance and coverage safeguards, licensing reform risks reinforcing selective investment rather than enabling inclusive and sustainable 5G deployment.

4.3.4 Regulatory Readiness for Active Infrastructure Sharing in Sri Lanka

Recent regulatory developments in Sri Lanka have formally enabled selected forms of active infrastructure sharing. The Telecommunications Infrastructure Sharing Regulations No. 1 of 2024 permit Radio Access Network (RAN) sharing using both MORAN and MOCN configurations, while explicitly prohibiting core network sharing. The regulations further establish a mandatory Infrastructure Sharing Agreement (ISA) framework, define objectives to reduce infrastructure duplication and capital and operating costs, and designate the Telecommunications Regulatory Commission of Sri Lanka (TRCSL) as the dispute resolution authority for sharing-related conflicts[71] Table 4.8 summarizes the practical scope of active sharing functions under the current regulatory framework. While RAN and backhaul sharing are permitted through ISAs, spectrum pooling is not explicitly provided for and would require additional policy amendments, coverage obligations, and competition safeguards. Furthermore, although the regulations establish a clear arbitration mechanism via TRCSL, they provide limited guidance on coordinated access to government-owned passive assets such as road authority ducts and utility poles. These gaps highlight the need for complementary policy instruments that align infrastructure sharing with national coverage targets and Standalone (SA) migration objectives.

4.3.5 Linking Gaps to Roadmap Development

The preceding discussion highlights a set of interlinked barriers fragmented spectrum, incomplete NSA to SA migration planning, high infrastructure and power costs, limited regulatory incentives, and uneven industry readiness. These challenges are not isolated; they converge to shape the broader readiness of Sri Lanka's 5G ecosystem. The analysis also shows that while operators are technically prepared, the absence of a unified, phased national framework risks producing fragmented, urban-centric deployments that fail to meet wider digital economy goals.

At the same time, comparative evidence from regional peers such as India, Vietnam, and South Korea demonstrates that countries which successfully operationalized 5G did so through structured roadmaps that balanced technical, regulatory, and market priorities. These cases underline that roadmap design must not only address existing constraints but also provide a sequenced pathway for long-term innovation and enterprise adoption.

Given these insights, the next section presents a Multi-stakeholder roadmap Proposal for Sri Lanka. This roadmap is designed to respond directly to the gaps identified in spectrum allocation, NSA$\rightarrow$SA migration, infrastructure readiness, regulatory in-

TABLE 4.8: FEASIBILITY OF ACTIVE SHARING FUNCTIONS UNDER CURRENT REGULATORY CONDITIONS IN SRI LANKA

Sharing Function	**Current Regulatory Status**	**Key Implication for 5G Deployment**
RAN sharing (MORAN / MOCN)	Permitted under Telecommunications Infrastructure Sharing Regulations No. 1 of 2024	Enables cost-efficient site deployment and supports phased Standalone (SA) rollout through shared radio access
Backhaul / passive-active infrastructure sharing	Permitted through Infrastructure Sharing Agreements (ISAs)	Facilitates accelerated fiber expansion and reduces duplication of transport infrastructure
Core network sharing	Not permitted	Operators must retain separate cores, limiting deeper network consolidation
Spectrum pooling	Not explicitly provided	Requires additional policy amendments, coverage obligations, and competition safeguards before implementation
Dispute resolution	Assigned to TRCSL	Provides a formal arbitration mechanism for access pricing, technical terms, and sharing disagreements

Note. Summary of permitted and constrained active sharing functions under Sri Lanka's Telecommunications Infrastructure Sharing Regulations No. 1 of 2024

centives, and industry adoption. It organizes action items into a phased approach: Enablement, Optimization, Innovation, and Reinvention—ensuring alignment with both immediate constraints and future national digital ambitions.

4.4 Triangulation with International Benchmarks Across the Themes

Introduction

This section consolidates stakeholder perspectives (Section 4.2) and international comparisons (Section 4.3) to highlight the key readiness gaps in Sri Lanka's 5G deployment. The discussion is organized under six thematic areas: Multi-stakeholder roadmaps, spectrum allocation, NSA$\rightarrow$SA migration, infrastructure and power costs, policy incentives, and industry adoption. Each theme combines local stakeholder outcomes with global benchmarks, followed by an integrated interpretation of implications for Sri Lanka.

4.4.1 Multi-stakeholder roadmaps & Readiness Frameworks

Stakeholder outcome:

Building on the strategic planning gaps identified in Section 4.3, triangulation with international benchmarks shows that Sri Lanka lacks a comprehensive national 5G roadmap. While local stakeholders reported fragmented implementation and an urban-first rollout bias, international peers demonstrate more integrated national approaches.

Global benchmark:

India's phased 5G roadmap combined spectrum allocation with rural coverage targets [30]. Malaysia's MyDIGITAL blueprint aligned spectrum release, infrastructure sharing, and enterprise adoption within a national digital economy vision [103]. South Korea embedded 5G into its industrial strategy, linking deployment directly to national innovation and productivity goals [104].

Discussion:

Triangulation highlights a strategic vacuum in Sri Lanka's planning. While global peers provide integrated roadmaps linking spectrum, migration, and industry adoption, Sri Lanka risks urban-centric deployment, delayed rural expansion, and missed enterprise opportunities. A phased roadmap that balances technical readiness with economic feasibility is urgently needed.

4.4.2 Spectrum Scarcity & Allocation

Stakeholder outcome:

Building on the spectrum-related gaps identified in Section 4.3, triangulation with international benchmarks confirms that delayed low-band availability and fragmented allocation practices represent significant constraints on Sri Lanka's 5G readiness. Local stakeholders emphasized that although the 3.5 GHz and 26 GHz bands have been cleared for auction, the 700 MHz low-band remains tied to broadcasting, delaying rural connectivity planning and creating uncertainty for long-term network investment. Concerns were also raised regarding fragmented spectrum assignments and relatively high spectrum pricing.

Global benchmark:

India's 2022 auctions harmonized low-, mid-, and high-band spectrum, creating long-term clarity for operators [105] [106]. Australia attached coverage obligations to licences, ensuring both urban and rural rollout [107].South Korea's early 2018 auctions enabled rapid network scaling, although uptake of mmWave spectrum remained limited [22].

Discussion:

Triangulation highlights that Sri Lanka's spectrum challenges are primarily institutional rather than technical in nature. While international peers adopted coordinated multi-band allocation strategies and embedded coverage commitments within licensing frameworks, Sri Lanka continues to face delays in low-band clearance and fragmented policy approaches. These factors constrain nationwide rollout potential and weaken investment certainty. The comparison underscores the importance of harmonized spectrum planning as a foundational enabler of inclusive 5G deployment and subsequent Standalone migration.

4.4.3 NSA to SA Migration

Stakeholder outcome:
Building on the NSA–SA migration gaps identified in Section 4.3, triangulation with international benchmarks highlights uncertainty surrounding Sri Lanka's transition toward Standalone architecture. Local operators confirmed technical readiness for NSA deployment but emphasized the absence of a clearly defined SA migration pathway. Regulators noted that technology-neutral licensing is under consideration, while enterprise stakeholders expressed uncertainty regarding the availability timeline of SA features required for mission-critical applications.

Global benchmark:
India adopted a dual-path model, with Reliance Jio launching SA and Airtel launching NSA [106] [108]. Malaysia prioritized nationwide NSA rollout under its DNB Single Wholesale Network, with SA migration deferred until after 2025 [103]. South Korea completed migration to SA by 2021, supported by a mature device ecosystem and coordinated policy initiatives [104]

Discussion:
Triangulation indicates that Sri Lanka faces a heightened risk of prolonged dependence on NSA in the absence of defined migration timelines. In contrast, international peers implemented phased transition strategies aligned with device readiness and policy frameworks. This divergence delays enterprise adoption of advanced 5G capabilities and increases the likelihood of incremental investments becoming stranded. The comparison underscores the importance of coordinated migration planning in enabling timely realization of SA-enabled services and broader socio-economic benefits.

