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Digital Transformation of the Modern Silk Road: Integrating Historical Trade Networks, Artificial Intelligence, and Intelligent Transportation Systems in Afghanistan

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Abstract. For centuries the Silk Road connected markets across the territory of present-day Afghanistan, and current road and railway initiatives create an opportunity to strengthen the country's role in regional logistics. This paper aims to specify what a digitally enabled Afghan trade corridor requires and how its readiness and implementation priorities can be assessed transparently under uncertainty. A conceptual framework-development design was used: transport-specific research and institutional evidence on freight corridors, customs and border digitalization, railway digitalization, and transportation digital twins were synthesized, while a separate thematic mapping of 19 studies by the authors and colleagues served only as contextual evidence on skills, trust, and technology adoption. The result is a five-layer framework comprising physical infrastructure, sensing and data, artificial intelligence (AI) analytics, intelligent transportation system (ITS) services, and governance and human capacity, together with an operational corridor digital readiness index (CDRI) and a multi-criteria priority score. In an explicitly hypothetical three-phase scenario, the CDRI rises from 1.23 to 3.80, and sensing and data (0.81) and governance and capacity (0.77) receive the highest priority. Adverse stress tests show that governance stagnation, infrastructure delay, failed AI pilots, and connectivity disruption can lower the index to between 1.73 and 3.50. The study concludes that data and governance should precede stand-alone AI expansion and that the framework is a planning instrument requiring expert validation, not a measurement of Afghanistan's current corridor performance.

Keywords: Afghanistan, Artificial Intelligence, Digital Transformation, Intelligent Transportation Systems, Modern Silk Road.

1 Introduction

Afghanistan lies where the Iranian plateau, Central Asia, and the Indian subcontinent meet. For centuries caravans crossed its territory between Chinese, Indian, Persian, and

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Mediterranean markets, stopping at oasis cities such as Balkh, Herat, Kabul, and Kandahar and crossing the Hindu Kush by passes that still carry traffic today. That history is now part of a policy argument. Uzbekistan, Afghanistan, and Pakistan signed a framework agreement on 17 July 2025 to prepare a feasibility study for a railway from Termez through Afghanistan to the Kharlachi crossing, a project that Uzbekistan first proposed in 2018 [1]. In June 2026 Uzbek officials put the cost at more than USD 7 billion and said construction would take at least five years [2]. Rahimi et al. examined the role of information technology (IT) in revitalizing Afghanistan's position along the historical and modern Silk Road [3].

A railway of that kind is a long-lead asset. The decisions that shape how well a corridor works in the meantime are about information: where a truck is, how long it will wait at a border, whether a mountain section is open, and who is allowed to see and share that data. Intelligent transportation systems (ITS) combine sensing, communication, and computing to manage traffic, freight, and infrastructure. Artificial intelligence (AI) adds prediction, classification, and optimization on top of the data those systems collect. Both can be introduced in stages and on existing roads, which makes them a practical complement to infrastructure that will take years to build.

This paper addresses three questions: which layers are required for a digitally enabled Afghan trade corridor; which transport-specific technologies and services are supported by established corridor, railway, customs, and ITS literature; and how can readiness and implementation priorities be assessed transparently under uncertainty? The contribution is a five-layer conceptual framework, an operational CDRI rubric, an illustrative three-phase demonstration, adverse stress tests, and a phased roadmap. The framework is not presented as a validated description of current Afghan corridor performance.

2 Background

2.1 Historical Trade Networks in Afghan Territory

The Silk Road was a set of overlapping routes, not a single road. In the second century BCE the Chinese envoy Zhang Qian reached Bactria, in what is now northern Afghanistan, and Kushan rulers later controlled routes that linked China, India, and the Mediterranean world. Cities such as Balkh, Herat, and Bamiyan lay on branches that joined the Oxus valley, the Iranian plateau, and the Indus basin.

Those routes worked because their nodes supplied services that travelers could rely on: water, fodder, lodging, market news, and protection. A node that became unreliable lost traffic to another branch. The modern equivalent of those services is information and predictability. A border post that publishes expected waiting times, a mountain road that reports closures before drivers reach it, and a customs system that clears documents before the truck arrives do what the old caravanserai did for a merchant planning the next stage.

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2.2 Current Corridor Initiatives

The Trans-Afghan railway would run roughly from Termez to Kharlachi across Afghan territory, and the three governments agreed in 2025 to commission a feasibility study [1]. A short rail link already joins Termez to Hairatan, so the northern end of the route is not new. The cost estimate has moved upward over time, and Uzbek officials said in 2026 that it could exceed USD 7 billion [2]. Because construction would take at least five years, road and existing border crossings will carry most traffic through the period in which digital systems can be put in place.

