

Blockchain and Knowledge Graphs for Cultural Heritage Repatriation: Strengthening Evidentiary Frameworks under Indonesian Law

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Abstract

The illicit trafficking and historically wrongful removal of cultural property continue to undermine heritage protection and repatriation. Focusing on Indonesia, this article examines how blockchain and knowledge graphs might improve the integrity, traceability, and contextual organization of provenance information without treating technological immutability as proof of factual truth. It applies doctrinal analysis to Indonesian cultural-heritage and electronic-evidence law and critically assesses documented technical projects. The analysis finds that blockchain may help demonstrate whether a record has been altered after authorized entry, while knowledge graphs may connect heterogeneous sources and reveal relationships requiring further investigation. Neither tool independently establishes ownership, authenticity, or admissibility. Their evidentiary value depends on source authentication, identifiable and competent contributors, documented validation procedures, audit trails, mechanism for contestation, and compliance with Indonesian procedural law. A permissioned pilot linked to, but not legally equated with, the Cultural Heritage Register is therefore proposed for testing. The article contributes a conditional legal-technical model and identifies regulatory, institutional, financial, and data-governance issues that require empirical evaluation before national or cross-border deployment.

Keywords: *Blockchain; Cultural Heritage Law; Knowledge Graph; Repatriation; Illicit Trafficking.*

1. INTRODUCTION

The illicit trafficking of cultural property is a transnational problem characterized by theft, unauthorized excavation, falsified provenance, and movement through multiple jurisdictions. Because the trade is clandestine, reliable global monetary rankings are unavailable; accordingly, this article does not compare its value with arms or drug trafficking. The legally relevant point is narrower: incomplete and unreliable provenance

makes it difficult to link an object to its source community, establish the circumstances of its removal, and authenticate the chain of custody necessary for its return.^{1,2,3,4}

Indonesia is an important jurisdiction in which to examine that problem. In July 2023, after bilateral provenance research and recommendations by the Dutch Advisory Committee on the Return of Cultural Objects from Colonial Context, the Netherlands transferred ownership of hundreds of objects requested by Indonesia, including the Lombok treasure and the Pita Maha collection. The process demonstrates both the practical importance of archival provenance and the extent to which repatriation depends on institutional cooperation, historical interpretation, and diplomatic decision-making. It also demonstrates why a digital record cannot substitute for provenance research: the decisive questions concern who created each source, what evidentiary weight it carries, how competing accounts are evaluated, and which authority is competent to determine return.^{5,6,7}

The applicable framework is fragmented. The 1970 UNESCO Convention facilitates prevention and interstate cooperation but operates primarily on a prospective basis and does not, by itself, resolve all colonial-era claims. Indonesia has not acceded to the 1995 UNIDROIT Convention. Domestically, Law No. 11 of 2010 regulates cultural heritage⁸ and the national register, while the Electronic Information and Transactions Law recognizes electronic information and documents as evidence subject to statutory requirements.⁹ These instruments do not specifically regulate blockchain-based provenance systems, knowledge-graph inferences, cross-border node governance, procedures for correcting tamper-evident records, or the evidentiary status of data contributed by foreign museums and communities. Article 26 of Law No. 11 of 2010 creates a reporting duty for discoveries; it should not be read as an independent authorization for continuous blockchain recording.^{10,11}

The practical and normative problem, therefore, is not the absence of law, but the gap between existing legal rules and the production of reliable, interoperable evidence. Existing legislation does not determine who may validate legacy documents, how a contributor's identity and competence should be authenticated, how conflicting provenance assertions should be represented, or how foreign-held data may be transferred and challenged. A technical system could support these functions only if its governance

¹UNESCO, "Addressing Illicit Trafficking of Cultural Property in Digital Era.," June 26, 2025, <https://www.unesco.org/en/articles/addressing-illicit-trafficking-cultural-property-digital-era>.

²"Fight Illicit Trafficking of Cultural Property | UNESCO," accessed December 2, 2025, <https://www.unesco.org/en/fight-illicit-trafficking>.

³Joris Kila and Marc Balcells, eds., *Cultural Property Crime: An Overview and Analysis on Contemporary Perspectives and Trends* (Leiden: Brill, 2015).

⁴Samuel Andrew Hardy, "Conflict Antiquities' Rescue or Ransom: The Cost of Buying Back Stolen Cultural Property in Contexts of Political Violence," *International Journal of Cultural Property* 28, no. 1 (n.d.), <https://doi.org/doi.org/10.1017/S0940739121000044>.

⁵I Made Lanang Sudarmayana et al., "PERLINDUNGAN HUKUM TERHADAP WARISAN BUDAYA INDONESIA GUNA MENANGGULANGI KLAIM DARI NEGARA ASING DITINJAU DARI HUKUM INTERNASIONAL," *Jurnal Komunikasi Hukum (JKH)* 8, no. 2 (August 2022): 719–30, <https://doi.org/10.23887/jkh.v8i2.52020>.

