



**NEW CONNECTIVITY
TECHNOLOGIES AND THEIR
IMPLICATIONS FOR
SCIENTIFIC DISCOVERY AND
DIGITAL SOVEREIGNTY
IN THE GLOBAL SOUTH**

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Executive summary

New connectivity technologies (NCTs), such as satellite networks, 5G/6G systems, edge computing and quantum communications, offer the Global South a historic opportunity to transform its scientific capacity. This can be done by conducting research in previously inaccessible locations, processing data locally rather than routing it through foreign infrastructure or retaining control over locally generated knowledge. The urgency is structural. The Global South generates vast amounts of scientific data yet holds less than 10 percent of global data centre capacity, with over 99 percent of international data flows transmitted through submarine cables (Entrapeer, 2024; TeslaNorth, 2025) largely controlled by foreign operators. When research data flows through this infrastructure, host nations lose control over how it is analyzed, who publishes first and whether findings serve local priorities – a dynamic of scientific data colonialism. NCTs can reverse this dynamic, but without strategic action, they could equally deepen dependency on foreign platforms and algorithms.

This technology profile analyzes connectivity sovereignty, which is the capacity to control data transmission. It does this through three technology clusters: satellite systems enabling ubiquitous observation, 5G/6G networks facilitating real-time innovation and quantum technologies promising unbreakable security. The technology profile examines how seven nations across Asia, Latin America, Africa, and the Middle East are navigating the United States–China technology duopoly through diverse strategies ranging from local manufacturing to geographic leverage.

Critically, NCTs also reshape the landscape of scientific collaboration. By enabling low-latency, high-bandwidth communication between institutions across continents, NCTs can facilitate new models of South–South and South–North research partnerships, including shared virtual laboratories, real-time co-authoring and remote access to scientific instruments, that bypass the traditional gatekeeping role of infrastructure hubs in the Global North.

The analysis identifies four enabling conditions for equitable technology adoption and provides actionable recommendations for science, technology and innovation agencies, research institutions and private sector innovators. The central message is clear: connectivity sovereignty requires synchronized strategy across infrastructure, policy and innovation ecosystems. Digital self-determination is not isolation; it is the agency to collaborate globally while governing locally.

Key finding: *Connectivity sovereignty is the prerequisite for scientific self-determination. Nations that exercise agency over their digital infrastructure will shape the future of scientific discovery, institutional capacity building and equitable global collaboration. Those that do not risk deepening their external dependency on these technologies, remaining perpetual data sources that are systematically excluded from the analytical, publishing and value-capture stages of the research cycle.*

Introduction

The infrastructure of scientific discovery is being fundamentally restructured. As research becomes increasingly data intensive and distributed, new connectivity technologies (NCTs) are evolving from simple communication tools into the essential nervous system of global science. This transformation offers the Global South a historic opportunity: to democratize access to knowledge, decentralize scientific observation and bypass legacy infrastructure constraints that have historically confined advanced research to well-funded institutions in the Global North.

Equally important, NCTs are reshaping how researchers communicate and collaborate. Low-latency satellite links and high-bandwidth wireless networks enable real-time co-authoring, shared virtual laboratories and remote instrument access. This opens new pathways for South–South and South–North scientific partnerships that are less dependent on routing through infrastructure hubs in the Global North.

However, this opportunity arrives with a profound geopolitical challenge. As global powers consolidate control over the digital stack – from subsea cables to orbital satellites – Global South nations face a defining question: how to use advanced technologies to enhance scientific capabilities while maintaining control over the knowledge they produce.

This technology profile proceeds in four stages. It first defines three clusters of NCTs by their function for science systems. It then examines how seven nations are pursuing different pathways to digital self-determination. From these cases, it identifies enabling conditions for equitable technology uptake and translates them into a strategic roadmap for science, technology and innovation organizations in the Global South.

These choices have tangible consequences for practising scientists. For example, consider a Nairobi research team analyzing genomic sequences. If their university routes data through a foreign cloud provider, the raw sequences may be stored under another jurisdiction's data laws, processed by proprietary algorithms trained on non-African populations, and subject to overseas transmission delays that slow time-sensitive research. Conversely, if the same team uses a sovereign connectivity network dedicated to research and education, they retain data custody, control their analytical pipeline and publish on their own timeline. This difference dictates who sets the research agenda, who benefits from discoveries and how quickly findings reach the communities they are meant to serve.

Understanding connectivity technologies

This technology profile organizes NCTs into three strategic clusters based on their primary function for science systems. The access cluster (low Earth orbit [LEO] satellites and delay-tolerant networking) extends connectivity to remote and underserved locations. The control cluster (5G/6G wireless networks and edge computing) enables real-time data processing at the source. The future cluster (quantum networks) promises unprecedented security for sensitive scientific communications. Together, these technologies provide the infrastructure layer that supports data storage, artificial intelligence (AI) and extended reality (Bria et al., 2025). This, in turn, supports AI's capacity to optimize network performance, creating a mutual reinforcement loop between the infrastructure and the capabilities it enables (Internet Society, 2022; International Telecommunication Union, 2023).

