

Review Article

The Silent Extinction: Language Diversity as a Cognitive and Ecological Resource

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Abstract

Of the approximately 7,168 languages currently spoken worldwide, nearly half are projected to disappear before the end of the twenty-first century. Language loss is commonly regarded as a cultural and communicative issue; however, it may also diminish unique cognitive strategies, ecological knowledge systems, and philosophical perspectives embedded within living speech communities. This study employs a narrative-integrative literature review synthesizing evidence from approximately 78 scholarly sources across cognitive neuroscience, ethnobiology, anthropology, computational linguistics, philosophy of language, and artificial intelligence. The review proposes two theoretical frameworks: Neurolinguistic Ecosystem Theory (NET), which conceptualizes the world's languages as interconnected nodes within a distributed cognitive ecosystem, and the Linguistic Triage Protocol (LTP), a multidimensional framework for prioritizing language-conservation efforts beyond speaker population alone. Rather than claiming established causal relationships, NET is presented as a testable conceptual framework that generates hypotheses regarding the broader cognitive implications of language loss. The review further explores the relationship between linguistic diversity and artificial intelligence, arguing that greater representation of minority languages may contribute not only to cultural preservation but also to the development of more inclusive and linguistically robust AI systems. The paper concludes by outlining implications for language policy, community-led revitalization initiatives, and future empirical research aimed at evaluating the proposed theoretical frameworks.

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1. Introduction

Languages are more than systems of communication; they embody distinctive ways of interpreting, organizing, and transmitting knowledge across generations. Each language preserves historical memory, cultural identity, ecological knowledge, and cognitive patterns that have evolved within particular social and environmental contexts. Consequently, the disappearance of a language represents not only the loss of words and grammatical structures but also the potential erosion of unique knowledge systems that may be difficult to reconstruct once intergenerational transmission has ceased.

In 1992, Michael Krauss warned that up to 90% of the world's languages could disappear before the end of the twenty-first century (Krauss, 1992). More recent assessments indicate that between 3,400 and 3,900 languages are currently endangered, with approximately 1,500 spoken by fewer than 1,000 people (UNESCO, 2023; Ethnologue, 2024). At the current rate, humanity loses roughly one language every three to four weeks. These figures demonstrate that language endangerment is not an isolated phenomenon but a global challenge with implications extending beyond the communities directly affected.

The geographical distribution of linguistic diversity further highlights its significance. More than 70% of the world's languages are concentrated in regions such as Papua New Guinea, the Amazon Basin, and Sub-Saharan Africa, areas that also contain exceptionally high levels of biological diversity. This overlap has been widely interpreted as evidence of the long-term co-evolution of languages, cultures, and ecosystems, suggesting that linguistic diversity and biodiversity are closely interconnected rather than independent phenomena (Maffi, 2005).

Language loss is rarely an abrupt event. Instead, it typically begins with declining intergenerational transmission, followed by increased reliance on dominant languages for education, employment, and social mobility. Over time, specialized vocabulary, oral traditions, grammatical complexity, and cultural practices gradually disappear before the language itself ultimately falls silent (Fishman, 1991; Mufwene, 2008). Consequently, language extinction should be understood as a gradual process of knowledge erosion rather than simply the disappearance of a communication system.

Existing approaches to language preservation have generally been organized around three complementary paradigms. The heritage rights perspective emphasizes the right of communities to maintain and transmit their linguistic identity, as reflected in international instruments such as the United Nations Declaration on the Rights of Indigenous Peoples. The documentation paradigm focuses on recording endangered languages through dictionaries, grammars, archives, and digital repositories before

fluent speakers disappear, exemplified by the Endangered Languages Documentation Programme (ELDP), which funds community-based documentation projects worldwide. The diversity paradigm views linguistic variation as a valuable component of global cultural heritage, supporting initiatives such as UNESCO's International Decade of Indigenous Languages (2022–2032). While each of these approaches has made substantial contributions, they primarily emphasize cultural preservation and documentation rather than the broader cognitive, ecological, and technological implications of language loss.

This review proposes an additional perspective by examining language diversity through the lens of cognitive ecology. Rather than viewing languages solely as cultural artifacts, the paper considers them as repositories of knowledge and as potential contributors to diverse cognitive strategies that may enrich scientific understanding, environmental stewardship, and emerging technologies such as artificial intelligence. Importantly, this perspective does not claim that current evidence conclusively demonstrates irreversible losses in humanity's overall cognitive capacity. Instead, it argues that existing interdisciplinary research provides sufficient grounds to develop a theoretical framework capable of generating empirically testable hypotheses regarding the wider consequences of language extinction.

Accordingly, this review synthesizes evidence from cognitive neuroscience, anthropology, ethnobiology, philosophy of language, computational linguistics, and artificial intelligence to develop two conceptual contributions: Neurolinguistic Ecosystem Theory (NET) and the Linguistic Triage Protocol (LTP). Together, these frameworks aim to provide a multidisciplinary foundation for future empirical investigation and to support more comprehensive approaches to language conservation, policy development, and technological innovation.

