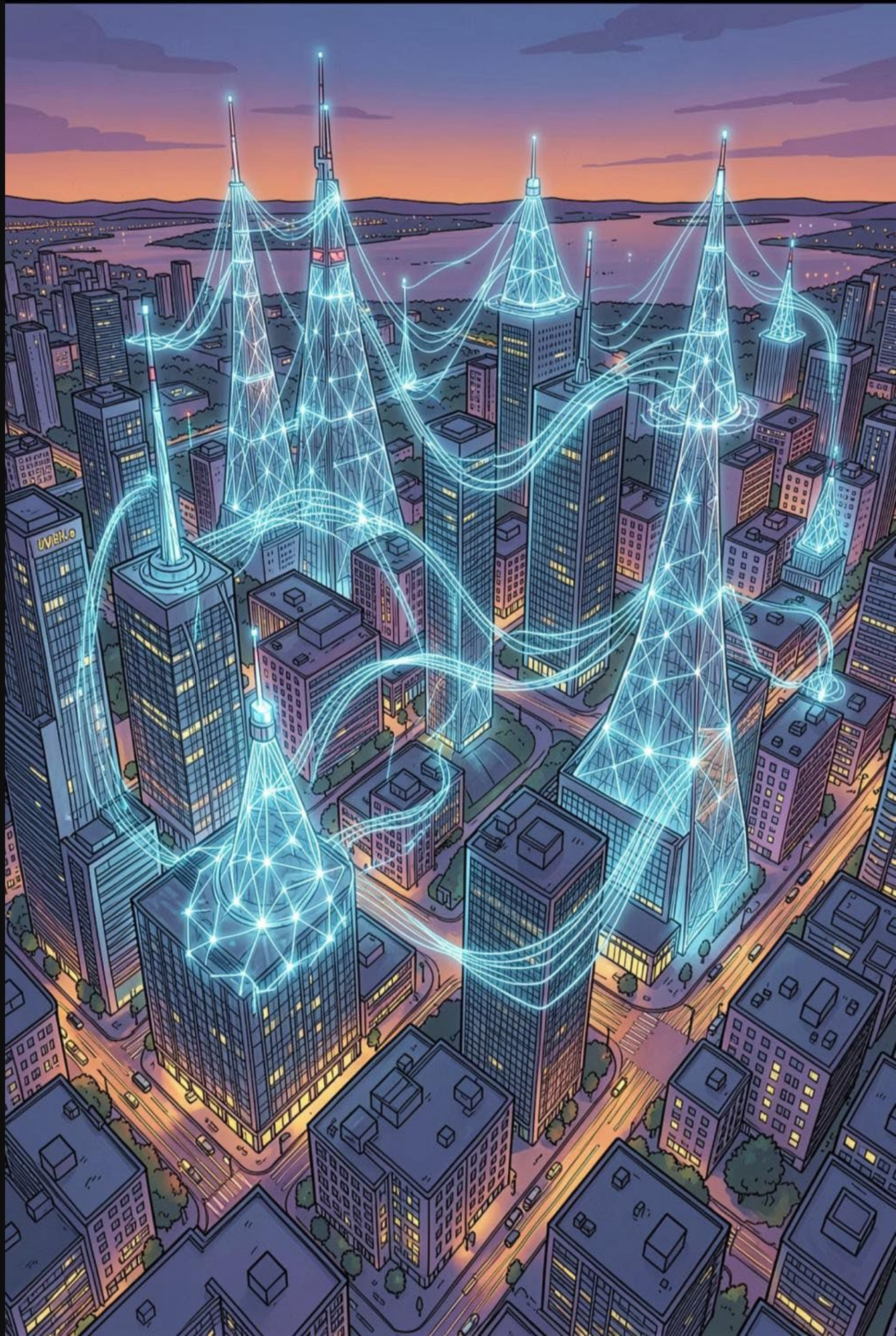
ITU UMC HACKATHON 2026

Bridging the Digital Divide by Uncovering Digital Deserts

We set out to ask a simple question: “ Does the connectivity that's reported match the connectivity that's felt on the ground?"

Live Tool: umc-network-monitor-t8xh.vercel.app

Presented By: Team QBits

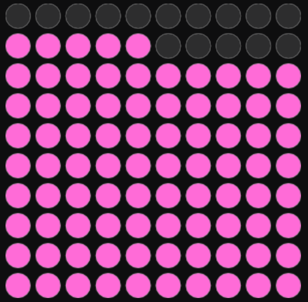


DIGITAL INCLUSION RESEARCH

The Connectivity Mirage — Measuring Real Network Coverage in Urban India

Official coverage maps record signal presence — not whether that signal is usable. This creates a critical measurement gap masking real disparities in speed, affordability, and access across urban India.

