

Artificial Intelligence in Developing Countries: A Systematic Review of Cross-Sector Applications and Implementation Challenges in South Asia

Md. Farhan Hossan Tamin¹, Md. Ruhul Amin^{2*}, Md. Salim³, Morium Akter Shefa⁴

^{1,2,3,4}Department of Public Administration, Comilla University, Cumilla, Bangladesh

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Corresponding Author:

Author Name*:

Md. Ruhul Amin

Email*:

rubel@cou.ac.bd

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Abstract. This review synthesizes how artificial intelligence (AI) is being applied across healthcare, education, agriculture, energy, business, and public services in five South Asian countries—Bangladesh, India, Pakistan, Sri Lanka, and Nepal—and identifies the implementation barriers that keep technically successful models from producing equitable development outcomes. A systematic literature synthesis of peer-reviewed journal articles and conference papers published from 2016 to 2025 was conducted in Elsevier, IEEE Xplore, Springer, PubMed, and MDPI. Search strings combined “artificial intelligence” or “machine learning” with country names and sectoral keywords. Eligible studies were thematically coded by country and sector; methods, performance metrics, and stated challenges were extracted. Keyword co-occurrence mapping was used to describe the regional research landscape. India has the broadest and most mature research base. Bangladesh concentrates on high-accuracy solutions for energy, disaster risk, and diagnostics under infrastructure constraints. Pakistan, Sri Lanka, and Nepal remain largely pilot-oriented, with notable work in e-learning, public-health communication, e-agriculture, and explainable fintech. Across all five countries, laboratory performance—including diagnostic accuracies above 99% in selected studies—outpaces governance, data quality, skills, and rural access. The paper offers a comparative, cross-sector synthesis of the South Asian AI ecosystem and frames a shared implementation gap that policy and capacity-building must close if research gains are to become developmental dividends.

Keywords: Artificial Intelligence, Machine Learning, South Asia, Healthcare, Agriculture, Education, Implementation Challenges

1. INTRODUCTION

Artificial intelligence (AI) has moved from a specialized computing research program into a general-purpose technology that now shapes how societies produce knowledge, deliver public services, and manage scarce resources. [1] In education, adaptive tutoring, automated assessment, and learner-performance prediction have been documented for more than a decade. [1], [2] Comparable claims are now made for healthcare diagnostics, precision agriculture, energy planning, and financial supervision. For developing countries, the promise is not merely efficiency. It is the possibility of stretching limited clinical, extension, and administrative capacity across large rural populations.

South Asia is a revealing test of that promise. The region combines dense development challenges—climate exposure, agrarian livelihoods, uneven digital infrastructure, and large informal labor markets—with a rapidly expanding research literature on machine learning (ML) and deep learning (DL). In Bangladesh, AI has been examined for solar-energy planning [3], scenario-based landslide casualty estimation [4], and high-accuracy screening for conditions such as thalassemia [5]. Indian studies range from air-pollution forecasting [6] to vocational-education reform and medical imaging [7]. Pakistani scholarship has given particular attention to personalized e-learning [8], while Sri Lankan work has tested educational chatbots [9] and AI-supported public-health communication [10]. Nepal remains at an earlier stage, yet already reports explainable models of fintech customer satisfaction [11] and a clear case for AI in low-resource healthcare [12].

The existing literature is nevertheless fragmented. Most papers are sector-specific, rest on controlled datasets or small pilots, and rarely compare countries. Global systematic reviews of AI in higher education have already noted a shortage of educator-centered and ethically grounded analysis [1], and the same imbalance appears in South Asian applied work: reported accuracies are high, while evidence on deployment, equity, and governance is thin. A few researchers have focused on single-country diagnostics or education pilots. There have been limited studies that place Bangladesh, India, Pakistan, Sri Lanka, and Nepal in one comparative frame covering health, education, agriculture, energy, business, and public services. Therefore, this research intends to synthesize peer-reviewed AI applications across those five countries, to contrast national patterns of adoption, and to identify the implementation constraints that recur regardless of sector.

The objectives of this research are (i) to map representative AI uses and reported outcomes by country and sector; (ii) to compare the depth and maturity of national research ecosystems; and (iii) to specify the policy, data, skills, and infrastructure conditions required to translate laboratory performance into equitable developmental gains.