The political and financial situation can limit access to outside finance and equipment, and this matters for the design. A framework for Afghanistan has to rely on modest hardware, free or low-cost data sources such as satellite imagery, and software that local universities and agencies can maintain.

2.3 AI and ITS in Corridor Management

ITS functions relevant to a trade corridor include traffic and freight monitoring, incident detection, traveler information, electronic pre-clearance at borders, and maintenance planning. AI methods enter in three ways: forecasting (for example, waiting times or hazard likelihood), classification (for example, damage in an image), and optimization (for example, routing and scheduling). The limiting factors in Afghanistan are less about algorithms than about power and communication coverage, the scarcity of labeled local data, and the number of trained staff.

2.4 Related Work by the Authors and Colleagues

A collection of 19 studies by the authors and colleagues serves as supplementary contextual material rather than as the principal evidence base. Its transport relevance is limited: the geohazard and remote-sensing studies inform possible methods for hazard monitoring, while studies on education, platform adoption, investor confidence, ethics, and law provide only indirect insights into workforce development, user trust, transparency, and institutional governance. These cross-domain findings are not treated as direct evidence of transport-system effectiveness.

Accordingly, the transfer of findings from non-transport domains is restricted to clearly stated propositions about adoption, skills, trust, and governance. No quantitative transport-performance claim or layer requirement is derived from education, investor-confidence, patent-law, or learning-analytics studies. Transport-specific claims are instead grounded in the supplementary literature on smart freight corridors, customs and border digitalization, railway digitalization, and transport digital twins [4]–[12].

A domain-transfer rule is applied throughout the manuscript: a non-transport study may inform only a general organizational mechanism (for example, adoption incentives, trust, training, or transparency) and is labeled as indirect/contextual evidence. It cannot establish the effectiveness, performance threshold, or technical design of a transport application. Technical layer definitions and transport recommendations are grounded in references [4]–[12]. This separation prevents the

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authors' publication portfolio from being mistaken for a representative transport-literature sample.

3 Method

3.1 Research Design

This paper uses a conceptual framework-development study with an illustrative scenario evaluation. It proceeds in four steps: (1) a focused supplementary search and screening of transport-specific literature and institutional guidance; (2) thematic synthesis of the transport evidence alongside a separately labeled contextual mapping of the authors' 19-study collection; (3) derivation of five framework layers and operational scoring anchors; and (4) demonstration of the CDRI, multi-criteria priorities, and adverse stress tests. The scenario is designed to demonstrate the calculation and decision logic; it is not a forecast or an empirical assessment.

3.2 Evidence Base and Thematic Mapping

The 19 studies were grouped into seven themes by the authors' judgment (Table 1 and Fig. 1). This mapping is exploratory and is not a systematic review: it has no reproducible database search, predefined eligibility criteria, independent screening, or formal quality appraisal. To strengthen the transport evidence base without overstating the method, a focused supplementary search was conducted in publisher and institutional sources using combinations of the terms "smart freight corridor", "transport corridor digitalization", "customs single window", "eTIR" (electronic *Transports Internationaux Routiers*), "railway digitalization", "railway ITS", "transportation digital twin", and "border crossing performance". Sources were retained when they directly addressed freight or passenger transport operations, corridor-level information exchange, customs/border processes, railway technology, or transport digital twins, and when they were peer-reviewed research or official institutional publications. This targeted update is a narrative evidence enhancement, not a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) systematic review; no claim of exhaustive retrieval or formal risk-of-bias assessment is made.

The transport-specific evidence provides a stronger and more direct foundation for the framework. Ge and Qin's systematic review synthesizes digital-twin ITS architecture and services [4]; Sarp et al. examine AI-enabled railway digitalization and digital-twin trains [5]; Werbińska-Wojciechowska et al. review digital twins for transport-system operation and maintenance [6]; Hadj-Mabrouk classifies AI applications across railway infrastructure, rolling stock, signaling, operations, and maintenance [7]; the Asian Development Bank (ADB) assessment for the Central Asia Regional Economic Cooperation (CAREC) program measures border-crossing performance and trade facilitation [8]; the eTIR system of the United Nations Economic Commission for Europe (UNECE) specifies secure electronic exchange among customs

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authorities and transit actors [9]; the World Bank's Middle Corridor analysis links digital data flows with cross-border coordination and logistics performance [10]; Nag et al. synthesize digital twins for transport planning [11]; and Ozbiltekin-Pala and Ozkan-Ozen identify organizational, technological, and regulatory barriers to rail-freight digitalization [12]. Together, these sources directly support the corridor-specific layers and the importance of governance and interoperability.

