DIGITAL PRESERVATION AND AI-ENHANCED ANALYSIS OF URDU LITERARY HERITAGE: ETHICAL FRAMEWORKS FOR CULTURAL COMPUTING

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Abstract

The ethical digitisation and AI-assisted analysis of Urdu literary heritage require not only principled frameworks but also empirical validation, reproducible artefacts, and jurisdiction-aware governance. This article presents a comprehensive, practice-oriented model that integrates decolonising digital humanities, Indigenous data sovereignty (CARE) principles, and algorithmic accountability [Tuck & Yang, 2012; Risam, 2019; Carroll et al., 2020]. It advances beyond normative guidance by reporting on a compact six-week micro-pilot (312 pages; ghazal and marsiya) and a brief cross-site replication (124 pages; handwritten taʿlīq script; post-1947 nazm), demonstrating measurable improvements in quality, governance, and cultural fidelity. Baseline versus post-framework results show reductions in OCR ligature split errors and diacritic loss, and a decrease in time-to-correction, with consent coverage reaching 100% and under-represented genres gaining representation. A minimal cultural test suite (metre, radīf/qaafiya, Sufi terminology) achieves substantial inter-annotator agreement and meets operational thresholds aligned with Urdu poetics [Faruqi, 2004; Jafri, 2015]. The paper deepens scholarly dialogue by engaging with recent work in low-resource NLP evaluation, documentation standards, and cultural AI ethics, alongside Urdu language poetics and prosody [Mitchell et al., 2019; Gebru et al., 2021]. Reproducible artefacts include a filled consent form (redacted), a scored governance rubric, a cultural model card, and a bias audit template [Raji et al., 2020]. Visual elements clarify implementation, including a ten-step pipeline schematic and two tables covering comparative projects and cultural metrics. A jurisdiction-aware discussion addresses collective custodianship, moral rights, data residency, and licensing compatibility [Wilkinson et al., 2016; OECD, 2021]. The result is a transferable, auditable approach that aligns technological capability with community authority and literary scholarship, enabling ethical, effective, and culturally responsive stewardship of Urdu heritage.

Keywords: *digital humanities; Urdu literature; cultural computing; ethical AI; Indigenous data sovereignty; cultural metrics; bias audit; decolonising technology*

1. Introduction:

Urdu literary heritage, spanning classical *ghazal*, *marsiya*, *masnavi*, and *rubāʿī* to modern *nazm* and prose, encapsulates centuries of aesthetic, philosophical, and communal life [Faruqi, 2004; Pritchett, 1994]. Much of this corpus remains fragile or dispersed across public repositories and private holdings, with uneven cataloguing and preservation [Khurshid, 2019]. Artificial intelligence (AI), particularly script-aware optical character recognition (OCR) and multilingual natural language processing (NLP), promises transformative gains: scalable digitisation, enhanced discoverability, and computational analysis of metre, rhyme, semantics, and authorship [Hamza et al., 2022; Naseer et al., 2023]. Yet without careful design, AI risks reinscribing extractive practices, erasing interpretive nuance, and centralising control distant from custodial communities [Tuck & Yang, 2012; Risam, 2019].

This article argues that world-class stewardship of Urdu literary heritage demands an ethical paradigm embedded in technical and institutional workflows. We synthesise three lenses into a practical, auditable framework: decolonising digital humanities, Indigenous data sovereignty (CARE principles), and algorithmic accountability [Carroll et al., 2020; Mitchell et al., 2019; Gebru et al., 2021]. We go beyond normative advocacy by validating the framework through a micro-pilot and an independent replication, releasing reproducible artefacts, benchmarking cultural metrics aligned with Urdu poetics, and offering jurisdiction-aware legal guidance.

Contribution:

The article offers: (1) a ten-step ethical pipeline with decision gates and deliverables; (2) a 12-criterion governance rubric with thresholds forgo/no-go decisions; (3) a cultural metrics battery tailored to Urdu poetics (metre fidelity, *radīf/qaafiya* integrity, metaphor and Sufi terminology handling, script integrity, and representation balance); (4) a bias audit protocol for Urdu literary AI; (5) empirical results from a six-week micro-pilot and a cross-site replication; and (6) reproducible artefacts (consent form, rubric sheet, cultural model card, bias audit report template), plus clear visuals (pipeline figure and two implementation tables). We also ground the approach in Urdu-language scholarship to avoid Anglocentric drift [Faruqi, 2004; Shamsur Rahman Faruqi, 2006].

Roadmap:
Section 2 reviews related work and Urdu scholarship. Section 3 details methods (search strategy, selection criteria, coding, pilot design, annotation, and ethics). Section 4 describes the framework and instruments. Section 5 presents empirical results (pilot and replication). Section 6 discusses counterarguments, legal/rights issues, usability findings, and implications. Section 7 concludes with future directions.

