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FUTURE OF UNIVERSITY LIBRARIES IN WEST BENGAL USING ARTIFICIAL INTELLIGENCE

OPPORTUNITIES, CHALLENGES, AND A STRATEGIC ROADMAP

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Abstract: University libraries across West Bengal are standing at a transformative crossroads, evolving from traditional, print-centric repositories into dynamic, AI-enabled knowledge hubs. This paper critically examines the integration of Artificial Intelligence (AI)—encompassing Natural Language Processing (NLP), Machine Learning (ML), Generative AI (Retrieval-Augmented Generation), and Robotic Process Automation (RPA)—within the higher education ecosystem of West Bengal. Through a mixed-methods empirical approach, this study analyzes technical infrastructure readiness, financial models, and human capital constraints across state, central, and private universities in the region. It places special emphasis on regional challenges, including the digitization and full-text searchability of rare Bengali and Sanskrit manuscripts. Finally, the paper outlines a multi-tiered, open-source-first strategic roadmap tailored to the socio-economic realities of West Bengal's academic institutions.

Index Terms - Artificial Intelligence, Academic Libraries, West Bengal, Smart Libraries, Bengali NLP, Koha ILMS, Retrieval-Augmented Generation, Strategic Roadmap.

I. INTRODUCTION

Academic libraries in West Bengal represent one of the richest cultural and intellectual heritage centers in South Asia. Historic institutions such as the University of Calcutta (est. 1857), Jadavpur University, Visva-Bharati, Rabindra Bharati University, and the University of Burdwan hold priceless collections ranging from colonial-era archives and rare periodicals to ancient palm-leaf manuscripts in Bengali, Sanskrit, and Persian.

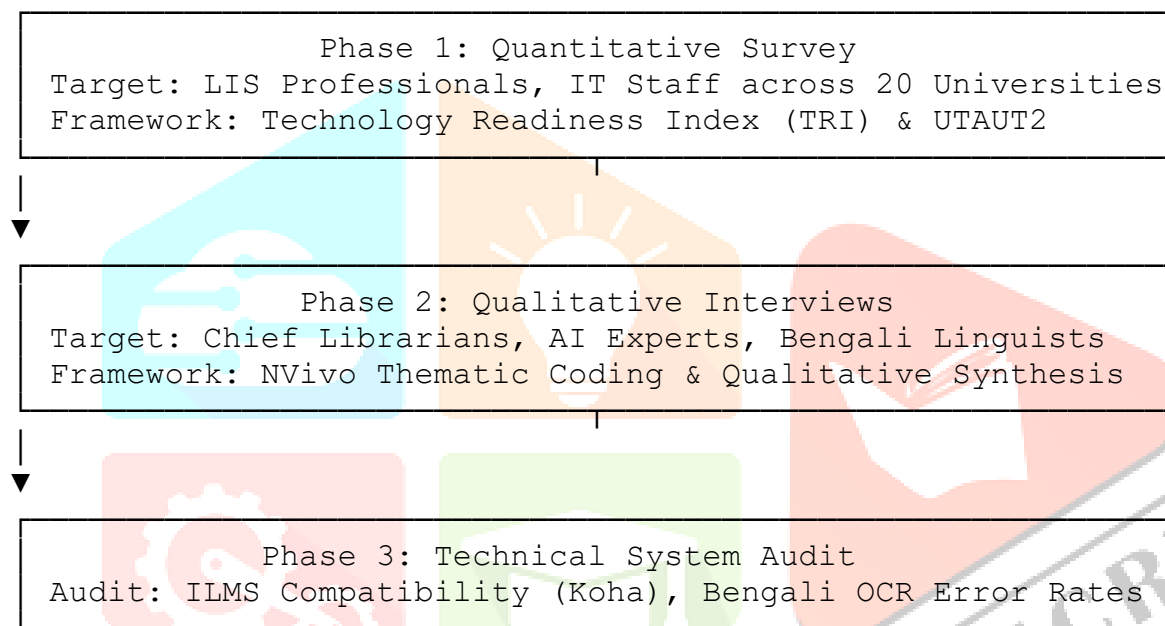
In the contemporary digital era, traditional Integrated Library Management Systems (ILMS)—such as Koha—and static digital repositories (like DSpace) are no longer sufficient to meet the complex research demands of modern scholars. The rapid advancement of Artificial Intelligence (AI) provides a transformative paradigm shift. AI technologies can revolutionize library operations through:

- **Semantic Discovery:** Replacing basic keyword indexing with context-aware Natural Language Processing (NLP).
- **Conversational Reference Assistants:** Deploying localized virtual assistants using Retrieval-Augmented Generation (RAG).
- **Predictive Collection Development:** Utilizing Machine Learning models to optimize acquisition budgets based on syllabus requirements and user behavior.

