



Guardians of the Blue Heritage: The Role of Pwani University Library, AI, and Traditional Knowledge Custodians in Equitable Knowledge Transfer for Aquatic Environments and Resources (2020–2026)

Guardianes del Patrimonio Azul: El papel de la biblioteca de la Universidad de Pwani, la IA y los custodios del conocimiento tradicional en la transferencia equitativa de conocimientos para los entornos y recursos acuáticos (2020-2026)

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ABSTRACT

Introduction: The sustainable management of aquatic ecosystems and food systems depends on effective knowledge transfer among scientists, policymakers, fishers, and local communities. However, barriers such as fragmented publishing models, limited access to Indigenous knowledge, and underutilised institutional repositories hinder progress. This paper investigates the role of Pwani University Library, AI technologies, and information managers in facilitating equitable knowledge transfer, with special attention to traditional knowledge custodians as co-equal knowledge producers.

Methodology: Using a mixed-methods design anchored in Knowledge Management Theory, the CARE Principles for Indigenous Data Governance, Epistemic Justice Framework, and Actor-Network Theory, the study analysed 2025 completion data for 48 master's and 12 PhD students in aquatic-related programs, reviewed 15 MoUs with fisheries and conservation bodies, and assessed Pwani Institutional Repository (PIR) usage.

Results: Findings show that only 33.3% of these were deposited in PIR within six months of graduation. AI-assisted metadata tagging and large language models improved discoverability by 41% in a pilot intervention. Librarians acted as critical intermediaries in digitizing Indigenous fishing knowledge, documenting 120 traditional ecological knowledge (TEK) units from Giriama, Digo, and Swahili custodians.

Conclusions: The paper concludes with the Pwani Model for Inclusive Knowledge Transfer (PMIKT), a framework for AI-librarian-custodian collaboration to capture past lessons for future aquatic resilience.

Keywords: Artificial Intelligence; Indigenous knowledge; Know-how transfer; Oral tradition; Records management.

JEL Classification: D83, D85; Q25.

RESUMEN

Introducción: La gestión sostenible de los ecosistemas acuáticos y los sistemas alimentarios depende de una transferencia de conocimiento eficaz entre científicos, responsables políticos, pescadores y comunidades locales. Sin embargo, barreras como los modelos de publicación fragmentados, el acceso limitado al conocimiento indígena y los repositorios institucionales subutilizados dificultan el progreso. Este artículo investiga el papel de la Biblioteca de la Universidad de Pwani, las tecnologías de IA y los gestores de la información para facilitar una transferencia de conocimiento equitativa, con especial atención a los custodios del conocimiento tradicional como productores de conocimiento en igualdad de condiciones.

Metodología: Utilizando un diseño de métodos mixtos basado en la Teoría de la Gestión del Conocimiento, los Principios CARE para la Gobernanza de Datos Indígenas, el Marco de Justicia Epistémica y la Teoría del Actor-Red, el estudio analizó los datos de finalización de 2025 de 48 estudiantes de maestría y 12 de doctorado en programas relacionados con el medio acuático, revisó 15 memorandos de entendimiento con organismos de pesca y conservación, y evaluó el uso del Repositorio Institucional de Pwani (PIR).

Resultados: Los hallazgos muestran que solo el 33.3% de estos se depositaron en el PIR dentro de los seis meses posteriores a la graduación. El etiquetado de metadatos asistido por IA y los modelos de lenguaje a gran escala mejoraron la capacidad de descubrimiento en un 41% en una intervención piloto. Los bibliotecarios actuaron como intermediarios clave en la digitalización del conocimiento pesquero indígena, documentando 120 unidades de conocimiento ecológico tradicional (CET) de custodios Giriama, Digo y Swahili.

Conclusiones: El artículo concluye con el Modelo Pwani para la Transferencia Inclusiva del Conocimiento (PMIKT), un marco para la colaboración entre IA, bibliotecarios y custodios con el fin de aprovechar las lecciones del pasado para la resiliencia acuática futura.

Palabras clave: Conocimientos tradicionales; Gestión de documentos; Inteligencia artificial; Tradición oral; Transferencia de conocimientos.

Clasificación JEL: D83, D85; Q25.

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INTRODUCTION

Africa's aquatic environments, from the Western Indian Ocean to Lake Victoria and inland aquaculture systems, are under pressure from climate change, overfishing, and pollution (Dongyu, 2024; McCabe, 2023). The Western Indian Ocean alone supports over 30 million people through fisheries, tourism, and coastal protection, yet small-scale fishers who contribute 70% of landed fish in Kenya's coastal counties remain marginalised in policy forums (Midlen, 2024; Wambugu et al., 2025). Knowledge transfer between scientists, extension officers, fishers, and local communities remains weak, leading to repeated policy failures and loss of traditional coping strategies that have sustained coastal communities for centuries (Cummings et al., 2023; Kwikiriza et al., 2026; Silas et al., 2023).

Pwani University, located in Kenya's coastal Kilifi County, hosts a School of Pure and Applied Science with strong programs in Marine Science, Fisheries and Aquaculture, and Environmental Science (Pwani University Library, 2025). The university library has evolved from a passive resource centre to an active knowledge hub, managing the Pwani University Library Institutional Repository (PIR) and engaging in multiple Memoranda of Understanding (MoUs) with organizations such as the Kenya Marine and Fisheries Research Institute (KMFRI), the Western Indian Ocean Marine Science Association (WIOMSA), the Food and Agriculture Organization (FAO), the Kenya Wildlife Service (KWS), Coastal Oceans Research and Development – Indian Ocean (CORDIO), and the Kenya Fisheries Service (KeFS) (Idhalama & Nwachukwu, 2025; Okafor et al., 2022). Despite these institutional arrangements, gaps persist: graduate research often remains unseen on hard drives, Indigenous knowledge is excluded from formal databases, and AI tools remain underutilized (Adam & Kaur, 2022; Baro & Nwabueze-Echedom, 2023).

The digital age offers unprecedented tools for knowledge capture, including institutional repositories, AI language models, mobile databases, and open-access platforms (Cox & Tzoc, 2023; Sousa, 2026). However, these technologies are designed within Western epistemological frameworks that privilege text-based, authored, and timestamped knowledge, while traditional knowledge is often oral, relational, collective, and place-based (Dewitt Prat et al., 2024; Mugoh et al., 2026). When digitized without cultural protocols, Indigenous knowledge risks becoming decontextualised, misappropriated, or commodified (Carroll et al., 2020; Dewitt Prat et al., 2024; Jennings et al., 2023).

Libraries have historically been custodians of written knowledge, but the 21st-century library is transforming into a knowledge commons a space where multiple knowledge systems coexist, are mediated, and are translated for diverse users (Blok & Jensen, 2025; Idrees et al., 2023). This paper argues that librarians, as trusted intermediaries, are uniquely positioned to broker ethical digital inclusion for marginalized knowledge custodians, particularly in the context of aquatic environments where traditional ecological knowledge (TEK) holds centuries of adaptive strategies for fisheries management, monsoon prediction, and mangrove conservation (Morris et al., 2024; Obiero, Klemet-N'Guessan, et al., 2023).

This paper addresses the central research question: *What role can AI, librarians, and traditional knowledge custodians play in capturing past lessons to solve future aquatic problems?* It focuses on Pwani University as a case study for the 2025 academic year, providing baseline data on graduate knowledge leakage, a tested framework for AI-librarian-custodian collaboration, and actionable recommendations for equitable knowledge transfer in aquatic sciences.

Objectives

This study was guided by the following objectives, which integrate both the assessment of academic knowledge transfer and the ethical integration of Indigenous knowledge systems:

1. To assess the completion rates of master's and PhD students (January–December 2025) in aquatic science, fisheries, aquaculture, and marine resource management at Pwani University.
2. To evaluate the deposit and discoverability of graduate theses in the Pwani University Library Institutional Repository (PIR).
3. To identify barriers to knowledge transfer between academic research and local/Indigenous knowledge

systems.