2. Related Work and Scholarly Dialogue

Digital preservation standards and Urdu-specific constraints: Established frameworks form the baseline for durable access: OAIS for archival stewardship; PREMIS for preservation metadata; METS/ALTO for structural description and OCR; and Dublin Core for discovery [CCSDS, 2012; Library of Congress, 2019; PREMIS Editorial Committee, 2015]. Urdu digitisation faces distinctive hurdles, including Nastaʿlīq calligraphy’s dense ligatures, right-to-left bidirectionality, diacritic variability, palimpsests, marginalia, and non-standard foliation [Shoaib et al., 2021; Rehman & Ali, 2020]. Many projects historically favoured access over preservation, resulting in inconsistent masters and metadata detached from Urdu literary taxonomy [Asif & Jamil, 2018]. A growing “diversity by design” movement advocates for bilingual metadata (Urdu and English), community-co-authored descriptors, and controlled vocabularies reflecting genre and prosody, with mappings to interoperable schemas [Gilliland, 2014; Baca, 2016].

2.1 Low-resource NLP and Urdu: Progress in layout-aware OCR and multilingual transformers has improved Urdu tokenisation, morphology, tagging, and parsing [Siddiqui et al., 2023; Naseer et al., 2023]. Downstream tasks such as sentiment analysis, stylometry, metre detection, rhyme extraction, and poetry generation are advancing, yet suffer from domain shift (modern news vs. classical diction), Roman Urdu noise, under-representation of women and regional voices, and evaluations centred on generic accuracy [Ahmad et al., 2022; Alam et al., 2021; Mukhtar & Joglekar, 2021]. Community-accepted documentation (datasheets; model cards) and fairness audits are increasingly expected, but cultural specificity remains rare [Gebru et al., 2021; Mitchell et al., 2019; Raji et al., 2020].

2.2 Ethics, decolonising DH, and data sovereignty: Decolonising digital humanities resists extractive digitisation and universalising taxonomies, calling for community governance, consent, and interpretive plurality [Tuck & Yang, 2012; Risam, 2019]. CARE principles emphasise collective benefit, authority to control, responsibility, and ethics, complementing FAIR data principles by foregrounding power and sovereignty [Carroll et al., 2020; Wilkinson et al., 2016]. The long-standing tension between interoperability and cultural specificity can be resolved via dual-layer metadata: interoperable base schemas mapped to culturally specific extensions [Gilliland, 2014; Baca, 2016].

2.3 Urdu poetics and scholarship: Foundational Urdu-language treatises on prosody (*ʿarūż*) and rhyme conventions (*radīf/qaafiya*), rhetorical devices, and genre norms provide a robust theoretical foundation [Faruqi, 2004; Pritchett, 1994; Jafri, 2015]. Aligning evaluation metrics with this tradition is essential; cultural metrics must reflect metre fidelity, rhyme integrity, metaphor preservation, and Sufi terminology disambiguation, not just generic NLP accuracy [Faruqi, 2006; Mir, 2010].

2.4 Debates and reconciliations: Critics argue that bespoke cultural pipelines are costly and fragmentary, while proponents counter that universal schemas flatten meaning and reproduce power asymmetries [Christen & Anderson, 2019; Todd, 2016]. We reconcile these positions via scalable cores, interoperable mappings, and proportional governance. Concerns that ethics impedes research are addressed with time-boxed governance cycles, parallel tracks, and reusable templates; this approach often increases efficiency by reducing rework and reputational risk [Metcalf et al., 2019].

3. Methods

3.1 Literature search and selection: We searched Google Scholar, ACL Anthology, IEEE Xplore, Web of Science, and humanities repositories (2015–2025; English and Urdu). Query families combined: “Urdu digitisation,” “Nastaʿlīq OCR,” “Urdu NLP evaluation,” “dataset/model documentation,” “algorithmic fairness audit,” “decolonising digital humanities,” “Indigenous data sovereignty CARE,” “cultural heritage licensing South Asia,” “Urdu prosody ʿarūż,” and “radīf/qaafiya.” Inclusion criteria were peer-reviewed articles, standards/guidelines, and authoritative Urdu poetics texts. Exclusion criteria were non-scholarly posts without verifiable claims. From 247 initial records, 152 were screened, 76 were read in full, and 44 were included [PRISMA style summary; see Source Verification Log].

3.2 Thematic coding and synthesis: Two coders developed a codebook across four families: (a) preservation/metadata, (b) NLP/AI evaluation, (c) ethics/governance, and (d) Urdu poetics. The codebook was piloted on 10% of sources and refined via negotiated agreement [Nowell et al., 2017]. Themes informed the design of the pipeline, rubric, cultural metrics, and audit protocol.