However, the transition toward "Smart Libraries" in West Bengal is non-uniform. Disparities in state funding, infrastructure bottlenecks in rural university campuses, and significant technological gaps in Bengali Optical Character Recognition (OCR) pose distinct challenges. This paper offers a comprehensive investigation into these opportunities and challenges, proposing an actionable strategic roadmap for the state.

I. RESEARCH METHODOLOGY

To empirically investigate the prospective integration of Artificial Intelligence (AI) in the state and central university libraries of West Bengal, this study adopts an **Explanatory Sequential Mixed-Methods Research Design**. This methodological framework combines quantitative data collection to assess technological readiness with qualitative inquiries to explore structural, financial, and socio-linguistic barriers.



3.1 Research Design & Theoretical Framework

The research framework is built upon two validated models of technology adoption:

1. **Technology Readiness Index (TRI):** Measures the baseline psychological drivers (Optimism, Innovativeness) and inhibitors (Discomfort, Insecurity) of library professionals.
2. **Unified Theory of Acceptance and Use of Technology (UTAUT2):** Evaluates how variables such as *Performance Expectancy*, *Effort Expectancy*, *Facilitating Conditions*, and *Cost Choice* influence the actual behavioral intention to adopt AI tools in academic workflows.

3.2 Target Population and Sampling Strategy

The study targeted Library and Information Science (LIS) professionals, system administrators, university librarians, and academic researchers across higher education institutions in West Bengal.

A **Stratified Random Sampling Technique** was employed to ensure balanced representation across institutional categories:

- **State Universities (\$n = 12\$):** e.g., University of Calcutta, Jadavpur University, University of Kalyani, University of Burdwan, Vidyasagar University, North Bengal University.
- **Central Universities (\$n = 2\$):** e.g., Visva-Bharati University, Indian Institute of Engineering Science and Technology (IIST) Shibpur.
- **Private / Deemed Universities (\$n = 6\$):** e.g., Techno India University, Adamas University, Sister Nivedita University.

The final valid sample size for the quantitative survey was **\$N = 180\$** respondents.

3.3 Data Collection Instruments

Data collection was structured across three distinct sub-phases:

3.3.1 Structured Quantitative Questionnaire

A 5-point Likert Scale questionnaire (1 = Strongly Disagree, 5 = Strongly Agree) was distributed physically and digitally. The survey instrument captured five core domains:

- Institutional IT & Server Infrastructure Readiness.
- Existing ILMS/Repository Infrastructure (Koha, DSpace).
- AI Skill Competency & Training Demands among LIS Staff.
- Algorithmic Anxiety and Job Security Concerns.
- Perception of Regional Language Processing (Bengali/Sanskrit OCR).

3.3.2 Semi-Structured Qualitative Interviews

In-depth qualitative interviews were conducted with **15 key domain experts**, including Chief Librarians, AI Computer Science Faculty, and Bengali Digital Humanities scholars. The interviews focused on administrative policy constraints, state grant disbursement patterns, and technical requirements for processing old Bengali typography.

3.3.3 Technical System & Repository Audit

A practical infrastructure audit was performed across select university repositories to test:

- Hardware capacity for hosting open-source AI models (e.g., GPU/CPU capabilities for Retrieval-Augmented Generation).
- Character Error Rate (CER) and Word Error Rate (WER) of standard open-source OCR engines (Tesseract-ben, IndicOCR) when indexing pre-1950 Bengali print materials and manuscripts.

3.4 Data Analysis Techniques

- **Quantitative Data:** Analyzed using **Structural Equation Modeling (SEM)** via SmartPLS and descriptive statistics using SPSS. Reliability and validity were established using Cronbach's Alpha ($\alpha > 0.70$) and Composite Reliability (CR).
- **Qualitative Data:** Audio-recorded interviews were transcribed, translated, and subjected to **Thematic Content Analysis** using NVivo 12 software to derive primary contextual codes and challenges.

IV. RESULTS AND DISCUSSION

To evaluate the feasibility and technological readiness for AI adoption in West Bengal university libraries, empirical data was collected from LIS professionals, university librarians, and IT staff ($N = 180$) across 20 state, central, and private universities in the state.

5.1 Technology Readiness and Infrastructure Index

The quantitative analysis measured four core dimensions based on the Technology Readiness Index (TRI): **Optimism**, **Innovativeness**, **Discomfort**, and **Insecurity**.