4. To pilot an AI-assisted metadata and summarization tool for enhancing aquatic knowledge retrieval.
5. To identify and document the types of traditional aquatic knowledge held by Giriama, Digo, and Swahili custodians in Kilifi County.
6. To evaluate the ethical and technical barriers to digitizing traditional knowledge within institutional repositories.
7. To analyse how existing MoUs (e.g., with KMFRI, WIOMSA, FAO) influence knowledge transfer from research to policy and practice.
8. To propose a collaborative, librarian-led, custodian-governed framework for equitable knowledge transfer in aquatic environments (the Pwani Model for Inclusive Knowledge Transfer, PMIKT).

These objectives are grounded in the understanding that knowledge transfer is not merely a technical problem but a governance and justice issue (Cummings et al., 2023; Pausits et al., 2025). Previous studies have documented low deposit rates in African institutional repositories (Adam & Kaur, 2022; Baro & Nwabueze-Echedom, 2023), the exclusion of Indigenous knowledge from formal databases (Morris et al., 2024; Obiero, Klemet-N'Guessan, et al., 2023), and the potential of AI to enhance metadata generation (Cox & Tzoc, 2023; Sousa, 2026), but no study prior to this one has systematically examined the intersection of all three dimensions within a Kenyan coastal university context (Idhalama & Nwachukwu, 2025; Okafor et al., 2022).

Research Questions

The following research questions guided this study, reflecting both quantitative and qualitative dimensions of knowledge transfer:

RQ1: What are the master's and PhD completion rates in aquatic-related programs at Pwani University in 2025, and how many theses are openly accessible via PIR within six months of graduation?

This question addresses the persistent problem of low deposit rates documented across Sub-Saharan African repositories, where rates range from 15% to 40% (Adam & Kaur, 2022; Baro & Nwabueze-Echedom, 2023). Understanding completion and deposit rates provides a baseline for measuring knowledge leakage from the university system (Kwikiriza et al., 2026).

RQ2: How do existing MoUs (e.g., with KMFRI, WIOMSA, FAO, KWS, CORDIO, KeFS) influence knowledge transfer from research to policy and practice?

MoUs are critical instruments for research partnerships, yet previous analyses have shown that they often prioritize data extraction over knowledge return to communities (Idhalama & Nwachukwu, 2025; Okafor et al., 2022).

This question examines whether and how MoUs include clauses on open access, benefit-sharing, and Indigenous knowledge governance (Carroll et al., 2020; Dewitt Prat et al., 2024; Jennings et al., 2023).

RQ3: What barriers do librarians face in integrating Indigenous fishing knowledge into digital repositories, and what barriers do custodians report regarding digitization?

Barriers to Indigenous knowledge integration include lack of digitization protocols, absence of legal frameworks for traditional knowledge copyright, insufficient funding for community engagement, language barriers, and fear of cultural misappropriation (Carroll et al., 2020; Dewitt Prat et al., 2024; Jennings et al., 2023; Obiero, Klemet-N'Guessan, et al., 2023). From the custodian perspective, mistrust of researchers, spiritual concerns about writing sacred knowledge, generational dynamics, and land/sea tenure conflicts have been documented (Cummings et al., 2023; Kwikiriza et al., 2026; Silas et al., 2023).

RQ4: Can generative AI (e.g., fine-tuned LLMs) improve the discoverability and cross-linking of past research to current aquatic problems compared to manual indexing?

Recent studies have shown that large language models can significantly enhance metadata generation and information retrieval in library settings (Cox & Tzoc, 2023; Sousa, 2026). However, LLMs trained on predominantly English, Global North corpora exhibit colonial biases. This question tests whether fine-tuning on local languages and aquatic TEK can improve performance while maintaining ethical standards (Dewitt Prat et al., 2024).

RQ5: What traditional ecological knowledge (TEK) themes (e.g., lunar calendars, spawning grounds, weather indicators) are actively held and transmitted by Giriama, Digo, and Swahili custodians in Kilifi County?

Documentation of TEK in East African coastal communities has revealed rich knowledge systems including monsoon-based fishing calendars, sacred grove protection of mangrove forests, and lunar spawning aggregation predictions (Midlen, 2024; Wambugu et al., 2025). This question aims to systematically catalog such knowledge themes as a precursor to ethical digitization.

RQ6: What is the perceived role of information managers in equitable knowledge transfer among fishers, students, and scientists, and what roles do traditional custodians and AI systems play in a governance framework for ethical knowledge transfer?

Librarians are increasingly recognized as knowledge brokers rather than passive custodians. This question explores the evolving role of information managers in negotiating open access, digitizing oral knowledge, and building trust with Indigenous communities (Blok & Jensen, 2025; Carroll et al., 2020; Idrees et al., 2023).

Hypotheses

Based on the research questions and existing literature, the following hypotheses were formulated and tested:

H1 (Deposit Rate Null): Less than 40% of 2025 aquatic science master's theses are deposited in the Pwani Institutional Repository within 6 months of graduation. This hypothesis is grounded in previous findings from Kenyan and broader African university repositories, where deposit rates consistently fall below 40% due to lack of mandates, poor metadata quality, and students' desire to publish journal articles first (Adam & Kaur, 2022; Kwikiriza et al., 2026; Ndebele et al., 2023).

H2 (AI Effectiveness Null): AI-assisted metadata generation does not improve retrieval precision and recall by more than 35% compared to manual indexing. The alternative hypothesis predicts an improvement greater than 35%, based on pilot studies of LLMs in academic libraries that have shown precision increases of 30–50% (Cox & Tzoc, 2023; Sousa, 2026).

H3 (Custodian Engagement Null): Librarian-led digitization efforts using ethical protocols do not significantly increase custodians' willingness to share traditional knowledge (measured via 5-point Likert scale). The alternative hypothesis predicts a significant increase ($p < 0.05$), drawing on evidence that the CARE principles (Carroll et al., 2021) and free, prior, and informed consent (FPIC) protocols increase Indigenous community trust and participation (Dewitt Prat et al., 2024; Mugoh et al., 2026).

H0 (Overall Knowledge Transfer Null): There is no significant difference in knowledge transfer outcomes between AI-enhanced librarian-mediated systems and traditional library systems. This null hypothesis is tested against the alternative that AI enhancement combined with librarian mediation improves outcomes, including deposit rates, discoverability, and user satisfaction (Blok & Jensen, 2025; Idrees et al., 2023).

These hypotheses are operationalized using mixed-methods data collection and statistical testing at $\alpha = 0.05$ significance level (Harrison et al., 2020; Levitt et al., 2018). Previous studies on gender and knowledge access in fisheries (Nyboer et al., 2022; Obiero, Mboya, et al., 2023) and Indigenous knowledge governance (Cummings et al., 2023; Pausits et al., 2025) have informed the theoretical grounding of these hypotheses.

Theoretical Anchorage

This study is grounded in four interlocking theoretical frameworks that together provide a comprehensive lens for understanding knowledge transfer in aquatic environments. Each framework addresses a distinct dimension of the research problem.

Knowledge Management Theory (SECI Model): Nonaka and Takeuchi's (1998) Socialization Externalization Combination Internalization framework, updated by Hislop et al. (2005), explains how tacit knowledge (e.g., a fisher's intuitive feel for ocean currents or a custodian's understanding of lunar cycles) becomes explicit (digitized records, written theses) and is then re-internalized by new users (students, policymakers, other fishers). In this study, librarians facilitate the externalization step by recording oral knowledge, transcribing it, and preparing it for

repository deposit (Baro & Nwabueze-Echedom, 2023). The SECI model has been applied to fisheries knowledge transfer in East Africa by Dei (2026) and to Indigenous knowledge management by Asamoah & Ngulube (2023).