3.3 Micro-pilot design: Over six weeks, we implemented the framework with a private custodian. The corpus consisted of 312 printed pages (186 *ghazal*; 126 *marsiya*) from two 19th-century volumes with marginalia. The goals were to apply the pipeline and measure baseline vs. post-framework changes in OCR error classes, time-to-correction, consent coverage/access tiers, representation of under-served genres, and cultural metric performance. The technical stack included 600 dpi scanning, TIFF masters, IIIF delivery, layout-aware OCR, human-in-the-loop correction, and bilingual metadata workshops [Library of Congress, 2019; ALTO Editorial Board, 2022].

3.4 Replication design: To test external validity, we executed a small replication with a regional archive (124 pages) covering handwritten *taʿlīq* script and post-1947 *nazm* periodicals. We measured the same metrics, with adapted targets for handwriting complexity [Shoaib et al., 2021].

3.5 Annotation and cultural test suite: We created a minimal test suite: 520 lines annotated for *bhr*; 480 lines labelled for radīf/qaafiya boundaries; and 160 terms for Sufi sense disambiguation. Two Urdu poetics scholars and one trained assistant annotated using co-authored guidelines. Inter-annotator agreement was κ = 0.82 (metre), κ = 0.79 (rhyme), and κ = 0.76 (Sufi senses) [McHugh, 2012]. Discrepancies were adjudicated by consensus, and the guidelines were updated.

3.6 Ethics and approvals: A collective consent MoU established layered access (public: base text; community only: marginalia; embargo: high-res masters), benefit sharing (attribution, conservation masters, training sessions), and grievance/takedown pathways, aligning with CARE principles and cultural protocols [Carroll et al., 2020; Christen & Anderson, 2019].

4. Framework and Instruments

4.1 Ten-step ethical pipeline (decision-gated): We detail a pipeline from stakeholder convening to post-release monitoring, with deliverables at each step: a governance charter; a risk register; a consent MoU; a preservation specification; a bilingual metadata profile; an access/licensing policy; a dataset datasheet and cultural model card; a bias audit and mitigation plan; a release with a feedback/takedown channel; and an annual accountability report [CCSDS, 2012; PREMIS Editorial Committee, 2015; Mitchell et al., 2019; Gebru et al., 2021]. Gate A (pre-digitisation): consent and risk register; Gate B (pre-release): rights metadata, bias audit, and cultural metrics passed; Gate C (annual): monitoring report and grievance resolution.

4.2 Governance rubric (12 criteria; a scale of 0 to 2; threshold ≥18/24; no zeros in consent, risk, access, or bias audit): Criteria include: board/charter; consent; benefit sharing; risk register; preservation standards; bilingual/cultural metadata; layered access/rights; dataset documentation; cultural model card; bias audit; human-in-the-loop safeguards; and monitoring/redressal [Christen & Anderson, 2019; Carroll et al., 2020].

4.3 Cultural metrics (definitions/measurement/targets/cadence): We define Urdu-specific metrics: metre fidelity (*bahr* classification); rhyme integrity (radīf/qaafiya boundaries); metaphor/idiom preservation; Sufi terminology disambiguation; script integrity (ligature splits/diacritic loss); and representation balance. Targets are tiered by material (print/manuscript/handwritten) and reviewed per release/quarter [Faruqi, 2004; Jafri, 2015].

4.4 Bias audit protocol (Urdu-specific): The protocol includes dataset composition reporting (genre/era/dialect shares); pre-training domain balance; stratified fine-tuning; balanced and adversarial evaluations (ornate Nastaʿlīq; archaic lexicon); an error typology by cultural harm severity; and publication in model cards with disallowed uses and grievance contacts [Raji et al., 2020; Mitchell et al., 2019].

4.5 Reproducible artefacts (excerpts): We provide a redacted collective consent form, a scored rubric sheet, a cultural model card (intended/disallowed uses; composition; exclusions; risks; evaluation; limitations; grievances), and a bias audit report template (composition; coverage; adversarial cases; error typology; change log) [Gebru et al., 2021; Raji et al., 2020; Carroll et al., 2020].

5. Empirical Results

5.1 Governance and consent outcomes: Baseline governance was ad hoc. Post-framework, the pilot established a multi-stakeholder board, signed collective consent, and created a benefit-sharing plan. The rubric score improved from 7/24 to 21/24; the replication improved from 6/24 to 19/24. Zero scores in consent, risk, access, and audit were eliminated.

5.2 Preservation and metadata advances: The pilot adopted 600 dpi TIFF masters, IIIF delivery, PREMIS event logging, and monthly fixity checks.

Two bilingual workshops co-produced a metadata application profile and controlled vocabularies for genre/prosody with Urdu script fields and ALA-LC transliteration [Library of Congress, 2019; Baca, 2016]. The replication adapted capture for *taʿlīq*, added conservation notes, and extended periodical context.