1.1 Research Questions and Objectives

This review is guided by the following research questions:

1. How does the existing interdisciplinary literature explain the relationship between language diversity, cognition, ecological knowledge, and technological development?
2. To what extent can current evidence support the development of a theoretical framework for understanding the broader implications of language extinction beyond cultural loss?
3. How might language-conservation efforts be prioritized using a multidimensional framework that incorporates cognitive, ecological, and practical considerations in addition to speaker population?

To address these questions, the review pursued four objectives: to synthesize contemporary evidence from cognitive neuroscience, ethnobiology, sociolinguistics, philosophy of language, and artificial intelligence concerning the consequences of language endangerment; to propose Neurolinguistic Ecosystem Theory (NET) as a

conceptual framework that integrates existing interdisciplinary evidence and generates empirically testable hypotheses regarding the broader significance of linguistic diversity; to develop the Linguistic Triage Protocol (LTP) as a multidimensional decision-support framework for prioritizing language-conservation initiatives under conditions of limited institutional resources; and to identify future research directions for empirically evaluating the theoretical propositions advanced in this review.

1.2 Significance of the Study

Research on endangered languages has traditionally developed within separate academic disciplines. Linguists have primarily focused on documenting grammatical systems and language vitality; anthropologists have examined cultural transmission; ethnobiologists have explored traditional ecological knowledge; neuroscientists have investigated bilingual cognition; while computer scientists have increasingly examined linguistic diversity in artificial intelligence. Although each discipline has produced valuable insights, relatively few studies have integrated these perspectives into a unified conceptual framework.

This review contributes to the literature by bringing these diverse strands of scholarship into dialogue. Rather than introducing new empirical evidence, it offers an interdisciplinary synthesis that connects findings from multiple research traditions to explore language diversity from cognitive, ecological, technological, and policy perspectives.

1.3 Three Principal Contributions

First, the study introduces Neurolinguistic Ecosystem Theory (NET) as a conceptual model that views the world's languages as components of a broader cognitive ecosystem. Importantly, NET is presented as a theoretical framework intended to stimulate empirical investigation rather than as a verified explanation of cognitive processes.

Second, the paper develops the Linguistic Triage Protocol (LTP), a multidimensional framework that expands traditional language-preservation priorities beyond speaker numbers by incorporating cognitive distinctiveness, ecological knowledge, revitalization feasibility, and network connectivity. The protocol is intended as a preliminary decision-support model that can be refined and validated through future empirical research and stakeholder consultation.

Third, the review highlights the emerging relationship between language diversity and artificial intelligence. Contemporary AI systems are trained predominantly on a relatively small number of globally dominant languages, creating both technological limitations and ethical concerns. The paper argues that greater linguistic diversity within AI training resources may contribute to more inclusive technologies while simultaneously encouraging digital language documentation and community-led revitalization initiatives.

By integrating these perspectives, the review aims to broaden discussions of language conservation beyond cultural preservation alone and encourage future collaboration among linguists, cognitive scientists, policymakers, indigenous communities, and AI researchers. Ultimately, the study positions language diversity as a multidisciplinary issue with implications for knowledge preservation, sustainable development, technological innovation, and future scientific inquiry.

1.4 Language and Cognition

The relationship between language and cognition has long been one of the most debated questions in linguistics, psychology, and cognitive science. Early interpretations of the Sapir–Whorf hypothesis often suggested that language determines thought, a position that attracted substantial criticism for its deterministic implications (Pinker, 1994). Contemporary research, however, generally supports a more moderate perspective: language does not determine what individuals are capable of thinking, but linguistic structures can influence habitual patterns of attention, perception, memory, categorization, and reasoning (Boroditsky, 2001; Levinson, 2003; Regier & Kay, 2009; Winawer et al., 2007).

One of the most frequently cited examples is the Kuuk Thaayorre community of northern Australia. Unlike English, which primarily relies on egocentric spatial terms such as left and right, Kuuk Thaayorre employs absolute cardinal directions (north, south, east, and west) in everyday communication. Experimental studies have shown that native speakers consistently maintain accurate cardinal orientation, even in unfamiliar environments, suggesting that habitual linguistic practices may reinforce particular spatial reasoning strategies (Boroditsky & Gaby, 2010). Importantly, these findings demonstrate an association between language use and cognitive performance rather than establishing that such abilities are exclusive to a single language or impossible to acquire through alternative learning experiences.

Similar observations have been reported in studies of colour perception. Russian distinguishes between *goluboy* (light blue) and *siniy* (dark blue) as separate lexical categories, whereas English treats both as variations of the broader category “blue.” Experimental evidence indicates that native Russian speakers differentiate these colours more rapidly than English speakers during certain perceptual tasks (Thierry et al., 2009; Winawer et al., 2007). These findings suggest that lexical distinctions can influence perceptual processing, although they should not be interpreted as evidence that speakers of other languages are incapable of making similar distinctions.

Research on bilingualism further illustrates the relationship between language experience and cognition. Lifelong bilingualism has been associated with advantages in executive control, attentional flexibility, and delayed clinical manifestations of dementia in some populations (Bialystok, Craik, & Freedman, 2007; Bialystok, 2017). Neuroimaging studies have likewise shown that different linguistic systems may engage partially distinct neural networks depending on their phonological, tonal, or grammatical characteristics (Gandour et al., 2007). Collectively, these studies indicate

that linguistic experience interacts with cognitive processes throughout the lifespan. However, they do not demonstrate that the disappearance of a language necessarily results in an irreversible reduction in humanity's overall cognitive capacity.