CARE Principles for Indigenous Data Governance: Carroll et al. (2020) proposed four principles specifically designed to address the power imbalances inherent in data collection from Indigenous communities: Collective benefit (data use must benefit the Indigenous community, not just researchers), Authority to control (Indigenous peoples have authority over data about their lands, resources, and knowledge), Responsibility (those who collect data are accountable for misuse and must build trusting relationships), and Ethics (respect for dignity, culture, and self-determination). These principles directly informed our digitization protocol, from FPIC to custodian-controlled access restrictions (Carroll et al., 2020; Dewitt Prat et al., 2024; Jennings et al., 2023). In the Kenyan context, Nakitare et al. (2025) have called for operationalizing CARE principles in marine management, while Wambugu et al. (2025) demonstrated their applicability to coral reef co-management.

Epistemic Justice Framework: Philosopher Miranda Fricker (2007) introduced the concept of epistemic injustice to describe how certain knowers are systematically discredited due to identity prejudice (testimonial injustice) or because the concepts needed to interpret their experiences are absent from dominant frameworks (hermeneutical injustice). Extended to Indigenous environmental contexts by Cummings et al. (2023) and to African knowledge systems by Omodan (2023), this framework reveals how academic libraries have historically committed testimonial injustice (disbelieving fishers' observations of stock decline) and hermeneutical injustice (lacking categories to interpret oral, relational, place-based knowledge). This paper treats knowledge transfer as a justice issue, arguing that equitable access to and recognition of multiple knowledge systems is a prerequisite for sustainable aquatic governance.

Actor-Network Theory (ANT): Latour's (2005) ANT, updated by Blok & Jensen (2025), views knowledge as produced through networks of human and non-human actors. In this study, the relevant actors include librarians, AI algorithms, repository software, custodians, fish, mangroves, ocean currents, and even the physical infrastructure of the university. ANT avoids technological determinism by showing that AI does not simply "improve" knowledge transfer; rather, it performs specific actions within a network of relations that must be negotiated (Cox & Tzoc, 2023; Sousa, 2026). For example, an AI model's misclassification of a fishing taboo as a "recommendation" is not a technical error but a performative act that could have real consequences for community relations (Dewitt Prat et al., 2024; Kwanya, 2026; Mugoh et al., 2026). ANT has been applied to library studies by Quan et al. (2025) and to Indigenous knowledge digitization by Ahmadi et al. (2025).

These four frameworks are complementary. Knowledge Management Theory provides the process model for how tacit knowledge becomes explicit. The CARE Principles supply the ethical guardrails for that process, particularly when Indigenous knowledge is involved. Epistemic Justice supplies the normative justification for why this work matters beyond efficiency, and Actor-Network Theory provides the analytic lens for tracing how power, trust, and meaning circulate through the human-AI-custodian network.

Conceptual Framework: The Pwani Model for Inclusive Knowledge Transfer (PMIKT)

Based on the theoretical anchorage and preliminary fieldwork, we developed the Pwani Model for Inclusive Knowledge Transfer (PMIKT), a conceptual framework that positions the university library as a central node connecting academic research, Indigenous knowledge systems, AI tools, and diverse user communities (Pwani University Library, 2025). The model comprises five concentric layers:

Layer 1 (Core) – Traditional Knowledge Custodians as Authority Holders: At the center of the model are the Giriama, Digo, and Swahili custodians who hold ancestral knowledge of tides, lunar cycles, fish behavior, weather prediction, and conservation taboos. This layer recognizes that custodians are not merely informants but co-equal knowledge producers with authority to decide what is shared, with whom, and under what conditions (Carroll et al., 2020).

Layer 2 – Ethical Protocols (CARE Principles + Local Mila Customs): Surrounding the core is a layer of governance protocols that mediate all knowledge transfer activities. These include the CARE principles (Collective benefit, Authority to control, Responsibility, Ethics) operationalized through FPIC, custodian-controlled access, and benefit-sharing agreements (Carroll et al., 2020; Dewitt Prat et al., 2024; Jennings et al., 2023). Additionally, local *mila* (customary laws) of the Giriama, Digo, and Swahili communities govern what knowledge can be digitized and how it can be used. For example, some spiritual knowledge associated with *pepo* (sea spirits) cannot be written

or spoken outside ritual contexts (Morris et al., 2024; Obiero, Klemet-N'Guessan, et al., 2023; Obiero, Mboya, et al., 2023).

Layer 3 – Pwani University Library (Digitization, Metadata, Preservation): The library acts as the institutional broker, providing the technical infrastructure for digitization (audio recorders, transcription software, repository platforms), professional expertise in metadata creation and preservation, and trusted intermediation between custodians and researchers (Pwani University Library, 2025; Kwanya, 2026). Librarians in this model are not passive cataloguers but active knowledge brokers who negotiate consent, build relationships over years, and translate between epistemic frameworks (Cox & Tzoc, 2023; Sousa, 2026).

Layer 4 – AI Tools (LLM for Tagging, Translation, Summarization): AI systems, specifically fine-tuned large language models, are deployed as assistants to librarians and custodians, not replacements (Mugoh et al., 2026; Sousa, 2026). In the PMIKT, AI performs three functions: (a) automated metadata tagging to improve discoverability of both theses and TEK records; (b) translation between Kiswahili/Kigirima and English to make knowledge accessible across language communities; and (c) summarization of lengthy documents for extension officers and fishers with low literacy levels. The model insists on AI epistemic humility, which is the system's ability to flag uncertainty, recognize when it lacks relevant context, and defer to human judgment (Hila, 2026).

Layer 5 – Users (Students, Fishers, Policymakers, Scientists): The outermost layer comprises the diverse users who access knowledge from the repository. The PMIKT distinguishes between different user needs: students require full academic theses; fishers need short, illustrated, local-language summaries; policymakers need policy briefs synthesizing research and TEK; and scientists need raw data and methodological details (Nyboer et al., 2022; Obiero, Mboya, et al., 2023). The model includes feedback loops so that users' questions and needs inform future digitization and AI training.

Knowledge Flows within the PMIKT: The model specifies five directional flows: (1) Custodians → Library: oral knowledge recorded with FPIC and translated. (2) Library → AI: structured data (transcripts, metadata templates) prepared for AI training. (3) AI → Repository: enhanced metadata, translated abstracts, and summaries deposited in PIR. (4) Repository → Users: equitable access via open access where permitted, custodian-controlled access where restricted. (5) Users → Custodians: feedback loops and benefit-sharing mechanisms (e.g., digitized calendars integrated into BMU plans, custodians invited as guest lecturers).

Barriers Acknowledged in the Model: The PMIKT explicitly identifies barriers that must be addressed for equitable knowledge transfer to occur. These include copyright restrictions that prevent open deposit of theses (Idhalama & Nwachukwu, 2025; Ndebele et al., 2023; Okafor et al., 2022); language gaps between local languages and English (Nakitare et al., 2025); low digital literacy among some custodians and older fishers (Kwanya, 2026); infrastructure limitations (intermittent electricity, low bandwidth) (Quan et al., 2025); and mistrust arising from previous extractive research practices (Cummings et al., 2023; Kwikiriza et al., 2026; Silas et al., 2023).

Outcomes: When the PMIKT functions effectively, the expected outcomes include: sustainable aquatic management through integration of TEK and science; reduced conflict between fishers and scientists over closed seasons; food security for coastal communities; enhanced human well-being through recognition and respect; and institutional transformation of the library from passive repository to active knowledge commons (Baro & Nwabueze-Echedom, 2023; Wambugu et al., 2025).

The PMIKT has been designed as a transferable framework for other Global South universities, with contextual adaptations for local languages, governance structures, and ecosystems (Adam & Kaur, 2022; Baro & Nwabueze-Echedom, 2023).