Table 1. Thematic mapping of the 19 studies in the contextual evidence base (grouping by the authors)

Theme	Studies	n	Use in this paper
Technical AI and remote sensing	[13]–[15]	3	Hazard prediction, satellite monitoring, long-term computing outlook
Regional connectivity and IT	[3]	1	Corridor context and the role of IT
Education technology and analytics	[16]–[20]	5	Training, validation and evaluation designs; institutional AI use
Teaching and learning design	[21], [22]	2	Project-based and inquiry approaches for workforce training
Framework and simulation design	[23], [24]	2	Framework building and simulation-based evaluation
Governance, law, and ethics	[25]–[27]	3	Legal standing, transparency, ethical leadership
Economy, labor, and platforms	[28]–[30]	3	Skills mismatch, platform adoption, investor confidence
Total		19	

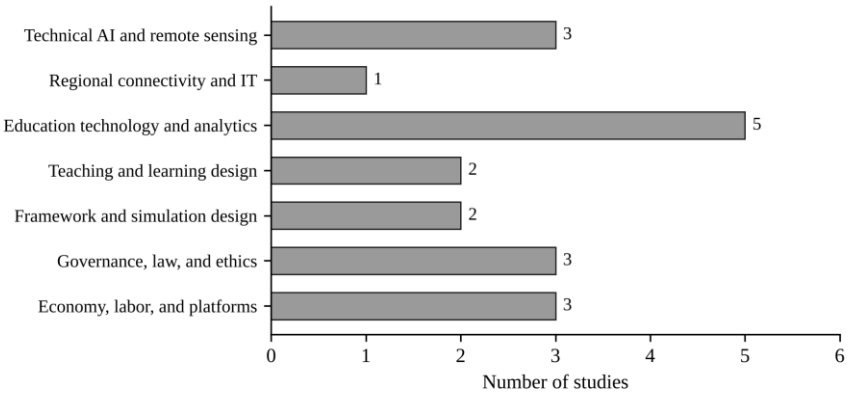


Fig. 1. Number of studies per theme in the contextual evidence base; themes were assigned by the authors.

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3.3 Corridor Digital Readiness Index

Each of the five framework layers is scored from 0 (absent) to 5 (corridor-wide, integrated, and independently verifiable). The score is assigned against the operational anchors below, using documentary evidence and the proportion of relevant critical assets, nodes, workflows, or staff covered. A layer score should be supported by an auditable evidence record; where evidence is unavailable, the score must be reported as "not assessed" rather than inferred. The CDRI for phase p remains the weighted sum of layer scores:

$$CDRI_p = \sum_k w_k s_{p,k}\,,\ \sum_k w_k = 1 \tag{1}$$

To identify implementation priorities, a multi-criteria score is used instead of multiplying the CDRI weight by assumed improvement. Four dimensions are rated from 0 to 5: dependency and criticality (D), risk-reduction urgency (R), feasibility (F), and expected improvement (I). Each rating is normalized by dividing by 5:

$$P^*_k = 0.30\frac{D_k}{5} + 0.25\frac{R_k}{5} + 0.20\frac{F_k}{5} + 0.25\frac{I_k}{5} \tag{2}$$

The weights in Eq. (2) are provisional analytical choices: dependency/criticality receives 0.30 because foundational layers enable downstream services; risk urgency receives 0.25; expected improvement receives 0.25; and feasibility receives 0.20. These coefficients should be tested through expert elicitation or a formal multi-criteria decision method before operational use. The resulting priority score is therefore a transparent screening aid, not an objectively validated ranking.

The scenario scores and baseline weights are illustrative assumptions used to demonstrate the index; they are not measurements of any corridor, and no field data were collected. The five CDRI weights describe the assumed contribution of each layer to overall digital readiness, not the order in which investment should occur. In particular, the lower governance weight must not be interpreted as lower strategic importance: governance is an enabling condition for data sharing, AI deployment, and service accountability. Independent expert elicitation and validation are required before the rubric or weights can be used for an operational assessment.