⁶Michael Press, "Constructing Provenance with Old Collections: The Case of Cumberland Clark," *International Journal of Cultural Property* 31, no. 3 (n.d.).

⁷Government Netherlands, *Colonial Collections to Be Returned to Indonesia and Sri Lanka*, July 6, 2023, <https://www.government.nl/latest/news/2023/07/06/colonial-collections-to-be-returned-to-indonesia-and-sri-lanka>.

⁸Undang-Undang Nomor 11 Tahun 2010 Tentang Cagar Budaya.

⁹Undang-Undang (UU) Nomor 1 Tahun 2024 Tentang Perubahan Kedua Atas Undang-Undang Nomor 11 Tahun 2008 Tentang Informasi Dan Transaksi Elektronik (2024).

¹⁰Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property - Legal Affairs (1970), <https://www.unesco.org/en/legal-affairs/convention-means-prohibiting-and-preventing-illicit-import-export-and-transfer-ownership-cultural>.

¹¹1995 Convention - UNIDROIT, June 19, 2021, <https://www.unidroit.org/instruments/cultural-property/1995-convention/>.

framework is legally authorized and its records remain subject to forensic scrutiny and judicial examination.

Previous studies address important but distinct parts of this problem. Del Vecchio and Bifulco and Stublić, Bilogrivić, and Zlodi review blockchain applications in cultural heritage but primarily focus on technological developments and implementation possibilities. Khelifi and colleagues present Salsal as a permissioned vetting architecture, not as a system judicially validated in Indonesia. Tsai, Liu and Zheng, Patil and colleagues, Su, and Kumar and colleagues examine digital evidence or chain-of-custody questions in other forensic or legal settings. Oldman and Tanase, Carriero and colleagues, and Giovanelli and Traviglia show how knowledge graphs and standard ontologies can integrate or investigate heritage data, but they do not determine the admissibility of Indonesian repatriation evidence. Research on colonial restitution and Indigenous data sovereignty, including Ochoa Jiménez and Spano and Zhang, further demonstrates that provenance and platform governance involve questions of power, participation, and control in addition to technical integrity.¹²¹³¹⁴¹⁵

The resulting gap is specific: existing scholarship has not systematically examined a combined blockchain-knowledge-graph design against Indonesian cultural heritage and electronic evidence framework while simultaneously addressing safeguards for source verification, differentiated evidentiary status, correction mechanism, jurisdiction, and community participation. This article therefore asks: under what legal, technical, and governance conditions could an integrated system support Indonesian cultural-heritage repatriation claims without determining their legal outcome? Its objective is to develop a conditional implementation model and identify the legal reforms and empirical tests required before deployment. The contribution is analytical, not proof of effectiveness. The study uses doctrinal analysis of relevant Indonesian legislation and international instruments together with critical technology assessment of documented projects; no Indonesian institutional pilot, interview, cost study, or judicial test was conducted.¹⁶

2. ANALYSIS AND DISCUSSION

2.1 Strengthening Evidentiary Value in Repatriation Claims

A persistent obstacle in repatriation is producing authenticated evidence of ownership, custody, and the circumstances of removal. The 2023 Dutch return to Indonesia illustrates the central role of bilateral provenance research and archival documentation: official decision-making followed investigation of the histories of the objects and recommendations by a specialized advisory committee. The example supports a limited claim. Better organized records may assist a request, but repatriation still depends on the

¹²Vissarion Giannoulis and Galatea Kapellakou, "Blockchain and Illicit Trafficking in Cultural Goods," *Santander Art and Culture Law Review* 9, no. 2 (December 2023): 117–42, <https://doi.org/10.4467/2450050XSNR.23.025.18645>.

¹³Helena Stublić, Matea Bilogrivić, and Goran Zlodi, "Blockchain and NFTs in the Cultural Heritage Domain: A Review of Current Research Topics," *Heritage* 6, no. 4 (April 2023): 3801–19, <https://doi.org/10.3390/heritage6040202>.

¹⁴Sander Münster, Ronja Utescher, and Selda Ulutas Aydogan, "Digital Topics on Cultural Heritage Investigated: How Can Data-Driven and Data-Guided Methods Support to Identify Current Topics and Trends in Digital Heritage?," *Built Heritage* 5, no. 1 (December 2021): 25, <https://doi.org/10.1186/s43238-021-00045-7>.

¹⁵Erica Del Vacchio and Francesco Bifulco, "Blockchain in Cultural Heritage: Insights from Literature Review," *Sustainability* 14, no. 4 (February 2022): 2324, <https://doi.org/10.3390/su14042324>.

¹⁶Saptaning Ruju Paminto Rusdin Tahir, I Gde Pantja Astawa, Agus Widjajanto, Mompang L Panggabean, Moh Mujibur Rohman, Ni Putu Paramita Dewi, Nandang Alamsah Deliarnoor, Muhamad Abas, Rizqa Febry Ayu, Ni Putu Suci Meinarni, Fatimah Hs, Ni Wayan Eka Sumartini, Dewi Kania Sugiharti, *Metodologi Penelitian Bidang Hukum: Suatu Pendekatan Teori Dan Praktek* (Jambi: Sonpedia, 2023).

applicable legal or policy framework, the quality and interpretation of the sources, and institutional or diplomatic judgment.