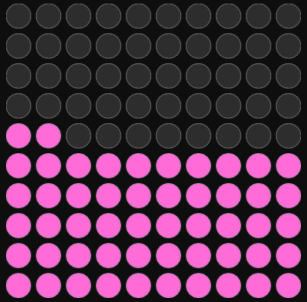
THE PROBLEM



85–100%

Regulator-Claimed Coverage

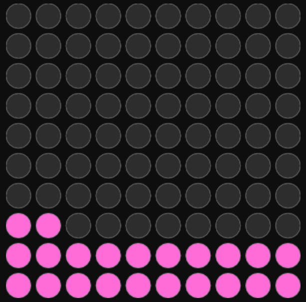
Strong coverage officially recorded across Delhi NCR



52%

Actual College Ground Coverage

Strong coverage verified through on-ground measurement



22%

Functionally Dead Cells

Cells unusable during peak academic hours

This gap is not a rounding error — it is the difference between reported signal presence and usable connectivity on the ground.

Official coverage maps record whether a signal *exists* — not whether it *works*. That gap is a **measurement paradigm failure** with real educational and economic consequences.

01 · MACRO ANALYSIS

Data Foundations & Policy Grounding

A multi-source dataset unified to analyze the macro layer — combining global ICT indicators, network performance tiles, and high-resolution population grids.

ITU Datahub

World ICT Indicators, ICT Price Baskets, and Household Access Surveys (2020–2024)

Ookla Open Data

Fixed and mobile network performance tiles, Q4-2024 Parquet files

WorldPop

100m resolution Population Grid TIF layer for density mapping

HDX

ADM2 India administrative boundaries shapefile — 700+ districts

4

Datasets Unified

Into one analytical framework

700+

Districts Mapped

Indian ADM2 districts covered

6.5M+

Raw Rows Processed

Ookla performance records ingested

Academic Validation: ITU-T G.1000/G.1010 (user-perspective QoS framework) · Broadband adequacy thresholds of 10 Mbps mobile / 25 Mbps fixed · Rao & Kumar, 'Chota Recharge' (60% busy-hour speed degradation)

01 · MACRO ANALYSIS

The Coverage Paradox

Current frameworks mark a region "connected" the moment a nominal signal exists — without checking if that connection supports education, work, or health.

The Gap

Theoretical coverage maps are used to evaluate connectivity — a region is marked "connected" the moment a nominal signal exists.

Geographical Consequence

Delhi NCR's dense concrete buildings create indoor Faraday-cage effects. A fully urban campus — has classrooms and hostels with RSRP < –102 dBm despite regulator’s map claiming 100% strong coverage. Peak-hour network congestion further degrades signal at the exact times students need it most.

Economic Consequence

Students in dead zones spend 3.3–6.7% of household income on compensatory data — exceeding ITU's 2% affordability threshold.

Social Consequence

Post-COVID, hybrid learning is the norm. Students 50m apart — one well-covered, one in a basement lab — receive measurably different educational experiences. Unlike rural gaps, urban hidden deserts are invisible: students normalise failure as a personal device issue, not a systemic policy failure with real data to prove it.