Operational scoring rubric. Common scale: 0 = absent or no verifiable evidence; 1 = isolated/ad hoc activity covering no more than 10% of relevant critical assets, nodes, or workflows; 2 = documented pilot covering 11–25%; 3 = repeatable operation covering 26–50% with assigned responsibility and basic performance records; 4 = integrated operation covering 51–80% with interoperability, service monitoring, and documented procedures; 5 = corridor-wide operation covering more than 80%, with sustained service-level monitoring, independent audit, and demonstrated continuity. Coverage percentages are calculated against a pre-defined inventory of critical corridor assets/nodes/workflows, not against an unspecified denominator.

Layer 1 (physical corridor). assess the proportion of designated critical road/rail links, border approaches, logistics nodes, and supporting power/telecommunications assets that have a verified asset register, condition inspection, maintenance plan, and

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documented year-round operational status. Score 0 if no inventory exists; 1 if isolated assets are recorded (≤10%); 2 if a pilot inventory and inspection program covers 11–25%; 3 if 26–50% have current condition and maintenance records; 4 if 51–80% are monitored and maintenance actions are tracked; and 5 if >80% are covered by an integrated, regularly audited corridor asset-management process.

Layer 2 (sensing and data). assess the share of critical nodes/vehicles with functioning global navigation satellite system (GNSS), traffic, weather, incident, e-seal, or satellite-derived data feeds; record data availability, update latency, uptime, metadata completeness, and interoperability. Apply the common 0–5 coverage bands, with level 3 additionally requiring routine data exchange at least at the pilot nodes and documented data-quality checks, level 4 requiring interoperable feeds across multiple agencies/nodes, and level 5 requiring corridor-wide monitored data services with agreed standards and audited uptime.

Layer 3 (ai analytics). assess the share of operational use cases with documented training data provenance, independent validation, a stated performance threshold, human oversight, drift monitoring, and a rollback procedure. Score 0 when no model is in use; 1 for an isolated proof of concept without validation; 2 for a pilot evaluated retrospectively on held-out data; 3 for a live pilot meeting a pre-registered performance threshold with human review; 4 for multiple monitored deployments with drift and bias checks; and 5 for independently audited, continuously monitored models integrated into corridor operations. A model demonstration alone cannot exceed level 2.

Layer 4 (its services). assess the proportion of priority workflows (freight tracking, traveler information, incident management, border pre-arrival processing, electronic documentation, and maintenance scheduling) delivered through operational digital services. Score 0 if services are absent; 1 for isolated one-agency tools (≤10% of workflows); 2 for pilot services covering 11–25%; 3 for repeatable services covering 26–50% with user and uptime records; 4 for interoperable services covering 51–80% across agencies or modes; and 5 for >80% coverage with measurable service-level performance, fallback procedures, and cross-border interoperability.

Layer 5 (governance and human capacity). assess the proportion of participating agencies with signed data-sharing agreements, defined data ownership/access rules, cybersecurity and privacy procedures, AI accountability arrangements, audit logs, incident-response responsibilities, and trained personnel assigned to relevant roles. Score 0 if no formal arrangements exist; 1 for informal arrangements in ≤10% of agencies; 2 for documented pilot agreements and training in 11–25%; 3 for approved rules, named accountable officers, and role-based training in 26–50%; 4 for harmonized arrangements and recurring competency assessments in 51–80%; and 5 for corridor-wide enforceable agreements, independent compliance audits, incident exercises, and >80% agency coverage.

4 Framework for a Digital Silk Road Corridor

The five-layer framework (Table 2 and Fig. 2) is consistent with transport-specific research that treats physical assets, communication and data infrastructure, analytics,

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services, and institutional coordination as interdependent components. Reviews of transportation digital twins identify connected physical, data, communication, and service architectures [4], [11], while railway digitalization research emphasizes sensing, maintenance, train operations, and system integration [5], [7].

Table 2. The five layers of the proposed framework

Layer	Function	Example components	Main data
1. Physical corridor	Carry vehicles, trains, and cargo	Roads, rail links, border crossings, dry ports, power, telecom towers	Asset registers, design records
2. Sensing and data	Observe the corridor and share observations	Roadside counters, GNSS fleet tracking, weather stations, satellite imagery, e-seals, data exchange	Positions, counts, imagery, weather, seal events
3. AI analytics	Forecast, classify, and optimize	Hazard models, waiting-time forecasts, image-based inspection, anomaly detection, routing	Labelled historical events, sensor streams
4. ITS services	Deliver decisions to users	Traveler information, freight tracking, incident management, border pre-clearance, maintenance scheduling	Outputs of layer 3, operational records
5. Governance and capacity	Set rules, skills, and trust	Data-sharing agreements, legal basis, transparency rules, training, multilingual interfaces	Agreements, staff records, audit logs

