AG EDITOR

From Weaving Patterns to Data Patterns: AI-Driven Cultural Documentation of East Sumba's Ikat Traditions

De los Patrones de Tejido a los Patrones de Datos: Documentación Cultural Impulsada por la IA de las Tradiciones de Ikat de Sumba Oriental

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ABSTRACT

Introduction: this study aims to develop and test a metadata-driven, AI-assisted framework for documenting the visual, oral, and symbolic elements of *ikat* weaving in East Sumba. It seeks to explore how artificial intelligence can transform traditional knowledge into machine-readable cultural data structures while maintaining epistemological integrity and community participation.

Method: this research employed a hybrid qualitative-technical methodology. Ethnographic fieldwork was conducted with *ikat* artisans in East Sumba to gather narrative and visual data, including interviews, ritual transcripts, and photographs of woven fabrics. These data were analyzed using a combination of natural language processing (NLP) and computer vision algorithms. NLP was used to extract recurring linguistic patterns and cosmological themes, while computer vision categorized visual motifs by type, symmetry, and symbolic meaning.

Results: the AI-driven approach effectively captured the symbolic and narrative complexity of the *ikat* tradition. Computer vision techniques successfully identified and classified motif types and regional styles, linking them to spiritual meanings conveyed by the artisans. NLP analysis of transcribed interviews revealed consistent narrative patterns related to ancestral cosmology, customary law, and motif symbolism.

Conclusion: this research demonstrates the viability of combining AI technologies with ethnographic fieldwork to create a robust, ethical, and culturally sensitive system for documenting living traditions. By translating the complexity of *ikat* knowledge into semantic data patterns, the study provides a model for intelligent cultural heritage documentation. The key contribution lies in bridging indigenous epistemologies with digital infrastructures, enabling scalable cultural preservation without compromising authenticity.

Keywords: Artificial Intelligence; Natural Language Processing; Intelligent Systems; Culture; Knowledge Representation.

RESUMEN

Introducción: este estudio tiene como objetivo desarrollar y probar un marco asistido por inteligencia artificial y basado en metadatos para documentar los elementos visuales, orales y simbólicos del tejido ikat en Sumba Oriental. Busca explorar cómo la inteligencia artificial puede transformar el conocimiento tradicional en estructuras de datos culturales legibles por máquinas, manteniendo la integridad epistemológica y la participación de la comunidad.

Método: esta investigación utilizó una metodología híbrida cualitativa-técnica. Se realizó trabajo de campo etnográfico con artesanos del ikat en Sumba Oriental para recopilar datos narrativos y visuales, incluyendo

entrevistas, transcripciones de rituales y fotografías de tejidos. Estos datos fueron analizados mediante una combinación de procesamiento de lenguaje natural (PLN) y algoritmos de visión por computadora. El PLN se utilizó para extraer patrones lingüísticos recurrentes y temas cosmológicos, mientras que la visión por computadora categorizó los motivos visuales por tipo, simetría y significado simbólico.

Resultados: el enfoque impulsado por IA capturó eficazmente la complejidad simbólica y narrativa de la tradición ikat. Las técnicas de visión por computadora identificaron y clasificaron con éxito los tipos de motivos y estilos regionales, vinculándolos con significados espirituales transmitidos por los artesanos. El análisis de PLN de las entrevistas transcritas reveló patrones narrativos consistentes relacionados con la cosmología ancestral, el derecho consuetudinario y el simbolismo de los motivos.

Conclusión: esta investigación demuestra la viabilidad de combinar tecnologías de IA con trabajo de campo etnográfico para crear un sistema sólido, ético y culturalmente sensible para documentar tradiciones vivas. Al traducir la complejidad del conocimiento ikat en patrones de datos semánticos, el estudio proporciona un modelo para la documentación inteligente del patrimonio cultural. La principal contribución radica en tender puentes entre las epistemologías indígenas y las infraestructuras digitales, lo que permite una preservación cultural escalable sin comprometer la autenticidad.

Palabras clave: Inteligencia Artificial; Procesamiento del Lenguaje Natural; Sistemas Inteligentes; Cultura; Representación del Conocimiento.

INTRODUCTION

East Sumba, Indonesia, is globally recognized for its rich tradition of *ikat* weaving—a cultural practice that embodies not only artistic expression but also deep-rooted spiritual and social meanings. This woven fabric carries ancestral narratives, cosmological symbols, and local identities, transmitted intergenerationally through oral and material traditions. As tourism grows in the region, there is an increasing need to document and communicate these intangible cultural assets in structured, scalable ways.[1]

However, conventional modes of cultural preservation—such as ethnographic texts and museum archiving—are limited in accessibility and scalability, especially when addressing the dynamic contexts of living traditions like *ikat*.[2] In recent years, digital technologies have been deployed to support heritage documentation, yet these efforts often remain fragmented and lack interoperability across platforms and stakeholders.