METHODOLOGY

Research Design

This study employed a convergent parallel mixed-methods design, which involves the simultaneous collection of quantitative and qualitative data, followed by integration during interpretation (Harrison et al., 2020). This design is particularly appropriate for knowledge transfer research because it allows for statistical generalisation alongside deep contextual understanding of barriers and enablers (Hislop et al., 2005). The quantitative strand focused on repository analytics, AI performance metrics, and survey data. In contrast, the qualitative strand involved semi-

structured interviews with custodians, focus group discussions with fishers, and discourse analysis of MoU texts. Integration occurred through a joint display matrix that compared quantitative findings with qualitative themes to identify convergence, divergence, and complementarity (Braun & Clarke, 2023; Fetters & Tajima, 2022; Guetterman et al., 2021).

Study Population

The study population comprised six groups, following purposive sampling strategies common in knowledge management and Indigenous research (Ahmad & Wilkins, 2025):

First, 60 graduate students (48 MSc and 12 PhD) in Aquatic Sciences, Fisheries, Aquaculture, and Marine Resource Management at Pwani University who were scheduled to graduate between January and December 2025. This represented a census of all completers in these programs for the 2025 academic year (Pwani University Library, 2025).

Second, 5 librarians from Pwani University Library who held active roles in digital repository management, digitization, or user services. This sample size was sufficient for in-depth qualitative interviews given the small number of specialized librarians at the institution.

Third, 25 traditional knowledge custodians from Giriama, Digo, and Swahili communities in Kilifi North, Kilifi South, and Rabai sub-counties, expanded from the original 8 to ensure representation of diverse knowledge themes and age groups.

Fourth, 6 MoU partner representatives from KMFRI, WIOMSA, FAO Kenya, Kenya Wildlife Service, CORDIO, and Kenya Fisheries Service, selected to represent the range of partnership types (research, conservation, policy).

Fifth, 120 repository users comprising researchers, students, and extension officers who had accessed PIR in the previous 12 months, selected through stratified random sampling by user role (Pwani University Library, 2025).

Sixth, community members for focus group discussions: four groups of 8–10 participants each, comprising fishers, youth, women, and elders, to capture diverse perspectives on knowledge transfer and digitization.

Sampling Procedures

Purposive sampling was used for graduate students (all eligible completers, $n=60$) to ensure complete enumeration of the graduation cohort. Snowball sampling was employed for Indigenous knowledge custodians, whereby initial key informants (identified through Beach Management Units and the Giriama Council of Elders) referred additional custodians, continuing until thematic saturation was reached at 25 participants. Stratified random sampling was used for repository users ($n=120$), with strata defined by user role (student, researcher, extension officer, policymaker) to ensure proportional representation. MoU partners were purposively selected to represent the diversity of partnership types (research, conservation, policy, development).

Data Collection Instruments

Six primary instruments were developed and validated for this study:

Repository Audit Checklist: This instrument captured deposit date, access status (open/embargoed/restricted), metadata completeness (number of fields populated, presence of abstract and keywords), and download counts for each thesis in PIR from the 2025 cohort. The checklist was piloted on 10 theses from the 2024 cohort and refined for inter-rater reliability ($\kappa = 0.89$).

Custodian Interview Guide: Translated into Kiswahili and Kigirima, this semi-structured guide covered themes including types of knowledge held, transmission methods, concerns about digitization, preferred governance arrangements, and experiences with previous researchers. Questions were developed in consultation with the Giriama Council of Elders and piloted with three custodians not in the main sample.

Librarian Survey: A 5-point Likert scale survey (1=not a barrier, 5=major barrier) assessed perceived barriers to Indigenous knowledge integration, including lack of digitization protocols, legal frameworks, funding, language support, technical literacy, and fear of misappropriation. The survey also included open-ended questions on desired competencies and institutional support needs.

AI Pilot Log: This instrument recorded precision, recall, F1-score, and time per record for both human indexers (n=3) and the fine-tuned AI model across 100 records (50 theses + 50 TEK records). The log also captured qualitative observations on AI errors, such as misclassification of taboos or failure to interpret metaphorical language.

Focus Group Discussion Guide: Four focus groups (fishers, youth, women, elders) used a guide exploring knowledge needs, access barriers, perceptions of university research, and attitudes toward digitization. Each session lasted 90–120 minutes, was audio-recorded, and transcribed verbatim with translation where necessary (Braun & Clarke, 2022).

MoU Analysis Matrix: This instrument systematically coded 15 MoUs for the presence/absence of knowledge transfer clauses, open access requirements, benefit-sharing provisions, Indigenous knowledge mentions, and librarian involvement in drafting. Inter-coder reliability was established with two independent coders (kappa = 0.85).

AI Pilot Design

The AI pilot involved fine-tuning a GPT-4 based large language model on a custom corpus designed for the aquatic and Indigenous knowledge context. The training corpus comprised three components: (a) 200 open-access fisheries abstracts from journals such as *Marine Policy*, *Fisheries Research*, and the *Western Indian Ocean Journal of Marine Science*; (b) 50 Kiswahili fishing proverbs and their meanings, sourced from community elders and existing ethnolinguistic studies; and (c) a custom taxonomy of aquatic TEK comprising 10 categories: tides, lunar cycles, fish behavior, weather indicators, gear types, taboos, governance systems, processing methods, conservation practices, and spirituality.

The fine-tuned model was then tested on 100 records: 50 randomly selected theses from PIR and 50 transcribed oral records from custodian interviews. Performance was compared against three human indexers (professional librarians with 5–15 years of experience) using the metrics of precision (proportion of relevant retrieved documents among all retrieved), recall (proportion of relevant retrieved documents among all relevant documents), F1-score (harmonic mean of precision and recall), and time per record in minutes. A paired t-test was used to compare AI and human performance, with significance set at $\alpha = 0.05$.

Statistical Data Analysis Plan

Quantitative Analysis

Quantitative data from the repository audit, AI pilot, and librarian survey were analysed using descriptive and inferential statistics. Descriptive statistics included frequencies, percentages, means, and standard deviations for deposit rates by program, AI performance metrics, and Likert-scale responses on barriers.

Inferential statistical tests were conducted at a significance level of $\alpha = 0.05$. A chi-square test of independence was used to examine whether deposit rates differed significantly by program type (MSc vs. PhD) and by gender of graduate, given evidence of gender disparities in knowledge access in fisheries contexts. A paired t-test compared AI and human indexer performance on precision, recall, F1-score, and time per record, with each of the 100 records serving as its own control.

A one-way ANOVA was used to compare willingness to share traditional knowledge across age groups of custodians (younger vs. middle vs. elder), followed by post-hoc Tukey tests where significant differences were found. For the pre- and post-digitization willingness measure among the same custodians, a paired t-test was used. Statistical analyses were conducted using SPSS version 30 (IBM, 2025) and R version 4.4 with the tidyverse and lme4 packages (R Core Team, 2025). Assumptions of normality, homogeneity of variance, and sphericity were tested prior to parametric tests, with non-parametric alternatives (Wilcoxon signed-rank, Kruskal-Wallis) used where assumptions were violated.

Qualitative Analysis

Qualitative data from custodian interviews, librarian surveys (open-ended responses), focus group discussions, and MoU texts were analysed using thematic analysis following Braun and Clarke's (2023) six-phase guide: familiarization with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and writing up. Analysis was conducted using NVivo 14 software, which facilitated coding across languages (English, Kiswahili, Kigirima) and data types (interview transcripts, focus group transcripts, MoU documents).

For the MoU analysis, discourse analysis was employed to examine power asymmetries, implicit assumptions about knowledge, and the positioning of Indigenous knowledge relative to scientific knowledge. Each MoU was coded for: (a) explicit mention of knowledge transfer; (b) open access or data sharing requirements; (c) benefit-sharing provisions for communities; (d) mention of Indigenous or traditional knowledge; (e) involvement of librarians or information managers in drafting or implementation; and (f) monitoring and evaluation mechanisms for knowledge transfer.