Blockchain may preserve evidence that a digital record has not been altered after entry, but immutability is not factual truth. Reliability begins before hashing: the source document must be authenticated, the contributor identified and authorized, the time and method of digitization must be documented, and the asserted fact must be reviewed by a competent institution.¹⁷ The treatment of blockchain evidence in China is useful only as comparative support for the proposition that courts may evaluate the technical integrity of digital records. It is not a precedent for Indonesia, whose rules of procedure, institutional competences, and statutory requirements must control admissibility and weight.¹⁸¹⁹²⁰²¹

Salsal is best understood as a documented research architecture with potential applicability rather than as an establishment operational infrastructure. Its permissioned design links provenance assertions to supporting documentation and illustrates how access control and auditability might be structured. The published study does not establish that the platform is operating as national heritage infrastructure, that its participant-validation arrangements satisfy Indonesian administrative law, or that its records have received judicial recognition. It therefore supports feasibility at the level of system design, but does not establish legal effectiveness or institutional validity.²²

A knowledge graph can organize objects, events, places, persons, documents, and legal proceedings, but each statement should retain explicit provenance. The system should record the source and date, the responsible contributor, the ontology and its version, whether a relationship is asserted or inferred, the applicable inference rule, the assigned confidence level, any expert review, and a complete audit trail. Authenticated source documents and verified official entries may be offered as evidence subject to procedural law; automated links, low-confidence matches, or uncorroborated community or market reports should be labelled as investigative leads rather than direct proof.²³²⁴

The proposed combination is therefore evidentiary infrastructure, not an automatic evidentiary result. Blockchain can supply tamper-evidence for a recorded event, while a knowledge graph can disclose context and contradictions. A court or negotiating body must still evaluate authenticity, relevance, hearsay or analogous evidentiary objections, institutional competence, continuity of custody, and competing evidence. The platform

¹⁷Chairul Huda, Puan Dinaphia Yunan, and Zulhilmi Bin Paidi, "Discourse Using Blockchain Technology for the Enforcement of Money Laundering Crimes in Indonesia," *Volksgeist: Jurnal Ilmu Hukum Dan Konstitusi*, December 10, 2025, 553–72, <https://doi.org/10.24090/volksgeist.v8i2.13376>.

¹⁸Shuaiqi Liu and Qingxiao Zheng, "A Study of a Blockchain-Based Judicial Evidence Preservation Scheme," *Blockchain: Research and Applications* 5, no. 2 (June 2024): 100192, <https://doi.org/10.1016/j.bcra.2024.100192>.

¹⁹Harsh Patil et al., "Potential Applicability of Blockchain Technology in the Maintenance of Chain of Custody in Forensic Casework," *Egyptian Journal of Forensic Sciences* 14, no. 1 (January 2024): 12, <https://doi.org/10.1186/s41935-023-00383-w>.

²⁰Feihao Xinda Dong Liu, "Blockchain in Digital Cultural Heritage Resources: Technological Integration, Consensus Mechanisms, and Future Directions," *Heritage Science*, ahead of print, 2025, <https://doi.org/https://doi.org/10.1186/s40494-025-01818-4>.

²¹Fu-Ching Tsai, "The Application of Blockchain of Custody in Criminal Investigation Process," *Procedia Computer Science* 192 (2021): 2779–88, <https://doi.org/10.1016/j.procs.2021.09.048>.

²²Adel Khelifi et al., "Salsal: Blockchain for Vetting Cultural Object Collections," *Heritage Science* 12, no. 1 (January 2024): 15, <https://doi.org/10.1186/s40494-023-01129-6>.

²³Riccardo Giovanelli and Arianna Traviglia, "AIKoGAM: An AI-Driven Knowledge Graph of the Antiquities Market: Toward Automatised Methods to Identify Illicit Trafficking Networks," *Journal of Computer Applications in Archaeology* 7, no. 1 (January 2024): 92–114, <https://doi.org/10.5334/jcaa.130>.

²⁴Valentina Anita Carriero et al., "Pattern-Based Design Applied to Cultural Heritage Knowledge Graphs: ArCo: The Knowledge Graph of Italian Cultural Heritage," *Semantic Web: – Interoperability, Usability, Applicability* 12, no. 2 (January 2021): 313–57, <https://doi.org/10.3233/SW-200422>.

should never convert an inference into an established fact merely because the inference is anchored on-chain.

