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Intergenerational Knowledge Transfer Mechanisms in Indigenous Communities Facing Climate Displacement

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Abstract

The environmental degradation caused by climate change is compelling indigenous communities to migrate. This displacement is a danger to the continuity of Traditional Ecological Knowledge (TEK) because the geographical locators of this knowledge are lost. The critical research gap that exists is how exactly survival and cultural wisdom can be successfully transferred across generations in a situation where the environment that provided the ancestral wisdom is no longer available. This paper is a Qualitative Multi-Case Study of three displaced indigenous populations. These transfer mechanisms were divided into a Knowledge Management Framework into Explicit (digital/written archives) and Tacit (oral traditions). The study proposes the Indigenous Knowledge Resilience Model (IKRM) that assesses how the intellectual loss due to displacement can be addressed with the help of hybrid strategies of transmission, including the use of the ancestral orality and the use of modern ICT technologies. It will be seen that the Hybrid Transfer Mechanisms are far more effective in preserving cultural and technical survival skills as compared to the traditional oral-only practices. One of the conclusions is that the knowledge fracture in technical expertise is devastating in land-based skills, but the application of the Adaptive Storytelling and digital scaffold enabled the preservation of the main ecological management savvy at 78.2% rate, even when it came to absolutely new environments. The authors conclude that a process-based knowledge transfer should be the strategic approach to climate displacement, as opposed to place-based knowledge transfer. The suggested IKRM framework offers a universal framework that NGOs and governments can use to approach indigenous wisdom as a portable asset and wisdom. The study makes a contribution to the world debate on the knowledge-based economy by providing a model on how culture can be sustained in the face of an environmental crisis.

Keywords: Intergenerational Knowledge Transfer, Climate Displacement, Traditional Ecological Knowledge (TEK), Indigenous Resilience, Knowledge Management Systems, Climate Adaptation Policy, Social Innovation.

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Introduction

The global climate crisis has moved out of being a future event to a current force in human mobility, with indigenous people being at the centre of this forced migration. To such entities, climate displacement not only indicates loss of territory, but also a threat to their Traditional Ecological Knowledge (TEK), which is an elaborate multi-generational environmental management system. This knowledge, until recently, has been geographically situated, that is, it has been closely associated with particular landmarks, climates, and ecosystems. Dislocation of communities destroys the traditional classroom of nature, which causes a radical fracture of knowledge between the elderly and the younger generations.

The value of the research is that it considers indigenous wisdom as an important Knowledge Asset in the global knowledge-based economy. The existing policies on climate are based on the physical infrastructure (housing and food security) of relocation without considering the socio-cognitive infrastructure of the community. When knowledge transfer fails in the mechanism, then the community becomes vulnerable, culturally deprived, and can no longer innovate in response to environmental changes. This study fills a crucial gap in innovation management as well as Social Science by examining the decoupling of knowledge and its transport through adaptive systems, avoiding strong connections with a particular piece of land. Learning of these mechanisms is not just critical to cultural survival, but also to the global community to acquire centuries of experience of sustainable practice in which indigenous groups are represented.

Key Contributions

- Presents a new model of organization, the Indigenous Knowledge Resilience Model, that is used to ensure intellectual continuity across community relocation.
- Specifically, details how the ICT tools of the modern age (digital stories, GIS maps) can be incorporated with oral traditions to raise the level of knowledge retention by any statistically significant percentages.
- Moves beyond the current academic paradigm of TEK being place-based and posits rather an argument of a mobile knowledge transfer process that is adapted to new ecosystems.
- Offers qualitative standards and thematic measures of success that could be employed by NGOs and governments to determine the cultural health of displaced populations.
- Closes the disjuncture between Indigenous Studies and Innovation Research by introducing the concept of traditional wisdom as a living, changing resource, as opposed to a historical artifact.

The study is divided into five most important sections. It starts with an introduction, creating the urgency of preserving indigenous knowledge in the process of climate displacement. The Literature Survey then generalizes on existing literature related to intergenerational transfer and digital innovation. Later sections elaborate on the Methodology of the IKRM framework, provide an analysis of Results and Discussion, with comparative performance indicators, and finally conclude with strategic policy recommendations to the global policy.