2. METHODS

This review used a systematic literature-synthesis design. The procedure followed the logic of identification, screening, eligibility, and inclusion illustrated in Figure 1. Because the corpus is geographically bounded and sectorally diverse, the analysis combined structured extraction with thematic synthesis rather than statistical meta-analysis.

Peer-reviewed journal articles and conference proceedings published from 2016 to 2025 were retrieved from Elsevier, IEEE Xplore, Springer, PubMed, and MDPI. The start year captures the period in which ML applications in the region become consistently visible; the end year includes the most recent diagnostic, generative-AI, and governance studies. Search queries combined “artificial intelligence” or “machine learning” with country names (Bangladesh, India, Pakistan, Sri Lanka, Nepal) and sectoral terms (healthcare, education, agriculture, energy, environment, business, technology, public services).

Records were screened at title and abstract for a South Asian application context and for reported uses or outcomes of AI or ML. Duplicates, non-peer-reviewed items, and papers without a country or sectoral anchor were excluded. Full texts of remaining studies were assessed for methods, datasets, performance metrics (for example accuracy, RMSE, or productivity change), and explicitly stated challenges. Eligible studies were then coded by country and sector using a thematic-analysis approach consistent with prior regional syntheses [6], [8].

Two additional procedures supported comparison. First, extracted findings were organized in a country–sector matrix so that similar applications (diagnostics, tutoring, yield prediction, compliance) could be read across borders. Second, keyword co-occurrence maps were produced to describe the intellectual structure of the regional literature (Figures 2 and 3). The review is limited to secondary evidence; it does not re-

analyze primary datasets. Where a cited claim in earlier drafts did not match the bibliographic record, the source was corrected or replaced before synthesis.