Under Indonesian law, technical documentation should be mapped to the requirements governing electronic evidence. At minimum, the proponent should be able to identify the natural or legal person responsible for each entry; demonstrate control of credentials; produce the original source or a verifiably faithful digital copy; explain the operation of hashing, timestamping, consensus mechanism, node membership, software versions, and any protocol changes; preserve system and access logs; and export a human-readable record suitable for independent examination. CIDOC CRM or another disclosed ontology can promote semantic consistency and interoperability, but compliance with an ontology does not, by itself, authenticate a proposition or establish its admissibility.²⁵²⁶

Existing INTERPOL and UNESCO initiatives confirm the operational importance of provenance documentation and information exchange, but they do not establish that a new platform would reduce a claimant's legal burden or increase success rates. Burdens and standards remain determined by the applicable substantive and procedural law, while outcomes may turn on jurisdiction, limitation periods, diplomatic relations, museum policy, and political judgment. The defensible expectation is that well-governed infrastructure may improve access to relevant material and enhance its auditability; while any effect on repatriation outcomes remains an empirical question.²⁷

A disputed or inaccurate immutable entry should not be deleted silently. A permissioned system should preserve the original record, append a cryptographically linked correction or revocation entry, mark the earlier assertion as contested, identify the authority and reasons for the modification, and prevent disputed information from being represented as verified while review is ongoing. An independent review body and an appeal route should be established by law or binding platform rules. These measures preserve the audit trail while recognizing that historical and provenance claims are corrigible.

2.2 Facilitating International Cooperation and Data Interoperability

Cross-border cooperation is impeded by more than incompatible databases. In Indonesian claims, relevant records may be held by foreign museums and archives, written in different languages, governed by different access and privacy rules, and interpreted under different restitution policies. Foreign institutions may not recognize Indonesian classifications or evidentiary consequences, and colonial archives may contain gaps or biased descriptions. These legal and institutional asymmetries explain why a shared technical format cannot, by itself, generate effective cross-border cooperation.

A permissioned ledger could provide a common log of submitted records and changes, but it should not be described as universally trusted. Participation would require agreements defining the operator, authorized nodes, identity assurance, data location, cybersecurity duties, applicable law, liability, audit rights, exit and migration procedures, and the effect of a participant's suspension. Each jurisdiction would remain authority

²⁵Zelin Su, "Evidentiary Value and Evidentiary Status of Blockchain Evidence," *The International Journal of Evidence & Proof* 29, no. 1 (January 2025): 58–76, <https://doi.org/10.1177/13657127241238020>.

²⁶Gulshan Kumar et al., "ZAKON: A Decentralized Framework for Digital Forensic Admissibility and Justification," *Information Processing & Management* 62, no. 6 (November 2025): 104226, <https://doi.org/10.1016/j.ipm.2025.104226>.

²⁷"Stolen Works of Art Database," accessed December 2, 2025, <https://www.interpol.int/en/Crimes/Cultural-heritage-crime/Stolen-Works-of-Art-Database>.

to determine the admissibility and evidentiary weight of records originating from or transmitted through the platform.²⁸

Integration of heterogeneous datasets also creates practical and legal risks. The model must reconcile multilingual names, inconsistent cataloguing, duplicate identities, incomplete dates, conflicting ownership narratives, confidential museum or law-enforcement information, personal data, and restricted traditional knowledge.²⁹ The platform should use controlled vocabularies with recorded translations; stable identifiers; source-level provenance; deduplication with human review; access tiers; data-minimization and retention rules; community protocols for culturally sensitive knowledge; and a documented process for preserving, comparing, and adjudicating conflicting assertions.

AIKoGAM³⁰ illustrates how automated extraction and network analysis can surface possible connections in antiquities-market material. Such outputs should be treated as investigative hypotheses whose reliability depends on source selection, entity resolution, ontology design, and human validation. Anchoring them to a blockchain may prove when an output was recorded but cannot cure an erroneous match. Accordingly, the proposed integration may support triage and provenance research, while legal claims must remain grounded in authenticated sources and reasoned expert assessment.

UNESCO could convene standards discussions or facilitate cooperation within its existing cultural-property mandate, but this article does not establish that UNESCO presently has authority, resources, or member-state consent to operate a global evidentiary platform. Any multilateral model would require a separate constitutive instrument or agreement among participating state addressing legal personality, funding, node allocation, data ownership and licensing, jurisdiction, and liability for inaccurate or unlawful entries, cybersecurity, independent oversight, and dispute settlement. A national or bilateral pilot is therefore more defensible than immediate global deployment.³¹

For Indonesia, institutional capacity constraints should be approached as empirical questions rather than assumed limitations. A feasibility assessment should inventory the Cultural Heritage Register, customs and museum systems, staffing, connectivity, cybersecurity controls, procurement rules, and community participation mechanisms. It should also identify which categories of data require Indonesian institutional control and which may be shared under defined legal and governance arrangements. Only that assessment can determine whether a domestic, bilateral, or federated architecture is institutionally appropriate.