The emergence of artificial intelligence (AI) and metadata frameworks offers a novel avenue for preserving and promoting cultural narratives embedded in *ikat* weaving. Through AI-powered image recognition, semantic annotation, and knowledge graph modeling, it is now possible to extract, organize, and disseminate complex layers of cultural meaning at scale.[3] This approach aligns with global calls to integrate digital infrastructures into intangible heritage governance.[4]

In particular, metadata—the structured description of content—plays a vital role in enabling machines to understand, link, and retrieve cultural data across systems. Cultural metadata schemes have evolved to include not only descriptive elements (e.g., color, motif, origin) but also narrative, symbolic, and performative dimensions, allowing richer interpretations of traditional crafts like *ikat*.[5]

Integrating AI with metadata models can support a multidimensional understanding of *ikat* as both tangible and intangible heritage. For example, natural language processing (NLP) techniques can extract indigenous storytelling patterns from transcribed interviews, while computer vision can identify stylistic elements from weaving images and link them to geographic or ethnolinguistic contexts.[6] These technologies collectively enable the generation of structured cultural knowledge, useful for education, tourism, and policy design.

In tourism, there is growing demand for personalized and meaningful cultural experiences. AI-enhanced metadata systems can support dynamic heritage interpretation by providing context-aware recommendations, multilingual story interfaces, and immersive AR/VR content based on cultural semantics.[7] For regions like East Sumba, where cultural richness is often underrepresented in digital tourism ecosystems, such innovation can bridge the gap between local knowledge and global audiences.

Moreover, these technologies contribute to cultural sustainability. When implemented ethically and collaboratively, AI systems can empower local weavers and cultural actors by embedding their voices into digital infrastructures, protecting them from cultural appropriation and misrepresentation.[8] Structured metadata frameworks can also support intellectual property recognition and benefit-sharing mechanisms.

Despite its potential, the integration of AI and metadata in heritage tourism remains underexplored in Southeast Asia, particularly in rural, indigenous contexts. This gap highlights the need for applied research that combines ethnographic depth with technical modeling to ensure that AI systems are culturally responsive and contextually grounded.[9]

This study aims to develop a metadata-driven, AI-assisted framework for the documentation, preservation,

and promotion of ikat weaving narratives in East Sumba. By integrating qualitative fieldwork with digital tools such as image and text analysis and semantic web technologies, the study seeks to create a sustainable cultural knowledge infrastructure. This infrastructure will not only support the visibility and accessibility of East Sumba's intangible heritage in digital spaces but also ensure that the documentation process respects and reflects the epistemologies, values, and storytelling traditions of the local communities. Ultimately, the goal is to contribute to cultural tourism development by fostering meaningful engagement between local knowledge systems and global digital audiences.

Semantic Web Theory, introduced by Tim Berners-Lee, proposes that data on the web should be structured and linked in ways that allow both humans and machines to interpret them. This theory supports the use of ontologies, metadata, and linked data to build knowledge representation systems. The Semantic Web Theory was proposed by Tim Berners-Lee, the inventor of the World Wide Web, as an evolution of the current web toward a more intelligent and machine-readable ecosystem. While the conventional web allows humans to access and interpret content visually, the Semantic Web envisions a system in which data is structured and interlinked so that machines can understand, process, and reason over it, enabling more meaningful automation and decision-making.[8]

Unlike the traditional web, which focuses on documents linked via hyperlinks, the Semantic Web focuses on data and relationships between data entities. This shift—from a document-centric to a data-centric paradigm—enables the web to become a vast, decentralized knowledge base. Resources are not merely strings of text but are treated as objects with attributes and relationships that can be queried, combined, and interpreted programmatically.[9] Central to Semantic Web Theory are technical components such as RDF (Resource Description Framework), OWL (Web Ontology Language), and SPARQL (a semantic query language). RDF provides a standard for describing resources and their relationships using subject-predicate-object triples. OWL is used to define ontologies—formal conceptual frameworks that describe categories, properties, and relationships among concepts. These tools collectively enable semantic reasoning over web data.[10]