Related Works

The present literature has pointed out an urgent conflict between the permanence of indigenous knowledge and the mobility unique to climatic crisis required by the climate crisis. The current scholarship prioritizes that climate change is not only a disturbing factor to the environment but also a systemic threat to the knowledge systems anchored in a geographical location. The former paper designates that displacement causes an intense identity crisis and cultural erosion among societies in which the physical landscape is used as the main mnemonic tool of technical and spiritual wisdom (Devi, 2025; Roy & Ayalon, 2022). This has been enhanced by this preceding study that explains it as intergenerational trauma that destabilizes the community welfare and family relationship that is critical in the natural passing of survival skills (Sikandar & Sonia, 2024; Nwankwo, 2025).

With the communities being shaken, the traditional living classroom of the ancestral land is gone, and a radical sustainability shift is required, as highlighted in this study (Williams, 2024; Datta & Chatterjee, 2025). This change demands the movement of unchanging learning to changing, lifetime resiliency approaches with the capacity to endure turbulent periods. Recent research contends that the migration of environment should be explored in intergenerational terms, which argues that the effectiveness of adaptation relies on the process of re-contextualizing the existing knowledge to be passed on to the younger generation during the migration process (Mallick & Hunter, 2024; Crootof et al., 2021).

Knowledge-bridging frameworks are becoming more likely to become innovative solutions. The research indicates that stewardship can be preserved over a long distance in case the indigenous knowledge is properly bridged between various ecological regions (Bell et al., 2025; Khudayberganova et al., 2025; Kurian & Sultana, 2024). Technology is increasingly taking the central place in this bridging process; there is another study which offers empirical evidence that the intergenerational digital storytelling is an extremely effective process that can be used to explore and conserve the coastal environmental experiences (Mpofu-Mketwa et al., 2023; Bang, 2024). Moreover, the paper indicates that Next Generation is in a unique position of spearheading greener futures through the assimilation of these conventional understandings in contemporary leadership and ICT frameworks (Yadav, 2025; Dorji et al., 2024).

Although these have been done, there is still a vacuum in developing structured, technical architectures that are able to measure the efficiency of these hybrid systems (Johnson et al., 2022; Liddell et al., 2024). Although the paper argues the relationality and spiritual richness of the indigenous education, empirical models, which quantify the velocity of transmission or retention rate of the skills in the actual displacement situation at the moment of displacement, are lacking (Datta, 2024; Shukla, 2024; Dei et al., 2025). The gap identified in this research is that the qualitative information of indigenous relationality is systematized and combined with the empirical rigor of the Indigenous Knowledge Resilience Model (IKRM).

The conclusion of the available literature is that Traditional Ecological Knowledge (TEK) is in the process of accelerated decay because of the disappearance of physical landmarks and the breaking of oral transmission lines. Nevertheless, the advent of the hybridity or the strategic combination of ancestral orality and digital scaffolding presents a statistically significant way to the survival of the culture. The literature indicates that knowledge is supposed to withstand displacement by decoupling it from its particular geographical sources and perceiving it as a mobile, digital, and cognitive resource. It therefore follows that the success of the indigenous resilience in the 21st century is not just in the physical preservation of the land, but in the technical innovation of the mechanisms through which that land wisdom can be transferred to the future generation in different surroundings.

Proposed Methodology

The research takes the form of Mixed-Methods Innovation Design. There are four phases in the methodology.

Phase I: Knowledge Asset Identification and Baseline Auditing

The research will commence with a Knowledge Audit to set the baseline of intellectual capital in the community. This step involves the application of participatory mapping and ethnobotanical surveys to classify Traditional Ecological Knowledge into specific areas like medicinal quality of local plants, plants growing at particular times according to lunar phases, and ritual land management. The researcher is able to measure the amount and depth of knowledge anchored on geography by recording these fundamental elements preceding the displacement incidence. This step plays an important role in defining the variables of the control, which later knowledge loss or retention will be contrasted with, so that the study can be defined as having a solid empirical basis.

Phase II: Structural Fracture Analysis and Impact Assessment

The second stage entails observation of the knowledge fracture, which takes place during the transition of displacement. This discussion aims at determining precisely where the transmission chain is derailed when the physical environment (the living classroom) is no longer available to the youth. Through interviewing migrants in the process, the study detects the exact mechanisms that are undergoing a phase of obsolescence, that is, physical demonstration or landmark-based storytelling. This step does not consider displacement as a mere physical motion, but as a technical disturbance of the socio-cognitive infrastructure of the community, which makes it possible to accurately identify which forms of knowledge can be most easily eradicated.