The interoperability dimension also raises questions about technical standardisation. For a shared blockchain ledger to function across jurisdictions, it requires agreement on data formats, metadata schemas, and API protocols. These technical standards also have legal implications because the format in which provenance data is recorded may affect whether courts in different jurisdictions can interpret it and whether it can be integrated into existing national and institutional databases. The development of such standards is therefore not merely a technical exercise but a legal and diplomatic one,

²⁸Pedro Azevedo, Jorge Gomes, and Mário Romão, "Supply Chain Traceability Using Blockchain," *Operations Management Research* 16, no. 3 (September 2023): 1359–81, <https://doi.org/10.1007/s12063-023-00359-y>.

²⁹Yuliatin et al., "Kawin Ajum in Jambi: Socio-Legal and Islamic Law Perspectives on Cultural and Religious Heritage," *Ijtihad: Jurnal Wacana Hukum Islam Dan Kemanusiaan* 25, no. 1 (June 2025): 165–89, <https://doi.org/10.18326/ijtihad.v25i1.165-189>.

³⁰Giovanelli and Traviglia, "AIKoGAM."

³¹María Julia Ochoa Jiménez, "European Countries' Policies on Restitution of Colonial Cultural Property: Some Comments from a Latin American Perspective," *International Journal of Cultural Policy* 30, no. 6 (September 2024): 701–13, <https://doi.org/10.1080/10286632.2023.2255199>.

requiring engagement from legal scholars, heritage professionals, and policymakers across multiple jurisdictions.

2.3 Bridging Legal-Technical Gaps within the Indonesian Statutory Framework

Compatibility with Indonesian law cannot be inferred from technical functionality. Four specific gaps require attention: no rule expressly assigns legal status to blockchain-based provenance entries; no rule defines the evidentiary status of knowledge-graph inferences; no dedicated framework authorises cross-border heritage-data nodes and allocates their responsibility; and no procedure links correction of immutable records to the Cultural Heritage Register or to court disclosure. These gaps do not necessarily preclude a pilot, but they undermine any claim that blockchain-based records would be automatically admissible or that the relevant institutions are presently ready for implementation.

Law No. 11 of 2010 establishes registration, protection, and management duties for cultural heritage. Article 26 requires a finder to report a discovery to the competent authority, while the statutory register records protected heritage. That reporting duty may provide data that a provenance system could later reference, but it does not authorize continuous blockchain recording, designate blockchain nodes, prescribe validation procedures, or determine the evidentiary effect of recorded entries. A separate administrative basis would therefore be required to authorize system operation, define institutional responsibilities, and regulate inter-agency data use.³²

A cautious institutional model would keep the Cultural Heritage Register as the legally authoritative record and use a permissioned pilot as a supplementary audit layer. The competent heritage authority would operate the platform; designated registrars and accredited archival or museum units would submit records; a second authorized officer would verify source documents; and customs would receive role-limited access to compare export-permit identifiers.³³ Corrections would be appended and synchronized back to the authoritative register after administrative approval. Interoperability, responsibility for inaccurate entries, retention, access, and security would need express regulation. Such a model may support compliance with Articles 26 and 66; it cannot be said to satisfy them without doctrinal and institutional validation.

Law No. 28 of 2014 is relevant where digitization or graph publication involves protected works, traditional cultural expressions, personal data, or culturally restricted material.^{34,35} The platform should not assume that state custody eliminates community interests. Consent or consultation protocols, access restrictions, attribution, benefit-sharing where applicable, and a procedure for requesting restriction or correction should be incorporated into governance and assessed against the relevant statutory rights.^{36,37,38}

³²Hardy, "Conflict Antiquities' Rescue or Ransom: The Cost of Buying Back Stolen Cultural Property in Contexts of Political Violence."

³³Denny Sanjaya et al., "Collaborative Governance in Building Utilization Cultural Heritage in Metro City Through the Lens of a Socio-Legal Regime," *Jambe Law Journal* 4, no. 2 (November 2021): 201–16, <https://doi.org/10.22437/jlj.4.2.191-210>.

³⁴Undang-Undang Nomor 28 Tahun 2014 Tentang Hak Cipta, accessed August 4, 2024, <https://peraturan.bpk.go.id/Details/38690>.

³⁵Dw Putu Alit Denbagus Rafli, "NFT Become a Copyright Solution," *Journal of Digital Law and Policy* 1, no. 2 (2022).

³⁶Henriette Roued-Cunliffe and Andrea Copeland Japzon, eds., *Participatory Heritage* (London: Facet Publishing, 2017).

³⁷Emmy Febriani Thalib, Ni Putu, and Suci Meinarni, "NON-FUNGIBLE TOKEN (NFT) SEBAGAI ASET DIGITAL: SEBUAH FENOMENA DAN PERLINDUNGAN HUKUM KEKAYAAN INTELEKTUAL DI INDONESIA," *CIVIC EDUCATION JOURNAL* 4 (2022), <https://ejournal2.undiksha.ac.id/index.php/GANCEJ>.