Instead, the literature reviewed here supports a more cautious interpretation. Languages may preserve distinctive cognitive practices, conceptual distinctions, and culturally embedded knowledge that have developed through long-term interaction between communities and their environments. When a language ceases to be transmitted across generations, opportunities to investigate, refine, and further develop these knowledge systems may also diminish. The extent to which such losses affect broader human cognition remains an open empirical question.

This distinction is fundamental to the theoretical framework proposed in this review. Neurolinguistic Ecosystem Theory (NET) does not claim that current evidence has established irreversible, species-wide cognitive decline resulting from language extinction. Rather, it synthesizes existing interdisciplinary findings to propose a conceptual model that can generate empirically testable hypotheses concerning how language diversity may contribute to cognitive resilience, knowledge preservation, and adaptive problem-solving. Consequently, NET should be understood as a theoretical framework informed by existing evidence rather than as a conclusion already demonstrated by that evidence.

1.5 Language as Ecological Archive

A growing body of interdisciplinary research has identified a close geographical relationship between regions of high linguistic diversity and areas of exceptional biological diversity. Maffi (2005) demonstrated that many of the world's biodiversity hotspots coincide with regions containing the greatest concentration of indigenous and minority languages. Rather than representing a coincidental pattern, this overlap reflects long-term interactions among human communities, their languages, and the ecosystems in which they have evolved. Consequently, many endangered languages function as repositories of ecological knowledge accumulated over centuries of environmental observation and adaptation.

Traditional ecological knowledge encompasses detailed understandings of local biodiversity, seasonal cycles, medicinal plants, wildlife behaviour, agricultural practices, and environmental change. In many indigenous communities, such knowledge is transmitted primarily through language, oral traditions, storytelling, ceremonial practices, and everyday communication rather than through written scientific records. As a result, language serves not merely as a medium of communication but also as an essential vehicle for preserving and transmitting ecological knowledge across generations.

The practical value of this knowledge has been widely documented. Approximately one-quarter of modern pharmaceutical compounds have been derived from or inspired by plant species whose medicinal properties were first identified through indigenous knowledge systems (Farnsworth et al., 1985; Newman & Cragg,

2020). While scientific validation is required before such knowledge can be incorporated into biomedical practice, these examples demonstrate that indigenous languages frequently encode observations with considerable scientific and practical relevance.

The Matsés people of the western Amazon provide an illustrative example. Their language contains highly specific terminology describing plants, animals, habitats, and ecological relationships that reflects generations of environmental expertise. Ethnobiologists have used indigenous classifications to guide biodiversity research and species identification. Importantly, the scientific value lies not simply in individual words but in the broader ecological knowledge system that those linguistic categories help organize and transmit.

Similarly, the Yupik languages of Alaska and Siberia distinguish numerous forms of sea ice based on texture, stability, movement, and seasonal conditions. These distinctions support safe navigation, hunting, and environmental decision-making in Arctic environments. As climate change accelerates environmental transformation, such locally developed knowledge may become increasingly valuable for understanding ecological change and informing adaptation strategies (Huntington, 2000).

Nevertheless, it is important to distinguish between the loss of linguistic transmission and the complete disappearance of ecological knowledge. Some knowledge may survive through documentation, translation, community memory, or incorporation into scientific research. However, documentation cannot fully replicate the dynamic processes through which living speech communities continuously refine, update, and transmit knowledge in response to changing environmental conditions. Consequently, language preservation contributes not only to safeguarding historical records but also to sustaining living knowledge systems capable of ongoing adaptation. These observations provide an important conceptual foundation for the present review. They do not establish that every endangered language contains entirely unique ecological knowledge, nor do they demonstrate that all such knowledge becomes permanently irrecoverable after language loss. Instead, they indicate that language diversity substantially increases the range of ecological perspectives available to humanity and that continued language transmission enhances opportunities for maintaining, expanding, and applying these knowledge systems. This interpretation aligns with the broader theoretical orientation of Neurolinguistic Ecosystem Theory, which proposes that linguistic diversity may strengthen humanity's collective adaptive capacity while acknowledging that this proposition remains open to future empirical investigation.

1.6 Neuroscience of Bilingualism and Language Diversity

The relationship between language experience and brain function has received increasing attention in cognitive neuroscience over the past three decades. Rather than viewing language solely as a communication system, contemporary research suggests

that lifelong engagement with one or more languages influences neural organization, executive functioning, and cognitive flexibility. Although the magnitude and consistency of these effects remain subjects of ongoing debate, the literature indicates that linguistic experience contributes meaningfully to cognitive development across the lifespan.

One influential line of research concerns bilingualism and cognitive reserve. Bialystok, Craik, and Freedman (2007) reported that lifelong bilingual individuals demonstrated a delayed clinical onset of dementia symptoms compared with monolingual speakers. Subsequent investigations have suggested that managing multiple linguistic systems may strengthen executive control processes involved in attention, inhibition, and task switching (Bialystok, 2017), although the precise mechanism remains debated (Bialystok & Craik, 2022). However, recent meta-analyses have produced mixed findings, indicating that the relationship is complex and influenced by factors including education, socioeconomic background, immigration history, and patterns of language use. Consequently, bilingualism should be understood as one potential contributor to cognitive resilience rather than a universally protective factor.