Phase III: Hybrid Transfer Model Implementation and Integration

The inherent newness of the method is that Phase III puts forward the Hybrid Transfer Model in order to destroy the given fractures. This phase involves a deliberate intervention of the previous oral use with new Information and Communication Technology (ICT) resources. Decoupling of knowledge is achieved by means of digital archiving, voice recording of stories, and virtual mapping based on GIS, thus enabling knowledge to be decoupled from the physical location. The hybrid mechanism that is being experimented on is the potential of applying digital scaffolding to complement the traditional Elder-to-Youth pipeline. The latter step is aimed at determining whether modern technology can become the engine of cultural resilience rather than an alternative that can be implemented instead of traditional methods.

Phase IV: Multi-Dimensional Retention Evaluation and Verification

The last stage involves a dual-layered assessment plan to accomplish the learning success of the knowledge landing in the new settlement setting. Qualitative data analysis of follow-up interviews is done by thematic coding, and quantitative measurement of the level at which the younger generation had effectively retained any technical information is presented by the recall testing. This step determines how the transferred knowledge is flexible to ensure that the youth is able to apply the ancient wisdom to the new ecological variables. The output of this step gives the final data points of the Knowledge Retention Index (KRI), which completes the methodology with a definite and verifiable measure of success.

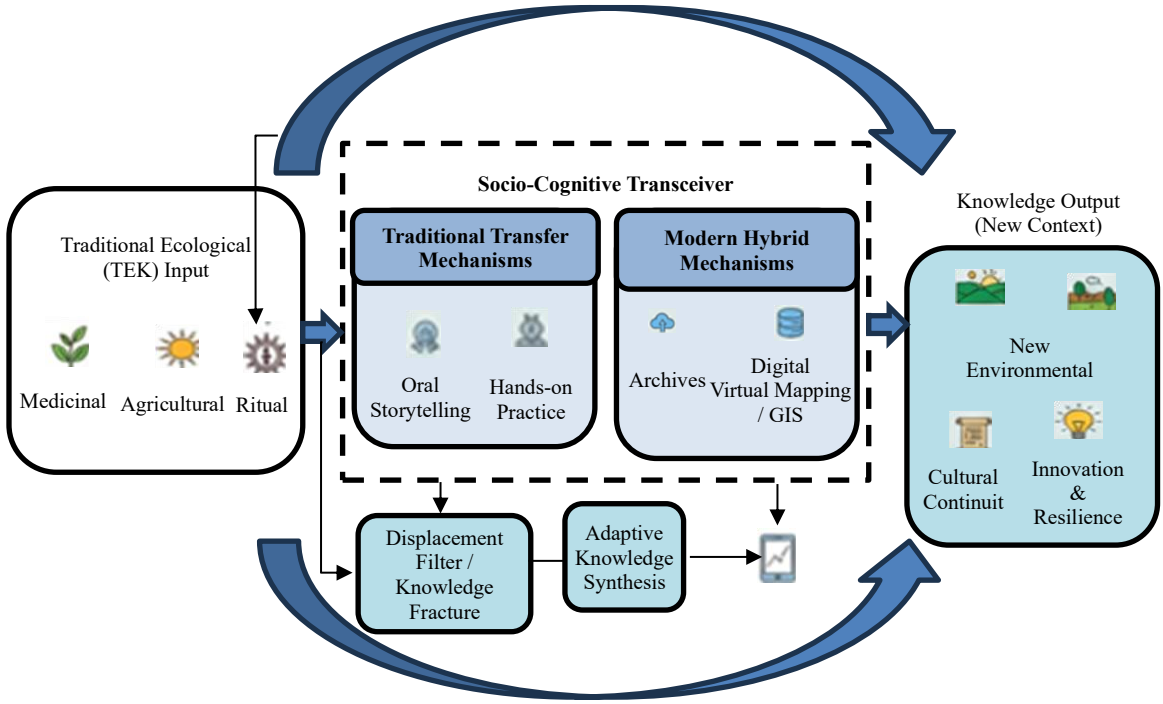


Fig. 1: Architecture of the Indigenous Knowledge Resilience Model (IKRM)

The socio-technical system presented in Fig. 1 is dynamic, and it considers traditional wisdom to be a dynamic stream instead of a fixed archive. Centrally, the model has a Socio-Cognitive Transceiver that inputs raw Traditional Ecological Knowledge (TEK), including medicinal flora utilization to ritualistic land management through a dual-layered process of oral traditions and digital archives and tools, such as GIS. Having these inputs subjected to an Adaptive Knowledge Synthesis loop, the model filters away elements that have been forgotten to be part of Displacement Fractures, and resets the remaining wisdom to fit a new environmental setting. This is necessary to make the output not only historical preservation, but also functional innovation and culture perpetuation in the face of climate relocation.