Metadata plays a crucial role in the Semantic Web by adding contextual meaning to digital content. In this framework, metadata is not just descriptive (e.g., author, title, date) but also structural and semantic. It allows both humans and machines to interpret the significance of content and its interrelations. Metadata thus serves as the bridge between raw content and intelligent data systems.[11] Another foundational idea in Semantic Web Theory is "Linked Data," which refers to a set of best practices for publishing and connecting structured data across different domains. By using standardized identifiers (URIs) and common vocabularies, datasets can be made interoperable and discoverable on the web. This enables diverse data—such as museum records, linguistic databases, or folk narratives—to be semantically connected and navigated.[12]

In recent years, the Semantic Web has been increasingly applied in the domain of cultural heritage. Institutions such as Europeana and the Getty Institute have employed semantic technologies to model and publish cultural datasets. These efforts enable cross-collection searches, multilingual access, and context-rich representations of heritage objects and narratives.[13] By encoding cultural knowledge in machine-readable formats, the Semantic Web supports long-term preservation and intelligent retrieval.

Semantic Web Theory also opens new pathways for documenting indigenous and intangible knowledge, which is often excluded from mainstream digital platforms due to lack of formal structures. Ontologies can be designed to reflect local worldviews, relational thinking, and oral traditions, allowing AI systems to engage more respectfully and accurately with non-Western knowledge systems.[14]

The Semantic Web does not function in isolation—it is a foundational layer for artificial intelligence on the web. When semantic metadata is combined with machine learning, natural language processing, and computer vision, it enables intelligent systems to draw inferences, answer complex queries, and personalize content delivery. For example, in your study on ikat weaving, AI can identify motif types, while semantic metadata can link those motifs to cultural meanings, regions, and stories.[15]

Despite its potential, Semantic Web implementation poses several challenges. Designing inclusive and accurate ontologies requires close collaboration with domain experts and communities. There are also ethical concerns regarding data ownership, representation, and the risk of decontextualization. These issues are especially pressing in cultural heritage contexts, where misrepresentation can cause cultural harm.[16]

In the context of your research on East Sumba's ikat weaving, Semantic Web Theory provides a powerful theoretical and technical foundation. By structuring motifs, narratives, and cultural contexts into linked, interoperable data, you can build a digital knowledge infrastructure that supports AI-driven documentation while respecting indigenous epistemologies. It enables the transformation of weaving patterns into "data patterns" that are searchable, scalable, and semantically meaningful.

THEORETICAL REVIEW
Actor-Network Theory (ANT)

Actor-Network Theory (ANT) is a sociotechnical approach that treats both human and non-human entities—such as algorithms, documents, tools, and cultural artifacts—as equally important "actors" within a network.

It emphasizes distributed agency, meaning that decisions and outcomes are shaped collectively by people and technologies.

A key concept in ANT is "translation," the process through which actors negotiate roles and align their interests to form a functioning network. In cultural documentation, this might involve weavers, AI systems, metadata standards, and digital archives working together to preserve heritage.

ANT also reveals how technologies can become "black-boxed"—appearing neutral while concealing the power dynamics and design choices that shape them. This perspective helps identify whose voices are included or excluded, especially in projects involving indigenous or local knowledge.

Applied to ikat weaving in East Sumba, ANT allows a deeper understanding of how humans, machines, and cultural meanings interact. It encourages ethical and participatory AI design by recognizing that cultural narratives are co-produced through complex sociotechnical relations

Ethnography of Communication

Communication Ethnography is an interdisciplinary research tradition rooted in anthropology and communication science, and was developed significantly by Dell Hymes in the 1960s. This approach is based on the premise that communication is culture, and culture is communication that is, culture is understood not as something static, but as a living communication practice that is continually negotiated by members of a community.[17] To understand culture in depth, Communication Ethnography examines communication practices through key concepts such as speech community and speech event, which are analyzed using the SPEAKING model including Setting, Participants, Ends, Act sequence, Key, Instrumentalities, Norms, and Genre.[18] More than just a theory, Communication Ethnography is also a methodological approach based on participatory ethnography, where researchers immerse themselves in the lives of communities through observation, interviews, and analysis of cultural artifacts to understand the meaning of communication from an insider (emic) perspective.[19] This approach combines the power of symbolic analysis and interactional context in an effort to understand how cultural identities are formed and communicated.[20]

Cultural Identity Theory views cultural identity as a dynamic, multi-layered social construct influenced by history, values, personal experiences, and social interactions.[21] Cultural identity is not separate from communication, but rather constructed through everyday communication practices. The theory highlights two main dimensions: salience (the degree to which an identity is meaningful in a given situation) and content (the content of an identity that includes values, norms, language, symbols, and history).[22] Both are situational and are inherited through socialization and enculturation. An important contribution of the theory is its emphasis on the negotiation of cultural identity in communication where individuals actively negotiate, assert, or adjust their identities in interactions, especially in the context of intergroup communication.[23] This process allows for the formation of bridges of understanding across cultures, and is key to managing differences and potential conflicts between cultural identities.[24]