4.4.4 Infrastructure & Power Costs

Stakeholder outcome:
Building on the infrastructure-related gaps identified in Section 4.3, triangulation with international benchmarks highlights persistent cost and deployment constraints in Sri Lanka's 5G rollout environment. Local stakeholders consistently emphasized high electricity tariffs, slow site approval processes, and limited fiberization as major barriers. While TRCSL acknowledged these challenges and proposed a single-window approval system, operators reported that overall deployment costs remain prohibitive.

Global benchmark:
India's RoW reforms and rural subsidies supported rapid rollout [109]. Malaysia's centralized SWN reduced duplication of infrastructure [103]. Australia mandated ru-

ral sharing agreements between Telstra and TPG [107], while South Korea offset high CAPEX through government incentives [104].

Discussion:
Triangulation indicates that Sri Lanka's infrastructure landscape remains comparatively cost-intensive and procedurally constrained. Elevated energy tariffs and regulatory delays restrict site densification, while limited fiber penetration weakens backhaul capacity. In contrast, international peers combined streamlined approvals, infrastructure coordination, and financial support mechanisms to improve deployment efficiency. Several markets also leveraged government owned passive infrastructure—such as road authority ducts, utility poles, and public corridors to accelerate fiber rollout and reduce duplication of civil works. The absence of systematic access to comparable public assets in Sri Lanka further amplifies deployment costs and approval timelines. Together, these factors reinforce the importance of coordinated infrastructure sharing, government asset access, and energy policy alignment as foundational enablers of scalable and geographically inclusive 5G deployment.

4.4.5 Policy & Regulatory Incentives

Stakeholder outcome:
Building on the regulatory incentive gaps identified in Section 4.3, triangulation with international benchmarks highlights limitations in Sri Lanka's current policy support framework. Local operators indicated that, beyond staggered auction payment options, few meaningful regulatory incentives are available. Spectrum pricing was perceived as disproportionate to market potential, and approval processes were described as lengthy. Industry users also emphasized the need for more flexible regulatory frameworks to enable private 5G deployment.

Global benchmark:
India abolished spectrum usage charges (SUC) and extended licences to 30 years, providing investment certainty [109]. South Korea's 5G+ Strategy explicitly linked telecommunications deployment to GDP growth and employment objectives [22]. Australia incorporated rural coverage obligations into spectrum licences [110], while Malaysia embedded 5G in the MyDIGITAL national digital transformation blueprint[103].

Discussion:
Triangulation indicates that Sri Lanka's incentive environment remains comparatively narrow relative to international peers. While other countries combined licensing reform, fiscal measures, and sectoral integration to stimulate investment and adoption, Sri Lanka's framework relies primarily on auction related payment flexibility. This divergence illustrates how broader policy alignment spanning licensing, pricing, and enterprise enablement has been leveraged elsewhere to support sustained network in-

vestment and digital economy outcomes.

4.4.6 Industry Use Cases & Adoption

Stakeholder outcome:
Building on the industry adoption gaps identified in Section 4.3, triangulation with international benchmarks highlights early demand alongside structural readiness constraints in Sri Lanka. Local stakeholders identified ports and logistics as initial demand drivers, while enterprises expressed uncertainty due to the absence of a dedicated private 5G licensing framework. Industry users reported readiness in principle but cited persistent gaps in infrastructure availability, affordability, and regulatory clarity as key constraints on adoption.

Global benchmark:
India ran enterprise pilots in manufacturing, healthcare, and logistics [108]. Malaysia focused on agriculture and smart cities under DNB [111]. South Korea's SA rollout supported robotics and smart factories [22]. Australia leveraged pilots in mining and agriculture [80].

Discussion:
Triangulation indicates that Sri Lanka's industrial 5G landscape is characterized by nascent demand but comparatively limited adoption readiness. In contrast, international peers combined sector-specific pilots, device ecosystem development, and regulatory facilitation to translate early interest into sustained enterprise uptake. This comparison underscores how coordinated industry engagement, affordability pathways, and enabling policy environments have supported application-driven 5G diffusion elsewhere.

This chapter examined Sri Lanka's 5G readiness through stakeholder interviews and triangulation with international benchmarks across strategic planning, spectrum availability, NSA–SA migration, infrastructure and energy constraints, regulatory incentives, and industry adoption. The findings reveal interconnected structural gaps spanning policy coordination, spectrum planning, infrastructure efficiency, investment frameworks, and enterprise enablement, while global comparisons demonstrate how integrated regulatory approaches, coordinated deployment strategies, and targeted industry engagement have supported more advanced 5G ecosystems elsewhere. Collectively, these insights provide the empirical foundation for the phased deployment roadmap presented in Chapter 5, which translates identified gaps and validated international practices into a structured national framework encompassing enablement, optimization, and innovation stages for Sri Lanka's 5G rollout.

CHAPTER 5

MULTI-STAKEHOLDER ROADMAP FOR 5G DEPLOYMENT IN SRI LANKA

5.1 Introduction

The findings from stakeholder interviews, global case studies, and the gap analysis collectively indicate that Sri Lanka's 5G journey is constrained by fragmented spectrum planning, the absence of a unified NSA–SA migration pathway, high infrastructure and energy costs, limited device readiness, and weak adoption across both consumer and enterprise segments. While operators and regulators have initiated early actions through NSA deployments and spectrum planning, the lack of coordinated progress across technical, regulatory, and market dimensions risks slowing deployment momentum and reducing the broader socio-economic impact of 5G.

In particular, delays in low-band spectrum availability due to the ongoing DTTB migration, fragmented site approval and rights-of-way processes, continued inflow of legacy devices, and uncertainty surrounding SA transition timelines have emerged as structural barriers that cannot be addressed through isolated policy measures. These challenges highlight the need for an integrated national framework that aligns spectrum strategy, infrastructure access, device ecosystem development, and enterprise enablement within a single implementation pathway.

To address these challenges, this chapter proposes a phased Multi-stakeholder roadmap for 5G deployment in Sri Lanka. The roadmap is designed to:

- Bridge gaps between local readiness and international best practices.
- Balance technical feasibility with economic sustainability through infrastructure sharing and cost-optimization mechanisms.
- Integrate regulatory, operator, and industry priorities within a coordinated deployment framework.
- Align 5G rollout with national digital economy objectives, ensuring relevance to broader transformation initiatives.

The roadmap adopts a four-phase approach, Enablement, Optimization, Innovation, and Reinvention—where each phase targets specific structural constraints while building progressively on prior achievements. Early phases focus on regulatory clarity, spectrum preparedness (including interim low-band strategies), government-enabled infrastructure access, and device ecosystem readiness to support NSA expansion. Subsequent phases introduce Standalone (SA) capabilities, enterprise clusters, private 5G frameworks, and advanced vertical deployments.

This phased structure provides a practical pathway for Sri Lanka to transition from initial NSA deployments toward nationwide SA readiness, and ultimately toward 5G-Advanced and Industry 4.0 integration. To ensure that strategic intent translates into measurable outcomes, the roadmap is supported by milestone checkpoints, phase-wise performance indicators, stakeholder governance mechanisms, and an integrated risk framework. Together, these elements enable systematic monitoring of progress while strengthening accountability across institutions involved in 5G deployment.

5.2 A Phased Roadmap Approach

The Multi-stakeholder roadmap was developed to translate qualitative insights from expert interviews and quantitative evidence from literature into a structured implementation framework. Rather than proposing a purely technical deployment sequence, the roadmap integrates regulatory, infrastructure, and market dimensions, reflecting the interconnected nature of 5G readiness identified throughout this study.

Four core design principles underpin the roadmap.
First, sequenced dependency resolution is emphasized. The analysis demonstrated that advanced 5G capabilities are constrained by upstream enablers, including spectrum availability, rights-of-way access, backhaul readiness, device ecosystems, and regulatory clarity. Consequently, the roadmap prioritizes foundational actions—such as spectrum preparation, government-enabled infrastructure access, device compliance, and approval streamlining—before introducing large-scale SA deployments and enterprise applications. This sequencing ensures that later investments are not undermined by unresolved structural bottlenecks.