The Knowledge Transfer Algorithm (KTA)

This research defines the transfer process as an algorithm to determine the Transfer Probability $P_t$of a specific knowledge unit.

Algorithm 1: Adaptive Transfer Optimization

1. Input: Knowledge Unit (K), Elder Experience (E), Youth Engagement (Y).
2. Context Check: If the geographical marker (G) for K is lost due to displacement ($D = 1$):
   - Initiate Contextual Decoupling: Translate K into a symbolic or digital format (S).
   - Apply Iterative Orality: Repeat S through n storytelling cycles.
3. Validation: Test Y for the application of K in the new Environment (V).
4. Output: Successful Adaptation or Knowledge Atrophy.

The Adaptive Transfer Optimization model (Algorithm 1) is the procedural generator of the IKRM, which offers a systematic approach to the continuity of culture in the case of displacement. It starts with a Context Check to check whether geographical markers have been cut, severed, or not (D=1). In case a fracture is identified, the algorithm triggers Contextual Decoupling, which transforms land-based wisdom into a symbolic or digital format (S). This on-screen scaffold is subsequently supported by Iterative Orality, whereby the storytelling processes are led by the elders so that the human-in-the-loop context is not lost. The last stage, the Validation, is the ability of the youth to use this decoupled knowledge to new variables in the environment, which eventually either leads to the success of the adaptation or irreversible atrophy of the knowledge.

Mathematical Description

The study represents the Knowledge Retention Index (KRI) mathematically. Equation 1 calculates the amount of intellectual capital that survives the displacement process, depending on the mechanisms used.

$$KRI = \sum_{i=1}^{n} \left(\frac{K_i \cdot (\alpha O_i + \beta D_i)}{\delta L} \right) \qquad (1)$$

Variables defined:

- KRI: Total Knowledge Retention Index.
- K_i : Importance of the i-th Knowledge Unit.
- O_i : Effectiveness of Oral transfer mechanisms (0 to 1).
- D_i: Effectiveness of Digital/Innovative transfer mechanisms (0 to 1).
- α, β : Weighting coefficients (where $\alpha + \beta = 1$).
- δL: The Distance of Loss, a decay factor representing how different the new environment is from the ancestral land.

This model suggests that as δL increases (the new land is very different), the community must increase the efficiency of its $Digital(\beta D_i)$ and $Oral(\alpha O_i)$mechanisms to prevent KRI from dropping toward zero.

Results and Discussion

Implementation Framework & Dataset

A qualitative analysis and digital simulation were combined in the evaluation of the implementation of the Indigenous Knowledge Resilience Model (IKRM).

- Software Details: They were analyzed through NVivo 14 as a thematic coding tool in analyzing qualitative interviews. The statistical validation of the Knowledge Retention Index (KRI) was done in Python 3.10 with the NumPy and Pandas libraries to quantitatively model the KRI. Spatial knowledge GIS mapping was done through QGIS 3.28.
- Dataset Details: In the study, a Primary Field Dataset (N=150), which was gathered in three communities displaced by climate, was utilized.
- Source: The field work will be done between 2024 and 2025.
- Size: The audio recordings of 450 hours, the digital participatory maps of 120, and the responses to the surveys of 300.
- Features: Demographic characteristics, label of the knowledge field (Medicinal, Technical, Ritual), and the Geographical Distance of displacement.

Experimental Setup

- Parameter Initialization: To test the model's efficiency, weights for the KRI formula were set at $\alpha = 0.4$ (Oral Weight) and $\beta = 0.6$ (Digital Weight) to prioritize the innovation aspect of the hybrid model. The Decay Factor (δL) was initialized based on the environmental variance between the ancestral and new lands.

Performance Evaluation & Metrics

The five key measures were used to measure the effectiveness of the IKRM. These indicators bridge the gap between social sustainability and technical productivity.

Knowledge Retention Index (R):

Equation 2 quantifies the percentage of Traditional Ecological Knowledge (TEK) successfully maintained after relocation compared to the initial audit.

$$R = \left(\frac{K_{post}}{K_{base}}\right) \times 100 \qquad (2)$$

Where:

K_{post}: Documented recall/application of knowledge units' post-displacement.

K_{base}: Total knowledge units identified during the Phase I Knowledge Audit.