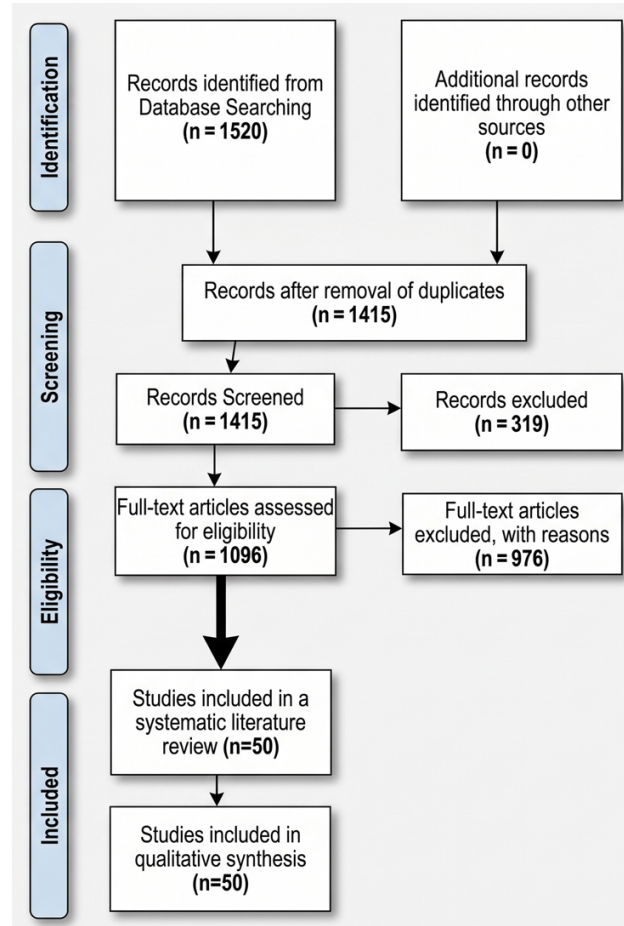


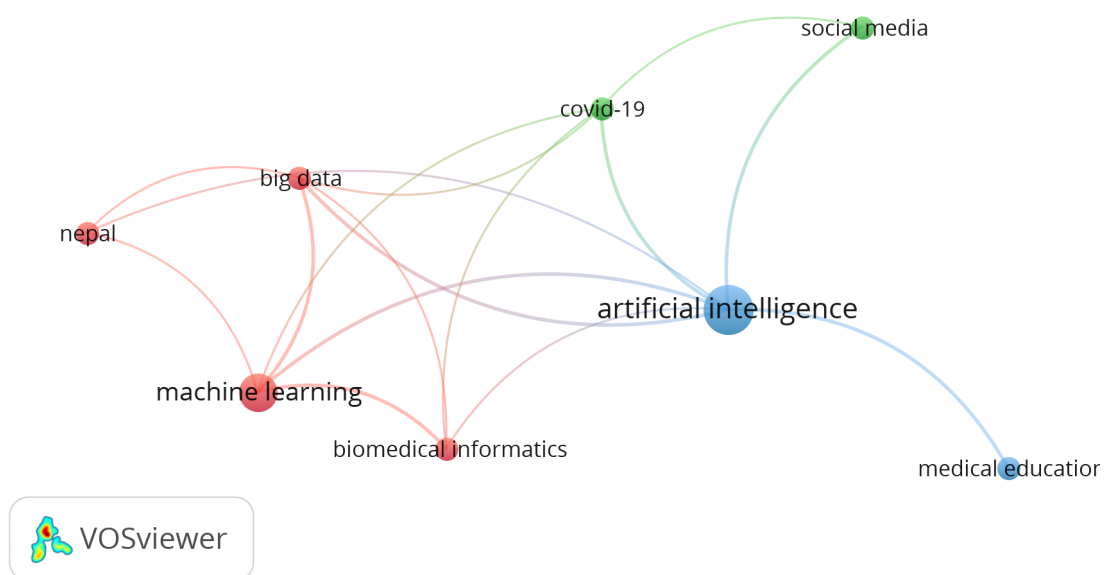
Figure 1. Study selection workflow used to identify, screen, and synthesize the South Asian AI literature.

3. RESULTS AND DISCUSSION

Table 1 summarizes the sectoral emphasis of the included literature. India appears in the largest number of domains. Bangladesh clusters around energy, disaster risk, and diagnostics. Pakistan, Sri Lanka, and Nepal show thinner but more focused portfolios. The keyword maps in Figures 2 and 3 corroborate this pattern: “machine learning” and “deep learning” form the methodological core, while country and application terms (Bangladesh, classification, prediction, COVID-19, neural networks) occupy the surrounding clusters, with more recent nodes shifting toward large language models and explainability.

Table 1. Cross-sector map of representative AI applications in five South Asian countries

Country	Key Sectors	Representative AI Uses
Bangladesh	Energy, health, agriculture, education, business	Solar forecasting, disease diagnosis, smart farming, generative AI learning
India	Environment, health, education, agriculture, business, technology	Smart grids, air pollution modeling, medical imaging, AI banking
Pakistan	Education, agriculture, health, business	Personalized e-learning, crop detection, COVID-19 analytics
Sri Lanka	Health, education, agriculture, public services	Health misinformation detection, chatbots, e-agriculture platforms
Nepal	Healthcare, education, fintech	Medical screening, AI-assisted teaching, explainable fintech models

**Figure 2.** Overlay visualization of keyword co-occurrence in the regional AI literature (VOSviewer). Color indicates average publication year.

3.1. Bangladesh

3.1.1. Energy and environment

Bangladesh's energy literature treats AI as a planning tool for a solar resource that is abundant but meteorologically volatile. Miskat et al. argue that ML and artificial neural networks can support forecasting, optimization, and spectral monitoring of solar systems,

thereby strengthening both operational efficiency and policy design [3]. Ensemble ML models trained on local irradiation records further improve short-term prediction relative to conventional linear baselines [13]. Beyond energy, Sufi, Alam, and Islam demonstrate a scenario-based casualty estimator for landslides in the Chittagong Metropolitan Area. Linear and logistic regressions are used to score an exhaustive space of 1.054×10^{41} scenario combinations built from seven attributes (including rainfall, area of mass, and elevation), with direct relevance to multi-hazard warning under the Sendai Framework [4].