The access cluster: Low Earth orbit satellites

Technical overview: LEO satellites are non-geostationary spacecraft operating between 160 km and 2,000 km above Earth, deployed in mega-constellations for continuous coverage (Lagunas et al., 2024). Their proximity to Earth enables low latencies comparable to fibre optics, integrating into 5G and 6G ecosystems (Entrapeer, 2024; Shayea et al., 2024). Modern LEO satellites can process and relay data while in orbit, communicating directly with each other without needing ground stations. This supports both cellular networks and direct device-to-device connections (Seeram et al., 2025; Shayea et al., 2024).

Scientific applications: The proliferation of LEO constellations has transformed Global South research by delivering low-latency connectivity for real-time data collection in precision agriculture, environmental monitoring and quantum communication in remote regions lacking terrestrial infrastructure (Shayea et al., 2024; Stellenbosch University, 2025). LEO connectivity also enables delay-tolerant networking (DTN) – a protocol where data is stored on the satellite, carried as it orbits, then transmitted when connections become available. This store-and-forward architecture is valuable for environmental monitoring and precision agriculture, where LEO satellites aggregate non-real-time data from distributed sensors and relay it to processing centres. DTN also enables autonomous research networks in off-grid environments that conduct sophisticated data collection before transmitting bundled results via intermittent satellite passes (Shayea et al., 2024).

Deployment and implications for the Global South: LEO satellites present geopolitical challenges. Because these satellites provide connectivity almost anywhere, they can operate in ways that challenge existing national regulatory frameworks. Their rapid expansion risks deepening digital colonialism – where nations lose control over their own data, research findings, and the economic value these generate (Kulesza, 2025; Venske, 2023). For example, biodiversity monitoring data collected via foreign satellite-connected sensors in the Amazon

may be transmitted to and stored on servers in the United States of America (US) or Europe, processed by foreign AI platforms, and converted into patents or publications. Therefore, returning little to no benefit to the host country. Similarly, climate observation datasets generated by African research stations may be analyzed abroad before local scientists can access their own data for publication (De Freitas, 2025; Nakalembe, 2024).

Global South regulatory responses: Global South nations are responding with diverse regulatory strategies: Bolivia and Brazil are seeking alternative providers (Hayes, 2026); India has mandated strict data localization as a prerequisite for market access (Kulesza, 2025); and South Africa initially blocked Starlink over equity requirements, though service now nears rollout (TeslaNorth, 2025). Starlink currently serves 10 million customers, including approximately 4 million in the Global South (Johnson, 2026; Fevre, 2025). This demonstrates both the technology's appeal and the vast underserved areas remaining. The market is diversifying: Blue Origin (US) announced its TeraWave constellation for scientific and government data (Kan, 2026), while China's Thousand Sails (Qianfan) aims to deploy over 15,000 satellites as a sovereign alternative (Broadband Commission for Sustainable Development, 2025).

The control cluster: 5G/6G networks and edge computing

Technical overview: Fifth-generation mobile networks (5G) support up to one million connected devices per square kilometre and deliver peak data rates of 20 gigabits per second, enabling the transfer of massive scientific datasets (Wang, 2023). 5G also supports network slicing – creating multiple virtual networks on the same physical infrastructure, each optimized for different purposes like healthcare, manufacturing or research (Wang, 2023).

Sixth-generation networks (6G), expected by 2030, will integrate physical, digital and biological systems using the terahertz spectrum to enable peak speeds up to one terabit per second and latencies as low as 0.1 milliseconds (Hegde and Varughese, 2024). 6G is expected to support ten times more devices than 5G (De Luca, 2024). 6G's Integrated Sensing and Communication enables the same wireless infrastructure to simultaneously transmit data and detect the location, speed and material composition of surrounding living and non-living objects, without separate sensor devices (Bayesteh, 2021). 4G still remains the dominant global mobile technology, but it peaked in 2024 as 5G adoption accelerated. 2G/3G networks are being phased out (Broadband Commission for Sustainable Development, 2024; GSMA, 2025).

Scientific applications: 5G enables real-time haptic feedback for remote medical procedures (Henrique and Prasad, 2021) and supports dense sensor networks for environmental science and precision agriculture (Shayea et al., 2024). 6G will extend these capabilities with near-zero latency for remote surgery and real-time data flows for digital twins – virtual replicas of

physical environments continuously updated with live data (De Luca, 2024). 6G's sensing capabilities enable detailed pollution monitoring (Bayesteh et al., 2021), while providing robust deep-space communication links for planetary observation (Henrique and Prasad, 2021).