Second, the roadmap adopts an NSA-first but SA-ready evolution path. Given current spectrum fragmentation, fiber limitations, and cost pressures, NSA provides a pragmatic entry point for expanding coverage and stimulating early adoption. However, both international experience and local operator feedback confirm that SA is essential for unlocking ultra-low latency services, private networks, and vertical-specific applications. The roadmap therefore treats NSA as a transitional architecture while embedding early preparation for SA through a national migration roadmap, interim low-band strategies where 700 MHz clearance is delayed, and phased activation of SA cores in enterprise clusters.

Third, multi-stakeholder coordination is embedded as a structural requirement rather than an assumed outcome. Interview findings highlighted misalignment between regulators, line ministries, local authorities, utilities, and operators as a major source of deployment delays. To address this, the roadmap incorporates governance mechanisms that define roles across institutions, supported by a RACI framework and a National 5G Steering Committee. This approach ensures that spectrum policy, infrastructure access, device regulation, and enterprise enablement progress in parallel rather than in isolation.

Fourth, the roadmap is designed to be outcome-driven and monitorable. Each phase is associated with milestone checkpoints that signal meaningful transitions in regulatory readiness, deployment efficiency, and service capability. These milestones are complemented by a phase-wise KPI dashboard tracking coverage expansion, fiberization, SA activation, device penetration, enterprise pilots, and energy efficiency. An integrated risk management framework further links identified constraints—such as delayed low-band clearance, extended NSA reliance, and legacy device inflows—to mitigation actions and ownership, ensuring that implementation risks are actively managed.

Together, these principles informed the selection of a four-phase structure, enabling, optimizing, Innovation, and Reinvention, that spans 2025-2030. This phased architecture provides a progressive pathway from regulatory preparation and NSA expansion toward SA-based enterprise services and nationwide digital transformation, while maintaining flexibility to accommodate evolving spectrum timelines and market conditions.

5.3 Phased Multi-stakeholder roadmap for 5G Deployment in Sri Lanka

Figure 5.1 presents the proposed phased Multi-stakeholder roadmap for 5G deployment in Sri Lanka over the period 2025–2030. The roadmap translates the study's findings into a structured implementation pathway, progressing from regulatory and infrastructure readiness toward nationwide Standalone (SA) capability and advanced digital services. The roadmap is organized into four sequential phases—Enablement, Optimization, Innovation, and Reinvention, each addressing specific structural constraints while building cumulatively toward long-term transformation.

The phased structure reflects both Sri Lanka's current network maturity and realistic implementation dependencies. Early phases prioritize regulatory clarity, spectrum preparedness, government-enabled infrastructure access, and device ecosystem readiness to support NSA expansion. Subsequent phases introduce SA activation, enterprise clusters, private 5G frameworks, and advanced vertical deployments. Progress across phases is guided through milestone checkpoints (Table 5.1), monitored via a phase-wise KPI dashboard (Table 5.6), and supported by governance and risk mitigation mechanisms outlined in Sections 5.5 to 5.7.

Phase 1 – Enablement (2025–2026): Decide, Prepare, Govern
Phase 1 establishes the foundational conditions required for scalable 5G deployment. This phase focuses on resolving upstream regulatory and infrastructure bottlenecks that currently constrain network expansion and SA readiness.

Key actions include:

- Finalization of a national NSA–SA migration roadmap with defined timelines and architectural targets.
- Advancement of low-band spectrum readiness, including interim low-band allocations for SA trials where 700 MHz clearance is delayed.

Fig. 5.1: Proposing Multi-stakeholder roadmap for 5G Deployment

Note. The action items and the roadmap timelines are derived based on the thematic analysis and from literature

- Operationalization of government-enabled infrastructure access through standardized use of RDA poles, ducts, and rights-of-way, supported by streamlined approval processes.
- Introduction of strengthened device compliance measures to restrict imports of legacy 2G-only devices and improve 5G handset affordability.
- Establishment of a National 5G Steering Committee and RACI framework to coordinate regulators, line ministries, local authorities, and operators.
- Launch of a single-window digital platform for site approvals and public asset access.

Expected Outcomes

- Reduced regulatory uncertainty around SA transition.
- Accelerated site rollout and fiberization.
- Improved device ecosystem readiness.
- Clear institutional accountability for 5G deployment.

Completion of Phase 1 culminates in Milestone M1, marked by publication of the national SA migration roadmap and activation of coordinated infrastructure access mechanisms (Table 5.1).

Phase 2 – Optimization (2026–2027): Expand, Integrate, Optimize

Phase 2 focuses on scaling NSA coverage while preparing operational systems for SA introduction. Emphasis shifts toward deployment efficiency, cost optimization, and early enterprise engagement.

Key actions include:

- Expansion of NSA coverage into secondary cities and underserved regions using shared infrastructure models, including RAN sharing where commercially viable.
- Acceleration of fiber backhaul deployment through coordinated access to public assets.
- Energy optimization initiatives, including renewable pilots and telecom electricity tariff reclassification.
- Launch of SA pilot clusters in priority enterprise zones.
- Introduction of device affordability programs to increase 5G handset penetration.
- Implementation of KPI-based performance monitoring across coverage, fiberization, energy metrics, and shared-site adoption.

Expected Outcomes

- Faster rollout timelines and reduced deployment costs through passive and selective active infrastructure sharing.
- Initial validation of SA capabilities in enterprise environments.
- Increased consumer device penetration.
- Improved operational efficiency across networks.

Phase 2 concludes with Milestone M2, signifying full operationalization of single-window approvals and measurable improvements in deployment velocity.

Phase 3 – Innovation (2027–2029): Activate SA, Enable Verticals

Phase 3 marks the transition from connectivity expansion toward service innovation. SA networks are activated at scale, enabling vertical-specific applications and private 5G deployments.

Key actions include:

- Commercial rollout of SA cores in major urban and industrial clusters.
- Expansion of private 5G networks across manufacturing, logistics, aviation, IT automation, and smart city environments.
- Integration of edge computing platforms to support low-latency services.
- Development of sector-specific regulatory frameworks for private networks and mission-critical applications.
- Strengthening of enterprise partnerships and ecosystem development.

Expected Outcomes

- Operational SA availability in high-value zones.
- Growth of enterprise and private 5G adoption.
- Emergence of Industry 4.0 use cases.
- Diversification of operator revenue streams beyond consumer broadband.

Phase 3 culminates in Milestone M3, marked by the first large-scale SA enterprise clusters going live.

Phase 4 – Reinvention (2029–2030): Scale, Transform, Sustain

The final phase focuses on nationwide SA readiness and integration of advanced 5G capabilities into the broader digital economy.

Key actions include:

- Expansion of SA coverage nationwide, reducing reliance on NSA.
- Introduction of 5G-Advanced features and AI-enabled network optimization.
- Scaling of vertical ecosystems across healthcare, manufacturing, transport, and public services.
- Continuous refinement of governance, KPI monitoring, and risk management frameworks.

Expected Outcomes

- Mature nationwide SA ecosystem.
- Sustained enterprise innovation.
- Measurable contributions of 5G to productivity, inclusion, and competitiveness.

Completion of Phase 4 aligns with Milestone M4, representing nationwide SA readiness and Industry 4.0 integration.

5.4 Milestone-Based Impact Analysis

While phased planning provides structural direction, the realization of 5G benefits depends on the timely achievement of critical implementation milestones. To translate roadmap progression into measurable national outcomes, a milestone-based impact analysis framework is introduced. This approach links key roadmap transitions to regulatory readiness, deployment efficiency, service capability, and socio-economic value creation.

Four strategic milestones are defined across the roadmap horizon, corresponding to major inflection points in Sri Lanka's 5G evolution: publication of the national SA migration roadmap, operationalization of coordinated infrastructure access, activation of SA enterprise clusters, and attainment of nationwide SA readiness. Each milestone represents a shift from preparatory actions toward tangible deployment and service outcomes.