Trustworthiness was established through member checking (preliminary findings presented to custodian focus groups for validation), peer debriefing (regular meetings with a panel of three senior researchers not involved in data collection), and reflexivity (maintaining a research journal documenting positionality and analytical decisions). Triangulation across data sources (interviews, focus groups, repository data, AI logs) and across methods (quantitative and qualitative) strengthened the credibility of findings.

Integration of Quantitative and Qualitative Strands

Integration occurred through a joint display matrix that placed quantitative findings (e.g., deposit rates, AI performance scores, Likert means) side-by-side with qualitative themes (e.g., reasons for non-deposit, concerns about AI, custodian mistrust) to identify convergence (where both strands told the same story), divergence (where they differed), and complementarity (where each strand revealed different dimensions of the same phenomenon) (Harrison et al., 2020). For example, the low deposit rate (quantitative) converged with student interview statements that “no one told me I had to” (qualitative). The high AI precision (quantitative) diverged from librarian observations that AI misclassified sacred knowledge (qualitative), leading to the refinement of the AI epistemic humility principle. This integrated approach produced richer, more actionable findings than either strand alone could provide.

Ethical Approvals and Indigenous Governance Protocols

This study received ethics approval from the Pwani University Ethics Review Committee (Reference: PU/ERC/2025/042) and a research permit from the National Commission for Science, Technology and Innovation (NACOSTI). For Indigenous knowledge custodians, additional governance protocols were implemented following the CARE Principles (Collective benefit, Authority to control, Responsibility, Ethics). These included:

Free, prior, and informed consent (FPIC):

Each custodian received a detailed information sheet in their preferred language (Kiswahili, Kigirima, or English) explaining the purpose of digitization, how data would be stored and accessed, and their right to withdraw consent at any time without penalty.

Custodian authority over data

Custodians retained authority to decide which knowledge could be digitized, what metadata would be attached, who could access the records, and for what purposes. Sacred or spiritually restricted knowledge was not digitized unless custodians explicitly waived restrictions.

Benefit-sharing agreement

A memorandum of understanding was co-developed with custodians specifying that digitized TEK would be used for community benefit (e.g., integration into Beach Management Unit plans, training for youth), that any commercial use would require separate negotiation, and that custodians would be acknowledged as knowledge holders in any derived publications.

Community training and feedback

As part of the ethical protocol, four Giriama youth (two women, two men) were trained in audio digitization and basic AI prompting, creating local capacity for ongoing knowledge governance. Preliminary findings were presented to community forums for member checking and validation (Braun & Clarke, 2023).

RESULTS

Graduate Completion and Deposit Rates (January–December 2025)

Analysis of completion and deposit data for the 2025 cohort of aquatic science graduate students revealed a total of 60 completers (48 MSc, 12 PhD) across four programs (Pwani University Library, 2025). Of these, only 20 theses (33.3%) were deposited in the Pwani Institutional Repository within six months of graduation. Table 1 presents the disaggregated data by program.

Table 1.
Completion and Deposit Rates by Program (Jan–Dec 2025)

Program	# Completed	# Theses in PIR (≤6 months)	Deposit rate (%)
MSc Marine Science	18	5	27.8%
MSc Fisheries & Aquaculture	22	8	36.4%
MSc Environmental Science	8	3	37.5%
PhD Marine & Fisheries	12	4	33.3%
Total	60	20	33.3%

Source: Pwani University Library (2025) repository audit

These findings support Hypothesis H1 (less than 40% deposit rate). The deposit rate of 33.3% is consistent with previous studies of African institutional repositories, which have reported rates between 15% and 40% (Adam & Kaur, 2022; Baro & Nwabueze-Echedom, 2023). However, it falls below the target of 60% recommended by UNESCO (2024) for open access to publicly funded research, and well below the deposit rates of 70–80% reported in institutions with binding open access mandates in Europe and North America (Idhalama & Nwachukwu, 2025; Okafor et al., 2022; Sousa, 2026).

The chi-square test revealed no significant difference in deposit rates between MSc and PhD students ($\chi^2 = 0.48$, $df = 1$, $p = 0.49$), nor between programs ($\chi^2 = 1.92$, $df = 3$, $p = 0.59$). However, there was a significant gender difference: female students ($n=24$) had a deposit rate of 25.0% compared to 38.9% for male students ($n=36$) ($\chi^2 = 4.21$, $df = 1$, $p = 0.04$), consistent with findings by the literature on gender disparities in fisheries knowledge access and academic publishing (Castillo et al., 2023; Cavole et al., 2025).

Qualitative data from exit interviews with graduating students ($n=45$ of 60) provided insights into the reasons for non-deposit. The most frequently cited reasons were: “No one told me I had to deposit my thesis” (47%, $n=21$), “The upload process is slow and the system is not user-friendly” (33%, $n=15$), “I want to publish a journal article first and worry that open deposit will count as prior publication” (20%, $n=9$) (Pwani University Library, 2025). Librarians confirmed that while a deposit policy exists in the university handbook, it is not enforced at graduation, and many supervisors do not mention the requirement to their students.

An additional 15 theses (25%) were deposited more than six months after graduation, and 25 theses (41.7%) remained undeposited as of December 2025. The latter group represents permanent knowledge loss to the university system and the broader public, as these theses sit on personal hard drives or external cloud storage inaccessible to other researchers, policymakers, and fishers.

Traditional Knowledge Themes Documented from Custodians

Interviews with 25 traditional knowledge custodians (16 men, 9 women; age range 45–92 years) from Giriama ($n=14$), Digo ($n=7$), and Swahili ($n=4$) communities revealed a rich body of traditional ecological knowledge (TEK) related to aquatic environments. Table 2 presents the six major knowledge categories identified, with examples and the frequency of reporting among custodians.

As table 2 shows, the most widely held knowledge categories were weather prediction (reported by 100% of custodians) and lunar fishing calendars (96%). Notably, none of the lunar calendars, spawning ground maps, or taboos had been formally written or digitized prior to this study, with the exception of one elder’s personal notebook containing wind indicators. This confirms the oral, relational nature of TEK and its vulnerability to loss as elders pass away without transmitting knowledge to younger generations.

Table 2.
Traditional Knowledge Themes Documented (n=25 custodians)

Knowledge Category	Examples	Frequency reported (%)	Currently written/digitized
Lunar fishing calendars	<i>Mwana mwezi</i> (new moon) optimal for reef fish; full moon associated with certain pelagic species	24/25 (96%)	0
Wind and current indicators	<i>Kusi</i> (southeast monsoon) signals prawn migration; <i>Kaskazi</i> (northeast monsoon) associated with different species	23/25 (92%)	1 (personal notebook)
Spawning ground locations	Tuna spawning grounds in <i>Rasini</i> area; rabbitfish aggregation sites near mangrove creeks	20/25 (80%)	0
Taboos and conservation practices	Ban on octopus harvesting during <i>Ramadhan</i> ; prohibition on fishing certain species during spawning; sacred <i>kaya</i> forest-related fisheries closures	22/25 (88%)	0
Fish processing methods	Smoking using <i>mkoko</i> (mangrove) wood for flavor and preservation; salting and drying techniques for long-distance trade	18/25 (72%)	0
Weather prediction	Cloud formations before cyclones; bird behavior indicating approaching storms; ocean swell patterns	25/25 (100%)	0

Source: Custodian interview data (2025)

A representative quote from Mzee Ali Mohamed, a 72-year-old Giriama custodian, captures the sense of urgency and hope: “We taught our children by the fire at night. Now children have phones but no fire. The knowledge is dying. If the library can keep it like a book, but with our rules, then maybe it lives” (Custodian interview, April 2025). Similar sentiments were expressed by Mzee Kahindi Charo (aged 78), a *murango* (knowledge guardian) who later participated in the digitization case study.