³⁸Isabella Spano and Yuxiao Zhang, "Indigenous Data Sovereignty in Intangible Cultural Heritage Governance: A Complementary Approach to Public-Private Partnerships," *International Journal of Cultural Property* 32, no. 2 (May

The ITE Law recognizes electronic information and documents within Indonesia's evidentiary framework subject to statutory exclusions and requirements concerning accessibility, display, integrity, and accountability. Those provisions create a possible route for offering a blockchain record, not a presumption that the record is authentic, relevant, or sufficient. The proponent would still need to establish the source, authorized creation, system reliability, continuity, and a connection between the electronic record and the heritage object or underlying document.³⁹

Accordingly, legal-technical alignment requires more than hashing a register entry. Implementing rules or a binding pilot instrument should identify the operator and participating nodes, establish verification and correction procedures, define audit and disclosure duties, regulate customs access, data-protection safeguards, and clarify the relationship between on-chain events and authoritative administrative records. Knowledge-graph outputs should disclose whether each relation is directly sourced, expert-assessed, or generated through inference. Courts and other decision-makers would retain authority to determine admissibility and weight in each proceeding.

Recent Indonesian legal scholarship has identified the protection of traditional cultural expressions as a specific area of vulnerability.⁴⁰⁴¹⁴² The controversy concerning the use of Balinese endek fabric by Christian Dior illustrates the challenges of protecting traditional knowledge and ensuring recognition, participation, and benefit-sharing in relation to traditional cultural expressions.⁴³ A knowledge graph system that documents the cultural relationships of heritage objects must therefore incorporate community consultation mechanisms and ensure that sensitive or restricted cultural information is protected through appropriate access controls. This is not merely an ethical consideration; depending on the nature of the material and the right involved, it may also engage obligations under Indonesian Copyright and relegated legal frameworks and affect the legitimacy of a digitisation initiative.⁴⁴

Complementing blockchain's to provide tamper-evident records, knowledge graphs provide a semantic framework for contextualizing provenance data. Rather than storing artefacts as isolated records, knowledge graphs map relationships between objects, historical events, archaeological sites, prior owners, and related legal cases. This relational structure allows investigators, curators, and legal teams to identify patterns that might otherwise remain hidden. Such as, a knowledge graph could identify potential links between two sculptures held by different museums on separate continents and indicate that they may have originated from the same looted temple complex during a particular conflict⁴⁵. Linking such patterns to blockchain-recorded transaction histories could create a complementary evidentiary framework; blockchain may support

2025): 167–93, <https://doi.org/10.1017/S0940739125100064>.

³⁹Undang-Undang (UU) Nomor 1 Tahun 2024 Tentang Perubahan Kedua Atas Undang-Undang Nomor 11 Tahun 2008 Tentang Informasi Dan Transaksi Elektronik, accessed August 4, 2024, <https://peraturan.bpk.go.id/Details/274494/uu-no-1-tahun-2024>.

⁴⁰Fadjar Ramdhani Setyawan, Sudarsono Sudarsono, and Yuliati Yuliati, "Teori Ajaran Cita Hukum (Idee Das Recht) Di Dalam Perlindungan Ekspresi Budaya Tradisional Di Indonesia," *De Jure: Jurnal Hukum Dan Syar'iah* 13, no. 1 (June 2021), <https://doi.org/10.18860/j-fsh.v13i1.10025>.

⁴¹Evelyn Angelita Pinondang Manurung* and Ni Putu Suci Meinarni, *Cultural Heritage Protection in the Digital Era from Indonesian Legal Perspective: Strategies for Preservation and Responsible Access*, November 30, 2024, <https://doi.org/10.5281/ZENODO.14250400>.

⁴²Setiyono Setiyono et al., "Has Indonesia Safeguarded Traditional Cultural Expressions?," *Jambura Law Review* 6, no. 2 (July 2024): 206–39, <https://doi.org/10.33756/jlr.v6i2.24106>.

⁴³Dina Widyaputri Kariodimedjo, Bernessa C. Rotua, and Mario Jon Jordi, "Pelindungan Dan Pemajuan Pengetahuan Tradisional Dan Ekspresi Budaya Tradisional Indonesia : Penggunaan Tenun Endek Bali Oleh Christian Dior," *Jurnal IUS Kajian Hukum Dan Keadilan* 10, no. 1 (April 2022): 78–97, <https://doi.org/10.29303/ius.v10i1.1002>.

⁴⁴Kariodimedjo, C. Rotua, and Jordi.

⁴⁵Giovanelli and Traviglia, "AIKoGAM."

verification of record integrity, blockchain-verified overstates what blockchain verifies; and substantially strengthen makes an untested causal claim .