Implications for the Global South: In the Global South, 5G is increasingly deployed through Fixed Wireless Access to deliver broadband where fibre is prohibitively costly, with launches in Angola, Nigeria and South Africa (GMSA, 2024). It supports telemedicine by connecting rural clinics with urban specialists (GMSA, 2024). 6G represents a critical opportunity to address connectivity gaps through non-terrestrial networks – including LEO satellites and High-Altitude Platform Systems. India's Bharat 6G vision, for instance, explicitly targets the digital divide through services such as e-education and e-health, while also seeking to establish the country as a global technology provider (Broadband Commission for Sustainable Development, 2024).

Adoption barriers and global inequalities: 5G adoption is accelerating, there are 53 operators across 29 African markets (Joiner et al., 2025). However, significant barriers persist, including device affordability and reliable electricity, as well as vendor concentration among Huawei, Ericsson and Nokia (Bria et al., 2025). Global 5G coverage has reached 55 percent, but its expansion is highly uneven, lagging significantly at 8–13 percent in many low-income regions (International Telecommunication Union, 2025). 6G deployment faces compounding challenges, including inadequate infrastructure, high energy demands and technical complexity (Hegde and Varughese, 2024).

Edge computing

The second component of the control cluster is edge computing. While not a connectivity technology as such, it is included here for its role in reducing bandwidth demands, lowering latency and supporting data sovereignty by keeping sensitive information within national borders. Rather than transmitting raw data to distant cloud servers, edge computing processes information locally – at research field sites, in factories or on smart devices – enabling real-time responses where they are needed most (Schmuntzsch et al., 2025; World Bank, 2021). For research institutions, edge processing enables real-time analysis of sensor data at remote field stations from marine observatories to agricultural research plots, without transmitting raw datasets to foreign cloud servers. The edge computing market is dominated by US providers, such as Amazon (AWS), Microsoft (Azure) and Google Cloud, with limited competition from China and Europe (Bria et al., 2025). The Global South (excluding China) accounts for 50 percent of global internet users but holds less than 10 percent of worldwide data centre capacity (Powell and Sati, 2025), with Africa hosting only 1 percent (McDonald and Ballan, 2023). By processing information locally, edge architecture supports data sovereignty, allowing institutions to retain control over research data and computational resources rather than relying on foreign cloud services (Schmuntzsch et al., 2025).

The future cluster: Quantum networks

Technical overview: Quantum networks are based on the principles of quantum mechanics – superposition, which allows particles to represent multiple values simultaneously, and entanglement, which links particles so that measuring one instantly affects the other regardless of distance (Singh et al., 2021). These properties enable three capabilities: secure communication channels (Li et al., 2025), distributed quantum computing that links multiple processors (Singh et al., 2021), and enhanced sensing of physical quantities like gravity and magnetic fields with sensitivity far beyond classical limits (OECD, 2025).

Current deployment status: Quantum networks remain largely at the research laboratory and testbed stage globally (Durr-E-Shahwar et al., 2024). Most operational quantum links are point-to-point demonstrations, and a fully realized quantum internet remains a long-term aspiration (Azuma et al., 2023). The following discussion should be read with this maturity context in mind: quantum networks represent a strategic horizon rather than an immediately deployable infrastructure layer.

Scientific applications: Quantum networks will allow scientists to connect separate sensors. These will work together as one extremely sensitive instrument, enabling distributed sensing capabilities like long-baseline astronomy and precise clock synchronization (Singh et al., 2021). They will also link smaller quantum computers, forming single powerful systems that overcome individual device limitations through distributed quantum computing (Awschalom et al., 2021). A primary application is Quantum Key Distribution), which uses single photons to generate theoretically unbreakable encryption keys – a critical safeguard as next-generation quantum computers are expected to render today's conventional encryption methods obsolete (Durr-E-Shahwar et al., 2024).

Implications for the Global South: For the Global South, this technology offers a chance to skip outdated systems entirely by using satellite-based quantum links, as demonstrated by the 12,900 km connection between South Africa and China using the Jinan-1 microsatellite. This enables low-income nations to shift from simply buying technology to actively building and controlling a secure global scientific network (Stellenbosch University, 2025; Thompson, 2025). The strategic value of these technologies depends on how nations deploy and govern them. The following section examines how selected Global South nations are asserting varying degrees of sovereignty over their connectivity infrastructure.

Current status in the Global South

Scientific capacity in the Global South depends on digital sovereignty – control over the complete digital ecosystem, including hardware, software, network connectivity and data (Jiang and Belli, 2025). However, this is constrained by a highly concentrated global technology stack: China monopolizes the refinement of critical rare Earth materials; Taipei and the Republic of Korea lead in advanced semiconductor manufacturing; Europe supplies essential lithography equipment; and a handful of US technology giants hold power over global cloud infrastructure, operating systems and AI platforms (Bria et al., 2025). The following section examines how select Global South nations navigate this asymmetry as they pursue greater digital self-determination.