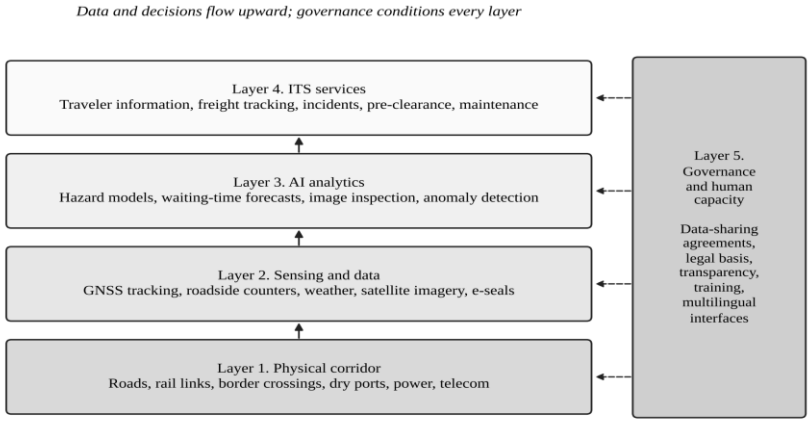


Fig. 2. The five-layer framework for a digitally enabled corridor: layers 1–4 pass data and decisions upward, and layer 5 sets the rules, skills, and trust on which every other layer depends.

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Two features of the design follow from the Afghan context. The first is that the layers can be built unevenly. A corridor can have good satellite-based hazard monitoring while its border systems are still paper based, and the index in Section 3 is meant to show that unevenness instead of averaging it away. The second is that every layer has a low-cost entry point. Satellite imagery, open weather data, and smartphone-based fleet tracking need little fixed investment, while the human and legal work of layer 5 has to start at the same time as layer 2, not after it.

5 Applications of AI within the ITS Layers

5.1 Hazard Forecasting and Asset Monitoring

Mountain sections of the corridor, including routes over the Hindu Kush, face seismic activity, landslides, and snow. Faqiri et al. studied AI-based predictive modeling for earthquakes, landslides, and volcanic risk [13]. Applying such models to road segments is a proposal made here; the cited study does not address roads. A practical version would combine slope, rainfall, and seismic data with a record of past closures to rank segments by short-term risk, then pass that ranking to the traveler information service.

Sediqi and Hakimi studied deep learning for remote sensing image analysis in natural resource monitoring [14]. Similar image-analysis methods could track road surface damage, slope movement, and flood extent from freely available satellite imagery, which suits a setting where roadside sensors are scarce. The adaptation from resource monitoring to road assets is again the authors' proposal.

5.2 Border and Freight Flow

Delays at border crossings are a main source of uncertainty for transit traffic. ITS tools that apply here include electronic seals, pre-arrival document submission, queue forecasting, and risk-based inspection, where anomaly detection on declaration data helps officers choose which consignments to inspect. These tools only work if traders and drivers use them. Khalida et al. studied platform retention in the sharing economy as a balance between gratification and perceived risk [29]. If the same balance holds for freight platforms, adoption will depend on whether users see a clear benefit and a clear limit on how their data are used. This recommendation is supported by transport-specific evidence: the ADB CAREC framework assesses border-crossing performance and institutional/regulatory constraints [8], UNECE's eTIR architecture enables secure electronic exchange of transit data among customs and other actors [9], and the World Bank identifies interoperable digital data flows and cross-border coordination as central to corridor performance [10].

Trust in the data rules matters for investors as well as users. Adiazmil et al. examined the relationship between AI disclosure and investor confidence [30], and Turan et al. examined transparency in ethical AI communication and public trust [25]. The implication drawn here is that corridor operators should publish what the AI systems do, what data they use, and who can see the results.

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5.3 Fleet and Traffic Management

Fleet tracking with GNSS devices gives dispatchers positions and speeds, and the same data can feed incident detection and travel-time estimates. Training operators to read and question model output is part of this application. Hakimi reviewed the use of augmented reality learning combined with deep learning to build critical thinking and science literacy [18]. A transport version would use simulated incidents to train control-room staff, though no such program has been tested. For future rail integration, railway digitalization research identifies sensor-enabled monitoring, digital maintenance, train operations, and data integration as key service areas [5], [7].

