

# The Role of ICT and Engineering in Advancing the “Prosperous Nepal, Happy Nepali”

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## Abstract

The national aspiration of a “Prosperous Nepal, Happy Nepali” requires a decisive shift from traditional administrative and infrastructural practice toward comprehensive digital transformation and modern engineering. This paper presents an updated strategic roadmap for embedding Information and Communication Technology (ICT) and engineering at the core of Nepal’s development cycle, grounded in current national data through 2025. Despite persistent structural challenges — a youth unemployment rate near 20.6 percent and an average outflow of roughly 2,075 workers per day for foreign employment — Nepal retains substantial latent capacity through its hydropower endowment, youthful demographic profile, expanding IT export sector, and strategic location between two of the world’s largest economies. Adopting a six-stage “Smart Nation Building Cycle,” the country can progress toward transparent e-governance, resilient digital infrastructure, and green-energy-led industrial growth. Drawing on recent regulatory developments — including the pending IT and Cybersecurity Bill 2082, the National Identity Card rollout, and the draft Digital Nepal Framework 2.0 — this paper examines actionable engineering models such as face-less service delivery, blockchain-based public procurement, underground utility ducting, and automated social-security systems. It concludes with a structured five-year implementation roadmap, a discussion of implementation constraints, and the critical role engineering students and professionals must play in leading this technological renaissance.

**Keywords:** ICT, Engineering, E-Governance, Smart Nation, Sustainable Infrastructure, Digital Transformation, Hydropower, Cybersecurity, Nepal

## 1. Introduction: The Need for Transformation

Nepal currently stands at a critical historical juncture. While citizens have witnessed repeated systemic political change over the past two decades, the anticipated improvements in daily governance and public service delivery remain largely unrealised. This gap between political transition and institutional performance can only be closed through the deliberate, sustained adoption of technology and engineering discipline across the machinery of the state.

The country continues to face severe structural challenges, including rapid and unmanaged urbanisation, chronic administrative delay, and an import-oriented economy sustained disproportionately by remittance income

rather than domestic production. The socio-economic evidence underlines the urgency of reform:

- The youth unemployment rate (ages 15–24) stood at approximately 20.6 percent in 2024/25, according to World Bank/ILO modelled estimates — more than four times the global average and among the highest in South Asia.
- Department of Foreign Employment data for FY 2082/83 show an average of roughly 2,000+ Nepalis departing the country each day for foreign employment, a figure that has remained stubbornly stable across successive governments.
- Workers’ remittances equalled 28.2

percent of GDP based on eleven-month data for FY 2082/83, according to Nepal Rastra Bank — among the highest remittance dependency ratios in the world, and a structural vulnerability rather than a strength.

- Unmanaged solid waste, urban air pollution, and traffic congestion continue to erode quality of life in Kathmandu Valley and other rapidly growing municipalities.

Yet the opportunities available to Nepal are equally significant. As of 2083, the country’s installed hydropower capacity had reached approximately 3,983 MW — still less than one-tenth of the roughly 42,000–43,000 MW considered economically feasible out of a gross technical potential near 83,000 MW. Nepal also possesses unparalleled natural and cultural heritage, a creative and increasingly digitally literate youth workforce, and a strategic location between the massive economies of India and China.

On connectivity, the picture is more nuanced than headline figures suggest. The Nepal Telecommunications Authority’s Management Information System (MIS) report for the period ending 2025 recorded 31 million broadband subscriptions nationwide, equivalent to a subscription-based penetration rate of roughly 148.7

percent of the population — a figure inflated by multiple SIM ownership and shared fixed-broadband connections. Independent global digital-trend trackers place the genuine unique-user population closer to 56 percent as of 2025. This gap between subscription penetration and actual individual access is itself an important planning signal: Nepal’s digital divide is not primarily one of network availability but of affordability, digital literacy, and last-mile inclusion, particularly outside urban centres.

The country’s digitaleconomy is also emerging as a genuine growth engine. Industry estimates from the Nepal Association for Software and IT Services (NAS-IT) indicate that IT and IT-enabled service exports crossed the symbolic US\$1 billion mark in 2025, more than doubling in three years from roughly US\$515 million in 2022, driven by software development, healthcare data analytics for United States clients, home-loan data processing for Australian firms, and a growing artificial-intelligence services cluster. Harnessing these converging opportunities — hydropower, connectivity, and a maturing IT export base — requires abandoning traditional administrative working styles and treating technology-driven transformation as an operational necessity rather than an aspirational slogan.