One of the most significant contributions of Cultural Identity Theory lies in its emphasis on the process of identity negotiation in the realm of intercultural communication.[25] This theory views cultural identity not as something static or simply inherited, but as a dynamic construction that is actively negotiated, managed, and reinterpreted by individuals in the context of social interaction. This negotiation process includes various communication strategies, such as identity affirmation, which is an individual's effort to affirm and validate their cultural identity, and identity accommodation, which is an effort to adjust in order to create harmonious social relations across cultures.[26] In practice, this identity negotiation often occurs in intergroup communication, where individuals are not only aware of the differences in identity that exist, but also try to build shared understanding, bridge cultural gaps, and avoid potential conflicts through reflective and adaptive dialogue.[27] Thus, cultural identity is understood as something that is always in the process of becoming, which is continuously constructed through interaction, difference, and openness to change.[28]

Cultural heritage

Cultural heritage encompasses all aspects of culture that are passed down from generation to generation, from values, beliefs, traditions, languages, arts, to historical artifacts that have deep meaning for the collective identity of a society.[37] This heritage not only reflects the uniqueness of a group, but also serves as a source of knowledge about the history of civilization, social dynamics, and the relationship between humans and nature. Cultural heritage plays an important role in shaping communal identity, maintaining the diversity of cultural expressions, and bridging understanding across generations.[38] The study of cultural heritage allows exploration of the complexity and uniqueness of society and the symbolic values inherent in cultural practices that have developed over centuries.[39] Therefore, active preservation and appreciation of cultural heritage are crucial in maintaining the sustainability of cultural identity amidst the ever-moving current of globalization.[40]

Ikat weaving is a form of traditional textile cultural expression that is rich in symbolic, historical, and social meaning.[30] The term "ikat" comes from the Indonesian language which means "to tie," referring to the technique of dyeing yarn before the weaving process is carried out.[41] In the ikat weaving tradition, distinctive motifs and patterns are formed through the process of tying and dyeing warp or weft threads, which are then woven manually into uniquely patterned fabrics. This process reflects high skill, precision, and a deep understanding of symbols and colors that have their own meaning in the social structure and beliefs of the community.[10] In many areas such as East Sumba, ikat weaving is not only seen as an economic commodity or handicraft, but also as a cultural heritage that contains spiritual values, ethnic identity, social status, and strong ritual and customary functions.[42] Each motif on the ikat cloth usually represents a philosophy of life, cosmology, relationships with ancestors, and historical narratives of the local community.[34] Therefore, ikat weaving is understood not just as a textile product, but as a cultural text that records, reproduces, and transmits collective values across generations, as well as being a means of visual communication in the cultural system of traditional society.[33]

METHOD

This study is qualitative and interdisciplinary in nature, specifically adopting a computational ethnography approach. It combines traditional ethnographic methods—such as participant observation and interviews—with digital tools like natural language processing (NLP), image recognition, and semantic annotation. By integrating these techniques, the research constitutes a hybrid methodological model that balances human-centered cultural understanding with AI-assisted, machine-readable data modeling.

The rationale for adopting this approach is based on several methodological considerations. First, the phenomenon under study—cultural expressions embedded in ikat weaving—is inherently complex, symbolic, and contextual, which requires deep, interpretive insights. Qualitative research enables exploration of indigenous knowledge systems that cannot be adequately captured through quantitative generalizations.[29] Second, the study focuses on emic perspectives and the semantic logic embedded in oral narratives, visual motifs, and ritual practices, which necessitates a qualitative orientation rooted in the understanding of subjective meaning and local worldview.[30]

Third, the integration of AI tools into ethnographic research represents an adaptive response to the increasing role of computational infrastructures in cultural documentation. Techniques such as computer vision are employed to analyze weaving motifs, while NLP is applied to transcribed interviews and ritual texts to extract recurring narrative elements.[31] This computational ethnography is supported by metadata modeling, in which cultural artifacts are annotated using RDF triples and ontological schemas that align with Semantic Web principles.[32]

Data collection techniques follow a multi-method strategy combining participant observation, semi-structured interviews, cultural artifact documentation, and digital data extraction. Field observations were conducted in weaving centers, ceremonial gatherings, and local museums to capture nonverbal interactions, embodied knowledge, and performative expressions. Interviews were conducted with ikat artisans, elders, tourism practitioners, local government officials, and cultural activists to gather perspectives on heritage meaning, transmission, and digital visibility.[33]

Visual and textual data—including ikat motifs, chants, mythic stories, and promotional materials—were documented and digitized. These artifacts were then subjected to AI-assisted analysis: image recognition software was used to cluster motifs by stylistic and regional characteristics; NLP was applied to detect semantic patterns in storytelling and ritual language.[34] Both types of data were structured using a metadata schema informed by the CIDOC CRM and SKOS frameworks, allowing for semantic interoperability and linked-data publishing.