International legal scholarship on digital governance in cultural heritage has consistently emphasized that the risk of “digital colonialism”, the reproduction of colonial power asymmetries through technologically mediated control of cultural data, is a genuine and documented concern rather than a theoretical abstraction⁴⁶. For Indonesia, this concern is amplified by the historical context of colonial-era cultural extraction. Any shared digital infrastructure for heritage provenance should therefore address Indonesian data-sovereignty interests from the outset, including questions of institutional control, access, data location, applicable law, and the terms governing cross-border data sharing .⁴⁷

The long-term sustainability of a blockchain-knowledge graph system for heritage repatriation also raises questions about technological continuity and institutional capacity. Blockchain protocols evolve over time, and systems that lack planned migration pathways may become technically obsolete before their heritage-protection objectives are achieved. Similarly, knowledge graphs require continuous curation to remain accurate and semantically coherent as new information becomes available⁴⁸. These technical sustainability requirements translate into institutional responsibilities: heritage agencies need the internal expertise to maintain and update these systems, while sustainable funding mechanisms are needed to support long-term technological stewardship as part of heritage governance.⁴⁹

The governance of shared platforms must also address the question of dispute resolution. Where blockchain records are contested, for example, where a party claims that a particular provenance record is inaccurate or was entered fraudulently, there must be a legally recognized mechanism for challenging and correcting records without compromising the integrity of the ledger as a whole. Smart contract mechanisms and permissioned blockchain architectures that allow designated authorities to flag disputed records while preserving the underlying data offer a technical approach to this challenge⁵⁰. However, the legal effect of such mechanisms would need to be established under the applicable national law or, where relevant, an international or inter-institutional agreement before they can be relied upon in repatriation proceedings.

2.4 Operationalizing the Framework: Practical and Institutional Dimensions

This section presents a proposed implementation model rather than established institutional benefits. Because the research did not include an Indonesian pilot, institutional interviews, cost estimates, or judicial testing, the claims below should be understood as design hypotheses requiring evaluation through a staged feasibility study. Relevant measures include data quality, validation time, correction frequency, interoperability, user capacity, operating cost, security incidents, and whether the system changes the time or quality of actual repatriation decisions.

⁴⁶Aishat Oyenike Salami, “Artificial Intelligence, Digital Colonialism, and the Implications for Africa’s Future Development,” *Data & Policy* 6 (2024): e67, <https://doi.org/10.1017/dap.2024.75>.

⁴⁷Salami.

⁴⁸Patil et al., “Potential Applicability of Blockchain Technology in the Maintenance of Chain of Custody in Forensic Casework.”

⁴⁹Sabine Von Schorlemer, “UNESCO and the Challenge of Preserving the Digital Cultural Heritage,” *Santander Art and Culture Law Review*, no. 2 (6) (2020): 33–64, <https://doi.org/10.4467/2450050XSNR.20.010.13013>.

⁵⁰Vacchio and Bifulco, “Blockchain in Cultural Heritage”; Giannoulis and Kapellakou, “Blockchain and Illicit Trafficking in Cultural Goods.”

A possible pilot operator is the Indonesian authority responsible for the Cultural Heritage Register, acting under an express ministerial regulation or other adequate legal instrument and overseen by a multi-stakeholder board. Authorized nodes could include the register authority and designated museum or archival units; customs and law-enforcement bodies could initially receive query access rather than unrestricted writing rights. Contributions should be classified by source and validation status, such as official authenticated record, expert-reviewed archival record, community-held knowledge subject to applicable consent protocols, third-party reports, or machine-generated lead. State origin should not create automatically confer greater probative value: evidentiary weight should instead depend on competence, authentication, procedural compliance, and source reliability.

Proposed Conceptual Governance Model for an Indonesian Blockchain–Knowledge Graph Pilot

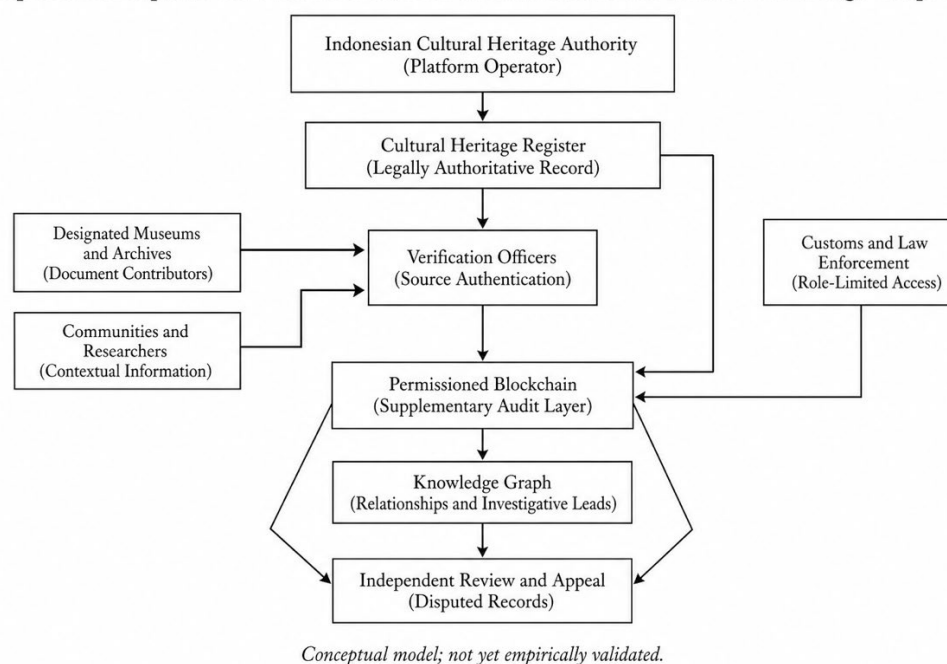


Figure 1. Proposed conceptual governance model for a limited Indonesian blockchain–knowledge graph pilot. Source: Authors’ elaboration.