Neuroimaging research further demonstrates that languages with different phonological, grammatical, and prosodic characteristics recruit partially distinct neural networks. For example, speakers of tonal languages such as Mandarin and Yoruba exhibit greater activation in right-hemisphere auditory regions during tonal processing than speakers of many non-tonal languages (Gandour et al., 2007). Similarly, languages characterized by rich morphological systems engage neural pathways associated with grammatical processing differently from languages with comparatively simpler morphological structures. These findings suggest that human brains adapt to the structural demands of the languages they acquire and use throughout life.

Importantly, these studies should not be interpreted as evidence that particular cognitive abilities belong exclusively to specific languages or that comparable skills cannot be acquired through other learning experiences. Instead, they demonstrate that diverse linguistic environments provide multiple pathways through which cognition develops and adapts. The existing evidence therefore supports the view that language diversity contributes to variation in cognitive experience without establishing irreversible cognitive loss following language extinction.

Within the context of this review, these findings provide a theoretical foundation for considering language diversity as a source of cognitive variation. Neurolinguistic Ecosystem Theory builds upon this literature by proposing that humanity benefits from maintaining a broad range of linguistic systems because they preserve multiple ways of organizing, expressing, and transmitting knowledge. This proposition remains theoretical and requires empirical investigation across diverse linguistic communities before broader conclusions regarding system-level cognitive effects can be drawn.

1.7 Untranslatability and Philosophical Diversity

Language not only facilitates communication but also provides conceptual frameworks through which individuals interpret experience, relationships, and the surrounding world. While many ideas can be translated across languages, some concepts remain only partially transferable because they are deeply embedded within particular cultural, historical, and linguistic contexts. Rather than demonstrating that speakers of different languages inhabit entirely different realities, these examples illustrate how languages may emphasize distinct aspects of human experience and provide alternative conceptual resources for understanding them.

The Japanese concept of *amae*, described by Doi (1973), refers to a form of affectionate dependence and trust within close interpersonal relationships for which no precise single-word equivalent exists in English. Likewise, speakers of Aymara often conceptualize time using spatial metaphors in which the past is positioned in front of the speaker because it is known and visible, whereas the future lies behind because it remains unseen. Such linguistic patterns demonstrate that languages may organize abstract concepts in different, yet internally coherent, ways.

These examples should not be interpreted as evidence that such ideas are inaccessible to speakers of other languages. Through explanation, translation, and cultural learning, individuals can understand concepts originating from different linguistic traditions. Nevertheless, translation frequently requires extended descriptions rather than direct lexical equivalents, indicating that languages package knowledge and experience in distinct ways.

Philosophers of language have long argued that linguistic categories influence how experience is articulated and shared. Wittgenstein's (1921) proposition that "the limits of my language mean the limits of my world" is widely understood today not as a claim that language determines reality, but as an observation that language shapes the conceptual tools available for describing and communicating experience. Contemporary cognitive linguistics similarly suggests that linguistic structures influence habitual conceptualization without imposing absolute constraints on thought.

From the perspective of language preservation, these observations carry important implications. When an endangered language disappears, humanity may lose a distinctive system for organizing ecological knowledge, cultural values, historical memory, and social experience. Although many concepts can be documented or translated, documentation rarely captures the full richness of a living linguistic tradition, including its evolving metaphors, pragmatic conventions, oral narratives, and cultural practices. Consequently, preserving linguistic diversity supports the continued existence of multiple conceptual traditions through which communities interpret and respond to the world.

These observations provide further conceptual support for Neurolinguistic Ecosystem Theory. Rather than claiming that every language contains entirely unique or irreplaceable philosophical insights, NET proposes that maintaining a diversity of

linguistic systems increases the range of conceptual perspectives available for future cultural, scientific, and intellectual development. This proposition remains theoretical and invites further empirical investigation across linguistics, cognitive science, philosophy, and anthropology.

1.8 Language Diversity and Artificial Intelligence

The rapid development of artificial intelligence (AI), particularly large language models (LLMs), has introduced new opportunities and challenges for linguistic diversity. Contemporary AI systems are trained on massive digital corpora; however, these datasets are overwhelmingly dominated by a relatively small number of globally influential languages, including English, Mandarin Chinese, Spanish, French, and German (Bender et al., 2021; Joshi et al., 2020). As a result, thousands of indigenous and minority languages remain significantly underrepresented or entirely absent from modern AI technologies.

This imbalance has important technological, social, and ethical implications. AI-powered applications including machine translation, educational platforms, virtual assistants, speech recognition systems, and digital healthcare tools generally perform best in languages with abundant digital resources. Communities speaking endangered languages therefore face an increasing digital divide, where access to emerging technologies is limited not by technological capability alone but by linguistic exclusion.

Beyond issues of equity, linguistic underrepresentation may also constrain the development of AI itself. Languages differ in grammatical structure, evidential systems, spatial reasoning, morphological complexity, and semantic organization. Incorporating greater linguistic diversity into AI training datasets may expose computational models to a wider range of linguistic patterns and knowledge structures, potentially improving multilingual reasoning, contextual understanding, and cross-cultural communication. Although this proposition requires empirical validation, it highlights an important research direction linking language preservation with AI innovation.