Table 5.1 summarizes the expected impacts associated with each milestone. Early milestones emphasize regulatory clarity, spectrum preparedness, and infrastructure accessibility, which are essential for reducing deployment uncertainty and accelerating network expansion. Intermediate milestones focus on operational performance improvements and enterprise enablement, marking the transition from connectivity provision to service innovation. Final milestones capture nationwide SA maturity and integration of advanced 5G capabilities into industrial and public-sector ecosystems.

By structuring impacts around milestone achievement, the framework enables policymakers and industry stakeholders to assess progress beyond coverage statistics alone. It provides visibility into how regulatory actions, infrastructure investments, and ecosystem development collectively contribute to enterprise adoption, productivity gains, and digital inclusion. This also supports adaptive policy intervention, allowing corrective measures to be introduced where milestone delays signal emerging implementation risks.

The milestone-based impact analysis further complements the phase-wise KPI dashboard presented in Section 5.6 by providing qualitative context to quantitative indicators. Together, these mechanisms establish a continuous feedback loop between roadmap execution, performance monitoring, and governance oversight, ensuring that strategic objectives remain aligned with implementation realities.

5.5 Governance and Stakeholder Coordination Framework.

Effective execution of the proposed roadmap requires coordinated action across multiple institutions whose responsibilities span spectrum management, infrastructure access, network deployment, device regulation, and industry adoption. The analysis revealed that fragmented decision-making among regulators, line ministries, local authorities, utilities, and operators has been a persistent source of deployment delays and cost escalation. Accordingly, a structured governance framework is proposed to ensure

TABLE 5.1: MILESTONE-BASED IMPACT ANALYSIS

Milestone	**Timeline**	**Expected Impacts**	**Primary Beneficiaries**
M1: National SA Migration Roadmap Published	2026	Regulatory clarity on NSA–SA transition; defined low-band strategy including interim options; coordinated infrastructure access framework; strengthened device compliance mechanisms; improved investor confidence	Regulators, Operators
M2: Single-Window Approvals Fully Operational	2027	Reduced site approval timelines; accelerated fiberization; streamlined access to RDA poles, ducts, and rights-of-way; lower deployment costs; improved rollout predictability	Operators, Towercos
M3: First SA Enterprise Clusters Live	2028	Enablement of low-latency and mission-critical applications; validation of SA business models; growth of private 5G adoption in manufacturing, logistics, aviation, IT automation, and smart city environments	Industry Users, Operators
M4: Nationwide SA Readiness Achieved	2030	Large-scale SA availability; reduced reliance on NSA; mature enterprise ecosystem; measurable contribution of 5G to productivity, digital inclusion, and national competitiveness	Government, Industry, Citizens

Note. Impact analysis at key roadmap milestones

alignment between policy intent and operational delivery.

At the national level, the roadmap prposes the establishment of a National 5G Steering Committee, chaired by the Digital Economy Ministry and comprising representatives from TRCSL, ICTA, RDA, CEB, BOI, relevant sector ministries, and licensed operators. This body provides strategic oversight, resolves cross-agency dependencies, and monitors progress against roadmap milestones and KPIs. Its mandate includes coordination of spectrum timelines, facilitation of passive infrastructure sharing and fibre infrastructure access through government assets (including RDA corridors, poles, ducts, and neutral-host fibre), alignment of device compliance measures, and prioritization of enterprise deployment zones.

Operational coordination is supported through a single-window digital approval platform, enabling operators and infrastructure providers to access rights-of-way, public assets, and construction permits through a unified interface. This mechanism reduces approval fragmentation by integrating workflows across local authorities, RDA, and utility agencies, while providing transparency on application status and processing timelines.

To clarify institutional responsibilities and strengthen accountability, stakeholder roles are formalized using a RACI framework, presented in Table 5.2. The framework assigns regulatory ownership to TRCSL for spectrum policy, NSA–SA migration planning, and licensing oversight; implementation responsibility to operators and infrastructure providers for network rollout and service delivery; facilitation roles to line ministries and local authorities for site access and approvals; and consultative roles to industry users in shaping enterprise use cases. This structure ensures that each roadmap activity has a clearly designated owner while maintaining collaborative engagement across stakeholders.

Dispute resolution and escalation mechanisms are embedded within the governance framework. Technical and operational issues are addressed at working-group level, while unresolved inter-agency conflicts are elevated to the Steering Committee for time-bound resolution. This tiered approach enables rapid problem-solving while preserving strategic oversight.

In relation to active infrastructure sharing, the governance framework assigns TRCSL responsibility for defining technical configurations, cost-sharing principles, spectrum coordination parameters in constrained bands, and service quality benchmarks for shared deployments. Operators retain implementation responsibility for RAN and backhaul sharing arrangements, while core network elements remain operator-specific to preserve competition. Compliance with non-discriminatory access and performance standards is overseen by the regulator. Any disputes arising from shared infrastructure, including access pricing, operational responsibilities, spectrum coordination, or performance attribution, are first addressed at working-group level and, if unresolved, escalated to TRCSL as the formal arbitration authority, with the National 5G Steering Committee providing strategic oversight. This ensures that active sharing contributes to rollout efficiency while preserving competitive neutrality and service accountability.

Together, these governance arrangements establish an institutional backbone for roadmap execution. By combining centralized coordination with clearly defined operational responsibilities, the framework supports consistent implementation across phases while reducing the risk of misalignment between regulatory decisions, infrastructure deployment, and market adoption.

5.6 Economic Considerations: CAPEX, OPEX, Sensitivity, and Funding Pathways

The feasibility of Sri Lanka's 5G roadmap is strongly influenced by both capital expenditure (CAPEX) requirements and ongoing operational expenditure (OPEX) pressures. Stakeholder interviews and international experience indicate that the largest cost components arise from radio access network expansion, fiber backhaul deployment, core network upgrades, and site energy consumption. Without targeted cost-reduction mechanisms, these factors risk slowing network rollout and limiting investment in Standalone (SA) capabilities and enterprise use cases.

TABLE 5.2: RACI MATRIX FOR KEY 5G ROADMAP ACTIVITIES

Activity	TRCSL	Line Ministries	Operators	Local Authorities / Utilities
Low-band spectrum clearance	R	A	C	I
Device regulation and 2G shutdown readiness	R	A	C	I
Site approvals and rights-of-way coordination	R	A	C	R
Electricity tariff reclassification for telecom	C	A	C	R
NSA to SA migration planning	R	A	C	I

Note. RACI Matrix (R: Responsible, A: Accountable, C: Consulted, I: Informed)

TABLE 5.3: KEY CAPEX AND OPEX DRIVERS AND ROADMAP MITIGATION MEASURES

Cost Component	Primary Driver	Roadmap Intervention	Expected Impact
Site CAPEX	New tower construction and densification	Passive infrastructure sharing and neutral-host models	Reduced duplication of sites and faster rollout
Fiber CAPEX	Backhaul expansion to support 5G and SA	Government duct access and coordinated fiberization	Lower deployment cost and accelerated coverage
Core Network CAPEX	SA core upgrades and cloud infrastructure	Phased NSA–SA migration and clustered SA deployment	Spread investment over roadmap phases
Energy OPEX	High electricity tariffs and diesel usage	Tariff reclassification and green power initiatives	Reduced operating costs per site
Device Ecosystem Costs	High handset prices and legacy devices	Device affordability programs and import controls	Faster adoption and smoother technology transitions

Note. Key CAPEX and OPEX Drivers

To address these constraints, the roadmap integrates several cost-optimization levers, including infrastructure sharing, government-enabled access to public assets, phased SA migration, energy tariff reforms, and device affordability initiatives. Table 5.3 summarizes the key CAPEX and OPEX drivers alongside the corresponding mitigation measures embedded within the roadmap.