Figure 1 translates the proposed governance arrangement into a conceptual institutional model. The Cultural Heritage Register remains the legally authoritative record, while the permitted blockchain functions only as a supplementary audit layer. Heritage authorities, designated museums, and archival institutions may act as authorised contributors, subject to source authentication and secondary verification. Customs and law-enforcement bodies receive role-limited access, whereas information submitted by communities and researchers is recorded according to its source and validation status. Disputed entries should be subject to an independent review and appeal mechanism rather than being deleted from the ledger. This model is proposed as a basis for a limited pilot and has not been empirically validated through institutional interviews, technical testing, cost analysis, or implementation within Indonesian heritage agencies.

Legacy documents should be digitized under a documented protocol recording custodian, physical condition, imaging method, equipment, operator, time, file format,

hash, quality review, and any transcription or translation. The physical original or legally adequate certified copy should remain available. The ITE Law may support the use of electronic documents where statutory conditions are satisfied, but it does not make every scan or blockchain entry authentic. Implementing rules and judicial practice would need to specify certification, preservation, disclosure, and expert-examination requirements.

The third institutional dimension concerns the training and capacity development of legal practitioners⁵¹. The effective use of blockchain and knowledge- graph evidence in repatriation proceedings depends not only on the availability of technically robust records but on the ability of judges, attorneys, and arbitrators to understand and evaluate such evidence. This presents a significant challenge: the technical properties of blockchain including cryptographic hashing, consensus mechanisms, and smart contracts may be unfamiliar to many legal practitioners, while knowledge graphs introduce additional complexity through their reliance on formal ontologies and semantic reasoning. Legal education and continuing professional development programmes must therefore incorporate digital evidence literacy as a component of heritage law training. At the international level, judicial training programmes supported by UNESCO or other intergovernmental organisations could contribute to developing the capacity of adjudicative bodies in multiple jurisdictions to evaluate blockchain-based provenance evidence.

The system should be designed to support rather than replace diplomatic negotiation, expert assessment, litigation, or arbitration. Experts may still be needed to authenticate legacy records, explain technical processes, resolve identity matches, and interpret disputed history. It is therefore premature to claim that blockchain-based evidence will reduce reliance on testimony, alter legal burdens, accelerate proceedings, or produce more consistent outcomes. A pilot should compare existing and proposed workflows before any such benefits are asserted.

The 2023 return from the Netherlands provides a concrete bilateral setting for a pilot because it involved extensive provenance research and cooperation between Indonesian and Dutch institutions. A limited project could link selected archival descriptions and Indonesian registry entries while retaining source documents off-chain and recording only hashes, identifiers, access permissions, and audit events on-chain. Participation would require a bilateral data-sharing instrument and approval from the competent institutions; the present study does not establish their willingness or the legal authority for automated exchange.

Financial sustainability likewise remains unresolved. Before identifying any international fund, the parties should prepare total-cost estimates covering development, digitization, security, legal compliance, training, independent audit, migration, and long-term curation. Funding eligibility and donor conditions must be verified. A staged, time-limited pilot with published evaluation criteria is preferable to assuming that UNESCO or bilateral assistance will finance a permanent platform.

3. CONCLUSION

This doctrinal and technology-assessment study indicates that blockchain and knowledge graphs may support Indonesian repatriation efforts under specified conditions; it does not establish their legal admissibility or practical effectiveness. Blockchain can

⁵¹Giannoulis and Kapellakou, “Blockchain and Illicit Trafficking in Cultural Goods.”

provide tamper-evidence after authorized entry, while knowledge graphs can organize contextual and competing claims. Their evidentiary value nevertheless depends on accurate initial data, authenticated sources, identifiable contributors, expert validation, correction and appeal mechanisms, procedural compliance, secure governance, and judicial or institutional acceptance.

Indonesia's current legislation provides relevant foundations but leaves significant uncertainty regarding digital provenance, node authority, cross-border data exchange, knowledge-graph inferences, and procedures for correcting of disputed records. The next step should be a legally authorized national or bilateral pilot accompanied by institutional interviews, data-protection and cybersecurity assessment, cost analysis, and evaluation against actual provenance workflows. Until those tests are completed, the proposed framework should be understood as a conditional research model whose potential contribution lies in improving record integrity and discoverability, not in proving ownership, establishing automatic admissibility, or guaranteeing accelerated repatriation.

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