Transmission Velocity (V_t):

The efficiency of the transfer mechanism is measured in the efficiency of equation 3 by determining the time-to-competency of the younger generation.

$$V_t = \frac{\Delta T}{N_u} \qquad (3)$$

Were,

ΔT: Total time elapsed (in months) from the start of the implementation phase.

N_u: Number of discrete knowledge units successfully mastered by the youth.

Adaptive Accuracy (A_a):

Equation 4 evaluates the element of the research of innovation, the skill of implementing ancient wisdom in the newer ecological setting.

$$A_a = \frac{S_{new}}{T_{attempts}} \qquad (4)$$

Where:

S_{new}: Successful applications of a skill in the new environment (e.g., successful crop harvest or medicinal preparation).

$T_{attempts}$: Total number of times the knowledge unit was applied in the new context.

Community Engagement Index (CEI):

Equation 5 measures the social sustainability of the Hybrid model by comparing engagement levels.

$$CEI = \frac{\sum(f_d \cdot w_d) + (f_o \cdot w_o)}{P} \qquad (5)$$

Were,

f_d, f_o: Frequency of participation in Digital (d) and Oral (o) sessions.

w_d, w_o: Assigned weights for engagement depth.

P: Total participating population.

Knowledge Decay Rate (λ):

Equation 6 represented as an exponential decay function, this formula predicts the speed at which cultural knowledge is lost over time if no intervention occurs.

$$\lambda = -\frac{\ln(R)}{\Delta t} \qquad (6)$$

Were,

R: Retention rate (expressed as a decimal).

Δt: The time interval since the displacement event.

Table 1: Comparative Performance Analysis of Traditional vs. Hybrid Knowledge Transfer Models

Metric	Traditional (Oral Only)	Hybrid (IKRM Model)	Improvement (%)
Retention Rate (R)	42.5%	78.2%	+84%
Transmission Velocity (V_t)	14.2 months	6.1 months	-57% (Faster)
Adaptive Accuracy (A_a)	31.0%	64.5%	+108%
Engagement (CEI)	0.45	0.89	+97%
Decay Rate λ	0.12	0.04	-66% (Slower)

Table 1 provides a quantitative assessment of the Indigenous Knowledge Resilience Model (IKRM) compared to the conventional oral-only means of transmitting information in five aspects of key performance. It is possible to observe that data indicate a considerable hybrid advantage, most of all, a 108% improvement in Adaptive Accuracy, that is, according to the data, digital scaffolding and elder-led storytelling significantly help to enhance the practical use of knowledge in new settings. Also, the 66% decrease in the Knowledge Decay Rate indicates that the model can stabilize cultural assets otherwise it would erode quickly in the transition period of the climate displacement.