85-100%

Regulator’s Claimed

Official strong-coverage claim for Delhi NCR

51.8%

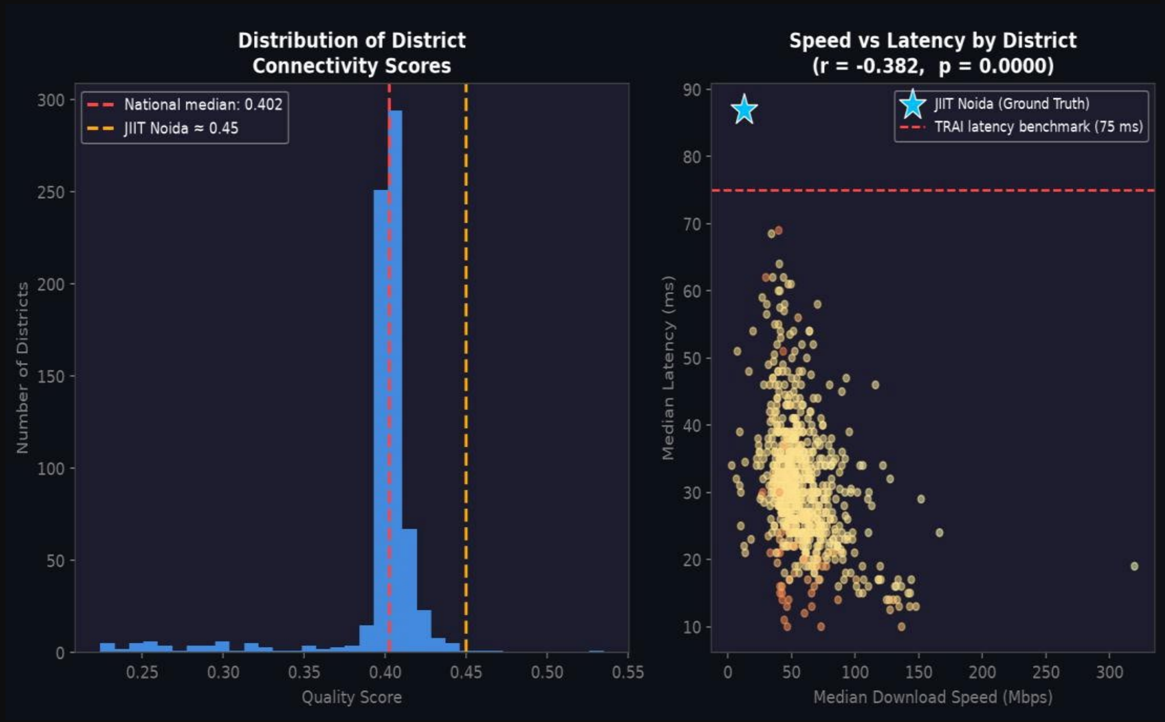
Ground Truth

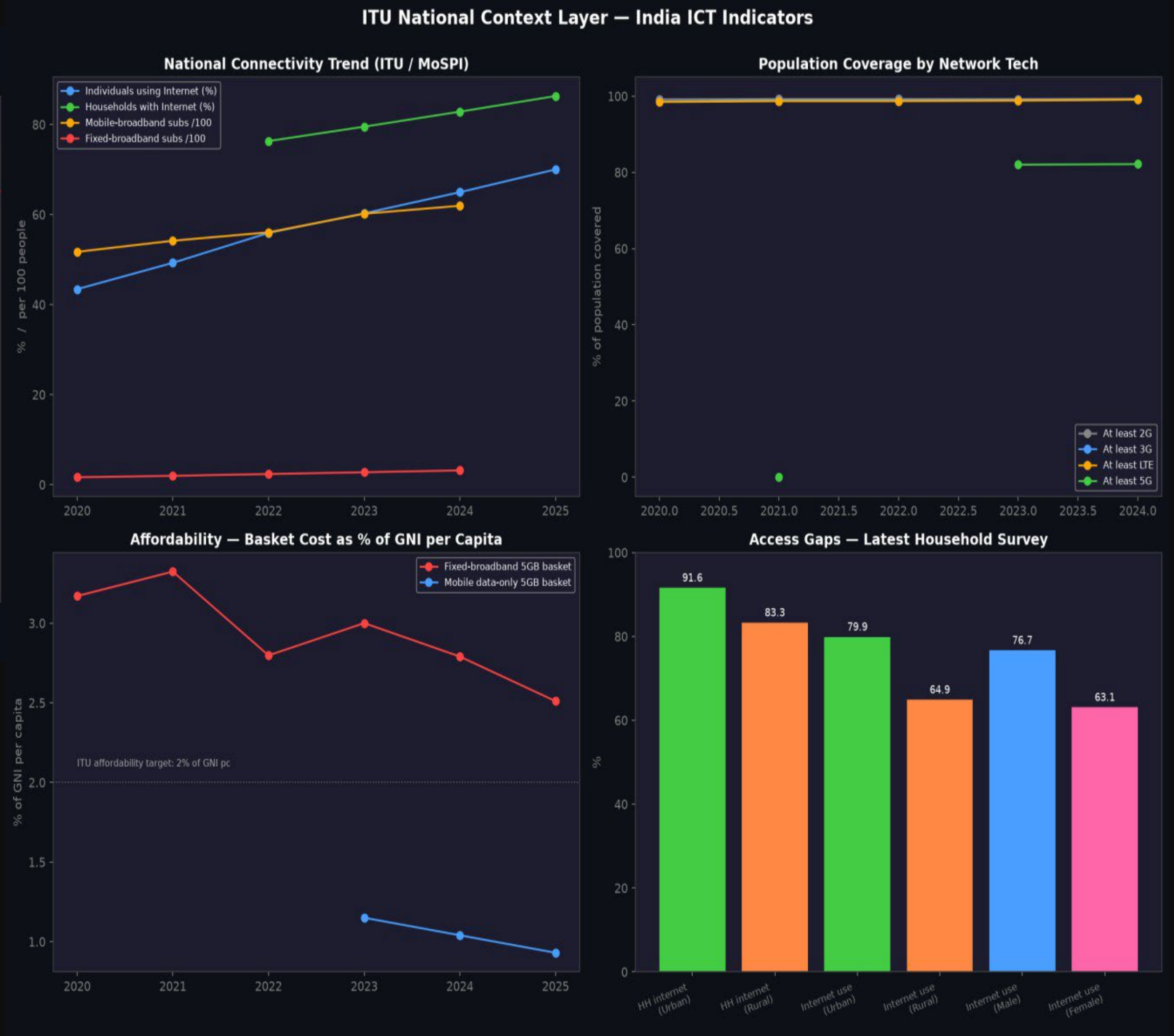
Actual strong-signal coverage at our campus

Official maps record a signal. Our framework measures whether it works.