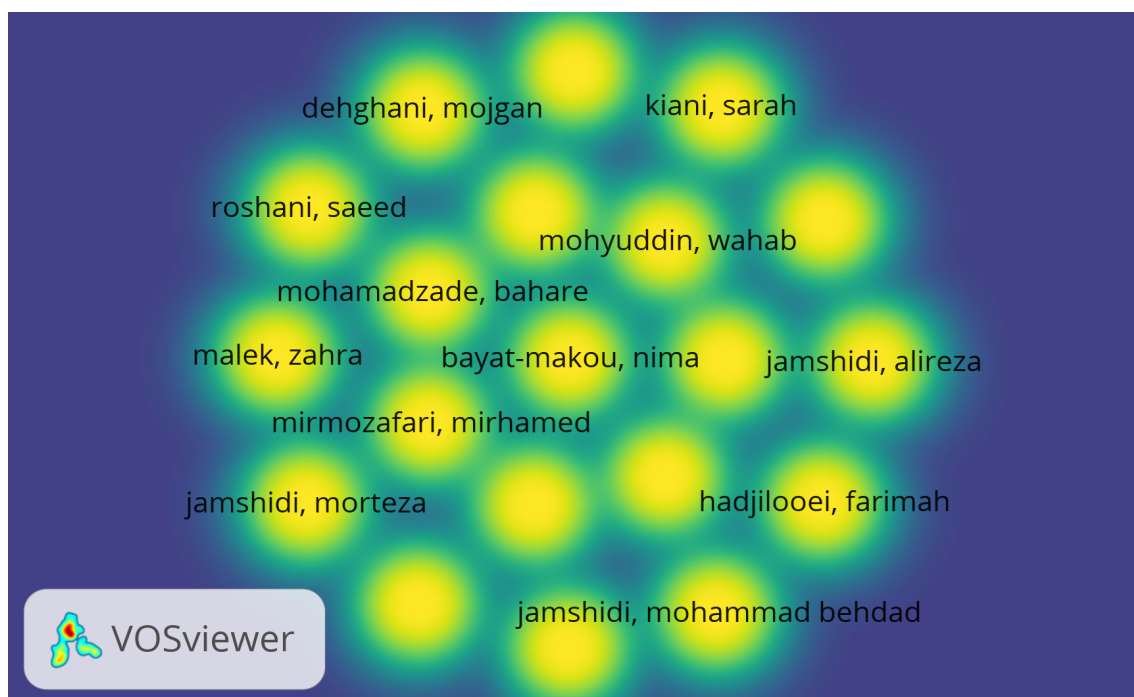


Figure 3. Density visualization of high-frequency keywords. Machine learning, classification, and neural-network terms occupy the densest core.

3.1.2. Business

Firm-level studies locate AI inside resource-based and dynamic-capability arguments. Polas et al. find that AI improves SME agility, strategic value, and knowledge management when it is combined with human and organizational resources [14]. AI-augmented human resource management is reported to activate digital culture and strategy for sustainable performance, with strategy showing stronger effects than culture in volatile settings, although mediation paths remain incompletely specified [15]. Hybrid AI-blockchain designs for anti-money-laundering reduce false positives relative to manual review and

are discussed in connection with mobile-money platforms such as bKash and the “smart nation 2041” agenda, while still facing scalability, regulatory, and privacy constraints [16].

Healthcare

Diagnostic work is the most quantitatively striking strand. A hybrid AHP–TOPSIS framework with XGBoost, CatBoost, random forest, and SHAP/LIME explanations achieved 99.28% accuracy for thalassemia risk in pregnant women on a 1,200-sample complete-blood-count and demographic dataset, prioritizing hematologic markers such as MCH, RDW, and hematocrit [5]. Recurrent networks applied to CT images from Dhaka have been reported at 99.89% accuracy for kidney-disease subtypes, illustrating a shift from classical segmentation toward adapted deep diagnostics [17]. Complementary hardware research describes a low-cost microwave imaging system with metamaterial antennas for breast-tumor detection, emphasizing gain, directivity, and non-ionizing operation [18]. These results show that high accuracy is attainable in Bangladeshi clinical datasets; they do not, by themselves, establish nationwide screening programs.

3.1.3. Agriculture, education, and software engineering

Agricultural constraints remain severe: irrigation efficiency of about 25–30%, pest-related rice-yield losses near 41%, heavy inorganic-fertilizer use, and slow mechanization. Smart farming proposals combine AI forecasting, UAV remote sensing, and in-field sensors for moisture, salinity, temperature, and leaf wetness, leveraging extensive 4G/5G coverage and low-power networks such as LoRaWAN [19]. In health education, a ChatGPT-based intervention on HPV concepts raised knowledge scores from 43.27% at baseline to 82.19% post-intervention ($t = -34.44$, $p < 0.00001$), with high self-reported ease of use, suggesting that generative models can substitute for scarce educators on mobile channels if hallucinations are controlled [20]. In the software industry, learning-to-rank and ranking-to-learn strategies for regression-test prioritization have been reported to improve fault localization by 20–30% over coverage baselines [21].