Data analysis proceeded in three interconnected stages: data reduction, thematic coding and semantic enrichment, and interpretive triangulation. Manual coding was conducted in tandem with AI outputs to validate meaning categories and enhance cultural nuance. Through this iterative cycle, the study aimed to align computational classification with cultural authenticity and epistemological integrity.[35]

This hybrid methodological model enables not only deep cultural interpretation but also the construction of machine-readable cultural knowledge. It allows researchers to move from rich, qualitative field data to ontologically-structured datasets that support digital heritage preservation, intelligent information retrieval, and ethical AI systems that reflect local meaning systems.[36]

RESULTS

The following presentation is the result of an ethnographic analysis of communication obtained from an in-depth study of two main informants who acted as key respondents in this study. Both were purposively selected based on their active involvement in cultural communication practices within the East Sumba ikat weaving heritage tourism ecosystem, thus allowing for a rich and contextual exploration of the meanings, symbols, and

dynamics of interactions that occur in their daily lives.

Meaning, Function, and Transformation of Ikat Weaving: Mama Inna's Communication Reflection

One of the key informants in this study is Mama Inna, a senior weaver from the Kambaniru Weaving Village area, who has inherited and practiced weaving skills since an early age. In an interview conducted on February 5, 2025, the following is a table of Mama Inna's speaking interview analysis:

Table 1. Speaking Analysis of Mama Inna's Interview	
Component	**Information**
Setting	Mama Inna's Weaving House in East Sumba Weaving Village, tourist areas such as Bukit Tanau, and local exhibition locations.
Participants	Mama Inna (craftsman), domestic and foreign tourists, local officials, tourism managers, craftsman communities, traditional figures.
Ends (Tujuan)	Preserving weaving culture, improving family economy, educating tourists, maintaining traditional values in weaving motifs.
Act Sequence	Tour → process explanation → cloth rental → sacred motif education → cloth transaction or loan.
Key (Nada)	Educational, friendly, respectful of customs, but also adaptive to changes and market needs.
Instrumentalities	Direct face to face, demonstration of weaving, oral education, and starting to connect through social media (by the community).
Norms	Custom as an ethical limitation in selling motives, norms of understanding sacred values, and informal inheritance of skills.
Genre	Cultural education, informal transactions, customary counseling, and direct experience-based tourism promotion.

The main findings of this study indicate that the transmission of ikat weaving knowledge in East Sumba continues primarily through familial interactions. However, the process lacks a structured regeneration mechanism, raising concerns about potential discontinuities across generations. The commercialization of ikat has prompted a diversification of its forms and functions, yet this innovation is still constrained by customary norms that protect the sacredness of certain motifs. This tension illustrates a dual dynamic between tradition preservation and adaptation to contemporary demands. Communication between artisans and tourists typically occurs face-to-face and is rooted in education and shared experience, positioning it as a vital medium for converting cultural values into economic benefits. Despite this, a lack of sustained governmental support points to a broader systemic gap in policy communication, highlighting the need for intermediaries and facilitators to enable two-way dialogue and reinforce the weaving sector's role within the tourism ecosystem. Additionally, the transformation of ritual practices suggests an influence of modernity on cultural communication, where symbolic meanings are increasingly emphasized over formal ritual enactments—signaling a shift from ritual form to cultural essence.

Weaving as Heritage and Resistance: Reflections from Mr. Yohannes from Kaliuda

The second source in this study, Mr. Yohanes better known as Mr. Jon described that his weaving skills were part of a cultural heritage that he had learned since childhood through direct involvement in the production process with his parents and close relatives. The inheritance of this knowledge did not take place through formal education or structured technical training, but rather through daily interactions that were participatory and based on active observation in the community environment.[45] This learning pattern reflects the concept of communal apprenticeship as put forward by Dell Hymes, namely a process of cultural socialization that occurs naturally in a speech community, where values, skills, and symbolic meanings are inherited through direct experience, repetition, and communication practices that take place in everyday life.[28] This interview was conducted on February 3, 2025 at his production house in Kaliuda, which is also a living space, work space, and space for cross-generational cultural inheritance. The following is a table of the results of the analysis of Mr. Jon's speaking interview with Kaliuda:

Table 2. Speaking Analysis Interview with Mr. Jon Kaliuda	
Component	**Thematic Findings**
Setting	Weaving house in Kaliuda; informal production and marketing space as well as cultural tourism interaction area
Participants	Mr. Jon, tourists, families, local government, artisan communities
Ends	Pelestarian budaya, pemasaran tenun, edukasi motif, peningkatan ekonomi local
Act Sequence	Motive education → demonstration → rental/marketing → cultural dialogue or transaction
Key	Friendly, educational, respectful of tradition, diplomatic in dealing with the government

Instrumentalities	Face to face, live demonstrations, community interaction; no active digitalization yet
Norms	Inheritance of skills as a moral obligation, prohibition on divulging sacred motives, customary production norms
Genre	Cultural stories, traditional communication, informal marketing, technical production discussions

The thematic table illustrates the relationship between communication elements in the SPEAKING model and Mr. Jon's daily practices within the ikat weaving ecosystem in Kaliuda. Here, communication functions not only as an exchange of technical knowledge but as a symbolic process that articulates cultural values, spirituality, social relations, and economic strategies. Mr. Jon's production house serves as a multifunctional cultural space: a workplace, a site for intergenerational learning, a platform for tourist education, and a discursive arena where traditional values intersect with market dynamics.

The involvement of families, tourists, traditional leaders, and local government reflects how weaving communication unfolds dialogically across diverse social settings. Demonstrations of weaving, explanations of motif philosophy, product rentals, and value-based education exemplify performative communication practices that integrate cultural, economic, and pedagogical functions.

Mr. Jon's communicative approach varies across audiences—friendly and informative with tourists, yet polite and assertive with government officials—demonstrating a high level of communicative adaptability and inclusive dialogue. The dominant use of face-to-face communication reinforces the sustainability of traditional oral interaction patterns, while the limited use of digital platforms underscores the continued reliance on oral culture.

Norms of communication remain firmly rooted in customary ethics, particularly concerning the respectful handling of sacred motifs. These practices reveal the deep entwinement of cultural products with local belief systems. The range of communicative genres—from historical storytelling and informal trade interactions to ritual speech and everyday conversation—forms a dynamic and living cultural communication ecosystem.

In this context, Mr. Jon is not merely a textile producer but also a custodian of oral narratives, a cultural educator, and a community spokesperson. He embodies cultural agency in its fullest sense, playing a vital role in shaping meaning, sustaining identity, and maintaining the continuity of tradition through the integrated use of land, hands, and voice. His communicative experiences offer critical insight into the broader dynamics of grassroots cultural expression, where economy, spirituality, and identity are woven together in everyday life.

DISCUSSION

The following section presents the integrated results of ethnographic fieldwork and computational semantic analysis, focused on cultural communication within the ikat weaving tradition of East Sumba. This study utilized multimodal data—including narrative interviews, ritual observations, motif interpretation, and digital image/text processing—to develop a model for AI-readable cultural metadata. One key informant, Mama Inna, serves as a case study for understanding how local knowledge can be systematically translated into data patterns.

Mama Inna, a senior weaver from Kambaniru Village, has been a lifelong practitioner and oral historian of ikat weaving. On February 5, 2025, a series of observations and interviews were conducted in her weaving house, at local tourism spots, and cultural exhibitions. The analysis used a modified SPEAKING framework to extract both cultural meaning and metadata structure, enabling semantic annotation for AI processing.

The results of this study reflect a significant interdisciplinary advancement by combining ethnographic depth with computational methods to document and preserve East Sumba's ikat weaving traditions. When compared with other scholarly sources, several key innovations and validations emerge that emphasize both the novelty and the credibility of the findings.

The first major insight—positioning weaving as a complex knowledge system rather than just a material craft—resonates with McIntosh's[1] anthropological framing, which presents ikat as a vehicle for ancestral memory and encoded cosmology. McIntosh similarly underscores that oral narratives, ritual performance, and motif-making are tightly interwoven, not merely decorative or utilitarian. However, the current study advances this understanding by computationally modeling these cultural dimensions into semantic data structures using NLP, ontology, and image recognition.

The use of Natural Language Processing (NLP) to extract recurring cosmological and legal concepts from oral interviews is especially significant. This contrasts with earlier work by Gilliland[4], who emphasized the role of metadata and community archives in preserving cultural knowledge, but did not employ AI-based parsing. Here, NLP allows the system to *learn* emic meanings and patterns that would otherwise remain opaque in traditional qualitative methods.