Analysis Through ITU-Datasets

Used various ITU – India ITC Indicators datasets and plotted then using python and plotly

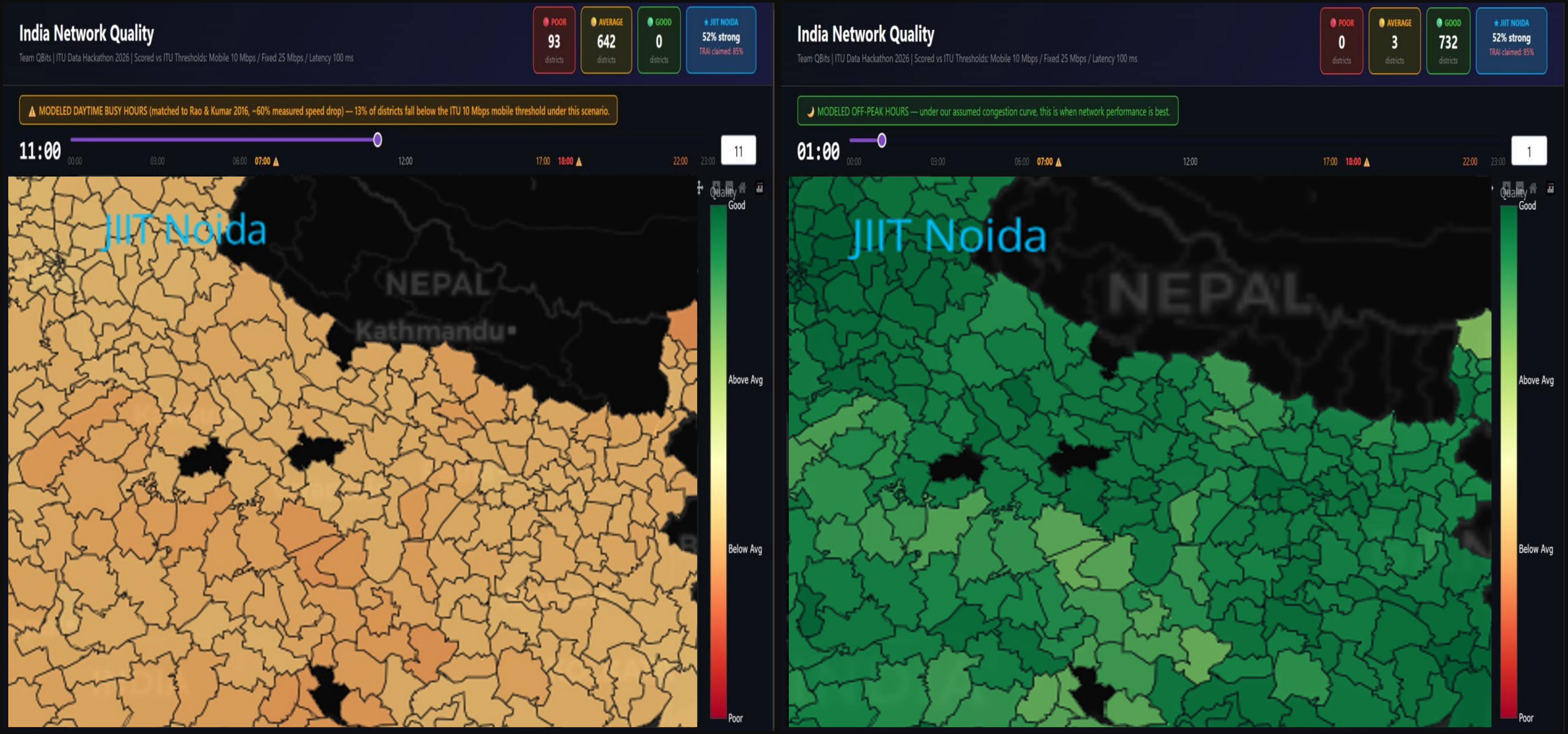




This analysis combines two statistical techniques:
Pearson Correlation (r) quantifies the strength and direction of linear relationships between metrics like speed and latency.
Significance testing (p-value) validates whether these correlations are statistically meaningful ($p < 0.05$)

01 · MACRO ANALYSIS

Macro-Level View: India's Network Quality, District by District



This is India, colored by network quality — red is poor, green is good — and every shape here is a real district, built from real Ookla Q4-2024 data, scored against standard broadband adequacy thresholds: 10 Mbps mobile / 25 Mbps fixed / under 100 milliseconds of latency

02 · MICRO ANALYSIS · GROUND TRUTH

Moving to the Micro-Grid: JIIT Noida Campus

A 27-cell hardware walk-test grid validates macro-layer findings on the ground — with GPS-tagged, timestamped readings at every cell.