5.4 Longer-Term Computing

Routing and scheduling on a large network are combinatorial problems that grow quickly with size. Khurami and Hakimi reviewed how quantum computing and machine learning might be combined [15]. Quantum-enhanced methods are not a near-term option for Afghan corridors and are listed here only as a horizon item for later phases. Table 3 summarizes the applications discussed in this section. Transport digital-twin reviews further show how synchronized physical and digital models can support simulation, asset monitoring, maintenance, and network-level decision support [4], [6], [11].

Table 3. Candidate AI applications along the corridor and the studies that inform them

Application	Corridor problem	AI method	Data needed	Informing studies
Hazard forecasting	Closures on mountain sections	Predictive modeling	Slope, rainfall, seismic, closure logs	[13]
Asset monitoring	Slow detection of road damage	Deep learning on imagery	Satellite and drone images	[14]
Border flow	Unpredictable waiting times	Forecasting, anomaly detection	Declarations, gate timestamps	[29], [30]
Fleet and traffic	Poor visibility of trucks and incidents	Travel-time estimation, incident detection	GNSS tracks, counts	[18]
Network optimization	Routing across a large network	Optimization (long term)	Network and demand data	[15]

6 Illustrative Demonstration Scenario

The three phases are planning assumptions rather than a project forecast. Phase 1 (years 0–2) establishes data foundations and governance arrangements; Phase 2 (years 2–5) pilots AI and ITS services at selected nodes; and Phase 3 (year 5 onward) scales

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interoperable services if infrastructure, financing, and cross-border agreements permit. Table 4 reports the assumed layer scores and weights, and Fig. 3 shows the layer scores by phase. These values are hypothetical and are intended only to demonstrate how the CDRI and priority model operate.

Table 4. Illustrative scenario: layer weights, scores (0–5), CDRI from Eq. (1), and multi-criteria priority score from Eq. (2). All values are assumptions, not measurements

Layer	Weight	Baseline	Phase 1	Phase 2	Phase 3	P*
Physical corridor	0.25	2.00	2.50	3.00	3.50	0.73
Sensing and data	0.20	1.00	2.50	3.50	4.00	0.81
AI analytics	0.20	0.50	1.50	3.00	4.00	0.65
ITS services	0.20	1.00	2.00	3.00	4.00	0.66
Governance and capacity	0.15	1.50	2.00	2.50	3.50	0.77
CDRI	1.00	1.23	2.13	3.03	3.80	

Priority-rating audit trail (0–5, illustrative): physical corridor D=5, R=4, F=2, I=3; sensing and data D=5, R=4, F=4, I=3; AI analytics D=3, R=4, F=3, I=3; ITS services D=4, R=3, F=3, I=3; governance and capacity D=5, R=5, F=3, I=2. Applying Eq. (2) yields the P* values in Table 4. Governance receives a high dependency and risk rating even though its planned score improvement is smaller, which shows that a low CDRI weight does not imply a low implementation priority.

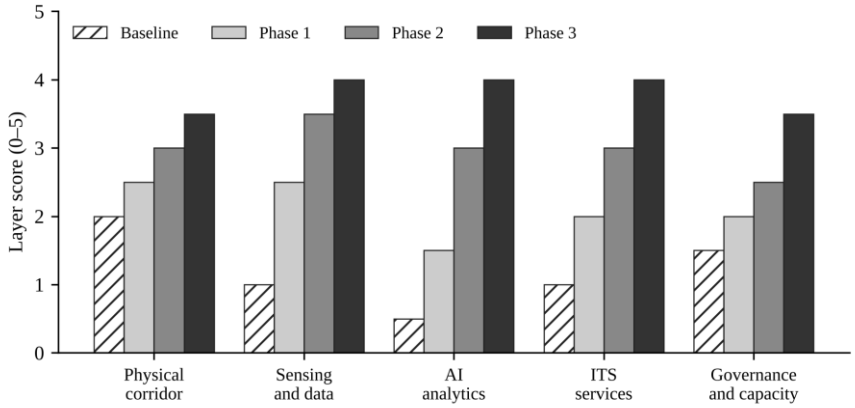


Fig. 3. Illustrative layer scores by phase (hypothetical values assigned by the authors).