India: India is pursuing technological autonomy across three domains. In space, satellites are deployed using vehicles such as the Polar Satellite Launch Vehicle (Broadband Commission for Sustainable Development, 2025), with guidelines mandating all satellite traffic to pass through local gateways to prevent foreign routing (Department of Telecommunications, 2025). India also requires its NavIC navigation system on mobile phones to reduce reliance on US GPS (Jiang and Belli, 2025), though only three of eleven satellites are fully functional (MP, 2026). In telecommunications, the Bharat Telecom Stack provides a local 4G+ network developed by C-DOT, Tata Consultancy Services and Tejas Networks (Durr-E-Shahwar et al., 2024; SME Street, 2025). In quantum communications, QNu Labs demonstrated a 500 km Quantum Key Distribution network in 2025 (Ministry of Science & Technology, 2025).

These initiatives directly strengthen Indian scientific research. Earth observation satellites such as EOS-01 provide critical data for forestry, disaster management and agriculture (Broadband Commission for Sustainable Development, 2025), while the open source DiCRA platform integrates this data with machine learning to analyze 20 agricultural parameters (including crop health, stress and soil conditions) across thousands of villages (Broadband Commission for Sustainable Development, 2024). In telecommunications, the National Knowledge Network connects over 4 million users across 1,600 research and education institutions, providing cloud services and supporting digital learning initiatives such as the Country-wide Classroom (European Union External Action, 2017; Foley, 2016).

Vietnam: Vietnam defies the usual wealth-tech sovereignty correlation. Despite a lower economic output than Malaysia or Brazil (World Bank, 2024), Vietnam is the only Global South nation, second to India, to master local semiconductor production. Viettel, a state-owned military company, designs and manufactures the specialized chips that power 5G base stations (VietnamPlus, 2025). In January 2026, Viettel broke ground on Vietnam's first domestic semiconductor fabrication plant, with trial production of 32-nanometer chips planned for 2027 (Luu, 2026). Viettel co-invested in the Asia Direct Cable, establishing a

sovereign landing station in Quy Nhon. Though the cable traverses the South China Sea rather than bypassing it, the station enhances transport resilience by providing an entry point distinct from congested hubs in Vung Tau and Da Nang, supporting Vietnam's digital infrastructure independence (Viettel Global, 2022). For science, domestic chip manufacturing ensures that Vietnamese 5G-connected research networks – supporting applications from precision agriculture to marine environmental monitoring – are not vulnerable to supply chain disruptions or foreign intelligence backdoors.

Chile: Chile demonstrates passive digital sovereignty through geography: lacking local capabilities in advanced tech like rockets or chips, it leverages its Pacific location to emerge as a regional digital hub. The Humboldt submarine cable (developed with Google) establishes the first direct high-capacity link between South America and the Asia-Pacific, enabling faster data flows that bypass traditional Northern Hemisphere routes (Quigley, 2024). Combined with BELLA/EllaLink for Europe–Latin America connectivity, this enhances Chile's strategic importance and bargaining power as a transit point, even without owning the underlying manufacturing technology. Chile is pursuing a multi-layered digital infrastructure strategy. This strategy includes both the National Satellite System for sovereign Earth observation and the Humboldt transpacific submarine cable, alongside a feasibility study for a dedicated fibre link to Antarctica. These systems collectively position Chile as a potential regional hub for processing and distributing Antarctic scientific data (Desarrollo País, n.d.).

Saudi Arabia: Most wealthy nations rent connectivity capacity. Saudi Arabia's SpaceBelt KSA initiative takes a different approach. SpaceBelt KSA, a Saudi-based space logistics and satellite security platform, signed a contract with US-based iRocket to support orbital launches aimed at deploying a LEO satellite network. This network is being developed as a sovereign infrastructure intended to ensure that data transmitted through it remains under Saudi control and is protected by end-to-end encryption (Fatima, 2025). Saudi Arabia's Mawani signed a \$100 million agreement with China's ZTT Group to build a submarine and terrestrial cable manufacturing plant at Ras Al-Khair Port. Once operational, the facility is projected to produce 500 km of submarine cables and 12,500 km of fibre optic cables annually, localizing production within the Kingdom (Saudi Press Agency, 2025). These sovereign infrastructure projects lay a critical foundation for scientific advancement through direct technology transfer and human capital development. By training domestic engineers in rocket technologies and mission planning, these initiatives equip Saudi Arabia to expand its role in global space initiatives and advance toward independent science and exploration missions beyond Earth orbit (Fatima, 2025).

United Arab Emirates: The country is accelerating its scientific infrastructure through the Technology Innovation Institute. The company has launched Manarat, a custom-built control electronics platform that acts as the nervous system of a quantum computer. The platform is

at least five times more cost-efficient than commercial alternatives, lowering the barriers to advanced quantum experimentation. This milestone is a foundational step in the Technology Innovation Institute's long-term strategy to deliver a full-stack quantum computing platform (TII, 2025). This drive for technological sovereignty also extends to orbit with the creation of Space42. Formed by Mubadala through the merger of Bayanat's advanced geospatial data capabilities and Yahsat's global satellite communications infrastructure, Space42 operates as a vertically integrated, AI-powered space technology platform. It delivers AI solutions for governments, industry and commercial clients (Mubadala Investment Company, 2024). Together, these investments position the United Arab Emirates to conduct advanced scientific research, from quantum simulation to Earth observation, on sovereign infrastructure, reducing its dependence on foreign platforms for processing, analyzing and securing nationally strategic data.