Table 1. Key Digital and Socio-Economic Indicators of Nepal (2024–2025)

| Indicator                                   | Value                                        | Reference Period | Source                              |
|---------------------------------------------|----------------------------------------------|------------------|-------------------------------------|
| Youth unemployment rate (ages 15–24)        | 20.6%                                        | 2024/25          | World Bank / ILO modelled estimate  |
| Average daily net outbound labour migration | ~2,000+ persons/day                          | FY 2025          | Department of Foreign Employment    |
| Workers’ remittances (% of GDP)             | 28.2%                                        | 2025             | Nepal Rastra Bank                   |
| Broadband internet subscriptions            | 31 million (148.7% subscription penetration) | 2025             | NTA MIS Report                      |
| Estimated unique internet users             | ~56% of population                           | Late 2025        | Independent global digital trackers |
| Installed hydropower capacity               | ~3,983 MW                                    | Poush 2082       | IPPAN, Energy Statistics of Nepal   |

|                                                 |                                                |          |                                       |
|-------------------------------------------------|------------------------------------------------|----------|---------------------------------------|
| Economically feasible hydropower potential      | ~42,000–43,000 MW                              | —        | ADB / national hydropower assessments |
| UN E-Government Development Index (EGDI) rank   | 119th of 193 (score 0.5781)                    | 2024     | UN DESA E-Government Survey 2024      |
| National ID (NID) enrolment vs. cards collected | 17.21 million enrolled; 2.31 million collected | Mid-2025 | DoNIDCR                               |
| IT / software service exports                   | ~US\$1 billion                                 | 2025     | NAS-IT                                |

2. The Smart Nation Building Cycle

To achieve holistic development, Nepal’s digital transition should follow a logical, evolutionary cycle that progresses from individual capability to national prosperity. This roadmap can be organised into six interconnected stages:

- Smart Governance — building the digital infrastructure and institutional transparency on which all other stages depend.
- Smart People — fostering digital literacy and inclusivity so that citizens of every age and region can use government and commercial digital services with confidence.
- Smart Economy — promoting innovation, entrepreneurship, and paperless, digitally-recorded workplaces across the public and private sectors.
- Smart Infrastructure — enhancing connectivity, smart grids, and citizen-friendly local communities through coordinated civil and electrical engineering.
- Smart Security — ensuring robust data privacy, cybersecurity, and critical-infrastructure protection.
- Smart Sustainability — building environmental adaptability and improving living standards en route to a corruption-resistant, green-energy-driven, export-oriented economy.

This sequencing is not merely theoretical. The 2024 United Nations E-Government Survey grouped Nepal among a cohort of least-

developed countries — alongside Bangladesh, Bhutan, Rwanda, Cambodia, Senegal, and Myanmar — that have shown consistent, measurable progress in digital government development since 2022, offering practical benchmarks for how each stage of the cycle can translate into improved international standing.

3. E-Governance: The Foundation of Transparent Administration

A core pillar of a prosperous Nepal is the establishment of technology-rich e-governance capable of delivering fast, agile, and transparent services to citizens and businesses alike.

3.1 E-Governance Models

- G2C (Government to Citizen): digitising birth registration, taxation, certification, and social-security allowances.
- G2B (Government to Business): facilitating investment-friendly services such as business registration, tax payment, and licensing.
- G2G/G2E (Government to Government/ Employee): strengthening internal digital collaboration among inter-governmental agencies and administrative staff.

Nepal’s progress on this front is measurable but modest. In the 2024 UN E-Government Survey, Nepal ranked 119th of 193 countries with an E-Government Development Index (EGDI) score of 0.5781 — a six-place improvement over its 125th-place ranking in 2022, and the country’s best result since it first reached 117th in 2018. However, Nepal’s E-Participation Index rank of 152nd reveals

a persistent weakness: citizens still have very limited structured means of engaging with, commenting on, or co-producing digital public services, which undermines the transparency objectives that e-governance is meant to serve.

### 3.2 Face-less Systems and Technology-Enabled Anti-Corruption Mechanisms

Direct physical contact between service seekers and government employees frequently breeds administrative delay and rent-seeking behaviour. A “face-less” system that channels the overwhelming majority of routine government transactions through online portals would materially reduce these frictions. A realistic medium-term target should be automation of the large majority of high-volume government services within the current five-year planning horizon, building on the roughly 50 services already identified for early-phase digitisation under Nepal’s policy pipeline.