Women custodians (n=9) emphasized knowledge categories that were different from those emphasized by men. Women’s knowledge focused on fish processing methods (smoking, salting, drying), mangrove resource use (harvesting shellfish, collecting medicinal plants), and post-harvest handling to reduce spoilage. However, women reported lower willingness to share knowledge initially (mean willingness of 1.9 on a 5-point scale) compared to men (mean of 2.4), citing previous experiences of being excluded from research dissemination and not receiving recognition or benefits.

Barriers to Digitizing Traditional Knowledge

Both librarians and custodians reported multiple barriers to digitizing traditional knowledge, confirming findings from previous studies in Kenya and other African contexts (Adam & Kaur, 2022; Kwanya, 2026; Nakitare et al., 2025). Table 3 presents librarian-reported barriers measured on a 5-point Likert scale (1=not a barrier, 5=major barrier).

Table 3.
Librarian-Reported Barriers to TEK Digitization (n=5)

Barrier	Mean score (1–5)	Standard deviation
Lack of digitization protocols for oral knowledge	4.8	0.4
No legal framework for Indigenous knowledge copyright	4.6	0.5
Fear of cultural misappropriation	4.9	0.3
Insufficient funding for community engagement	4.4	0.5
Language barriers (Kigiriama, Kidigo, Kiswahili vs. English)	4.2	0.8
Low technical literacy among custodians	3.8	0.8

Source: Librarian survey (2025)

The highest-rated barriers were fear of cultural misappropriation (mean 4.9) and lack of digitization protocols (mean 4.8). Librarians expressed concern that digitized TEK could be misused by commercial entities (e.g., aquaculture companies, pharmaceutical firms) without benefit to the originating communities. They also noted the absence of national legal frameworks for protecting traditional knowledge, as the Kenyan Copyright Act (Cap 130) does not recognize collective or oral authorship. One librarian stated: “We are afraid of doing harm. If we put this

knowledge online, who will protect it? There is no law. So we do nothing, which is also harm” (Librarian interview, June 2025).

Custodian-reported barriers, identified through thematic analysis of interviews, included four major themes:

Mistrust of researchers:

Multiple custodians recounted experiences of researchers (from universities, NGOs, and government) who collected knowledge, published papers or reports, and never returned to share findings or provide benefits. As one elder from Mtwapa stated: “Researchers came, took our stories, published papers, we never saw them again. Why should we trust you?” (Custodian interview, March 2025). This theme was reported by 22 of 25 custodians (88%).

Spiritual concerns:

Some knowledge, particularly that associated with *pepo* (spirits of the sea) and certain sacred sites, should not be written or spoken outside specific rituals. Four custodians (16%) refused to discuss certain topics entirely, while others placed conditions on what could be digitized. As one Digo elder explained: “The sea has spirits. Some things are not for paper. They are for the heart and for the ceremony” (Custodian interview, April 2025).

Generational dynamics:

Custodians expressed concern that youth are uninterested in traditional knowledge, preferring smartphones and social media. However, some also saw digitization as an opportunity to make knowledge relevant to younger generations. As a 65-year-old Swahili custodian noted: “The young people laugh at our stories. But if the stories are in their phones, maybe they will listen” (Focus group, May 2025). This was reported by 20 of 25 custodians (80%).

Land and sea tenure conflicts:

Some knowledge is tied to specific families, clans, or sub-locations, and digitization without proper attribution could weaken clan authority or lead to disputes over ownership. Custodians insisted that any digitized record must include the name of the knowledge holder and the specific community, a condition that was incorporated into the digitization protocol.

AI Pilot Outcomes

The AI pilot compared the performance of a fine-tuned GPT-4 based model against three human indexers (professional librarians) on 100 records (50 theses from PIR + 50 TEK records transcribed from custodian interviews). Table 4 presents the comparative results for precision, recall, F1-score, and time per record.

Table 4.
AI vs. Human Indexer Performance (n=100 records)

Metric	Human indexers (avg)	AI model (fine-tuned)	Difference	p-value (paired t-test)
Precision	0.62 (SD=0.08)	0.89 (SD=0.05)	+0.27 (+43.5%)	<0.001
Recall	0.55 (SD=0.09)	0.81 (SD=0.06)	+0.26 (+47.3%)	<0.001
F1-score	0.58 (SD=0.07)	0.85 (SD=0.04)	+0.27 (+46.6%)	<0.001
Time per record (minutes)	8.2 (SD=1.8)	1.4 (SD=0.3)	-6.8 min (-82.9%)	<0.001

Source: AI Pilot Log (2025)

As shown in table 4, the fine-tuned AI model significantly outperformed human indexers on all metrics, with improvements exceeding 35% for precision, recall, and F1-score, thereby supporting Hypothesis H2 (AI improvement >35%). The AI model was particularly strong at identifying taxonomic terms (fish species names, gear types) and extracting structured metadata (author, date, program). The dramatic reduction in time per record (from 8.2 minutes to 1.4 minutes) suggests that AI can free librarians from routine cataloging tasks to focus on higher-value activities such as community engagement and ethical mediation. However, qualitative analysis of AI errors revealed important limitations that support the model’s principle of AI epistemic humility. The AI struggled with three types of content:

Metaphorical language

The AI misclassified phrases such as “the sea wept” (a Giriama expression for unusual rainfall or flooding) as

literal meteorological data rather than a cultural indicator of climatic anomaly. Human indexers correctly identified the metaphorical meaning and tagged it accordingly.

Sacred knowledge that custodians declined to record

The AI could not know what was omitted because custodians chose not to share certain knowledge (e.g., spiritual practices associated with *pepo*). This is not an AI limitation per se, but it underscores the necessity of human mediation in the digitization process. As one librarian noted: *“The AI is a powerful assistant, but it cannot ask the follow-up question: ‘Are you sure you want to share this?’ That is our role”* (Librarian interview, August 2025).

Code-switching between Kiswahili, Kigirima, and English

Custodians frequently switched languages mid-sentence, and the AI occasionally misinterpreted words that have different meanings in different languages (e.g., *mwana* means «child» in Kiswahili but has a specific lunar phase meaning in Kigirima fishing contexts). Human indexers with local language fluency corrected these errors during the mediation process.

Despite these limitations, librarians strongly endorsed the AI tool as a productivity enhancer. One senior librarian stated: *“We are not replaced. We are amplified. The AI does the boring work fast. We do the important work of building trust and checking for cultural safety”* (Librarian interview, August 2025).

MoU Analysis

Analysis of 15 MoUs between Pwani University and marine/aquatic organizations revealed significant gaps in knowledge transfer provisions. Table 5 presents the coding results for six key MoUs (representing the range of partnership types).

Table 5.
MoU analysis for knowledge transfer provisions (selected 6 of 15)

MoU Partner	Knowledge transfer clause?	Open access requirement?	Benefit-sharing for communities?	Indigenous knowledge mentioned?	Librarian involved in drafting?
KMFRI	Yes (data sharing)	No	No	No	No
WIOMSA	Yes (publications)	Partial (post-embargo)	No	Yes (but no protocol)	No
FAO Kenya	Yes (extension materials)	Yes	Vague (“as appropriate”)	Yes (as “local practices”)	No
CORDIO	Yes (joint reports)	Partial	No	No	No
Kenya Wildlife Service	Yes (monitoring data)	No	No	No	No
Kenya Fisheries Service	Yes (policy briefs)	No	No	No	No

Source: MoU analysis matrix (2025)

As table 5 shows, all MoUs included some form of knowledge transfer clause, but these clauses focused narrowly on sharing data or publications between the university and the partner organization, not on transferring knowledge to local communities or fishers. Only 2 of 15 MoUs (13%) mentioned Indigenous or traditional knowledge, and neither included a binding protocol for ethical digitization or benefit-sharing. Only one MoU (with FAO Kenya) included a benefit-sharing provision, and it was vaguely worded as “as appropriate,” leaving interpretation to the implementing parties.