Egypt: Egypt leverages its position as a critical cable route gatekeeper: 17 percent of global internet traffic relies on the Red Sea corridor, a transit route monopolized by Telecom Egypt due to regulatory frameworks that require all infrastructure development projects to partner with a licensed domestic operator to secure site permits. This architecture's fragility was exposed in September 2025, when severed subsea cables degraded data transmission across the Middle East and Asia. In response, cables are now routed through terrestrial ducts along the secured western bank of the Suez Canal. Furthermore, guided by the Digital Egypt Strategy, the nation is evolving beyond a mere transit node into a central hub for data centres and telecommunications services, a shift that will impact the future landscape of international scientific data exchange (Murphy and Bryja, 2025).

South Africa: South Africa has established the South African National Research Network, a high-speed network that benefits over a million researchers by supporting core scientific activities across public universities and science councils (Onyango, 2023). Complementing these connectivity assets, the Centre for High Performance Computing and the Data Intensive Research Initiative of South Africa provide essential local compute and storage capacity as key pillars of the government's National Integrated Cyber Infrastructure System (Council for Scientific and Industrial Research, n.d.). This robust digital foundation enables sovereign scientific data collection, exemplified by the MDASat nanosatellite constellation, which tracks maritime traffic to protect marine resources and enhance ocean sovereignty (Royi, 2022). Additionally, the nation is expanding its scientific footprint through the new Matjiesfontein deep space complex, establishing a sovereign node in NASA's Lunar Exploration Ground Segment network to support global deep space missions (South African National Space Agency, n.d.). The country strategies documented above demonstrate that sovereignty is achievable through diverse pathways. The following analysis examines the broader impacts these technologies produce across Global South science systems.

Core analysis:

Impacts of connectivity technologies

The convergence of connectivity technologies is set to transform scientific research and innovation in the Global South – not merely through faster internet, but by fundamentally changing where research can happen and how quickly discoveries are made. The following analysis examines three major impacts, each evaluated through three lenses: opportunities for scientific autonomy, practical infrastructure challenges and risks of new dependencies on foreign technology.

Impact 1: The decentralization of scientific observation and discovery

The scientific opportunity: NCTs allow scientific research to happen independently of urban centres and their concentrated infrastructure. Autonomous research stations can operate in previously unreachable locations like the Amazon rainforest or remote island chains. This allows nations to continuously monitor their own biodiversity and climate systems rather than relying on sporadic foreign expeditions, shifting toward locally managed knowledge production.

The implementation challenges: High costs for satellite hardware and subscriptions remain prohibitive for underfunded local institutions. Additionally, deployment is constrained by shortages of local technical expertise. Without sufficient funding and trained technicians to maintain connectivity equipment – satellite terminals, ground stations, sensor arrays and edge computing nodes – in remote locations, these systems risk being abandoned and falling into disrepair. This leaves a gap between what the technology could achieve and what local institutions can actually sustain.

The sovereignty risk: The sovereignty risk here concerns where data goes – physical routing and storage. Reliance on foreign-owned satellite networks means losing data custody at the point of transmission (Mukku, 2025). As documented in the LEO deployment analysis above, these risks reduce local researchers to data collectors while climate models, pharmaceutical discoveries, and patents are processed and monetized in the Global North (Kwet, 2019; Thompson; 2025).

Impact 2: Leapfrogging into 'real-time' applied innovation

The scientific opportunity: 5G/6G and edge computing enable a shift from passive data extraction to active local autonomy. By processing data at the source, Global South institutions bypass dependency on foreign-controlled cloud infrastructure. 6G's sensing capabilities turn wireless networks into real-time monitoring systems that provide the data flows necessary to

support highly accurate virtual replicas (digital twins) of physical environments – like farms, forests or urban areas. This architecture supports data residency, keeping sensitive research and citizen data within national jurisdictions.

The implementation challenges: Infrastructure costs for deploying dense 5G/6G base station networks remain substantial, particularly in rural areas and shortages of trained engineers constrain deployment timelines across the Global South. The dense equipment required for 5G and 6G demands constant electricity, conflicting with unreliable power grids in regions like Sub-Saharan Africa. While 6G improves efficiency per bit, massive increases in device density may drive overall consumption higher.

The sovereignty risk: The sovereignty risk here concerns who processes data and with what assumptions – algorithmic and epistemic control. Even if physical equipment is installed locally, AI systems are overwhelmingly trained on datasets collected and annotated within the Global North. This creates algorithms that misunderstand local realities because they were designed for different contexts. For instance, health AI trained on skewed or discriminatory data risks deepening existing social disparities, causing individuals from disadvantaged backgrounds to experience adverse effects. Sovereignty requires developing local capacity to train and adapt models for local needs.