Beyond direct costs, the economics of 5G deployment are highly sensitive to a small number of structural variables. In particular, energy tariffs, availability of fiber backhaul, spectrum pricing and payment terms, and end-user device affordability have a disproportionate impact on investment viability. Within this context, spectrum-related regulatory charges, including Spectrum Usage Charges (SUC), represent a significant ongoing financial burden, particularly in low-ARPU markets where capital recovery timelines are extended. International experience with reducing or abolishing SUC demonstrates how regulatory cost relief can stimulate network investment. In Sri Lanka, comparable reforms would require amendments to the Sri Lanka Telecommunications Act and related Finance Acts governing sector levies, together with updates to Gazette notifications defining spectrum fee structures, coordinated between TRCSL and the Ministry of Finance to balance fiscal objectives with sector sustainability. In addition, prolonged delays in low-band spectrum assignment increase the number of sites required to achieve coverage parity, raising both CAPEX and OPEX. Similarly, limited fiber availability constrains SA performance and increases reliance on costly microwave backhaul. These sensitivities reinforce the importance of early regulatory action on spectrum readiness, government-enabled infrastructure access, and energy pricing reforms, enabling operators to redirect savings toward fibre expansion, energy efficiency, and Standalone 5G deployment.

International regulatory experience further suggests that electricity tariff reclassification alone may not provide a timely or sustainable solution to rising telecom energy costs. As mentioned in the literature review, evidence from India indicates that, while telecom towers are formally recognised as infrastructure assets, regulators have tended to favour targeted government support and operational efficiency measures over preferential tariff structures, due to concerns around cross-subsidisation and utility financial stability. In this context, Sri Lanka's roadmap adopts a complementary approach that combines policy reform with renewable energy deployment and blended financing mechanisms. Where tariff reclassification is delayed or constrained, site-level solar and hybrid power systems, supported through green finance facilities, climate funds, and operator sustainability programs, provide an alternative pathway to manage OPEX while strengthening network resilience. In parallel, public–private partnerships can be leveraged for shared energy infrastructure and large-scale renewable integration, reducing upfront investment burdens while aligning telecom expansion with national sustainability objectives.

In recognition of fiscal constraints faced by both operators and government, the roadmap adopts a blended funding approach that combines regulatory incentives, public–private collaboration, and market-driven investment. Rather than relying on a single financing mechanism, different roadmap interventions are supported through targeted funding pathways, as summarized in Table 5.4.

By aligning technical priorities with realistic cost structures and diversified funding mechanisms, the roadmap seeks to balance investment feasibility with long-term digital outcomes. This integrated CAPEX–OPEX perspective supports phased deploy-

TABLE 5.4: FUNDING PATHWAYS FOR KEY ROADMAP INTERVENTIONS

Roadmap Intervention	Primary Funding Pathway
Electricity tariff reclassification	Government policy and regulatory reform
Accelerated fiberization	Operator co-build and public–private partnerships
Device affordability programs	Tax waivers, vendor financing, and operator bundles
Private 5G and enterprise pilots	Enterprise co-investment models
Open RAN and innovation pilots	Government innovation funds and vendor partnerships
Green power at telecom sites	Green finance facilities, green climate funds, and operator sustainability programs
Shared renewable infrastructure	Public–private partnerships and co-investment models
Energy efficiency upgrades	Government incentives and operator CAPEX

Note. Funding Pathways

ment of SA capabilities, wider geographic coverage, and progressive enterprise adoption, while reducing the risk of stalled investment due to cost escalation or demand uncertainty.

5.7 Phase-Wise KPI Dashboard

To ensure that roadmap execution translates into measurable outcomes, a phase-wise Key Performance Indicator (KPI) dashboard is introduced as the primary monitoring mechanism. While milestones capture strategic transitions, KPIs provide continuous visibility into deployment progress across coverage expansion, infrastructure readiness, SA activation, device adoption, enterprise enablement, and energy efficiency.

The KPI framework is aligned with the objectives of each roadmap phase. Early phases prioritize readiness indicators such as population coverage, fiberization, and site rollout. Intermediate phases introduce SA-related metrics, including SA-enabled sites and enterprise pilots, while later phases focus on ecosystem maturity through private 5G adoption, device penetration, and energy consumption per site.

Table 5.5 presents the Phase-Wise KPI Dashboard, linking each roadmap phase to specific performance indicators and targets. Table 5.6 defines the KPIs, including measurement frequency and data ownership, with regulatory metrics overseen by TRCSL, infrastructure indicators tracked by operators and infrastructure providers, and adoption metrics coordinated with ICTA and sector agencies.

Together, the KPI dashboard and definitions framework provide a structured feedback mechanism between roadmap implementation and governance oversight, enabling early identification of bottlenecks and evidence-based adjustments to deployment strategies.

TABLE 5.5: PHASE-WISE KPI DASHBOARD

Roadmap Phase	**KPI Category**	**Key Indicator**	**Target / Direction**
Phase 1: Enablement	Regulatory Readiness	National NSA–SA migration roadmap published	Achieved
	Spectrum Preparedness	Interim low-band availability for SA trials	Initiated
	Infrastructure Access	Single-window approvals launched	Operational
	Device Readiness	New 2G-only device imports restricted	Implemented
Phase 2: Optimization	Coverage Expansion	5G population coverage (%)	↑ Increasing
	Fiberization	Fiberized macro sites (%)	↑ Increasing
	Energy Efficiency	Average energy consumption per site	↓ Reducing
	SA Preparation	Number of SA pilot clusters	↑ Increasing
Phase 3: Innovation	SA Deployment	SA-enabled sites / clusters	↑ Scaling
	Enterprise Adoption	Private 5G / enterprise pilots	↑ Scaling
	Latency Performance	Average network latency (SA zones)	↓ Improving
	Ecosystem Growth	Sector-specific use cases launched	↑ Expanding
Phase 4: Reinvention	SA Maturity	Nationwide SA availability (%)	High coverage
	Advanced Capabilities	5G-Advanced features introduced	Implemented
	Device Penetration	5G-capable device penetration (%)	↑ Increasing
	Sustainability	Network carbon intensity per GB	↓ Reducing

Note. Phase-wise KPIs for monitoring roadmap execution

5.8 Risk Integration and Mitigation Framework

The successful implementation of the proposed 5G roadmap depends on proactive identification and management of deployment risks arising from regulatory delays,

TABLE 5.6: KPI DEFINITIONS AND GOVERNANCE

KPI	**Definition**	**Measurement Frequency**	**Data Owner**
National NSA–SA roadmap status	Publication and formal adoption of national migration framework	Annual	TRCSL / Digital Ministry
Low-band readiness	Availability of sub-1 GHz spectrum for SA trials or commercial use	Annual	TRCSL
Single-window approval efficiency	Average approval duration for sites and fiber routes	Quarterly	TRCSL / Local Authorities
5G population coverage	Percentage of population covered by 5G signal	Quarterly	Operators / TRCSL
Fiberized macro sites	Share of macro sites connected by fiber backhaul	Quarterly	Operators / Towercos
Energy consumption per site	Average electricity usage per active site	Annual	Operators / CEB
SA-enabled sites	Number of operational SA-capable sites or clusters	Quarterly	Operators
Enterprise pilots / private networks	Count of active enterprise or private 5G deployments	Quarterly	Operators / ICTA
5G device penetration	Percentage of subscribers using 5G-capable devices	Quarterly	Operators
Network carbon intensity	Energy-related emissions per GB of traffic	Annual	Operators

Note. Definitions, monitoring frequency, and ownership of roadmap KPIs

spectrum uncertainty, infrastructure constraints, market readiness gaps, and coordination challenges. To address these uncertainties, a structured risk management framework is embedded within the roadmap.

Key risks were identified through expert interviews and gap analysis and mapped directly to roadmap phases, milestones, and KPIs. This ensures that risks are addressed as part of implementation rather than treated in isolation. The framework covers regulatory and spectrum risks (such as delayed low-band clearance and prolonged NSA reliance), infrastructure and cost-related risks (including approval delays and high energy tariffs), market risks (such as low device penetration and enterprise readiness), and governance risks linked to inter-agency coordination.