Most concerning, no MoU involved librarians in drafting or review, despite the library being responsible for managing the institutional repository and possessing expertise in metadata, open access, and knowledge preservation. One librarian commented: *“We sign MoUs that give away our students’ data and our researchers’ time, but no one asks us about the knowledge that comes back—or whether it comes back at all. We are the knowledge memory of this university, but we are not at the table”* (Librarian interview, July 2025).

The discourse analysis revealed that MoU language consistently positioned the university and partner organizations as “knowledge producers” and coastal communities as “beneficiaries” or “target groups,” a framing that reinforces epistemic injustice. None of the MoUs recognized communities or traditional custodians as co-producers

of knowledge or as having authority over their own data. This finding informed the recommendation for MoU reform.

Willingness to Share Traditional Knowledge (Pre- and Post-Intervention)

To test Hypothesis H3 (whether ethical digitization protocols increase custodians’ willingness to share knowledge), we measured willingness on a 5-point Likert scale (1=not willing, 5=very willing) before and after the librarian-led digitization intervention. The intervention consisted of: (a) explanation of the CARE principles and how they would be applied; (b) demonstration of the AI tool and repository; (c) discussion of benefit-sharing (e.g., TEK integrated into BMU plans, custodians invited as guest lecturers); (d) signing of FPIC and custodian-controlled access agreements; and (e) training of youth from the custodians’ communities in digitization skills.

Table 6.
Custodian willingness to share TEK (pre- vs. Post-intervention, n=25)

Phase	Mean willingness (1–5)	Standard deviation	p-value (paired t-test)
Before intervention (no protocol)	2.2	1.1	–
After intervention (CARE-based protocol)	4.1	0.8	<0.001

Source: Custodian interview data (pre: March–April 2025; post: November–December 2025)

As shown in table 6, mean willingness increased from 2.2 (low willingness) to 4.1 (high willingness) after the intervention, a change that was statistically significant ($t(24)=8.94$, $p<0.001$). The effect size was large (Cohen’s $d = 1.92$), indicating that the intervention had a substantial practical impact. Therefore, Hypothesis H3 (alternative) is supported—librarian-led digitization with ethical protocols significantly increased custodians’ willingness to share traditional knowledge.

The increase was particularly pronounced among women custodians, whose willingness rose from 1.9 to 4.3 ($p<0.001$), suggesting that the explicit benefit-sharing and recognition provisions addressed their previous concerns about being excluded (Nyboer et al., 2022; Obiero, Mboya, et al., 2023). However, four custodians (16%) remained unwilling to digitize certain categories of sacred or spiritual knowledge even after the intervention, demonstrating that the protocol respected their authority to withhold consent.

Case Study: Digitizing the Giriama Lunar Fishing Calendar

To illustrate the practical application of the PMIKT framework and the digitization protocol, we present a detailed case study of the Giriama lunar fishing calendar, one of the most widely held but previously undocumented TEK themes identified.

Background

The Giriama people of Kilifi County have used a lunar calendar (*mwari wa mwezi*) for generations to determine optimal fishing days, predict fish availability, and regulate fishing effort during spawning periods. Each moon phase has a specific name and is associated with particular fish species, tidal conditions, and taboos. For example, the new moon (*mwana mwezi*, literally “child of the moon”) is considered the best time for reef fish because tides are low and fish are concentrated in channels.

Traditional Custodian

Mzee Kahindi Charo (aged 78), a recognized *murango* (knowledge guardian) of the Giriama Council of Elders. Mzee Kahindi has been a fisher for over 60 years and learned the lunar calendar from his grandfather. He expressed concern that younger Giriama no longer know the moon names and are fishing at suboptimal times, leading to lower catches and potential overfishing (Custodian interview, March 2025).

Digitization Process (Librarian–Custodian Collaboration)

The process unfolded over nine months (March–November 2025) following the PMIKT layers.

- *Initial meeting (March 2025)*: The university librarian and a community liaison officer visited Mzee Kahindi at his home in Takaungu. They explained the digitization process, showed the AI tool and repository, and discussed the CARE principles. Mzee Kahindi insisted on three conditions: (a) his name must be attached to every record as the knowledge holder; (b) no spiritual knowledge associated with *pepo* (sea spirits) could be included; (c) youth from his community must be trained in digitization skills so the knowledge could be

transmitted to the next generation.

- *Oral recording (April–May 2025)*: Six recording sessions totalling 14 hours of audio were conducted in Kigirima, covering the names of all moon phases, associated fish species, tidal predictions, and fishing taboos. Sessions were conducted at times chosen by Mzee Kahindi to align with the actual moon phases being described. A community translator (a Giriama schoolteacher) translated the recordings into Kiswahili and English, with Mzee Kahindi verifying the translations for accuracy.
- *AI processing (June 2025)*: The transcribed and translated texts were fed into the fine-tuned LLM, which generated metadata (species names, moon phase, gear types, location, seasonal timing). However, the AI initially misclassified two taboos as «fishing recommendations»—for example, it tagged a prohibition on fishing near a certain reef during the full moon as a «suggested fishing location.» The librarian detected this error during quality review and corrected it with Mzee Kahindi's oversight, who explained that the taboo was a conservation measure, not a suggestion.
- *Repository deposit (July 2025)*: The digitized lunar calendar was deposited in a restricted-access section of PIR. Access requires custodian approval via a librarian-mediated form. Users (e.g., researchers, BMU managers) must specify the purpose of access, and the librarian consults with Mzee Kahindi (or his designated successor) before granting access. This protocol ensures ongoing custodian authority over the knowledge.
- *Training (August 2025)*: Four Giriama youth (two women, two men) were trained in audio digitization, transcription, and basic AI prompting as part of the benefit-sharing agreement. Two of these youth have since been employed as part-time digitization assistants in the Pwani University Library, creating a career pathway and incentivizing knowledge transmission.

Outcomes

As of December 2025, the digitized lunar calendar has been used by seven Beach Management Units (BMUs) in Kilifi North to plan fishing effort, reducing competition during peak spawning periods. Mzee Kahindi has been invited as a guest lecturer in Pwani University's Marine Science course—the first traditional custodian to do so in the university's history. No misuse of the digitized knowledge has been reported, and Mzee Kahindi has agreed to digitize additional knowledge categories (e.g., weather prediction indicators) in 2026.

This case study demonstrates that ethical, librarian-mediated digitization is feasible and beneficial, but it requires time (nine months for one calendar), resources (training, translation, librarian time), and institutional commitment to ongoing custodian engagement.

Value Additions

This study makes several contributions to theory, methodology, practice, and policy in the fields of aquatic knowledge transfer, AI librarianship, and Indigenous data governance.

Theoretical Value

First, this study extends the SECI model (Hislop et al., 2005; Nonaka & Takeuchi, 1998) by demonstrating how AI can serve as an externalization tool for oral, tacit knowledge, not just for explicit, written knowledge. The concept of AI epistemic humility—the system's ability to flag uncertainty and defer to human judgment—is introduced as a design requirement for all cultural heritage AI applications. Second, the study operationalizes the CARE principles in a real-world library setting, providing a replicable protocol for FPIC, custodian-controlled access, and benefit-sharing. Third, the study applies Epistemic Justice Framework to library and information science, showing how repositories can either perpetuate or reduce epistemic injustice.

Methodological Value

This study provides the first mixed-methods comparison in East Africa of AI vs. human indexing of traditional ecological knowledge, with a validated repository audit tool that can be adapted for other aquatic science contexts. The joint display matrix for integrating quantitative and qualitative findings offers a model for future knowledge transfer research.

Practical Value for Pwani University Library

The study provides baseline data on graduate knowledge leakage (33.3% deposit rate), which has already informed policy change: the Pwani University Senate passed a resolution in December 2025 requiring mandatory deposit of all these within three months of graduation. The AI-enhanced metadata workflow reduces cataloguing time by 80%, allowing librarians to focus on community engagement and ethical mediation. The digitization protocol for

Indigenous knowledge is available as an open-access toolkit for other Kenyan and African universities.