3.2. India

3.2.1. Environment and energy

Indian environmental AI is distinguished by both urban energy-system modeling and national air-quality forecasting. AI-optimized distributed energy resources, energy-management systems, and storage in smart microgrids are associated with efficiency

gains of up to 25% in international reference cases, with public-private partnerships cited as the adoption path in India despite cost and cybersecurity barriers [22]. For air pollution, traditional linear models (MLR, ARMA) underperform relative to ANN, SVM, random forest, CNN, RNN, and LSTM architectures. Spatio-temporal deep models have reduced forecast error substantially (LSTM/ST-DNN RMSE = $7.27 \mu\text{g}/\text{m}^3$ in the reviewed study), improving the operational basis for environmental management [6].

3.2.2. Education

ICT platforms and blended learning have already been used to offset trainer shortages in technical and vocational education [7]. More recent work treats AI as the next scaling layer: adaptive learning, intelligent tutoring, immersive simulation, and generative assessment. These tools can narrow rural and informal-sector equity gaps if teacher training, privacy safeguards, and infrastructure investment accompany them [7], [23]. Exploratory evidence that large-language-model uptake among students can be very low even where predictive models reach 90% recall indicates that trust and implementation, not raw algorithmic capacity, are the binding constraints [23].

3.2.3. Healthcare

Generative systems are entering public-health communication as chatbots, medication guides, and crisis summaries, expanding access while introducing bias, hallucination, and trust-loss risks that require hybrid human oversight [24]. Medical-education research has moved from historical AI benchmarks to CNNs and large language models, with documented gains in diagnostic support and equally documented ethical gaps [25]. Surveys report substantial error reduction in student testing alongside a large majority of students lacking AI-ethics training, motivating integrated curricula aligned with professional-body guidance [26]. In clinical screening, CNNs applied to smartphone and standard fundus imaging continue to advance diabetic-retinopathy detection, although interpretability remains an open requirement for safe scale-up [27].

3.2.4. Agriculture, business, and analytics

Across the biological sciences, ML/DL pipelines now support disease detection (CNN accuracies near 99% in cited crop-pathology experiments), yield prediction, and industrial enzyme optimization, while genome-editing programs combine CRISPR/Cas tools with AI phenotyping and speed breeding [28], [29]. In banking, logistic regression, decision trees,

SVM, random forest, and XGBoost models for credit-risk prediction exceed 95% accuracy in reported evaluations, with hybrid designs recommended for crisis defaults [30]. Strategic HRM research uses generative AI for literature review, analysis, and predictive recruitment, but flags opacity, bias, and privacy as unresolved design problems [31]. Taken together, the Indian corpus is the region's most institutionally backed: it spans basic environmental science and bankable decision systems, yet still reproduces the familiar ICT barriers of cost, data rights, and last-mile access.

3.3. Pakistan

3.3.1. Education

Pakistani educational-technology research sits at the intersection of educational data mining, clustering for adaptive grouping, and intelligent tutoring. Kausar et al. integrate clustering into personalized e-learning and, in reviewing the field, situate earlier work on risk prediction, ontology-based guidance, and scaffolding frameworks as contributors to learner satisfaction [32]. A global systematic review of ICT in TVET, authored from a Pakistani group, maps 134 papers and underscores how thin the TVET-specific AI evidence still is [33]. Broader reviews of personalized e-learning catalogue knowledge tracing, recommender systems, and media-adaptation techniques, while stressing that much of the evidence remains siloed [8].

3.3.2. Agriculture and healthcare

Fruit-detection pipelines for agricultural robots have progressed from hand-crafted image processing through classical ML to CNN segmentation. Zhang et al. adapt multi-task cascaded convolutional networks for orchard fruit detection, targeting the real-time and overfitting problems that persist in field imagery [34]. At the breeding layer, AI is used to characterize germplasm across omics layers and, more recently, to assist de novo gene-editor design as a complement to CRISPR-Cas9 [35]. During COVID-19, DL methods—including GANs, extreme learning machines, LSTM/GRU variants, and CNNs—were applied to outbreak prediction, imaging differential diagnosis, and drug-related tasks, with the explicit aim of reducing dependence on slow laboratory pipelines [36]. Sentiment analysis of contact-tracing apps found generally favorable public affect coupled with strong privacy concern, a reminder that health-AI adoption is a communications problem as much as a modeling problem [37].