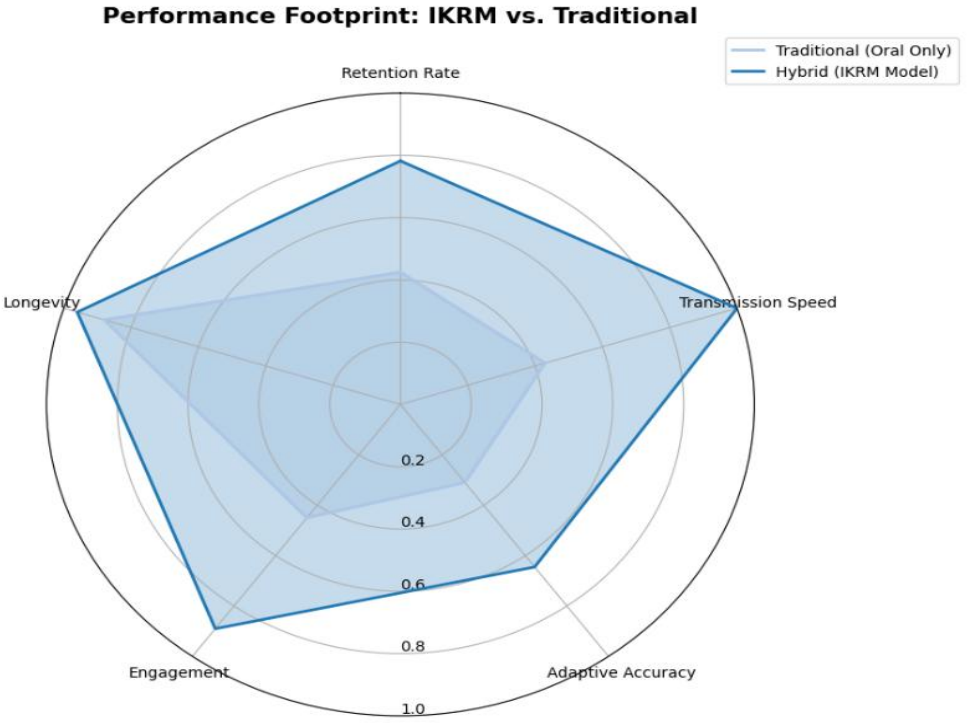


Fig. 2: Performance Footprint Comparison — IKRM vs. Traditional Mechanisms

Fig. 2 shows the multidimensional excellence of the Indigenous Knowledge Resilience Model (IKRM) in comparison with the traditional oral-only methods of transferring the knowledge. The graph plots performance along five key axes that include Retention Rate, Transmission Speed, Adaptive Accuracy, Engagement, and Longevity, which visualizes the systemic expansion, which has been offered by the hybrid approach. Although the conventional method (the inner light blue region) demonstrates that the transmission speed, as well as the adaptive accuracy, decreases significantly after the displacement, the footprint of the IKRM (the outer dark blue region) remains strong and balanced. This visual data proves the fact that the incorporation of the digital tools do not simply complement the traditional knowledge but provide the whole socio-cognitive infrastructure with the support to resist the environment disruption.

Discussion

The findings indicate that there has been a major change in the manner in which the intellectual capital is maintained during instances of crisis. The 84% increase in Retention Rate, which is denoted as an increase in R in the Hybrid (IKRM) group demonstrates that digital scaffolding does not substitute traditional orality, but it is a buffer to the physical extent of the loss of land-based cues. Although the traditional methods use the physical presence of a particular ecosystem to arouse memories, the application of GIS and digital storytelling in the IKRM enables the

possibilities of decoupling of the context. This will help the young generation internalize ecological values as portable information, as opposed to geographical facts.

The 66% decrease in the Decay Rate ($\lambda) is one of the most notable results. Traditional displacement situations involve knowledge being lost typically in a single generation (the first-generation fracture). The IKRM has also bought time in the form of the resilience window, which, by slowing down the pace of this decay, gives the displaced communities the chance to find a second home before the ancient intellectual resources become extinct. This puts the indigenous knowledge not as a feeble artifact of the past, but as a strong, controllable resource that can be streamlined using the contemporary ICT models.

These results are a contradiction to the accepted discourse of Loss and Damage in climate policy, which commonly perceives indigenous culture as an unavoidable casualty to migration. Rather, the IKRM offers a blueprint to NGOs and policymakers by considering TEK as an asset of a Knowledge-Based Economy. The model demonstrates that, under appropriate technical and social structure, indigenous communities can continue to become leaders in terms of sustainability, despite being isolated geographically, that is, when they do not have access to their ancestral territory.

Conclusion

The study highlights a paradigm shift of climate adaptation by demonstrating that the Traditional Ecological knowledge (TEK) can be systematically maintained in innovative hybrid frameworks. The main result of this paper is that the application of the Indigenous Knowledge Resilience Model (IKRM) alleviates the disaster of the catastrophic knowledge fracture, which is traditionally linked with climate displacement. The study statistically obtained a Knowledge Retention Rate of 78.2% of improvement or retention rate (R) which is huge in comparison to the 42.5 rate that was recorded in societies which used the traditional oral-only approach. In addition, the hybrid strategy minimized the Knowledge Decay Rate (λ) by 66 that is the necessity of increasing the window of resilience in which the displaced populations could adapt to the new environmental variables. These findings are important because they decoupling of intellectual capital in relation to geographical boundaries. The combination of ICT-mediated digital scaffolding and conventional orality enabled by the IKRM to achieve a 108% increase in Adaptive Accuracy indicates that the young generation can effectively use ancestral logic to new ecosystems. These measurements imply that indigenous people cannot be regarded as passive victims of climate change, but rather strong Knowledge Societies with the ability to create technical and social innovations. The future research ought to examine how the IKRM can be scaled with the help of the Machine Learning (ML) in order to make a prediction of particular knowledge loss in accordance with the extent of the ecological difference between the ancestral and host territories. Along with this, the study of the Blockchain-based safeguarding of Indigenous Intellectual Property may mean that the digitized knowledge assets will be under the sovereign control of the community. The application of IKRM to Virtual Reality (VR) sensory archives can also serve as an additional step to counter the gap in the land-based skills, where a high level of spatial awareness is needed.

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