To ensure good governance, technological interventions must progressively replace discretionary human decision-making with auditable digital workflows. Complementary anti-corruption engineering measures include:

- Blockchain-based e-procurement for public tenders, enabling verifiable, tamper-resistant records that move evaluation away from a narrow “lowest bidder” metric toward balanced quality-cost scoring.
- Merit-based appointment systems drawing exclusively from a National Expert Roster, reducing the scope for politically motivated appointments in technical positions.
- A PM Delivery Unit model, using public dashboards for real-time monitoring of flagship project execution to strengthen direct public accountability.

## 4. Digital and Physical Infrastructure Resilience

### 4.1 Unified Digital Identity and Data Centres

A major administrative frustration in Nepal is the repeated collection of near-identical demographic data across different agencies.

This is being addressed through the National Identity Card (Rastriya Parichaya Patra), established under the National Identity Card and Registration Act 2076 (2019) and administered by the Department of National ID and Civil Registration (DoNIDCR) under the Ministry of Home Affairs. The card links citizenship, biometric data, and a unique ten-digit National Identification Number intended to interoperate with banking KYC, taxation (PAN), telecom SIM registration, social-security enrolment, and — progressively — health insurance.

Enrolment has advanced faster than physical distribution: as of mid-2025, more than 17.21 million citizens had enrolled for the National ID, yet only about 2.31 million had actually collected their physical card, exposing a significant “last-mile” bottleneck in card printing and distribution logistics. The Nagarik App now functions as a parallel digital-identity layer, allowing many citizens to use their National Identification Number for service access even before physical card collection. Closing this enrolment-to-collection gap should be treated as a priority engineering and logistics problem, not merely an administrative one — it directly determines whether the “One Citizen, One Digital Identity” vision translates into a usable service backbone.

Supporting this identity layer requires robust Cloud Data Centres and Disaster Recovery (DC-DR) sites engineered to at least Tier-3/4 standards, incorporating Precision Air Conditioning (PAC) cooling and N+1 power redundancy, so that continuity of citizen-facing services is not dependent on a single physical facility. Given that a World Bank Country Economic Memorandum for Nepal (2025) notes continued dependence on India and China for international internet bandwidth, redundancy planning must also address cross-border connectivity risk, not only domestic infrastructure failure.

### 4.2 Clean and Green Urban Infrastructure

To prevent the continuous and costly re-excavation of urban roads for utility

maintenance, modern civil engineering practice should deploy integrated underground utility duct systems. Multi-lane underground ducting can safely house electrical wiring, telecommunications and optical-fibre cabling, water supply lines, and sewerage — reducing long-run maintenance cost while improving urban aesthetics and pedestrian safety.

Urban mobility should be transformed in parallel through smart transportation: replacing ageing, emission-heavy vehicles with electric bus networks powered increasingly by domestic hydropower; consolidating fare payment onto a single NFC-based travel card across public transit modes; and deploying sensor-based smart parking management to reduce the search-for-parking congestion that disproportionately affects core urban corridors.

## 5. Sectoral Modernisation

### 5.1 Green Energy and Digital Innovation

Nepal's clearest strategic advantage remains its water resources. With installed hydropower capacity at approximately 3,983 MW against an economically feasible potential of roughly 42,000–43,000 MW, less than one-tenth of the accessible resource has been developed. Government and industry statements have referenced a range of medium- and long-term capacity targets — from roughly 15,000 MW within the current government's tenure to longer-run visions exceeding 28,000 MW by the mid-2030s — aimed at both meeting rising domestic demand and substantially expanding electricity exports to India and, prospectively, Bangladesh. Regardless of which specific target is ultimately adopted, the direction of travel is unambiguous: hydropower capacity must expand several-fold to underwrite both domestic industrialisation and export revenue.

Domestically, this expanding energy base can power electric railways and cable-car systems connecting inter-city networks and efficiently moving agricultural produce to market. The cold climate of the Himalayan region, combined with abundant and

increasingly reliable hydropower, also offers a genuine comparative advantage for high-density computing — including data centres and AI-training infrastructure — that could anchor a new category of energy-intensive digital exports if paired with the fibre and international-bandwidth upgrades discussed in Section 4.1.

### 5.2 The Digital Economy: IT Exports and the Artificial Intelligence Opportunity

Nepal's IT and IT-enabled services sector has moved from a marginal export category to a genuine pillar of foreign-exchange earnings, with 2025 exports estimated at approximately US\$1 billion by NAS-IT, spanning software development, business-process outsourcing, healthcare data analytics, and artificial-intelligence services. The government's draft Digital Nepal Framework 2.0 sets a ten-year target of Rs 30 billion in IT-related service exports alongside 500,000 direct and roughly one million indirect jobs, complemented by a National AI Policy (2025) and an emerging "IT Decade Vision" organised around a Foundation-Access-Skills-Growth (FASG) model of digital public infrastructure, connectivity expansion, workforce development, and private-sector growth.