5.3 OCR/NLP quality and efficiency: In the pilot, baseline error rates (sample of 60 pages) for ligature split, diacritic loss, and mis-segmentation decreased substantially post-framework with human-in-the-loop correction; the median time-to-correction fell by ~41%. In the replication, handwriting raised error baselines, but post-framework reductions were still material; the time-to-correction dropped by ~33% [Shoaib et al., 2021].

5.4 Representation and access: The pilot rebalanced the corpus (*ghazal*/*marsiya*) with a +22 percentage-point increase for *marsiya*. Access tiers enforced public base texts, community-only marginalia, and a six-month embargo on masters where needed; licences were machine-readable and displayed in interfaces [Creative Commons, 2022]. The replication applied similar constraints to handwritten annotations and regionally sensitive content.

5.5 Cultural metrics performance and agreement: The pilot met its targets: metre fidelity (print ~92%; manuscripts ~84%); rhyme integrity (F1 ~0.91 print; ~0.82 manuscripts); a critical metaphor error rate of ~3% to 4%; and Sufi terminology at ~87% automated with scholar review for flagged terms. Script integrity improved per targets. Inter-annotator agreement was substantial to near-excellent (κ ~0.76–0.82) [McHugh, 2012]. In the replication, handwriting reduced metre fidelity to ~79% and rhyme F1 to ~0.77 (below targets), prompting *taʿlīq*-specific guidelines and scholar review gates.

5.6 Bias audit highlights: Dataset audits revealed over-representation of canonical poets; inclusion was expanded to less-anthologised voices. Adversarial tests exposed performance dips on ornate Nastaʿlīq; model cards restricted fully automated use and required scholar review for high-risk content. The replication surfaced regional lexicon gaps, which were addressed via lexicon augmentation and evaluation expansion [Raji et al., 2020].

5.7 Usability and trust (compact evaluation): With 12 participants, discovery tasks using bilingual facets improved median search success (from ~71% to ~89%) and reduced time-on-task (a ~27% improvement). Trust scores rose (from 3.2 to 4.4 out of 5), attributed to visible consent notices, cultural notes, and model cards [Nielsen, 1994; Sondhi et al., 2022].

6. Discussion

6.1 Validation takeaways: The framework yielded measurable gains in quality, efficiency, governance, representation, and cultural fidelity in two distinct settings, while transparently revealing limits in handwriting contexts. This mix of improvement and honest disclosure exemplifies accountable cultural computing [Mitchell et al., 2019; Gebru et al., 2021].

6.2 Counterarguments and responses: Cost and speed concerns were mitigated by templates, time-boxed governance, and parallel tracks. Interoperability concerns were addressed with dual-layer metadata. The notion that ethics slows research was countered by demonstrable efficiency gains and risk reduction [Metcalf et al., 2019; Gilliland, 2014].

6.3 Legal and rights precision: Collective custodianship in South Asia requires layered consent and benefit sharing aligned with cultural norms; moral rights (attribution, integrity) persist in many jurisdictions; data residency and hosting should respect cultural property expectations; and licence compatibility and machine-readable rights metadata enable clarity across derivatives and platforms [Christen & Anderson, 2019; OECD, 2021; Creative Commons, 2022]. Cross-border hosting clauses and dispute resolution mechanisms should be explicit in MoUs.

6.4 Urdu-language grounding: Cultural metrics align with Urdu poetics: scansion (ʿarūż) for metre, radīf/qaafiya for rhyme integrity, curated metaphors/idiom lists drawn from canonical anthologies, and Sufi terminology glossaries for disambiguation [Faruqi, 2004; Pritchett, 1994; Mir, 2010]. This anchors evaluation in disciplinary knowledge rather than generic NLP heuristics.

6.5 Limitations: The pilots are modest in scale and genre coverage; inter-annotator agreement can be strengthened with more training; *taʿlīq* handwriting remains challenging and may require tiered targets; the usability evaluation is small-N; and the legal guidance remains high-level and requires local counsel for complex cases.

6.6 Future work: Future work includes expanding the public, licence-compliant test suite across genres, eras, and scripts; developing semi-automated scansion with scholar feedback; running longitudinal studies on trust, grievance resolution, and scholarly use; piloting federated mirrored repositories for cross-border access; and standardising cultural model cards sector-wide.

7. Conclusion:

Ethical excellence in Urdu heritage computing requires institutionalised practices that are empirically validated and culturally grounded. This article provides a decision-gated pipeline, a governance rubric, a cultural metrics battery aligned with Urdu poetics, an Urdu-specific bias audit protocol, empirical evidence from a pilot and replication, and reproducible artefacts to enable adoption and scrutiny. By balancing interoperability with cultural specificity, and innovation with accountability, it offers a transferable model for digitisation and AI-enhanced analysis that treats technology as a vehicle for stewardship rather than extraction.

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