3.3.3. Business and environment

Uncertainty-aware graph models (fuzzy sets, soft sets, and topological indices on fuzzy soft graphs) have been proposed for supply-chain and customer-network decisions under vague preferences and risk [38]. At the research-practice layer, ML and NLP automate literature search and synthesis in business studies, while TAM-based accounts identify trust, privacy, and algorithmic bias as adoption barriers [39]. Macro assessments for Asia-Pacific treat AI as simultaneously productivity-enhancing and labor-displacing, with outcomes depending on policy readiness [40]. Environmental work using convergent cross mapping on satellite and climate outputs finds the strongest soil-moisture-precipitation coupling in semi-arid zones, a result with agricultural warning value for Pakistan's climate-exposed districts [41].

3.4. Sri Lanka

3.4.1. Healthcare and education

Sri Lankan public-health AI is notable for its attention to the information environment rather than only to clinical imaging. Machine-learning bot detection, network analysis, and community detection have been used to trace how automated accounts amplify polarized and misleading health narratives, especially since COVID-19 [42]. Institutional case evidence shows that AI can support health-promotion messaging and coordination, although sustained engagement and long-term effects remain under-evaluated [10]. In education, the Edubot chemistry tutor reached more than 70% accuracy on interactive tutorials and self-assessment in a resource-constrained setting [9]. Global AI-in-education reviews, which Sri Lankan authors also invoke, warn that profiling, prediction, and intelligent tutoring have advanced faster than pedagogical theory or privacy critique [1]. Parallel computing-systems work argues that CPU-centric operating systems under-serve GPU/TPU workloads and that fairness, portability, and explainability must be designed into AI-first system software [43].

3.4.2. Public technology and agriculture

Extensions of the Technology Acceptance Model that add trust, design, and social influence have been used to explain AI-chatbot uptake in Sri Lanka's digital government, a setting where TAM alone is under-specified [44]. Sports-analytics studies of ODI cricket illustrate a wider shift from statistical margin models to Naïve Bayes, SVM, and random-forest classifiers, while still suffering class imbalance and real-time degradation [45]. In

agriculture, the Ceylon E-Agro application links farmers to AI agents and IoT services for pest advice, buyer matching, and price prediction, with a reported productivity gain of 45% in the evaluated maize-farming context [46]. Because laboratory soil-nutrient tests remain costly and slow, IoT colorimetric sensing combined with Gaussian process regression has been shown to classify nutrient levels at about 93% accuracy on small field datasets, offering a lightweight path into existing IoT workflows [47].

3.5. Nepal

3.5.1. Healthcare

Nepal's health literature is still sparse, but it is tightly bound to low-resource constraints. Epidemiological work on avian influenza H9 in Chitwan and adjoining districts identifies distance from roads, proximity to infected farms, and wild-bird contact as leading risk factors, with protective clothing as a key biosecurity practice [48]. Medical-education surveys in Nepal and comparable South Asian settings find moderate awareness of AI in medicine among undergraduates and interns, but little structured curriculum [49]. Commentaries on AI and health in Nepal argue that tools for diabetic retinopathy and neonatal risk are particularly relevant where specialists are scarce [12]. Empirically, a deep-learning system for retinopathy of prematurity achieved high examination-level discrimination on Nepali (Forus) and Mongolian (RetCam) images, supporting telemedicine and portable-camera workflows [50]. Reviews of maternal and neonatal AI in low-resource settings similarly emphasize early screening—including for birth asphyxia and related perinatal risk—while warning that infrastructure, integration, and rural equity remain the binding constraints [51].