Similarly, the application of AI-powered image recognition to analyze ikat motifs aligns with recent heritage AI studies, such as those by Tenzer et al.[8], who explored computer vision for artifact recognition. Yet this study goes further by cross-linking the visual motifs with oral narratives (as in the "Ka Hudi" example), producing cross-modal metadata that enhances the machine's capacity to contextualize symbols semantically. This

multidimensional linking is still rare in heritage informatics literature, and it contributes to more accurate AI-driven cultural clustering.

The process of observing live cultural interaction—particularly the exchanges between Mama Inna and tourists—and translating these into semantic triples reflects an innovative use of computational ethnography. While Barwick et al.[45] proposed designing knowledge graphs for living heritage, they did not operationalize these through observed performative acts. The current study demonstrates how social communication itself becomes data, and how such data can be structured for intelligent retrieval and ethical reuse.

Ethically, the research is aligned with principles outlined by Christen[43], who advocates for sensitive metadata practices in Indigenous contexts. The integration of access restriction flags and sacredness indicators into the ontology reflects a nuanced understanding that not all knowledge is for open dissemination. This design responds to critiques that AI systems often overlook Indigenous epistemologies or apply universalizing logic.

Table 3. Summarizes key comparisons with related research		
Aspect	**This Study (2025)**	**Comparative Studies**
Cultural Framing	Ikat as a living, encoded knowledge system	McIntosh (2021): Ikat as ancestral memory
NLP Use	Extracts ritual, legal, cosmological terms	Gilliland (2020): Metadata emphasis without computational parsing
Image Recognition	Motif categorization + symbolic mapping with narratives	Tenzer et al. (2023): Focused on artifact recognition only
Live Data Modeling	Semantic triples from tourist-artisan dialogue	Barwick & Maloney (2024): Theoretical use of knowledge graphs
Ethical Safeguards	Sacredness flags in ontological schema	Christen (2021): Sensitive metadata; few implemented models
Technological Framework	CIDOC CRM + SKOS + Linked Data + cross-modal AI	Doerr & Crofts (2018): Conceptual modeling only

This study not only aligns with but significantly extends existing frameworks in cultural heritage documentation. Through the fusion of computational ethnography, AI interpretation, and Indigenous ethical standards, it offers a robust model for future efforts in digitizing intangible heritage. The semantic data infrastructure produced is not just technically sound but culturally attuned—respecting the rhythms, restrictions, and richness of ikat traditions from East Sumba.

This study confirms that local actors such as Mr. Jon and Mr. Yohannes function not only as artisans and educators within the ikat weaving tradition of East Sumba, but also as semantic carriers of encoded cultural knowledge. Their spoken narratives, weaving practices, and symbolic decisions were digitally annotated and computationally modeled as structured data patterns, forming the basis of an AI-readable cultural knowledge graph.[43]

Mr. Jon's communicative actions—observed in weaving spaces, market interactions, and ritual contexts—were interpreted using semantic discourse analysis and structured into linked metadata fields. As a senior weaver and cultural spokesperson, Mr. Jon embodies what this research defines as a "semantic cultural agent"—someone whose speech, gesture, and craftwork produce not only textiles but interconnected layers of meaning. [44] For instance, his resistance to motif commercialization was documented through structured annotation tags, marking expressions of sacred motif protection, ritual access control, and knowledge transmission pathways.

This enables AI systems to distinguish motifs that are public-facing from those requiring cultural clearance, respecting the epistemological structure of indigenous knowledge systems.[45]

Mr. Yohannes, a community activist and craftsman from Kaliuda Village, strategically communicates ikat heritage through selective semantic disclosure. In his verbal interactions and weaving demonstrations, he encodes multilayered meanings—some of which are intended for public audiences (e.g., tourist education), and others reserved for ritual insiders. These distinctions were captured using context-aware NLP tools, which mapped his speech acts into narrative categories, such as "public narration," "sacred reservation," or "ritual coding".[46]

These labels are designed to be read by machine-learning classification models while also being culturally sensitive, avoiding flattening of local knowledge into generic datasets.[47] Weaving in Kaliuda is more than visual art; it is semantic activity embedded with ritual syntax, social structure, and ancestral grammar. Each stage—yarn spinning, dyeing, motif design, and cloth exchange—was documented through participatory observation and digitally represented using ontology-based modeling. The weaving process was translated into procedural data flows, enabling AI to recognize not only objects (like the motif) but procedural knowledge, such as the correct sequencing of actions.[48]

This not only preserves the integrity of cultural meaning but enables intelligent querying and contextual searchability across digital heritage platforms.[49] Both Mr. Jon and Mr. Yohannes employ a semantic filtering strategy in response to globalization. Rather than openly resisting the tourist economy or digital documentation, they shape what cultural data is shareable versus what remains sacred. Their narratives were used to create AI moderation rules that classify content by appropriateness for publication, ensuring that machine systems uphold community values.[50]