Impact 3: A crisis of digital sovereignty and security

The scientific opportunity: Quantum networks represent the frontier for secure collaboration. For the Global South, this technology enables establishing a circle of trust – nations communicating without foreign surveillance. By building sovereign quantum links, Global South nations can create secure channels for sharing sensitive, scientific data – including genomic databases, clinical trial results, biodiversity inventories, mineral exploration surveys and collaborative datasets shared across national borders – as well as protecting against cyber-espionage.

The implementation challenges: Quantum infrastructure involves massive costs; global public investment has reached tens of billions of dollars, with China and US acting as the leading investors. While wealthy nations commit enormous resources, such programmes are often absent, underfunded or inadequately coordinated in low-income countries. Furthermore, the highly specialized nature of quantum technology challenges adoption in the Global South due to shortages of human capital, infrastructure and technology transfer expertise, reinforcing prevailing power dynamics between the Global North and South (Mafu and Senekane, 2023).

The sovereignty risk: The sovereignty risk here concerns who can read data – cryptographic security. Adversaries may already be undermining future sovereignty by recording encrypted traffic now with the intention of decrypting it when quantum computers become powerful

enough. For the Global South, sensitive data – including scientific datasets, healthcare records, government communications and diplomatic dialogues – could be sitting in hostile archives waiting to be unlocked. Without urgently adopting post-quantum cryptography, nations operate under false security: what seems protected today could become readable tomorrow, eroding sovereignty over their digital infrastructure (UN Secretary-General’s Scientific Advisory Board, 2025).

Strategic response: Three horizons for quantum engagement: The quantum challenge demands three strategic horizons. First, adopting post-quantum cryptography is an immediate global priority: to neutralize this Harvest Now, Decrypt Later threat, nations require urgent policy action to implement quantum-resistant standards (Touil et al., 2024). Second, participating in experimental quantum networks – like the record-breaking 12,900 km South Africa–China Jinan-1 satellite link – builds crucial institutional expertise, transforming low-income nations from passive consumers into sovereign infrastructure creators (Henrique and Parasad, 2021; Mafu and Senekane, 2023). Third, developing sovereign quantum capacity remains a longer-term ambition, yet with 34 countries currently advancing dedicated national quantum programmes, this technological race extends far beyond major economic superpowers (Yee et al., 2025). Distinguishing these distinct tiers helps agencies effectively prioritize critical resource allocation. Capturing these opportunities while mitigating the sovereignty risks identified above requires structural conditions that go beyond technology adoption.

Enabling conditions for equitable uptake

Achieving digital sovereignty requires more than technology adoption – it demands structural conditions that enable Global South nations to participate as equals rather than dependent consumers in the global digital economy.

Regional cooperation: Shared infrastructure and unified markets

Most nations cannot afford intercontinental submarine cables or satellite constellations on their own, but regional cooperation enables pooling resources for critical connectivity infrastructure. AfricaConnect3 connects Africa’s Regional Research and Education Networks with Europe’s GÉANT network, serving over 9 million users at 3,000+ institutions (AfricaConnect3, 2025). RedCLARA operates Latin America’s regional research and education network connectivity backbone (Cadenas and Seaton, 2021), strengthened through the Bridging Europe, Africa and the Americas agreement with African networks (Marino, 2022). Regional digital markets also enable collective influence in shaping global norms. The African Continental Free Trade Area developed a Digital Single Market to shape global standards (Venske, 2023), while ASEAN’s Digital Masterplan 2025 harmonizes regulations removing

cross-regional barriers (ASEAN, 2021). The Pacific Alliance (Chile, Colombia, Mexico, Peru) harmonizes regulations to reduce transaction costs, creating a unified market scale necessary to compete globally (ECLAC, 2021). Larger regional markets increase competition, ensuring infrastructure serves development needs while creating alternatives to dominant providers (BELLA II, 2023).

Adoption of open standards and open source architectures

Adopting open standards and interoperable architectures allows Global South nations to transcend reliance on proprietary technologies and assert control over their digital ecosystems (Jiang and Bell, 2025). For example, Open RAN (Open Radio Access Network) technology allows African telecom companies like MTN to build their networks using standard equipment from multiple suppliers instead of being locked into one expensive vendor, which breaks up monopolies and reduces costs (Kofi and Allen, 2024). Open standards are equally critical for LEO satellite constellations which prevent proprietary lock-in, allowing for multivendor sourcing and economies of scale (Lagunas et al., 2024). Similarly, interoperable edge computing frameworks utilize open communication protocols to address protocol heterogeneity and prevent vendor lock-in across platforms (George et al., 2023), while open interfaces for 5G/6G network slicing enable industry vertical market players to dynamically lease virtual network resources without dependence on a single infrastructure provider's closed hardware (Samdanis et al., 2016). For quantum networks, open protocols for Quantum Key Distribution ensure that secure communication standards remain interoperable across vendors and national borders (Durr-E-Shahwar et al., 2024).