3.5.2. Business and education

Customer-satisfaction research in Nepalese fintech has seldom used ML or explainable AI. Khanal et al. address that gap by combining principal component analysis with ML and SHAP/LIME explanations inside a local fintech firm, showing that interpretability methods can travel to small-market settings [11]. In schools, teachers recognize AI's potential for personalization and administrative automation but report limited proficiency, fear of job displacement, and weak policy guidance under the Digital Nepal Framework [52]. Complementary Nepalese analysis treats AI as both a stimulant and a challenge for academia and calls for a balanced strategy in which AI augments rather than replaces

teachers [53]. The implication is consistent with the health findings: motivation exists, local proofs of concept exist, and system-level adoption does not.

3.6. Comparative synthesis and the implementation gap

Read comparatively, the five national literatures do not occupy the same stage of ecosystem maturity. India combines environmental science, clinical imaging, vocational education, and production-grade analytics in banking and HR, reflecting thicker institutional and industry backing [6], [30]. Bangladesh's distinctive contribution is problem-led accuracy under constraint: disaster casualty scenarios, hematologic screening, and solar forecasting that are designed around local data and limited infrastructure [4], [5]. Pakistan, Sri Lanka, and Nepal contribute important but more fragmented pilots—personalized learning, public-health infodemiology, e-agriculture, portable imaging, and explainable fintech—without comparable evidence of national scale-up [8], [9], [11].

The shared finding is an implementation gap. Technical metrics in several diagnostic and prediction studies exceed 99% accuracy, yet the same papers, or adjacent commentaries, report missing digital infrastructure, scarce local AI expertise, unresolved privacy and bias issues, and thin policy support [12], [14]. Table 2 organizes those constraints. They are not residuals to be cleaned up after the algorithm is published; they are the conditions under which South Asian AI either becomes a public capability or remains a sequence of impressive pilots. Practitioner research on fairness in ML development likewise shows that teams often lack shared definitions and operational strategies for equity—an observation that travels directly to regional deployment [54].

Table 2. Recurring implementation constraints across the five-country corpus

Constraint	How it appears in the literature	Implication
Data quality and locality	Small, hospital- or pilot-bound datasets; limited rural representation	High accuracy may not generalize beyond the training site
Infrastructure	Uneven connectivity, scarce GPU/TPU capacity, costly laboratory assays	IoT, mobile, and low-cost sensing become necessary design choices

Constraint	How it appears in the literature	Implication
Skills and curriculum	Low LLM uptake; missing AI-ethics training; teacher proficiency gaps	Technology outruns the workforce that must operate it
Governance and ethics	Privacy concern, bias, hallucination, weak sectoral AI policy	Oversight and XAI are required before public-scale deployment
Equity of access	Urban and formal-sector concentration of pilots	Without rural design, AI can widen rather than close development gaps

3.7. Limitations and future direction

The review is bounded by its secondary corpus. Conclusions inherit the quality, scope, and methods of the included studies, which are mostly sector-specific and often rest on controlled or pilot data [3], [6]. Few items predate 2020, so long-run evidence on adoption and sustained impact is thin. Bibliometric maps describe keyword structure; they are not a substitute for effect-size pooling. Several claims in the source literature are themselves reviews of global work applied to a South Asian discussion, and those layers of citation were preserved rather than treated as local primary evidence.

Future research should evaluate AI systems in real service settings with longitudinal and mixed-method designs [54], [12]. Priority topics include explainable and contestable models, sectoral data-governance rules, teacher and clinician AI literacy, and cross-country comparisons that hold the application constant (for example diabetic-retinopathy screening or soil-nutrient sensing) while varying institutional context [16], [1]. Without those steps, the region will continue to accumulate high-performing prototypes that do not compound into public capability.

4. CONCLUSION

This systematic review shows that artificial intelligence is now a visible, but unevenly institutionalized, force in South Asian development practice, with documented applications in health, education, agriculture, energy, business, and public services. India leads in research depth and sectoral diversity; Bangladesh demonstrates how high-

accuracy models can be aimed at immediate disaster and diagnostic needs under infrastructure constraint; and Pakistan, Sri Lanka, and Nepal contribute focused pilots whose scale-up remains limited. Across all five countries, technical performance is running ahead of governance, workforce readiness, data stewardship, and rural access, so that impressive laboratory metrics have not yet become equitable developmental dividends. The practical implication is straightforward: South Asia will realize the socio-economic value of AI only if algorithmic work is paired with local human-capital investment, context-specific ethics, and policy instruments that treat implementation—not publication accuracy—as the criterion of success.

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