Table 5.7 presents the Risk Register, detailing the likelihood and impact of each risk, corresponding mitigation actions, designated owners, and residual risk levels. Mitigation measures are aligned with roadmap activities, including interim low-band spectrum options, strengthened device compliance, government-enabled infrastructure access, tariff reforms, and phased SA activation.

Integration with the KPI dashboard enables early detection of emerging risks through performance trends, supporting timely corrective action. By embedding risk management within the roadmap structure, the framework strengthens implementation resilience and supports sustained progress toward nationwide SA readiness.

5.9 Chapter Summary and Strategic Implications

This chapter presented a structured and implementable Multi-stakeholder roadmap for 5G deployment in Sri Lanka, translating the study's analytical findings into a coherent national deployment framework. Building on the challenges identified in earlier chapters—particularly fragmented spectrum planning, uncertainty in NSA–SA migration, infrastructure and energy constraints, limited device readiness, and adoption barriers—the roadmap provides a phased pathway that aligns regulatory action, infrastructure development, and market evolution.

The four-phase roadmap—Enablement, Optimization, Innovation, and Reinvention—was designed to reflect Sri Lanka's current readiness while maintaining flexibility to accommodate evolving spectrum timelines and market conditions. Early phases prioritize regulatory clarity, spectrum preparedness, government-enabled infrastructure access, and device ecosystem readiness to support efficient NSA expansion. Subsequent phases focus on activating Standalone (SA) capabilities, enabling enterprise and private 5G use cases, and scaling advanced services that support long-term digital transformation.

To strengthen implementation credibility, the roadmap was complemented by a milestone-based impact analysis, demonstrating how key transition points translate into tangible regulatory, operational, and socio-economic outcomes. A phase-wise KPI dashboard and detailed KPI governance framework were introduced to enable continuous performance monitoring, while a structured governance model and RACI framework clarified institutional responsibilities across regulators, operators, line ministries, and local authorities. An integrated risk management framework further ensured that key deployment risks—such as delayed low-band spectrum availability, prolonged NSA reliance, and weak device adoption—are proactively managed within the roadmap structure.

Together, these elements elevate the roadmap beyond a conceptual timeline into an outcome-oriented implementation framework. By linking phases, milestones, KPIs, governance, and risk mitigation, the chapter demonstrates how strategic intent can be translated into coordinated action. The proposed roadmap therefore provides a practical reference for policymakers, regulators, and industry stakeholders seeking to accelerate 5G deployment while maximizing its contribution to Sri Lanka's digital economy and long-term competitiveness.

TABLE 5.7: RISK ANALYSIS

Risk	**Category**	**Likelihood**	**Impact**	**Mitigation**	**Owner(s)**	**Timeline**	**Residual Risk**
Delayed clearance of 700 MHz band	Spectrum/ Regulatory	High	High	Cabinet-level coordination; phased migration of broadcasting	TRCSL; Cabinet; Ministry of Digital Infrastructure	Medium	Medium
High spectrum pricing deterring operator investment	Economic/Policy	Medium	High	Flexible payment models; SUC abolition; tax incentives	TRCSL; Ministry of Finance; Operators	Short-Medium	Medium
Delayed transition from NSA to SA architecture	Technical/Strategic	Medium	High	Timely allocation of low-band spectrum; interim spectrum refarming options if 700 MHz clearance is delayed; publication of a national SA migration roadmap with clear milestones; targeted SA pilots in enterprise zones	TRCSL; Ministry of Mass Media; Operators	Medium	Medium
High electricity tariffs impacting site rollout	Infrastructure	High	High	Tariff reclassification/deployment of solar and hybrid power systems; energy-efficiency upgrades/shared renewable infrastructure via PPP models	Ministry of Energy; PUCSL; CEB; Operators	Medium	High
Regulatory delays in site approvals	Governance	High	Medium	Single-window approval; local authority coordination	Local Authorities; RDA; TRCSL	Short–Medium	Medium
Low device penetration slowing adoption	Market/ Consumer	High	Medium	Device affordability programs; duty waivers; strict device import controls	TRCSL; Customs; Operators	Short-Medium	Medium
Resistance to infra sharing among operators	Industry	Medium	Medium	Mandated cost models; regulatory enforcement	TRCSL; Operators; Towercos	Medium	Medium
Limited enterprise readiness for private 5G	Adoption	Medium	Medium	Government-backed pilots; awareness campaigns	Operators; ICTA; Industry Bodies	Medium	Medium
Policy instability or changes in leadership	Political	Medium	High	Multi-stakeholder steering committees; continuity frameworks	Cabinet; TRCSL	Ongoing	High
Continued import of legacy 2G-only devices delaying early 2G shutdown and low-band spectrum refarming	Market/ Consumer	High	High	Enforce strict device type approval and minimum capability requirements; strengthen customs surveillance; operator-led migration and affordability programs	TRCSL; Sri Lanka Customs; Operators; Ministry of Trade	Short–Medium	Medium

Note. Risk Analysis

CHAPTER 6

CONCLUSIONS AND FUTURE WORK

6.1 Key Conclusions

This research evaluated Sri Lanka's readiness for 5G deployment and developed a phased Multi-stakeholder roadmap informed by regulatory, operator, vendor, and industry user perspectives. The findings indicate that although initial 5G services are already available, the transition toward nationwide Standalone (SA) readiness remains constrained by several structural challenges. These include delays in low-band spectrum availability, uncertainty in NSA–SA migration pathways, high infrastructure and energy costs, limited device penetration, fragmented governance processes, and modest enterprise adoption.

The study further confirms that spectrum policy alone is insufficient to deliver sustainable 5G outcomes. Effective deployment requires coordinated action across regulation, infrastructure access, energy policy, device ecosystems, and industry enablement. Without such alignment, Sri Lanka risks a fragmented rollout concentrated in urban areas, prolonged dependence on transitional NSA networks, and underutilization of 5G for productivity-driven applications.

In response, this research proposes a four-phase roadmap—Enablement, Optimization, Innovation, and Reinvention—that integrates regulatory reform, infrastructure readiness, market development, and ecosystem activation. Supported by milestone-based impact analysis, a phase-wise KPI framework, governance structures, and risk management mechanisms, the roadmap provides an implementable national pathway rather than a purely conceptual deployment timeline.

6.2 Strategic Implications of the Proposed Roadmap

The proposed roadmap reframes 5G deployment as a national transformation program rather than a standalone network upgrade. It emphasizes that progress toward SA maturity depends not only on spectrum assignment and radio access expansion, but also on enabling policies that reduce deployment friction, improve investment efficiency, and stimulate demand across key economic sectors.

For Sri Lanka, as a low-ARPU developing market, this integrated approach is particularly important. Shared infrastructure, coordinated government asset access, phased spectrum strategies, and targeted affordability measures are essential to contain costs while extending coverage. At the same time, enterprise adoption and private 5G deployments must be actively encouraged to ensure that network investments translate into measurable productivity gains and digital innovation.

By linking roadmap phases to milestones, KPIs, governance responsibilities, and risk mitigation actions, the framework establishes a continuous feedback loop between policy intent and implementation outcomes. This structure enables adaptive regulation, evidence-based course correction, and sustained stakeholder coordination, thereby strengthening the credibility and resilience of the deployment strategy.

6.3 Stakeholder-Aligned Strategic Recommendations

Successful execution of the roadmap requires clearly defined roles and collaborative engagement across the 5G ecosystem.

For the Regulator (TRCSL):
Key responsibilities include finalizing the national NSA–SA migration roadmap, accelerating low-band spectrum clearance while enabling interim access arrangements, operationalizing technology-neutral licensing, and issuing practical frameworks for infrastructure sharing and private 5G deployments. TRCSL should also lead KPI governance through regular performance reviews and act as the designated arbitration authority for active sharing arrangements.

For Government and Line Ministries:
Central government plays a critical enabling role by coordinating spectrum clearance, supporting electricity tariff reclassification for telecom infrastructure, and facilitating access to public assets such as poles, ducts, and rights-of-way. Establishing a single-window approval mechanism across local authorities is essential to reduce site and fiber deployment delays. Ministries responsible for digital development should further promote enterprise adoption through innovation sandboxes, pilot programs, and blended funding mechanisms.