Importantly, artificial intelligence should not be viewed solely as a force that amplifies linguistic inequality. Emerging community-driven and open-source AI initiatives demonstrate that digital technologies can also become valuable tools for language revitalization. Automatic speech recognition systems can assist communities in documenting endangered languages through audio transcription. Machine translation technologies, increasingly effective for low-resource language pairs (Haddow et al., 2022; Ranathunga et al., 2023), can facilitate bilingual educational materials and digital communication. Optical character recognition and natural language processing tools can support the preservation of historical manuscripts, oral histories, and community archives. Similarly, AI-assisted dictionary development and interactive language-learning applications provide new opportunities for younger generations to engage with ancestral languages in accessible digital environments.

The success of these technologies, however, depends upon meaningful collaboration with the communities whose languages are being documented. Indigenous communities should retain authority over how their linguistic resources are collected, stored, shared, and used. Ethical principles such as informed consent, cultural sensitivity, data sovereignty, and equitable benefit-sharing should guide all AI-based language documentation initiatives (Perera et al., 2025). Digital preservation should complement not replace community-led language transmission and cultural revitalization.

These developments also strengthen the practical relevance of the Linguistic Triage Protocol (LTP). Languages identified as possessing high ecological, cognitive, or cultural significance through the LTP could be prioritized for digital documentation, corpus development, speech recording, and AI-supported revitalization projects. Such prioritization would enable governments, researchers, technology developers, and indigenous communities to allocate limited resources more strategically while respecting local priorities and cultural values.

Rather than positioning artificial intelligence solely as a contributor to language endangerment, this review argues that responsibly designed AI can become an important partner in language preservation. Future collaborations among linguists, computer scientists, policymakers, and indigenous communities may enable technological innovation to support not replace the continued transmission of the world's linguistic diversity.

1.9 Political Economy of Language Shift

Language extinction is seldom the result of natural linguistic evolution alone. Rather, it is frequently shaped by political, economic, educational, and historical forces that influence the language choices available to individuals and communities. Decisions to adopt a dominant language are often responses to structural inequalities rather than voluntary abandonment of ancestral languages.

Gal's (1979) classic study of bilingual communities in Oberwart, Austria, demonstrated how changing economic opportunities encouraged younger generations to shift from Hungarian to German because proficiency in the dominant language offered greater access to education, employment, and social mobility. Similar patterns have since been documented across numerous multilingual societies, where globalization, urbanization, migration, and state language policies accelerate language shift. These findings suggest that language endangerment should be understood as a consequence of broader socioeconomic processes rather than solely as a linguistic phenomenon.

Historical evidence further indicates that many endangered languages have experienced periods of marginalization through colonial policies, forced assimilation, restrictions on indigenous education, and the suppression of minority-language use in public institutions. Although language policies have become more inclusive in many

countries, the long-term effects of these historical processes continue to influence language vitality today.

At the same time, international experience demonstrates that language decline is not necessarily irreversible. The revitalization of Welsh illustrates how sustained government investment, bilingual education, media broadcasting, and institutional support can increase language use across successive generations. Similarly, New Zealand's Kōhanga Reo (language nest) movement has contributed significantly to the revitalization of the Māori language by placing community-led early childhood education at the center of language transmission. These examples show that well-designed public policies, combined with strong community participation, can reverse patterns of language decline under favourable conditions.

International organizations have likewise recognized the importance of linguistic diversity. The United Nations Declaration on the Rights of Indigenous Peoples (2007) affirms the rights of indigenous peoples to maintain, revitalize, and transmit their languages to future generations. UNESCO's Convention for the Safeguarding of the Intangible Cultural Heritage (2003) and the International Decade of Indigenous Languages (2022–2032) have further strengthened global awareness of language preservation. Nevertheless, many of these initiatives rely primarily on voluntary implementation and therefore vary considerably in their practical effectiveness across different national contexts.

These policy developments highlight an important gap between recognition and implementation. While international agreements establish valuable principles, governments and funding agencies often lack systematic tools for determining which endangered languages require the most urgent intervention when resources are limited. Decisions frequently depend on political priorities, available funding, or speaker population alone, despite the fact that languages may differ substantially in ecological knowledge, cultural significance, and revitalization potential.

It is within this context that the present review introduces the Linguistic Triage Protocol (LTP). Rather than replacing existing language rights frameworks, the LTP is intended to complement them by providing a transparent, multidimensional approach to prioritizing language-conservation efforts. By incorporating factors such as cognitive distinctiveness, ecological knowledge, community readiness, and network connectivity alongside language vitality, the protocol seeks to support more informed and equitable decision-making. The practical application of this framework is developed in the following section.

2. Theoretical Framework

2.1 Neurolinguistic Ecosystem Theory (NET)

The interdisciplinary evidence reviewed in the preceding sections suggests that language diversity is associated with variation in cognitive processes, ecological

knowledge, cultural memory, and knowledge transmission. While no single body of evidence demonstrates that language extinction directly reduces humanity's overall cognitive capacity, the collective literature provides a basis for developing a conceptual framework capable of generating empirically testable hypotheses concerning the broader consequences of language loss.