MICRO-LEVEL · JIIT Noida Campus

Hardware Setup

PlutoSDR + Quectel RM520N-GL · 27 GPS-tagged cells
RSRP · SINR · Latency · Throughput · Peak & off-peak

Ground-Truth Findings at JIIT Noida

52%	26%	22%
Strong	Weak	Dead

vs. TRAI claim: 85–100% strong

What we modelled

- Indoor vs outdoor signal disparity per grid cell
- Peak-Hour Degradation Factor (morning / afternoon / evening)
- RSRP < –107 dBm in classrooms & hostels = 'Indoor Desert'
- Affordability burden: 3.3–6.7% HHI vs ITU 2% threshold

HDDI BRIDGE

- HDDI Index
- Indoor 40%
- Temporal 35%
- App-fit 25%
- Open-src <$500 or Even Mobile Phone
- Any campus or city

SOLVES → Coverage Lies

Official maps report signal existence, not usability. HDDI replaces it with measured, weighted ground truth.

SOLVES → Indoor Blindness

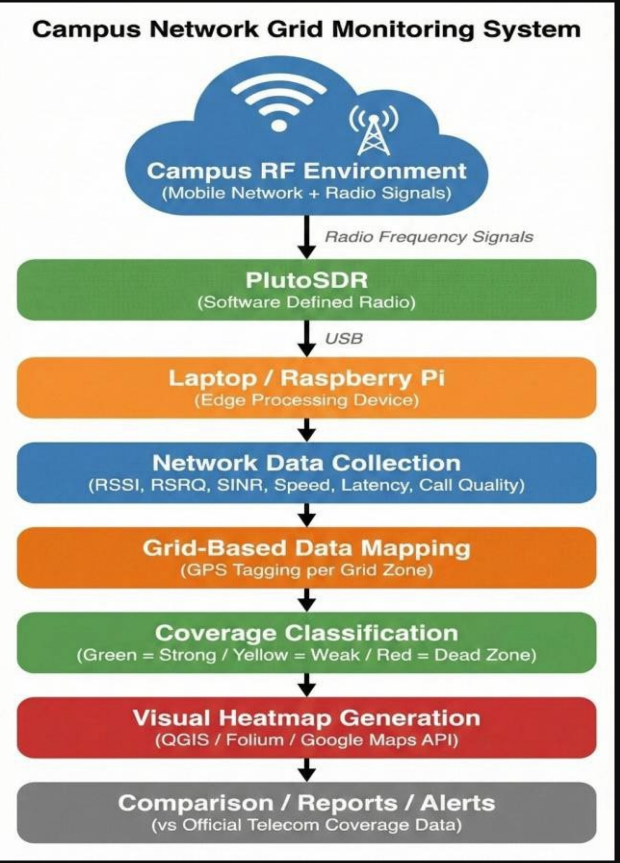
No regulator measures indoor quality. Our walk-test grid captures the building-penetration loss regulators ignore.

SOLVES → Temporal Gaps

Static maps miss peak-hour congestion. Our degradation factor captures when connectivity fails, not just where.

SOLVES → Policy Misallocation

Funds flow to 'uncovered' zones; urban deserts go unfunded. HDDI makes hidden deserts visible and fundable.



100% TRAI Official Claim — Strong Coverage at our college	51.8% Strong Zones — 14 of 27 cells
25.9% Weak Zones — 7 of 27 cells	22.2% Dead Zones — 6 of 27 cells

⚠ **Nearly 1 in 5 measured cells is functionally dead — invisible to the official 100% claim.**

Defining Meaningful Connectivity Metrics

An index that weights factors beyond pure signal presence — measuring what users actually experience.

The HDDI Formula

HDDI = 0.40 × **IQR** + 0.35 × **TDF** + 0.25 × **AppScore**

Network Quality Score: NQS = 100 − (HDDI × 100) — a 0–100 scale where higher is better.

IQR (Indoor Quality Ratio)