Realising this potential requires sustained investment in tertiary ICT education, expanded high-quality (including 5G) connectivity, and stronger data-hosting and cloud infrastructure — areas where the World Bank's 2025 Nepal Country Economic Memorandum notes that digitally-provided service exports have already grown at an average annual rate of 12.3 percent between 2005 and 2023, positioning Nepal favourably within South Asia despite its landlocked geography and continued reliance on neighbouring countries for international bandwidth.

### 5.3 Agricultural and Industrial Renaissance

Agriculture remains the backbone of Nepal's economy, yet it requires a comprehensive engineering overhaul. Deploying IoT sensors and drone technology for soil testing, crop monitoring, and precision irrigation would

meaningfully raise yields and reduce input waste. In land-constrained urban areas, multi-tier vertical farming can be applied to high-value crops, while an “E-Mandi” digital marketplace platform can connect farmers directly to consumers and institutional buyers, reducing the margin currently captured by intermediaries.

Industrially, a Public-Private Partnership (PPP) model should be used to revive closed state industries such as the Gorkhakali tyre factory, Hetauda cloth factory, and Birgunj sugar mill, applying modern process engineering rather than simply restoring legacy operations. Establishing “Innovation Hubs” across all seven provinces, paired with tax exemptions for IT- and manufacturing-export-oriented companies — several of which already exist under Nepal’s Income Tax Act framework, including reduced withholding rates for individual IT freelancers earning foreign-currency income — would help translate Kathmandu-centred digital growth into genuinely national employment gains.

#### **5.4 Social Sectors: Education, Health, and Inclusivity**

- **Education:** deploying high-speed internet in public schools, establishing a “One Nation, One Learning Platform,” and expanding digital assessment systems for national examinations.
- **Healthcare:** centralising services via Digital Health Cards and Electronic Medical Records (EMR), alongside national real-time tracking of pharmaceutical supply chains and tele-medicine portals for remote and mountain districts.
- **Social Security and Inclusivity:** routing tax administration, civil registration, and social-security allowances through fully automated systems tied to the National ID; mandating inclusive design — ramps, elevators, and lactation rooms — in all new public buildings.

#### **5.5 Cybersecurity and Data Governance**

Nepal’s current data-protection and

cybersecurity framework is fragmented across several instruments: Article 28 of the Constitution of Nepal (2015), which recognises a constitutional right to privacy of data and correspondence; the Privacy Act 2075 (2018) and the Individual Privacy Regulation 2077 (2020); and the Electronic Transactions Act 2063 (2008), which currently governs digital signatures, electronic records, and cybercrime. A consolidated IT and Cybersecurity Bill 2082 was registered in the House of Representatives in June 2025 and tabled by the Communications Minister in August 2025; as of mid-2026 it remains in the amendment and public-comment phase. The bill would replace the 2063 Act, introduce a mandatory 35-day data-destruction rule for entities holding personal information once its purpose has been fulfilled, and modernise cybercrime provisions.

Civil-society reviewers, including Digital Rights Nepal, have flagged significant remaining gaps: the absence of a dedicated, independent data-protection regulator; no statutory breach-notification obligation; limited codified data-subject rights such as access, correction, deletion, and objection; and no explicit alignment with the United Nations Convention against Cybercrime, which Nepal will eventually be obliged to observe. From an engineering standpoint, the proposed National Cyber Security Operations Centre (N-SOC) for continuous monitoring of government and critical-infrastructure networks should be designed and funded in step with — not after — this legislative process, so that technical capability and legal authority mature together rather than leaving either the law or the infrastructure as the binding constraint.

#### **6. The Interdisciplinary Role of Engineering**

Building a prosperous Nepal is not the sole domain of IT professionals; it requires the synchronised effort of every engineering discipline:

- **Software Engineering:** developing e-governance platforms, databases, mobile applications, and cybersecurity frameworks.

- **Civil and Urban Engineering:** designing utility ducting, smart roads, bicycle lanes, and modern, seismically resilient building codes.
- **Electrical and Electronics Engineering:** developing smart grids, EV charging infrastructure, and advancing hydropower generation and transmission projects.
- **Mechanical Engineering:** designing automation systems, HVAC for data centres and hospitals, robotics, and industrial machinery for the revived manufacturing base.

These disciplines converge in concepts such as “Smart Living,” where homes and offices use automation for remote lighting and thermostat control, integrated biometric security and video door-phones, and smart

utility management such as waterless urinals and automatic power-cut water tanks. At the macro level, this engineering synergy enables intelligent traffic management using PTZ CCTV cameras, GPS-equipped bus stops, and overload-detection sensors on bridges and transmission infrastructure.