For Operators and Infrastructure Providers:
Operators are expected to progress from NSA stabilization toward phased SA activation, expand fiberization of macro sites, participate in passive and active sharing arrangements where feasible, and lead early enterprise deployments. Infrastructure providers and tower companies should support accelerated rollout through shared assets, energy-efficient site designs, and increased use of renewable power.

For Industry and Ecosystem Partners:
Industry users, vendors, and innovation agencies are central to building demand beyond consumer broadband. Early adoption across manufacturing, logistics, utilities, aviation, and smart cities should be supported through private 5G pilots and sector-focused use cases. Device vendors and financing partners also have an important role in improving affordability and expanding the availability of 5G-capable devices.

Together, these stakeholder actions convert the roadmap into a coordinated national delivery framework.

6.4 Phase-Based Policy Actions

The strategic recommendations are operationalized through four sequential roadmap phases.

Phase 1 – Enablement (Decide, Prepare, Govern):
This phase establishes regulatory clarity and foundational readiness. Priority actions include assigning mid-band and high-band spectrum, preparing alternative low-band options while 700 MHz clearance progresses, publishing the national SA migration roadmap, launching single-window approvals, strengthening device compliance to prevent legacy imports, initiating electricity tariff reform consultations, and activating governance mechanisms. These measures reduce uncertainty, improve investor confidence, and prepare the ecosystem for scaled deployment.

Phase 2 – Optimization (Build, Share, Scale):
The second phase focuses on operational efficiency and coverage expansion. Key priorities include implementing passive infrastructure sharing agreements, accelerating fiberization of macro sites, activating interim low-band spectrum for SA trials, rolling out device affordability programs, and formalizing technology-neutral licensing. During this phase, KPI monitoring becomes fully operational, enabling data-driven adjustments to rollout strategies.

Phase 3 – Innovation (Activate, Experiment, Adopt):
With core infrastructure in place, attention shifts toward SA deployment clusters, enterprise pilots, Open RAN experimentation, and green network initiatives. Private 5G use cases are expanded across priority industries, validating new business models and demonstrating the value of low-latency and mission-critical connectivity.

Phase 4 – Reinvention (Transform, Mature, Sustain):
The final phase targets nationwide SA readiness, integration of advanced 5G capabilities, and long-term sustainability. Spectrum refarming and harmonization are completed, diversified funding mechanisms support large-scale rollout, and 5G becomes embedded within national digital services and industrial ecosystems. Continuous KPI tracking and periodic roadmap reviews ensure adaptability to evolving market conditions.

6.5 Expected National Outcomes

Effective implementation of the roadmap is expected to deliver multiple long-term outcomes.

- **From a connectivity perspective,** Sri Lanka progresses from fragmented NSA deployments toward broad SA availability, supported by improved fiber backhaul, shared infrastructure, and energy-efficient networks.

- **From an economic standpoint,** phased investments, tariff reforms, and infrastructure sharing reduce deployment costs while improving investment viability, enabling sustainable expansion even under low-ARPU conditions.
- **From an industry and innovation perspective,** private 5G and enterprise pilots catalyze digital transformation across manufacturing, logistics, utilities, and smart cities, supporting productivity improvements and new service models.
- **From a societal perspective,** wider coverage, improved device penetration, and ecosystem development contribute to digital inclusion and strengthen national competitiveness.

By aligning regulatory reform, infrastructure development, and market enablement within a unified implementation framework, the roadmap provides Sri Lanka with a practical pathway to move beyond incremental upgrades toward a resilient, inclusive, and innovation-driven 5G ecosystem.

6.6 Future Work

While this study presents a structured Multi-stakeholder roadmap for 5G deployment in Sri Lanka, several areas remain open for future research and extension. First, as national policies and spectrum timelines evolve, the roadmap should be periodically updated using real deployment data, KPI trends, and post-implementation reviews. Longitudinal studies tracking coverage growth, SA adoption, enterprise uptake, and energy efficiency would provide valuable insight into the effectiveness of the phased approach.

Second, future work could develop quantitative techno-economic models to complement the qualitative framework presented here. Detailed cost–benefit analyses at operator and national levels, incorporating traffic growth, device penetration, and sector-specific use cases, would strengthen investment planning and policy prioritization.

Third, deeper investigation into enterprise and vertical-specific adoption is recommended. Sector-focused case studies in manufacturing, logistics, utilities, healthcare, and smart cities could assess how private 5G deployments translate into measurable productivity gains and operational efficiencies.

In addition, further research may explore emerging technologies such as Open RAN, network slicing, and edge computing in the Sri Lankan context, particularly their potential to reduce costs and enable new digital services. Environmental sustainability also warrants continued attention, including lifecycle assessments of 5G infrastructure and the role of renewable energy in reducing network carbon intensity.

Finally, comparative regional studies across South Asia and other developing markets could benchmark Sri Lanka's progress and identify transferable best practices. Extending the readiness assessment framework to additional countries would help validate its broader applicability and contribute to regional policy learning.

6.7 Final Remarks

This thesis demonstrates that successful 5G deployment in Sri Lanka depends on more than spectrum allocation or network expansion alone. It requires coordinated regulatory reform, shared infrastructure, sustainable investment models, and active industry engagement. By integrating stakeholder perspectives with global best practices, this study offers a practical and implementable roadmap tailored to Sri Lanka's development context.

The proposed framework provides policymakers, regulators, operators, and industry stakeholders with a structured reference to guide decision-making and prioritize interventions across the 5G lifecycle. With sustained commitment and collaborative execution, Sri Lanka has the opportunity to move beyond incremental connectivity improvements toward a digitally enabled economy that supports innovation, productivity, and inclusive growth.

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APPENDIX A

SATKEHOLDER QUESTIONNAIRE

This questionnaire forms part of the MSc thesis titled *"A Multi-stakeholder Roadmap for 5G Deployment in Sri Lanka: Regulatory, Operator, and Enterprise user Perspectives"* All the interview responses are handled confidentially and used solely for academic purposes.

Telecom Operator Questionnaire

Section 1: Organisational Readiness & Strategy

1. How would you assess your organisation's current technical and operational readiness for 5G deployment? (1 = Poor, 5 = Excellent)

2. What phased approach (NSA to SA) do you plan to follow, and why (cost, timeline, technology maturity, demand)?

3. What main factors influence your deployment roadmap? (Urban demand, enterprise opportunities, infrastructure readiness, spectrum availability, cost optimisation, regulatory directives, others)

4. How do you balance urban densification with rural coverage goals over the next three years?

Section 2: Technical & Infrastructure Readiness

5. What are your main infrastructure gaps today? (Power, backhaul, fibre, towers, site acquisition, workforce, supply chain, others)

6. How do Open RAN, cloud-native cores, or AI/ML contribute to your 5G strategy?

Section 3: Use Cases & Business Outcomes

7. Which industry verticals are most critical for near-term 5G deployment?

8. Which use cases should be prioritised in Sri Lanka? (eMBB, URLLC, smart cities, slicing, private 5G, massive IoT, others)

9. Do you see Private 5G as a viable revenue stream? What factors support or hinder adoption?

10. How do you assess local vendor readiness for devices and applications?

Section 4: Challenges & Partnerships

11. Rank the top three challenges in 5G deployment (spectrum, ROI, infrastructure upgrades, regulation, ecosystem readiness, skills, etc.).