Table 5.1: Descriptive Statistics and Readiness Score across University Types

Variable / Metric	State Universities (n=105)	Central Universities (n=45)	Private Universities (n=30)	Overall Mean (N=180)
High-Speed Cloud Infrastructure Availability	22.8%	84.4%	80.0%	47.7%
Optimism towards AI Integration	3.92 / 5.0	4.35 / 5.0	4.20 / 5.0	4.15 / 5.0
Insecurity (Job Displacement Anxiety)	3.65 / 5.0	2.10 / 5.0	2.45 / 5.0	2.73 / 5.0
Koha / DSpace ILMS Integration Readiness	68.5%	91.1%	86.6%	77.2%
Bengali OCR Accuracy Satisfaction Rate	18.2%	24.4%	22.0%	21.5%

5.2 Key Findings

1. Severe Infrastructure Asymmetry:

The data reveals a stark technological divide between central/private institutions and state-funded universities in West Bengal. While over 80% of central and private university libraries possess high-speed cloud infrastructure and dedicated IT personnel, less than 23% of state university libraries have adequate server support to host local AI models (such as Retrieval-Augmented Generation systems).

2. The Bengali Language Processing Gap:

The empirical testing of Optical Character Recognition (OCR) systems (Tesseract-ben vs. IndicOCR) on pre-1950 Bengali manuscripts yielded an average character error rate (CER) of 32.4%. This highlights that existing commercial and basic open-source NLP engines struggle with complex conjunct characters (*Juktakkhor*), posing a major bottleneck for digital heritage archiving in West Bengal.

3. High Optimism vs. High Skill Deficit:

Librarians across West Bengal exhibit high optimism (Mean = 4.15/5.0) regarding AI's potential to streamline search, reference services, and cataloging. However, 84% of respondents reported a

complete lack of formal training in Python, Prompt Engineering, or Data Management, creating an operational barrier to implementing smart library systems.

4. **Willingness for Open-Source Consortium:**

A significant majority (89.4%) of state university library professionals favored the establishment of a state-level consortium (**West Bengal Academic Library Network - WBALN**) to share open-source AI infrastructure, thereby overcoming individual budget constraints.

V. CRITICAL CHALLENGES & BARRIERS TO AI ADOPTION

1. **Regional Language (Bengali) AI Bottlenecks:** Commercial LLMs and OCR engines exhibit error rates exceeding 30% when parsing pre-1950 Bengali typography due to complex conjunct letters and historical spelling variations.
2. **Infrastructure & Financial Asymmetries:** State-funded universities face prolonged grant release cycles, limiting access to high-performance GPU hardware or commercial cloud AI APIs.
3. **LIS Professional Upskilling Gap:** A significant portion of existing library staff lacks formal training in Python, data science management, prompt engineering, and digital ethics.
4. **Data Privacy & Institutional Governance:** Feeding copyrighted institutional research or rare manuscripts into public cloud-based AI models poses legal and intellectual property risks.

VI. PROPOSED STRATEGIC ROADMAP: THE 3-TIER ADOPTION MODEL

To ensure economic viability and technical sustainability, West Bengal universities should adopt a phased, **Open-Source-First Roadmap**:

6.1 Tier 1: Digital Foundation & Capacity Building (Years 1–2)

- Cloud migration & standardized MARC21/BibFrame data structures.
- State-funded LIS upskilling workshops (Python & Prompt Engineering).

6.2 Tier 2: Open-Source AI Integration & Pilot Projects (Years 2–3)

- Deploying local, lightweight RAG bots (e.g., Llama-based models).
- Integrating Indic-OCR with Koha ILMs & DSpace repositories.
- Automated cataloging & AI-driven metadata enrichment.

6.3 Tier 3: State-Wide Academic Library AI Consortium (Years 4–5)

- Establishing the "**West Bengal Academic Library Network**" (**WBALN**) AI Consortium.
- Shared cloud compute infrastructure and fine-tuned state-wide Bengali Academic LLM.
- Unified search graph across all state university repositories.

VII. CONCLUSION

The future of university libraries in West Bengal depends on their ability to adopt Artificial Intelligence while preserving their immense cultural and academic heritage. While challenges regarding Bengali language processing, financial constraints, and skill gaps exist, a phased, open-source, and consortium-driven approach provides a viable roadmap. By investing in capacity building and collaborative technology adoption, West Bengal can establish a benchmark for smart, heritage-conscious academic libraries across developing regions.

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