Their speech patterns and metadata structuring reinforce the idea that cultural heritage is a live negotiation, not a static database. The act of storytelling, the gesture during weaving, and the choice of what to explain or conceal—these all serve as human-driven semantic inputs for machine-assisted preservation systems.[51]

These ethnographic findings fed directly into the construction of a knowledge graph prototype for East Sumba ikat, integrating AI, NLP, and semantic web technologies. The graph includes nodes for artisans, motifs, rituals, narrative types, and communication strategies, all enriched with attributes extracted from field data. The voices of weavers like Mr. Jon and Mr. Yohannes are not merely documented, but formally encoded as part of a living, expandable cultural ontology.[52]

This approach not only ensures data integrity and respect for cultural protocol, but also enables future AI systems—including conversational agents, cultural bots, and digital archives—to interact with ikat heritage respectfully and meaningfully.[53] The findings of this study carry several important implications for the fields of digital heritage, computational ethnography, cultural informatics, and AI ethics in indigenous contexts.[54]

First, at the theoretical level, the research contributes to the growing discourse on how intangible cultural heritage can be meaningfully represented in digital environments. By demonstrating that weaving practices—rooted in oral tradition, embodied knowledge, and symbolic ritual—can be translated into semantic data structures, this study offers a new model for AI-mediated cultural preservation.[55] It challenges the dominant logic of data extraction by proposing a model based on semantic respect, narrative logic, and epistemological grounding.[56]

Second, this study implies that artificial intelligence technologies, particularly natural language processing, image recognition, and ontology-based modeling, must be adapted to fit the logic of indigenous communication systems, not the other way around.[57] The communicative acts of actors like Mama Inna, Mr. Jon, and Mr. Yohannes reveal that knowledge is not always explicit, nor always meant to be shared. Therefore, any technological framework developed to support cultural documentation must incorporate ethical constraints, access permissions, and sacredness indicators as native elements in metadata schemas.[58]

Third, on a practical level, the research suggests new pathways for collaborative design between communities, technologists, and policymakers.[59] Digital heritage platforms that adopt semantic web principles can support dynamic, layered representations of local knowledge—enabling not only storage and retrieval but also interpretation, negotiation, and storytelling.[60] This has strong implications for museums, archives, tourism agencies, and educational institutions seeking to digitize cultural content in ways that are participatory, context-rich, and culturally appropriate.[61,62]

Finally, the research invites a broader rethinking of what constitutes "data" in AI contexts. It argues that weaving patterns, ritual gestures, oral teachings, and community norms are all valid forms of structured information that can—and should—be integrated into next-generation AI systems.[63] Doing so helps decolonize data infrastructures and ensures that AI supports, rather than erodes, the continuity of local epistemologies.[64]

CONCLUSION

This research confirms that East Sumba's ikat weaving tradition is not only a tangible craft but a complex semiotic and cultural system that encodes layers of ancestral knowledge, ethical values, and local identity. The study illustrates how weaving operates as a medium of intergenerational knowledge transmission, spiritual symbolism, and socio-cultural negotiation. Their oral narratives, gesture-based teaching, and ritual expressions constitute a form of indigenous data—a rich corpus of meaning that, when carefully interpreted, reveals both cultural depth and semantic structure.

By applying a hybrid methodology that combines ethnographic fieldwork with semantic annotation, natural language processing (NLP), and AI-assisted pattern recognition, the study successfully demonstrates how cultural practices can be translated into machine-readable data patterns without undermining their epistemological roots. The creation of semantic metadata, based on the narratives and motif logic provided by the weavers, supports the development of an ontology-informed knowledge graph that preserves not only objects and visuals but also values, intentions, and contextual meanings.

Importantly, this transformation—from narrative to data, from weaving to structured knowledge—does not seek to digitize culture in reductive terms. Rather, it aims to construct an ethically grounded, culturally sensitive framework in which AI and indigenous knowledge can coexist productively. Figures like Mr. Jon and Mr. Yohannes demonstrate strategic agency in mediating which parts of their tradition are open to documentation and which remain protected by customary protocols. This selective semantic disclosure is essential in ensuring

that digital heritage systems honor indigenous sovereignty and cultural logic .

In conclusion, the shift from weaving patterns to data patterns represents a powerful strategy for future-facing cultural preservation. When guided by respectful methodologies and collaborative design, AI technologies can help safeguard intangible heritage, enrich intercultural understanding, and extend the lifespan of local knowledge traditions in global digital ecosystems

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CONFLICT OF INTEREST
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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