Under the illustrative baseline weights, the CDRI rises from 1.23 at baseline to 2.13 after Phase 1, 3.03 after Phase 2, and 3.80 after Phase 3. This monotonic trajectory is conditional on the assumed improvement in every layer; it is not evidence that such improvement is likely. Implementation priority is assessed with a multi-criteria score

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that explicitly considers dependency/criticality, risk-reduction urgency, implementation feasibility, and expected improvement. On the stated illustrative ratings, sensing and data (0.81) and governance and capacity (0.77) receive the highest priority, followed by the physical corridor (0.73), ITS services (0.66), and AI analytics (0.65). This ordering reflects the fact that data and governance are prerequisites for reliable analytics and services. The ratings are transparent planning judgments, not expert-validated estimates.

The comparison of four weighting schemes in Fig. 4 (baseline weights; equal weights of 0.20; an infrastructure-led scheme with 0.40 on the physical corridor and 0.15 on each other layer; and a governance-led scheme with 0.40 on governance and 0.15 on each other layer) serves only as a descriptive arithmetic check. Because every layer was assumed to improve in each phase, the same phase ordering is built into the scenario and cannot establish robustness. A more informative test is to introduce adverse conditions that interrupt one or more layers. Table 5 therefore reports five stress cases, including governance stagnation, infrastructure delay, AI-pilot failure, connectivity disruption, and a combined disruption. These cases are not forecasts; they expose the framework's sensitivity to plausible implementation failures.

Table 5. Adverse stress-test scenarios using the baseline CDRI weights

Stress case	Physical	Sensing	AI	ITS	Governance	CDRI
Governance stall	3.5	4.0	4.0	4.0	1.5	3.50
Infrastructure delay	2.0	4.0	4.0	4.0	3.5	3.43
AI-pilot failure	3.5	4.0	1.0	4.0	3.5	3.20
Connectivity outage	3.5	2.0	4.0	2.0	3.5	3.00
Combined disruption	2.0	2.0	1.0	2.0	1.5	1.73

The stress-test scores are deliberately severe but plausible illustrations, not estimates of event probabilities. Each case changes only the affected layer scores, while retaining the baseline weights (0.25, 0.20, 0.20, 0.20, and 0.15). The results show that a connectivity disruption affecting sensing and ITS reduces the CDRI to 3.00, while a combined disruption reduces it to 1.73. These cases reveal failure modes that the alternative-weight comparison in Fig. 4 cannot test.

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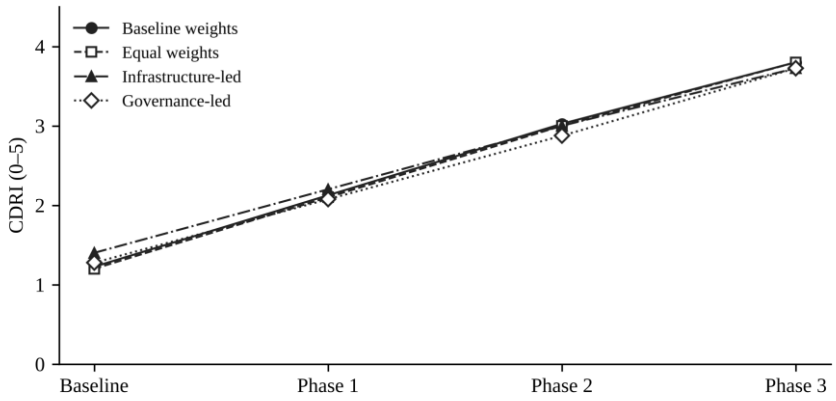


Fig. 4. Illustrative CDRI under four weighting schemes; the monotonic phase ordering is assumption-driven and is not evidence of robustness.

7 Roadmap and Implications

7.1 Phased Roadmap

Table 6 turns the scenario into actions. The phases are ordered by dependency, not by calendar certainty, since the rail timeline itself is uncertain [2].

Table 6. Phased roadmap with indicators

Phase	Timing	Main actions	Indicators
1	Years 0 to 2	Digitize border and road records; install low-cost sensing at selected nodes; agree data-sharing rules; begin staff training	Share of crossings with electronic records; number of trained staff
2	Years 2 to 5	Pilot hazard forecasting and waiting-time forecasts; launch traveler information and freight tracking at main nodes; publish AI-use statements	Forecast error against logged events; user uptake
3	Year 5 onward	Integrate services along the corridor; link with rail operations as they open; review legal basis and audit logs	Door-to-door transit time; closure notice lead time

7.2 Skills and Training

A digital corridor needs people who can run it. Miskinyar et al. examined education–job mismatch among Kabul University graduates [28], and the authors read that finding as a warning that training for corridor roles should be tied to specific jobs. Hakimi and Sazish assessed the opportunities and challenges of AI tools in research at Samangan