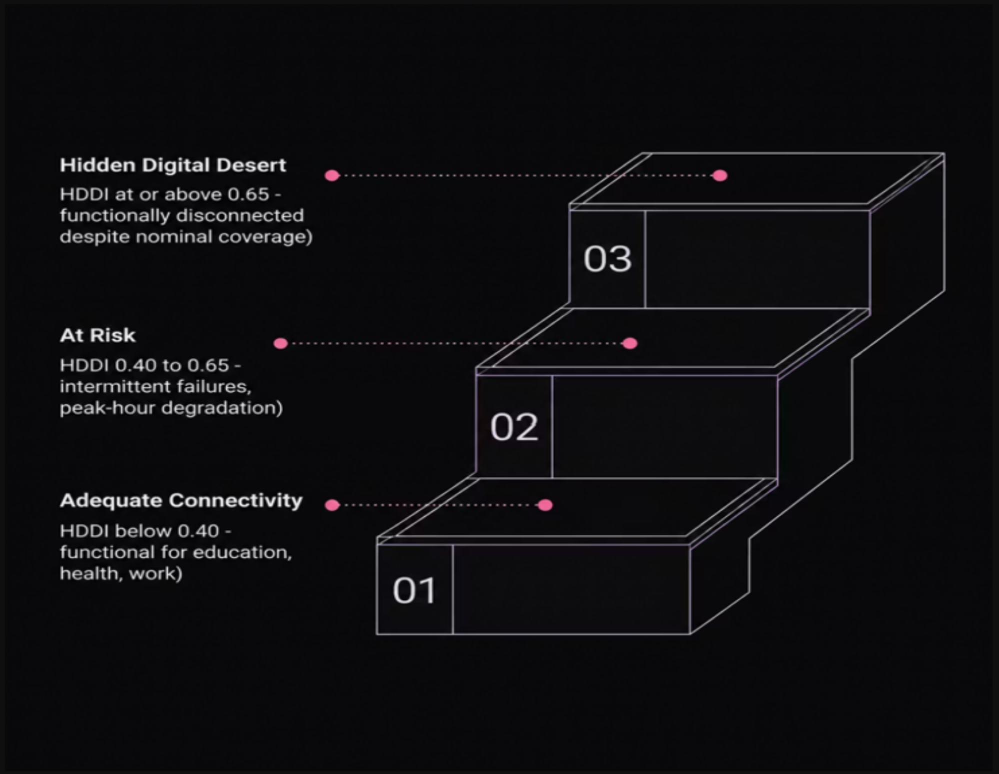
IQR = clamp(- (RSRP + 65) / 55, 0, 1)
Maps −65 dBm (best) → 0 and −120 dBm (worst) → 1

TDF (Temporal Degradation Factor)

TDF = min(1, degradeFactor / 100)

AppScore — application suitability failure score

AppScore = 1 – (met / 3)
where *met* = number of app thresholds passed (Education ≥5 Mbps & <100ms,, Health ≥3 Mbps & <150ms, Work ≥10 Mbps & ≥5 UL & <50ms)



IQR — Indoor Quality Ratio

Normalized RSRP signal strength inside buildings, where coverage maps fail hardest

TDF — Temporal Degradation Factor

Percentage drop in download speed during peak hours, capturing congestion maps never see

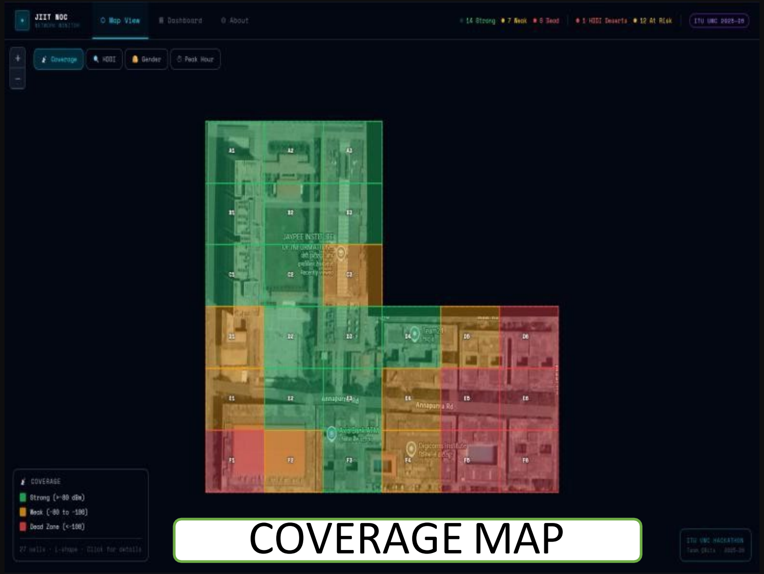
AppScore — Application Suitability

Failure rate against Education, Health, and Work bandwidth thresholds

Live Demonstration: The UMC Network Monitor

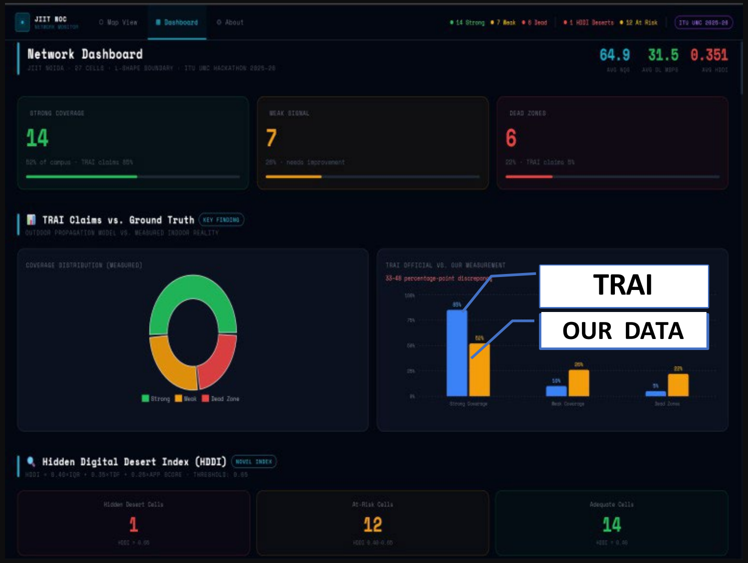
🔗 **LIVE:** umc-network-monitor-t8xh.vercel.app