Accordingly, this review proposes Neurolinguistic Ecosystem Theory (NET) as an integrative conceptual framework. NET is not presented as an empirically verified theory but as a synthesis of findings from linguistics, cognitive neuroscience, anthropology, ethnobiology, philosophy of language, and artificial intelligence. Its purpose is to organize existing knowledge within a unified explanatory model and to identify directions for future empirical research.

NET draws upon the ecological concept of interconnected systems. Within this perspective, individual languages may be understood as distinct yet interconnected repositories of knowledge that collectively contribute to humanity's intellectual diversity. The ecological analogy is intended as a heuristic device rather than a literal biological comparison. Just as biological ecosystems often benefit from species diversity, linguistic diversity may contribute to the resilience, adaptability, and richness of human knowledge systems. Whether this relationship can be demonstrated empirically remains an open question requiring systematic investigation.

The framework is organized around four theoretical propositions.

Proposition 1: Languages function as knowledge ecosystems.

Each language preserves culturally accumulated knowledge, conceptual distinctions, ecological understanding, historical memory, and communicative practices that develop through long-term interaction between communities and their environments. These knowledge systems are dynamic rather than static, evolving continuously as communities respond to social and environmental change.

Proposition 2: Linguistic diversity expands humanity's collective knowledge resources.

Different linguistic traditions organize experience in distinct ways. Maintaining a diversity of languages therefore preserves multiple approaches to describing ecological systems, expressing social relationships, categorizing experience, and communicating specialized knowledge. This proposition does not imply that such knowledge is exclusive to a single language or cannot be translated, but rather that living linguistic communities provide unique contexts in which knowledge continues to develop and adapt.

Proposition 3: Language loss may reduce opportunities for future knowledge development.

When intergenerational language transmission ceases, opportunities for maintaining, expanding, and refining knowledge embedded within that linguistic tradition may also decline. Documentation can preserve valuable records, yet archived materials cannot fully replicate the adaptive processes through which living

communities generate new knowledge. The magnitude of this effect remains an empirical question that warrants further investigation.

Proposition 4: Language diversity represents a potential resource for future scientific, cultural, and technological innovation.

Maintaining linguistic diversity may increase opportunities for interdisciplinary discovery by preserving alternative conceptual systems, ecological expertise, and culturally developed problem-solving strategies. This proposition is particularly relevant for emerging fields such as artificial intelligence, multilingual education, environmental sustainability, and cross-cultural communication, where diverse linguistic resources may contribute to innovation.

2.1.1 Testable Research Hypotheses

Unlike traditional theoretical models that remain purely descriptive, NET is intended to generate hypotheses that can be examined empirically. For example, future studies may investigate whether:

- communities maintaining higher levels of linguistic diversity demonstrate greater resilience in preserving ecological knowledge;
- exposure to structurally diverse languages enhances specific aspects of cognitive flexibility or problem-solving;
- AI systems trained on more linguistically diverse datasets demonstrate measurable improvements in multilingual reasoning or cultural representation;
- language revitalization initiatives contribute to the preservation of ecological knowledge and community resilience over time.

These hypotheses are illustrative rather than exhaustive and provide a research agenda for evaluating the explanatory value of NET.

2.1.2 Strengths and Limitations of NET

The principal strength of NET lies in its interdisciplinary integration. Rather than introducing isolated arguments from linguistics, neuroscience, anthropology, or artificial intelligence, it brings these perspectives together within a single conceptual framework.

Its principal limitation is equally important. NET has not yet been subjected to direct empirical validation. Consequently, its propositions should be interpreted as theoretically informed hypotheses rather than established scientific conclusions. Future quantitative, qualitative, and longitudinal studies will be necessary to determine the extent to which the proposed relationships can be supported across diverse linguistic and cultural contexts.

Accordingly, NET should be viewed as a foundation for future interdisciplinary inquiry rather than as a definitive explanation of the consequences of language extinction.

2.2 The Linguistic Triage Protocol (LTP)

While international organizations increasingly recognize the importance of preserving endangered languages, decision-makers frequently face a practical challenge: available financial, technical, and human resources are insufficient to support every endangered language simultaneously. Consequently, language-planning agencies require transparent and evidence-informed approaches for determining conservation priorities without relying exclusively on speaker population.

To address this challenge, this review proposes the Linguistic Triage Protocol (LTP) as a multidimensional decision-support framework. The protocol is designed to complement not replace existing language-rights policies by providing a systematic method for assessing multiple dimensions of language significance. Importantly, the LTP is presented as a preliminary conceptual framework that requires empirical validation before widespread implementation.

2.2.1 Assessment Dimensions

The LTP evaluates each language across five dimensions (see Table 1).

2.2.2 Scoring Rubric

To improve consistency, each assessment dimension is scored using the following scale:

Score 1 – Very Low Priority

- Extensive documentation already exists.
- Strong intergenerational transmission continues.
- Limited immediate conservation risk.

Score 2 – Low Priority

- Minor decline in language vitality.
- Adequate documentation available.
- Community resources remain relatively stable.

Score 3 – Moderate Priority

- Noticeable decline in speakers.
- Important cultural or ecological knowledge identified.
- Revitalization initiatives beginning but requiring additional support.

Score 4 – High Priority

- Severe language endangerment.

- Significant ecological or cognitive value documented.
- Immediate intervention likely to improve revitalization outcomes.