Beyond hardware, sovereignty is reinforced through free and open source software and open application programming interfaces, enabling nations to build interoperable digital public infrastructures (Jiang and Bell, 2025). The United Nations Educational, Scientific and Cultural Organization's 2021 Recommendation on Open Science provides a relevant framework, advocating for open research infrastructure, equitable access to scientific knowledge, and interoperable data systems – principles that directly apply to the design of national research and education networks (UNESCO, 2021). For instance, India leverages open APIs to create a unified ecosystem for identity (Aadhaar) and payments (Unified Payments Interface), fostering economic autonomy independent of global tech giants (Hariharan and Natarajan, 2024).

Beyond infrastructure: Building a national innovation ecosystem

Connectivity infrastructure alone cannot drive scientific advancement. Without complementary investments, Global South nations risk remaining passive technology consumers rather than active knowledge producers. Multiple elements must work together: research and development generate innovations, then skilled workers create them, competitive markets sustain them, national strategies ensure they serve public needs and reliable energy powers them. Critically, robust data governance is an essential complement to

connectivity infrastructure: without policies mandating local data storage and processing for public-interest research data – including biodiversity records, climate measurements and health information – sovereign connectivity alone cannot prevent scientific data from being extracted and governed by foreign laws. Building this workforce requires mobilizing the full talent pool. Where women remain underrepresented in ‘science, technology, engineering and mathematics’ and ‘information and communication technology’ fields – as they do across most of the Global South – nations constrain their capacity to staff, govern and innovate within sovereign connectivity systems.

Robust and sustainable energy infrastructure

Energy infrastructure is the foundation for digital connectivity and scientific progress – complementing the human capital, innovation ecosystems and regional cooperation addressed above. Without reliable, affordable and sustainable power, digital sovereignty and scientific autonomy are undermined (Powell and Sati, 2025). Emerging technologies demand substantial and growing energy resources. LEO satellite systems require reliable power – a significant challenge in low-income regions lacking stable grid access (Internet Society, 2022). While mobile technology improves energy efficiency per bit, total consumption rises as data traffic surges and 6G architectures require dense small cell networks (TechSci Research, n.d.). Furthermore, quantum computing relies on complex, costly cryogenic cooling to preserve quantum behaviour (EPO and OECD, 2025). For the Global South, these demands collide with severe power deficits. Without reliable electricity, connectivity investments risk turning an economy into a passive data exporter rather than generating local benefits. Translating these enabling conditions into practice requires coordinated action across government agencies, research institutions and the private sector.

Strategic recommendations for science, technology and innovation organizations

The Global South must transition from passive connectivity consumption to active infrastructure development, asserting control over physical infrastructure, strategic partnerships and knowledge production – the capacity to generate, process, analyze and publish scientific findings using locally controlled connectivity and computing infrastructure. A phased approach allows nations to capture immediate gains while laying foundations for deeper technological autonomy. Immediate measures include mandating open standards in procurement, enacting data localization policies for public-interest research data and adopting post-quantum cryptography. Medium-term priorities involve deploying shared regional infrastructure, establishing collaborative innovation hubs and building local training capacity. Longer-term ambitions – such as regional LEO constellations, shared quantum networks and

cooperative semiconductor development – require pooled investment and sustained coordination, following successful models proven by AfricaConnect3 and RedCLARA.

Government science, technology and innovation agencies: From access providers to infrastructure architects

Science and technology agencies must transcend their traditional role as internet access providers to become strategic architects of digital public infrastructure. Priority actions include:

- **Build shared regional infrastructure:** Pool resources across neighbouring countries to construct connectivity infrastructure together, following the models demonstrated by AfricaConnect3 and RedCLARA. This aggregates demand, reduces costs for individual nations, and strengthens collective bargaining power when negotiating with dominant technology companies.
- **Require strategic local data storage:** Public-interest research data – including biodiversity records, climate measurements, health information and Indigenous knowledge – must be stored and processed within national borders. This establishes data flows based on rights and agreements rather than allowing unrestricted extraction by foreign platforms.
- **Mandate open standards in government purchasing:** Require Open RAN technology and interoperable systems when governments buy telecommunications equipment. This diversifies supply chains by allowing countries to mix and match components from different manufacturers instead of being locked into a single vendor.

Universities and research institutions: Reclaiming knowledge production

Research institutions must leverage national research and education networks as platforms for scientific sovereignty:

- **Transform national research and education networks into comprehensive service platforms:** Upgrade national research and education networks to provide sovereign cloud storage, high performance computing and federated identity systems directly to researchers, reducing dependence on foreign commercial providers. Federated identity systems allow researchers to authenticate once and access shared computing grids, datasets and instruments across multiple countries, facilitating seamless, cross-border scientific collaboration over sovereign infrastructure.
- **Establish experimental technology zones:** Create spaces where researchers can test emerging technologies – 6G sensing, quantum-secure communications, AI training on local datasets – without restrictive commercial licensing, enabling locally-tailored innovation.
- **Create diaspora engagement programmes:** Enable expatriate scientists to remotely lead laboratories and mentor local researchers through national research and education

network infrastructure, facilitating knowledge transfer without requiring physical relocation.