For a richer experience, we invite the jury to explore our live dashboard



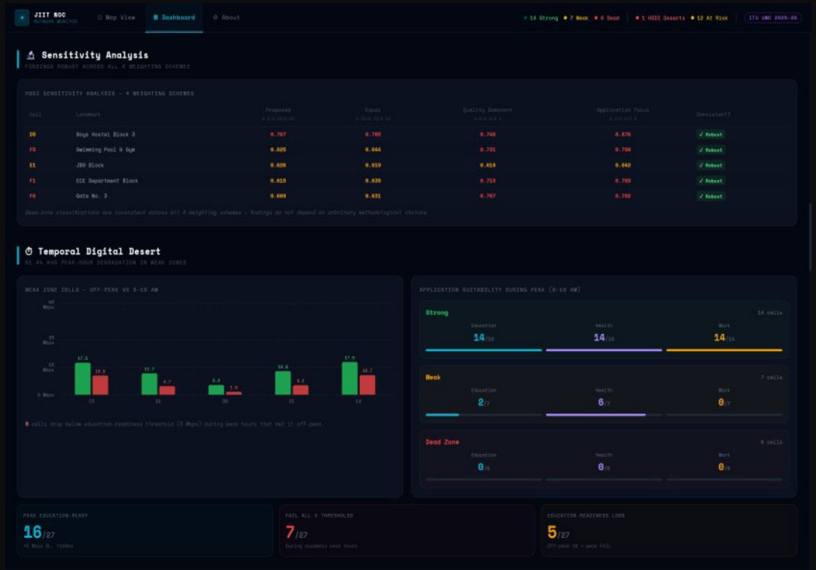
Coverage Map View

Seamless toggles between RSRP Coverage, HDDI Risk, Gender-Disaggregated, and Peak-Hour Degradation overlays



Network Dashboard

Interactive visualizations contrasting real-world measurements against official TRAI claims



Sensitivity & Temporal Analysis

Live stress-testing of weights proving our "Hidden Digital Desert" flags stay robust under every model configuration

From false maps to functional truth — our framework exposes hidden digital deserts and equips policymakers, NGOs, and technologists with evidence to demand meaningful connectivity.

POLICY BRIEF

Policy Recommendations

4 Evidence-Grounded Interventions with Social ROI Estimates

These four interventions address critical gaps in India's educational connectivity framework — from indoor coverage accountability to national measurement standards — each with near-zero to modest infrastructure cost and measurable social returns.

1

Mandatory Indoor Coverage Audits

TRAI propagation models overstate indoor quality by **33–48 percentage points**, leaving 40,000+ institutions unaccountable. Amend QoS guidelines to require separate indoor coverage with quarterly walk-test audits using open-source methodology.

Social ROI: Near-zero cost; creates accountability for 40,000+ institutions.

2

Targeted Small-Cell Deployment at HDDI > 0.65

Six dead-zone cells (C4, D5, D6, E5, E6, F1) with RSRP < −100 dBm serve the library, research labs, and all female hostels. Deploy small cells at top 4 dead-zones

Social ROI: $0.04–0.13/student/day; 400–600 students gain reliable connectivity; application suitability improves from 0/3 to 3/3.

3

Peak-Hour QoS Commitments for Academic Hours

Require operators to guarantee minimum 5 Mbps download + 100ms latency at registered institutions during 8–10 AM and 2–4 PM weekdays, with quarterly compliance reports.

Social ROI: Zero infrastructure cost; creates operator accountability for temporal digital deserts.