12. Are there partnership models that could accelerate deployment?

Section 5: Spectrum & Policy

13. Does the current spectrum framework support sustainable 5G growth? What improvements would you recommend?

14. What regulatory or policy changes are holding back deployment?

15. What risks affect your 5G plans, and what policy support would help mitigate them?

16. What actions should be fast-tracked nationally to accelerate 5G?

Section 6: Revenue Outlook

17. By which year do you expect 5G to generate substantial revenues?

18. Any additional comments on Sri Lanka's 5G roadmap?

Telecom Operator Questionnaire (Small / Emerging Operator – Variant)

Section 1: Organizational Readiness & Strategy

1. Rate your organisation's readiness for 5G (1–5).

2. What phase are you currently in (trial, planning, rollout)?

Section 2: Technical & Infrastructure Readiness

3. What infrastructure gaps affect your 5G plans?

4. How do you plan to manage multi-generation coexistence and eventual legacy network sunset?

5. Do technologies such as Open RAN or vendor partnerships help reduce rollout cost?

Section 3: Use Cases & Business Outcomes

6. Which industry verticals matter most for your 5G business?
7. Which use cases should be prioritised (eMBB, FWA, private 5G, slicing, IoT)?
8. Do you see Private 5G as a viable revenue stream in Sri Lanka's context?
9. How do you assess local vendor readiness for 5G deployment & use cases?

Section 4: Challenges & Policy

10. What are your top challenges in moving toward 5G?
11. What partnership models would help deployment?
12. Does the current spectrum framework support long-term sustainability?
13. What regulatory support would strengthen your 5G business case?

Section 5: Revenue

14. By which year do you expect meaningful 5G revenues?
15. Any additional recommendations?

Regulator Questionnaire

Section 1: Strategic Vision & Spectrum Policy

1. How is TRCSL preparing for 5G rollout, and what key areas are currently prioritized in your roadmap? -If we go for rural we need low band frequency, how to address that?
2. How does TRCSL's 5G strategy align with Sri Lanka's broader digital transformation and economic goals?
3. Is there a roadmap for releasing more spectrum in the future , particularly low-band frequencies to support coverage in rural or underserved areas? -Does the operator has to buy both together? -What do you think about the ecosystem readiness for this situation?
4. Could you elaborate on why TRCSL selected 3.5 GHz and 27 GHz bands and chose the auction method for spectrum assignment?
5. Has TRCSL considered flexible pricing options such as deferred payments or phased licensing to support investment readiness among operators?

Section 2: Licensing Obligations & Infrastructure Enablement

6. What deployment timelines or geographic coverage requirements are imposed on 5G licensees? How does TRCSL monitor their compliance?

7. Is there an established mechanism through which TRCSL collaborates with other government agencies to streamline the site acquisition and approval process, particularly to reduce delays and accelerate infrastructure rollout in rural areas?

8. What measures is TRCSL considering to promote infrastructure sharing (towers, fiber, RAN)? Is there any movement towards common utility models?

9. How does TRCSL envision enabling easier access to public infrastructure such as poles?

10. Has TRCSL initiated any engagement with power utilities to ensure sustainable electricity pricing for 5G networks?

Section 3: Ecosystem Development & Industry Use

11. Which industries or enterprise verticals do you believe are most ready to adopt 5G? Is TRCSL involved in any initiatives to support such sectoral adoption? -What about the support can be given for device adoption in the industry?

12. What is TRCSL's current position on licensing private 5G networks for verticals like ports, factories, or campus-based networks?

13. Beyond general awareness, what specific measures are being considered to promote 5G device availability, affordability, and adoption across the public? -Do you have any idea about the current device penetration?

14. Is TRCSL considering a timeline for 2G shutdown? Are there any policies in place to discourage the import of legacy devices?

Section 4: Innovation, Fair Competition & Challenges Ahead

15. Are there mechanisms to engage academia, vendors, and startups for collaborative R&D, skills development, or solution localization?

16. In light of potential consolidation in the telecom sector, how does TRCSL plan to safeguard fair competition and spectrum distribution equity?

17. What are the main challenges TRCSL anticipates in Sri Lanka's 5G journey and how can regulation evolve to address them effectively?

18. Is there anything else you would like to share regarding TRCSL's long-term vision, partnerships, or expectations for 5G?

Vendor Questionnaire

Section 1: Radio Access Network (RAN)

1. What types of RAN solutions are you currently deploying in Sri Lanka? -Could you elaborate on whether these are mostly macro base stations, small cells, Massive MIMO antennas, or any other advanced technologies?

2. Where do you see the biggest opportunities and challenges when it comes to the spectrum bands that will be used for 5G in Sri Lanka? -Could you share any technical or policy challenges that operators face when trying to refarm or aggregate spectrum for 5G?

3. Could you share some of the key challenges you encounter when deploying RAN sites in Sri Lanka's urban areas compared to rural or remote regions? -For example, how do you handle issues like site acquisition, power supply?

4. How future-ready are your current 4G sites for 5G? -Could you explain how your hardware or software solutions make it easier for operators to upgrade to NSA or SA 5G without major new investments?

Section 2: Deployment Efficiency & Sustainability

5. How does your solutions address energy efficiency and sustainability goals for 5G networks?

Section 3: Core Network Solutions & Transport Network

6. Could you describe the core network solutions you supply to Sri Lankan operators today? -For instance, do you mainly provide EPC for 4G or full 5G core systems?

7. How does Huawei help local operators transition from 4G EPC to NSA and eventually SA 5G architecture? -Could you give an example of how this step-by-step migration works in practice?

8. What integration or regulatory challenges do you usually face when rolling out core upgrades in Sri Lanka? -Are there any lessons learned you can share that might help regulators or operators address these issues?

9. How do you help local operators strengthen their transport network to handle growing 4G/5G traffic? -What mix of fiber, microwave, or IP router solutions do you usually provide in Sri Lanka's context?

Section 4: Enterprise & Private 5G

10. Globally, you are active in private 5G, could you share whether any pilot projects or discussions are happening in Sri Lanka yet? -For example, have you worked with ports, large factories, or smart campuses so far?

11. Which industries in Sri Lanka do you see as the most likely early adopters of private 5G or smart campus solutions? -Could you describe why these sectors are ready or what benefits they might expect?

12. Do you promote 5G related solutions, what kind of industries have the potential for adopting 5G related solutions in Sri Lankan context?

Section 5: Local Partnerships, Skills & Recommendations

13. How do you work with local partners like contractors, universities, or local service companies when deploying and maintaining networks in Sri Lanka? -Could you share any capacity building or skills transfer initiatives you run?

14. What training or talent development activities do you support locally? For example, any ICT academies, scholarships, or on-the-job training for local engineers?

15. From an operational view, do you face any supply chain or sourcing challenges here for example delays in equipment delivery or local approvals for 5G?

16. What policy, regulatory, or industry-level changes do you believe would help the vendors contribute more effectively to Sri Lanka's 5G goals? -Any best practices from other markets that Sri Lanka could learn from?

17. Finally, is there anything else you'd like to share that operators, regulators, or policymakers should know to ensure successful and sustainable 5G deployment in Sri Lanka?

TowerCo / Infrastructure Provider Questionnaire

1. How do you see your organisation's role in supporting 5G rollout in Sri Lanka compared to your experience in other countries?

2. What types of sites are currently most in demand for 5G deployment (e.g., macro towers, rooftops, indoor systems)?

3. What is your view on the importance of in-building 5G solutions in the Sri Lankan context?

4. From your regional experience, what models work best for indoor coverage, operator-specific deployments or shared systems?

5. Are small cells or street-level solutions being explored locally? If so, could you describe current plans or pilots?
6. Do you see opportunities to support 5G deployment in sectors such as ports, airports, industrial zones, or large campuses?
7. What kinds of infrastructure requests do you typically receive from enterprise customers?
8. How are you addressing rising energy costs and power availability challenges at tower sites?
9. Have renewable or hybrid energy solutions (e.g., solar, battery systems) been implemented locally, similar to deployments in other markets?
10. Have recent infrastructure sharing regulations made it easier to collaborate with mobile operators? If not, what practical barriers remain?
11. From your experience, are there additional policy or regulatory changes that could help accelerate nationwide 5G deployment?
12. Looking ahead, what trends do you believe will shape the next phase of tower and passive infrastructure in Sri Lanka? How is your organisation preparing for these changes?

APPENDIX B

INTERVIEW TRANSCRIPT: THEMATIC ANALYSIS TABLES

The Excel file is available here: Download Excel Dataset.