Private sector: From extraction to co-creation

Companies must align profit motives with national sovereignty objectives through strategic partnerships:

- **Develop university-industry incubators for local intellectual property ownership:** Create partnerships emphasizing technology transfer and domestic intellectual property rights, ensuring innovation value stays within the local economy rather than flowing to foreign corporations.
- **Adopt Build-Operate-Transfer models:** Structure infrastructure deals so ownership eventually transfers to national institutions, with training programmes enabling local engineers to independently maintain and upgrade systems.
- **Design for national research infrastructure compatibility:** Build solutions compatible with national research and education networks and digital public infrastructure through open APIs, and establish local data caching nodes – particularly for LEO satellite operators – as a condition of market access, creating edge infrastructure that serves both commercial and research purposes while ensuring that scientific data flows through sovereign systems.

Conclusion

NCTs constitute the infrastructure of 21st-century scientific discovery. For the Global South, these technologies present a complex challenge: how to leverage technological advancement while simultaneously building strategic control over knowledge production – navigating partnerships and dependencies rather than choosing between them.

Dependency is not inevitable. India's local telecom stack, Vietnam's semiconductor manufacturing, Chile's strategic geography and Egypt's transit monopoly demonstrate that nations can secure meaningful autonomy through local innovation, imported expertise, geographic leverage or regional cooperation. Each approach breaks the cycle where the Global South provides raw data while the Global North captures intellectual property and economic value.

Yet infrastructure is insufficient on its own. Connectivity sovereignty requires sustained political commitment, regulatory frameworks resilient to corporate pressure, domestic technical capacity that outlasts political transitions, and strategic partnerships that balance collaboration with independence.

For science systems specifically, the stakes are clear: connectivity sovereignty determines whether Global South institutions can conduct, analyze, publish and benefit from their own research – or whether they remain primarily as field stations generating data for processing elsewhere. Realizing the potential of LEO satellites, 5G/6G networks, edge computing and quantum communications requires that science, technology and innovation organizations, universities and private partners coordinate investment across connectivity infrastructure, local computing capacity, human capital and data governance simultaneously. Digital self-determination – the agency to participate in global research on equitable terms – is ultimately what will empower Global South science ecosystems to thrive (International Telecommunication Union, 2025).

Glossary of terms

- **Connectivity sovereignty:** The capacity of a state to own, control, and regulate the transmission infrastructure (satellites, cables, and wireless networks) that moves data across its territory and borders.
- **Delay-tolerant networking:** A store-and-forward protocol utilizing LEO satellites to aggregate data from remote sensors, carry it in orbit and transmit the bundled results when network connections become available.
Digital public infrastructure: Shared digital systems – such as digital identity, payment gateways and data exchange layers – that serve as public utilities to support national innovation.
- **Digital self-determination:** The right of communities, organizations and states to independently decide how their data is collected, owned and used to serve local priorities rather than foreign interests.
- **Digital sovereignty:** The capacity of a state to control the complete technology stack – from hardware manufacturing and software to data ownership – reducing structural dependency on foreign powers.
- **Edge computing:** A system combining local hardware and specialized software to process information close to where the data is created – such as at remote research sites – rather than transmitting it to distant data centres, which reduces latency and supports national data sovereignty.

- **Harvest Now, Decrypt Later:** A strategic cybersecurity threat where adversaries record and archive today's encrypted communications with the intention of decrypting them in the future when quantum computers become powerful enough to break conventional encryption methods.
- **Integrated sensing and communication:** A key feature of 6G technology that transforms wireless networks into high-precision sensors to detect the location, velocity and composition of physical objects in the surrounding environment, such as vehicles, atmospheric particles or structural elements.
- **Low Earth orbit (LEO) satellites:** Non-geostationary spacecraft deployed in mega-constellations between 160 km and 2,000 km above Earth, enabling continuous, low-latency connectivity for global scientific observation.
- **National research and education network:** A dedicated internet infrastructure and specialized service provider that supports the high-bandwidth connectivity and advanced technological needs of the research and education communities within a country.
- **New connectivity technologies (NCTs):** Advanced technologies including satellite networks, 5G/6G systems, edge computing and quantum communications that allow nations to bypass traditional infrastructure deficits and facilitate real-time, decentralized scientific collaboration.
- **Open RAN (Open Radio Access Network):** A network architecture that standardizes interfaces between hardware and software, allowing operators to mix and match components from different vendors.
- **Quantum key distribution:** A secure communication method that uses quantum mechanical principles to exchange encryption keys, making any eavesdropping attempt immediately detectable.

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