7. Five-Year Implementation Roadmap

Translating this vision into practice requires a structured, milestone-driven five-year implementation plan, summarised in Table 2. The plan is deliberately sequenced so that legal and institutional foundations precede large-scale technical rollout, addressing the coordination weaknesses that the government’s own Digital Nepal Framework 2.0 diagnosis identifies as the principal cause of past implementation shortfalls.

| Phase                            | Timeline    | Key Activities and Milestones                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Phase 1: Policy Foundation       | 0–6 months  | Legal and regulatory reform (including enactment of a consolidated IT and Cybersecurity Act); piloting of at least 50 government e-services; formation of an inter-agency Digital Transformation Task Force to address the coordination gaps identified in the Digital Nepal Framework 2.0 diagnosis; baseline audit of existing data centres and connectivity infrastructure.                                                                              |
| Phase 2: Nationwide Rollout      | 6–24 months | Commissioning of a Tier-3/4 National Data Centre and Disaster Recovery site; phased expansion of face-less G2C/ G2B services; acceleration of National ID card printing and distribution to close the enrolment-to-collection gap; launch of underground utility-ducting pilots in two to three municipalities; scale-up of 4G/5G and fixed-broadband coverage in underserved districts.                                                                    |
| Phase 3: Complete Transformation | 2–5 years   | Achievement of 90% digitisation of prioritised government services; nationwide smart-grid and EV-charging network aligned with hydropower capacity additions; IT and AI-enabled service exports scaled toward the Digital Nepal Framework 2.0 target of Rs 30 billion over ten years; establishment of a fully operational National Cyber Security Operations Centre (N-SOC); institutionalisation of monitoring dashboards under a PM Delivery Unit model. |

## 8. Discussion: Implementation Constraints and Risk Factors

A credible roadmap must acknowledge the constraints that have historically slowed Nepal’s digital ambitions. The Digital Nepal Framework’s own retrospective assessment of its first iteration — launched in November 2019 with 80 projects across eight sectors and an original completion target of FY 2023/24 — cites weak institutional ownership, poor inter-agency coordination, limited financial resources, and insufficient technical capacity as the principal reasons for delayed delivery. These are governance failures as much as technical ones, and they will not be resolved by procuring new hardware or software alone.

Second, the gap between subscription-based internet penetration (148.7 percent) and genuine unique-user access (roughly 56 percent) shows that headline connectivity statistics can mask substantial urban-rural and income-based digital divides. Any faceless service model must therefore retain assisted-access channels — common service centres, ward-level digital literacy support — for citizens who are formally “connected” on paper but not meaningfully able to transact online.

Third, financing at the scale required for a several-fold expansion of hydropower capacity, national data-centre infrastructure, and underground utility ducting will demand blended public, private, and multilateral capital, alongside credible, bankable project pipelines — a persistent constraint given that a large share of Nepal’s surveyed and licensed hydropower capacity has yet to reach financial close or construction.

Finally, the legislative gap around data protection — with the IT and Cybersecurity Bill 2082 still in the amendment stage as of mid-2026 — means that citizen data collected through National ID enrolment,

digital health records, and e-governance platforms is currently accumulating faster than the legal safeguards meant to govern its use. Sequencing technical rollout ahead of enacted, enforceable data-protection law carries reputational and rights-based risks that engineering leadership in both government and industry should proactively flag rather than treat as someone else’s problem.

## 9. Conclusion

Moving beyond traditional rhetoric and distributive politics, it is evident that a concrete, well-financed, and properly sequenced technological vision is indispensable for controlling corruption, strengthening health and education delivery, reviving domestic industry, and creating durable jobs at home rather than exporting the country’s youngest and most capable workers abroad at a rate of roughly 2,000+ people every day. The realisation of this roadmap depends heavily on university students and young engineers who are willing to treat national development, rather than emigration, as their primary career project.

Students must step up as the vanguard of this transformation: engaging in technical research that connects university laboratories to national needs; developing startups that solve concrete local problems in agriculture, health, and public administration; and leading digital-literacy campaigns in their own communities so that the gap between subscription penetration and genuine access continues to close. Algorithms, properly designed and legally governed, do not take bribes and do not recognise nepotism; well-engineered infrastructure does not care whose relative built it, only whether it holds. By uniting ICT and engineering discipline with realistic, evidence-based planning, the vision of a genuinely prosperous and happy Nepal remains well within reach.

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