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University [16], which indicates that universities already work with AI tools and could host applied programs. Albaiti et al. studied creativity among prospective chemistry teachers in project-based learning [21], and a project-based format could be adapted for transport technician training. Erita et al. reviewed robotics in elementary classrooms [20], and Harahap et al. studied reflective inquiry learning for preschool children in a border region [22]. These two studies suggest that science, technology, engineering, and mathematics (STEM) exposure in early schooling, including in border communities, belongs in a long-term plan even though it will not affect the corridor for years. Training materials can be checked with a validation system of the kind Safrizal et al. built for learning tools [19], and outcomes can be tracked with learning analytics along the lines of Deljuy and Hakimi [17]. Because the corridor crosses several language communities, interfaces and training should be multilingual, and Qadiri et al. offer a six-dimension framework for ethical AI leadership in multilingual education that can be adapted [27].

7.3 Governance, Law, and Trust

Legal clarity helps investors and operators. Khairunnas et al. compared how jurisdictions treat the legal standing of AI as an inventor [26]. For the corridor, the relevant question is who owns models, data, and software built with public money, and the comparative approach in that study suggests reviewing several jurisdictions before settling on rules. Table 7 lists the main risks and a mitigation for each.

Table 7. Main risks and mitigations

Risk	Layer	Mitigation
Unreliable power and connectivity at remote nodes	1, 2	Solar-powered sensors; store-and-forward data links; offline-capable apps
Scarce labeled local data for AI models	2, 3	Start with pooled open data; log closures and delays from day one; retrain as local data accumulate
Low user adoption of freight platforms	4	Pilot with a few carriers; state data rules plainly; keep a manual fallback
Opaque or contested use of AI at borders	5	Publish AI-use statements; keep human review of flagged consignments; keep audit logs
Skills gap in operating agencies	5	Job-linked training with universities; project-based courses; track outcomes
Project delay or border disruption	1	Plan for road-first operation; design services to work with or without the railway

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8 Discussion and Limitations

The scenario shows how the framework could be used to set priorities and track progress. It does not show that any corridor will reach the scores assumed, and it does not estimate costs, travel times, or traffic volumes.

Three methodological safeguards are built into the analysis. First, the 19-study collection is treated as contextual rather than transport-specific evidence; the five-layer framework is supported by a targeted supplementary set of transport and institutional sources [4]–[12]. Second, the 0–5 scale is accompanied by observable layer-specific anchors, while all unobserved values remain hypothetical. Third, the sensitivity analysis includes adverse stress cases rather than relying only on alternative weights. Nevertheless, the supplementary search was focused rather than systematic, the rubric has not yet undergone inter-rater reliability testing, and the illustrative scores and priority ratings have not been validated by corridor authorities or independent experts. These limitations preclude empirical claims about Afghanistan's current readiness.

Future work should apply the rubric through a documented expert panel involving transport operators, customs authorities, railway agencies, telecommunications providers, and academic specialists; assess inter-rater agreement; and validate the layer scores against operational indicators such as border dwell time, freight transit-time variability, data-system uptime, incident-detection lead time, and customs pre-arrival processing rates. A pilot at one border crossing or freight node should precede corridor-wide scaling.

9 Conclusion

Afghanistan's role in the modern Silk Road will depend not only on roads and railways but also on interoperable data, reliable services, and institutions capable of governing them. This paper proposes a five-layer framework and an operational scoring rubric to organize those requirements. The illustrative CDRI rises from 1.23 to 3.80 under a deliberately optimistic three-phase scenario, but adverse stress tests demonstrate that governance stagnation, infrastructure delays, failed AI pilots, and connectivity disruption can materially reduce readiness. The priority model places sensing and governance ahead of stand-alone AI expansion because analytics and ITS services depend on reliable data, legal authority, institutional coordination, and skilled personnel. The framework is a planning instrument requiring expert validation and field testing, not a measurement of present-day Afghan corridor performance.

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Author Contributions

Conceptualization, A.R.; methodology, A.R. and S.E.S.; investigation, A.R., S.E.S., and A.F.F.; writing—original draft, A.R.; writing—review and editing, S.E.S. and A.F.F. All authors have read and agreed to the published version of the article.

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Data Availability Statement
The CDRI scores, weights, layer-level ratings, and stress-test values are hypothetical analytical assumptions created solely to demonstrate the proposed method. They are not observations, survey results, expert-panel ratings, or measurements of Afghanistan's transport corridors. No primary field data were collected for this study.

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