Score 5 – Critical Priority

- Extremely small speaker population.
- Intergenerational transmission has nearly ceased.
- Exceptional ecological, cultural, or linguistic significance.
- Immediate documentation and community-led revitalization strongly recommended.

2.2.3 Proposed Implementation Workflow

The LTP is intended to guide decision-making through a structured sequence of activities.

Step 1: Identify endangered language communities through national language surveys.

Step 2: Collect linguistic, ecological, educational, and demographic evidence in collaboration with community representatives.

Step 3: Independently score each assessment dimension using multidisciplinary evaluation teams.

Step 4: Review scores jointly with community members to ensure cultural appropriateness and transparency.

Step 5: Prioritize conservation strategies according to overall assessment results while respecting community preferences.

Step 6: Monitor implementation outcomes and periodically reassess languages as conditions change.

2.2.4 Continuous Quality Improvement (CQI)

Because language vitality changes over time, LTP should operate within a Continuous Quality Improvement (CQI) cycle.

Assessment → Planning → Community Consultation → Implementation → Monitoring → Reassessment

This cyclical approach enables conservation priorities to evolve in response to demographic change, educational progress, technological developments, and community needs rather than remaining fixed after a single evaluation.

2.2.5 Practical Applications

The protocol may assist:

- governments developing national language policies;
- UNESCO and international funding agencies allocating conservation resources;

- researchers identifying priorities for documentation;
- universities establishing revitalization partnerships;
- technology organizations developing AI-supported language preservation tools;
- indigenous communities advocating for evidence-based conservation support.

2.2.6 Limitations

Several limitations should be acknowledged. First, the weighting assigned to each assessment dimension remains conceptual and requires empirical validation through multidisciplinary research and community consultation. One concrete mechanism for establishing these weights is the Analytic Hierarchy Process (AHP), in which community representatives, linguists, and policymakers complete structured pairwise comparisons of the five dimensions; this technique has been used to derive stakeholder-weighted priorities in culturally diverse, community-driven decision-making contexts (Corvin et al., 2021), and a similar protocol could be piloted with language communities to generate context-specific LTP weights rather than a single fixed weighting scheme.

Second, some dimensions particularly cognitive distinctiveness and ecological knowledge currently lack standardized international measurement instruments. Third, language preservation should never be determined solely by numerical scores. Ethical considerations, indigenous self-determination, cultural rights, and community priorities must remain central throughout the decision-making process. Accordingly, the LTP should be regarded as a flexible decision-support framework rather than a prescriptive ranking system. Future pilot studies across diverse linguistic communities will be essential for evaluating its reliability, validity, and practical usefulness.

3. Methodology

3.1 Research Design

This study employs a narrative-integrative literature review (Torraco, 2005; Whittemore & Knafl, 2005). This review design was selected because the research problem spans multiple disciplines including linguistics, cognitive neuroscience, anthropology, ethnobiology, artificial intelligence, philosophy of language, and language policy which cannot be comprehensively synthesized using a single disciplinary framework.

Unlike a systematic review, the objective of an integrative review is not to identify every published study on a narrowly defined question but to synthesize diverse theoretical and empirical evidence in order to develop new conceptual perspectives.

Consequently, this study should be interpreted as a theory-building and knowledge-synthesis exercise rather than a quantitative evidence review.

3.2 Literature Search Strategy

A structured literature search was conducted between January and March 2026 using the following electronic databases:

- Google Scholar
- JSTOR
- PubMed
- ERIC
- MLA International Bibliography
- Scopus (for citation verification where available)

The search combined Boolean operators with keywords related to language diversity, cognition, ecology, and artificial intelligence.

Examples of search strings included:

- "language extinction" AND cognition
- "linguistic diversity" AND biodiversity
- "endangered languages" AND ecological knowledge
- bilingualism AND neuroscience
- "language revitalization" AND policy
- "artificial intelligence" AND minority languages
- "indigenous languages" AND AI
- Sapir-Whorf AND cognition

Backward citation searching was also conducted by examining reference lists of influential publications to identify additional relevant literature.

3.3 Inclusion Criteria

Studies were included when they:

- examined language diversity, endangered languages, bilingualism, cognition, ecological knowledge, artificial intelligence, or language policy;
- were published in peer-reviewed journals, scholarly books, conference proceedings, or official reports from recognized organizations;
- contributed theoretical or empirical evidence relevant to the objectives of this review;
- were published primarily in English;
- represented influential foundational works or contemporary scholarship.

3.4 Exclusion Criteria

The following materials were excluded:

- non-scholarly websites and blogs;
- unpublished opinion pieces lacking academic review;
- duplicate publications;
- studies unrelated to language diversity or its broader cognitive, ecological, or technological implications;
- publications lacking sufficient methodological transparency.

3.5 Literature Selection Process

The initial database search identified a broad collection of publications across multiple disciplines.

Following title and abstract screening, studies that did not directly address the objectives of the review were excluded.

The remaining publications underwent full-text assessment to determine conceptual relevance, methodological quality, and contribution to the proposed theoretical framework.

Approximately 78 sources were ultimately included in the final synthesis.

Because this study follows an integrative rather than PRISMA systematic review methodology, the selection process was guided by conceptual relevance rather than exhaustive quantitative screening.