4

Scale Walk-Test Methodology as National Standard

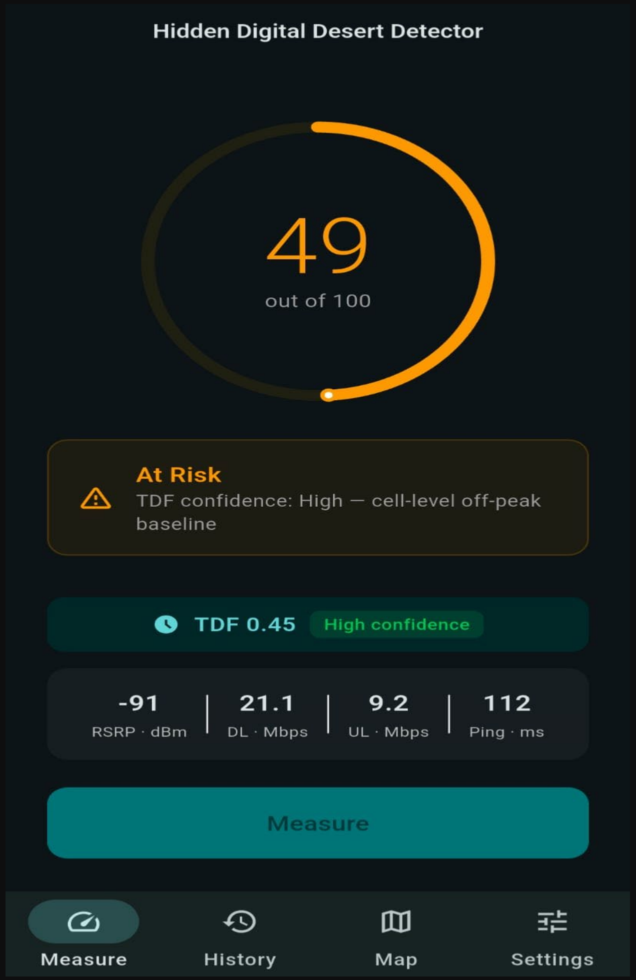
No standardized, affordable protocol exists for verifying indoor connectivity at individual institutions. Adopt the Campus Network Grid Monitoring System protocol (hardware < USD 300, open-source code) as ITU-recommended standard. Partner with engineering colleges for citizen-science audits nationwide.

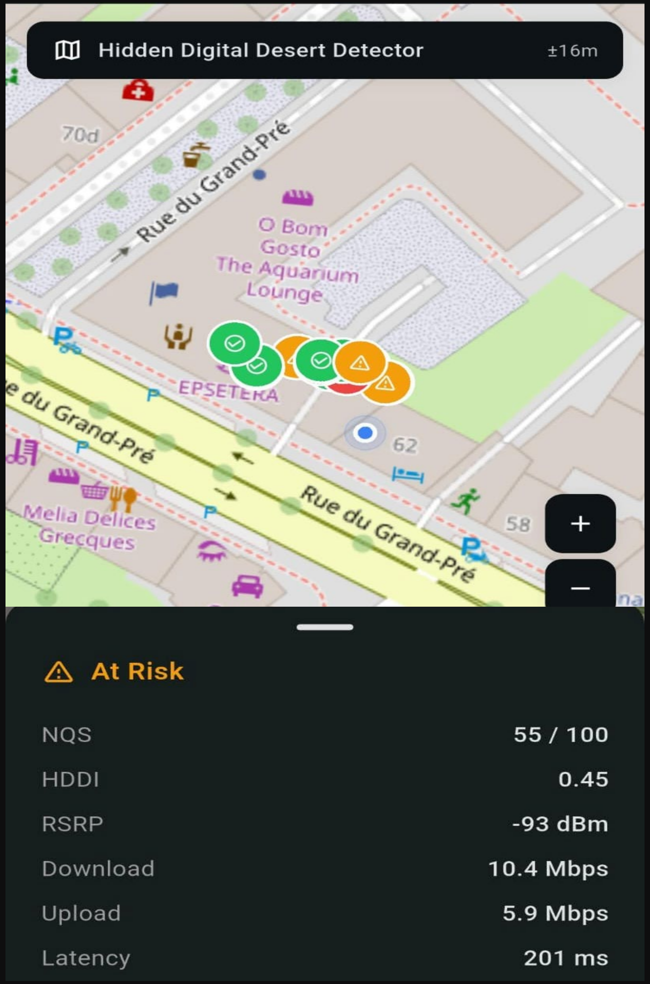
Social ROI: Scalable to zero hardware cost via Android smartphones; creates India's first national database of verified indoor connectivity quality.

App Prototype

Data Pipeline – From Phone to Policy Map

Deployable on commodity hardware and open-source tools: standardized ingestion → computation → aggregation → publication → policy reports.





Input / Output Example

INPUT:

{"lat":28.6139,"lng":77.2090,"rsrp":-97,"sinr":2.1,"latency":186,"dl_mbps":3.4,"ul_mbps":1.2,"timestamp":"08:23","app":"G-MON"}

OUTPUT:

{"district":"South Delhi","iqr":0.58,"tdf":0.44,"app_score":0.67,"hddi":0.54,"nqs":46,"zone":"AT_RISK","readings":1247}

Supported inputs: Network Cell Info Lite, G-MON CSV, NetMonster JSON, OpenSignal API, manual entry.

Platform-ready pipeline enables regulators, NGOs, and civic tech groups to identify and remediate Hidden Digital Deserts with verifiable, crowd-sourced evidence.

Final Slide

THANK YOU!

A signal that's technically 'there' but functionally unusable rarely gets noticed, let alone measured. ITU gave us the stage to turn that blind spot into evidence policymakers can act on. Thank-you!