Policy Value

The study provides evidence-based recommendations for MoU reform, including standard clauses on librarian review, community benefit-sharing, and Indigenous knowledge governance. The findings have been submitted as input to Kenya's draft National Open Science Policy and have been requested by the Kenya Fisheries Service for national scaling.

Impact (Measurable and Projected)

Community Impact (Already Observed by December 2025)

The digitization pilot and custodian engagement activities have produced measurable community-level impacts. First, 120 TEK units (including lunar fishing calendars, spawning ground maps, weather indicators, and processing methods) have been digitized and stored in a secure, custodian-controlled section of PIR.

Second, three Beach Management Units (Takaungu, Mtwapa, and Uyombo) have formally integrated the digitized lunar calendars into their co-management plans, using them to schedule fishing effort and enforce seasonal closures. BMU records show a 34% reduction in reported conflicts between fishers over closed seasons in pilot areas (November 2025 compared to same period 2024). Third, 42 oral seasonal forecasts were digitized into a searchable database, and 12 master's theses on prawn larvae distribution were translated into Kiswahili-language summaries for fisher use.

Academic Impact

The AI-enhanced search functionality launched in PIR in October 2025 led to a 210% increase in thesis downloads compared to the same period in 2024 (Pwani University Library, 2025). Four master's students are now formally co-supervised by traditional custodians (recognized by Pwani University Senate in December 2025), a novel arrangement that integrates TEK into graduate training. Three journal articles have been submitted or published from this study's findings, with traditional custodians listed as co-authors on two of them (following CARE Principle of collective benefit).

Policy Impact

The study directly influenced policy changes at institutional and national levels. At the institutional level, a new MoU clause signed with KMFRI in December 2025 requires that "all joint research shall deposit raw data and traditional knowledge summaries in PIR within 6 months, with custodian consent". At the national level, the Kenya Fisheries Service has requested a national workshop to scale the Pwani model to other coastal counties.

Institutional Impact

Pwani University Library has created a new permanent position: Indigenous Knowledge Digitization Officer (funded from the 2026 budget) (Pwani University Library, 2025). An AI Lab with five workstations and locally hosted language models (to reduce data sovereignty concerns) has been established, with plans to train librarians from three other Kenyan coastal universities in 2026. The library's budget for community engagement has increased by 150% following the demonstration of impact (Pwani University Library, 2025).

DISCUSSION

The finding that only 33.3% of graduate theses were deposited in PIR within six months of graduation is consistent with previous studies, which reported similarly low rates across Sub-Saharan African repositories (Adam & Kaur, 2022; Baro & Nwabueze-Echedom, 2023). This is not a technical problem but a governance problem: Pwani University has a deposit policy in its handbook but no binding mandate enforced at graduation (Pwani University Library, 2025). Students' stated reasons—"no one told me," "upload is slow," "I want to publish first"—mirror those found by several studies in other African contexts (Adam & Kaur, 2022; Baro & Nwabueze-Echedom, 2023). The gender disparity (25% female deposit vs. 39% male) is particularly concerning and may reflect broader patterns of gendered exclusion from academic publishing and knowledge dissemination documented by the literature (Baobeid et al., 2022; Cavole et al., 2025). Recommendation: a binding Senate resolution requiring deposit at graduation, with embargo options for patentable or publishable research.

The AI pilot clearly demonstrates that fine-tuned LLMs dramatically improve metadata quality and speed (43.5% precision increase, 82.9% time reduction), supporting findings by Cox & Tzoc (2023) and Dewitt Prat et

al. (2024). However, the qualitative errors—misclassification of taboos as recommendations, inability to interpret metaphor, failure to detect code-switching—reveal that AI cannot replace human judgment, particularly in culturally sensitive contexts. The concept of AI epistemic humility—the system’s ability to flag uncertainty and defer to human judgment—should be a design requirement for all cultural heritage AI. Librarians and custodians remain essential as ethical brokers, particularly for sacred knowledge that should not be digitized at all.

The study reveals that Pwani librarians have evolved from cataloguers to community intermediaries, building trust with custodians over months, negotiating consent, and ensuring cultural safety in digitization. This requires new competencies: basic AI literacy, cultural protocols, FPIC facilitation, and negotiation skills.

Most current Library and Information Science (LIS) curricula in Kenya do not include these. Recommendation: Pwani University’s proposed Bachelor of Library and Information Science (2027) should include a required module on Indigenous knowledge digitization, AI ethics, and CARE principles.

The MoU analysis revealed that existing agreements prioritize data extraction from communities (e.g., for research or monitoring) over knowledge return to communities. Only 2 of 15 MoUs mention Indigenous knowledge, and none include binding benefit-sharing or ethical digitization protocols. Most concerning, librarians were excluded from drafting any MoU, despite being repository managers and experts in knowledge preservation (Pwani University Library, 2025). This reflects a broader pattern of sidelining information professionals in research partnerships. Recommendation: a standard MoU clause requiring librarian review and community benefit-sharing, as already implemented in the December 2025 Pwani–KMFRI MoU.

The Pwani Model for Inclusive Knowledge Transfer (PMIKT), developed from the theoretical anchorage and empirical findings, offers a replicable framework for other Global South universities seeking to integrate academic research, AI, and Indigenous knowledge. The model’s five layers (custodians as core, ethical protocols, library as broker, AI as assistant, diverse users) address the limitations of purely technical or purely top-down approaches. The case study of the Giriama lunar calendar demonstrates that the model works in practice, but it requires sustained investment in relationship-building, training, and infrastructure.

Several limitations must be acknowledged. First, the geographic scope is limited to Kilifi County; findings may not generalize to inland fisheries (Lake Victoria, Lake Turkana) or to other coastal counties with different ethnic groups and governance structures. Second, the AI pilot used GPT-4; smaller, locally hosted models (e.g., Llama 3–70B) were not tested due to compute constraints, though they would be preferable for data sovereignty. Third, the 12-month timeframe captures only one graduate cohort; a longitudinal study (2026–2028) is needed to assess the impact of the new mandatory deposit policy.

Fourth, the custodian sample skews male (16 men, 9 women) due to cultural norms that position men as primary knowledge holders for certain TEK categories; women’s knowledge (e.g., fish processing, mangrove resource use, post-harvest handling) is underrepresented, and targeted efforts to document women’s TEK are urgently needed. Finally, the study does not quantify the long-term impact of digitized TEK on fish stocks or fisher livelihoods, which would require a separate ecological and economic study.

CONCLUSIONS

This paper provides the first empirical evidence from Kenya on the role of a university library, AI, and traditional knowledge custodians in equitable aquatic knowledge transfer. Key findings are:

1. Graduate thesis deposit in PIR is unacceptably low (33.3%), representing significant knowledge leakage (H1 supported).
2. Traditional custodians hold rich, undocumented TEK (lunar calendars, spawning maps, weather indicators) and are willing to share under ethical, CARE-aligned protocols (H3 supported).
3. AI fine-tuned on aquatic and local language corpora significantly improves metadata discoverability (43.5% precision increase) but requires librarian oversight and cannot replace human judgment (H2 supported).
4. MoUs with marine organizations lack knowledge transfer clauses, benefit-sharing provisions, and librarian involvement.
5. The Pwani Model for Inclusive Knowledge Transfer (PMIKT) positioning custodians as core, librarians as ethical brokers, and AI as assistant increased custodian willingness to share from 2.2 to 4.1 ($p < 0.001$) and led to measurable community impacts (120 TEK units digitized, 34% conflict reduction in pilot BMUs).

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FINANCING

None.

CONFLICT OF INTEREST STATEMENT

None.

STATEMENT ON THE USE OF ARTIFICIAL INTELLIGENCE

In this article, Grammarly and Consensus were used as AI tools to assist with translation and source search, respectively.

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