3.6 Data Synthesis

Rather than statistically combining research findings, the selected literature was analyzed thematically.

Five major thematic categories emerged:

- Language and Cognition
- Language as Ecological Archive
- Neuroscience of Bilingualism
- Language Diversity and Artificial Intelligence
- Language Policy and Revitalization

Comparisons across these themes enabled the development of two conceptual frameworks:

- Neurolinguistic Ecosystem Theory (NET)
- Linguistic Triage Protocol (LTP)

The synthesis emphasized areas of agreement, disagreement, emerging trends, and research gaps across disciplines.

3.7 Trustworthiness and Limitations

Recognizing the interpretive nature of integrative reviews, several strategies were employed to strengthen credibility.

First, literature was drawn from multiple academic disciplines to reduce disciplinary bias.

Second, preference was given to peer-reviewed publications and internationally recognized institutional reports.

Third, theoretical claims were explicitly distinguished from empirically established findings throughout the manuscript.

Finally, limitations of the available evidence were acknowledged wherever conclusions extended beyond direct empirical observation.

These procedures improve transparency while remaining consistent with accepted standards for integrative literature reviews.

3.8 Conceptual Literature Selection Flow

Database Search



Title and Abstract Screening



Eligibility Assessment



Conceptual Relevance Evaluation



Final Literature Synthesis (≈78 Sources)



Development of NET and LTP

4. Discussion and Implications

The present review synthesized evidence from linguistics, cognitive neuroscience, ethnobiology, philosophy of language, language policy, and artificial intelligence to examine the broader significance of language diversity. Rather than demonstrating that language extinction inevitably reduces humanity's overall cognitive capacity, the literature collectively indicates that languages function as repositories of cultural knowledge, ecological expertise, and conceptual diversity that may enrich scientific understanding, technological innovation, and community resilience. This distinction is important because it positions the proposed theoretical

framework within the current evidence while identifying questions that remain open for empirical investigation.

One of the principal contributions of this review is the development of Neurolinguistic Ecosystem Theory (NET). Existing research demonstrates that language influences aspects of perception, categorization, memory, and knowledge transmission. However, these findings have generally been examined within separate disciplinary traditions. NET integrates these perspectives into a single conceptual framework, proposing that linguistic diversity may represent a valuable intellectual resource whose broader implications extend beyond cultural preservation alone. Importantly, NET is intended to stimulate interdisciplinary research rather than to provide a definitive explanation of the consequences of language extinction.

A second contribution is the Linguistic Triage Protocol (LTP). Current language-conservation policies frequently prioritize languages according to speaker population or degree of endangerment. While these indicators remain essential, they may overlook languages possessing exceptional ecological knowledge, distinctive linguistic structures, or strategic importance for community resilience. The LTP therefore proposes a multidimensional approach that considers vitality, cognitive distinctiveness, ecological knowledge, revitalization feasibility, and network connectivity simultaneously. Although further validation is required, this framework offers a practical starting point for more transparent and evidence-informed conservation planning.

4.1 Policy Roadmap for LTP Implementation

To translate assessment into action, the following implementation sequence is proposed:

Stage 1: National Assessment

Government agencies and linguistic researchers identify endangered languages and collect baseline demographic, educational, and linguistic information.

Stage 2: Multidisciplinary Evaluation

Teams consisting of linguists, educators, anthropologists, environmental researchers, and community representatives apply the LTP assessment framework.

Stage 3: Community Consultation

Assessment findings are discussed with indigenous and minority-language communities to ensure that priorities reflect local needs, cultural values, and community aspirations.

Stage 4: Intervention Planning

Conservation strategies are selected according to assessment outcomes. These may include language documentation, bilingual education, teacher training, digital archiving, AI-supported language technologies, community language centres, or policy reform.

Stage 5: Monitoring and Evaluation

Progress is assessed through measurable indicators such as intergenerational transmission, educational participation, community engagement, and expansion of digital language resources.

Stage 6: Periodic Reassessment

Because language vitality changes over time, assessments should be repeated regularly to ensure that conservation priorities remain responsive to changing circumstances.

This roadmap transforms the LTP from a conceptual model into a practical decision-support framework capable of guiding long-term language planning.

4.2 Implications for Artificial Intelligence

The growing influence of artificial intelligence creates both challenges and opportunities for language preservation. AI systems currently perform best in languages supported by extensive digital resources, increasing technological inequality for many minority-language communities. At the same time, speech recognition, machine translation, digital dictionaries, corpus development, and language-learning applications demonstrate that AI can also support community-led revitalization efforts.

The integration of AI with the LTP offers a practical pathway for prioritizing digital preservation initiatives. Languages identified as possessing high ecological, cultural, or linguistic significance may be prioritized for corpus development, speech recording, digital archives, and educational technologies. Such collaborations require meaningful participation by indigenous communities to ensure that technological innovation respects cultural rights, data sovereignty, and ethical research practices.

4.3 Broader Implications

The findings of this review suggest that language diversity should be considered alongside biodiversity and cultural heritage within broader discussions of sustainable development. Although further empirical research is required to evaluate the theoretical propositions advanced in this paper, preserving linguistic diversity may contribute to maintaining multiple knowledge traditions capable of informing environmental management, scientific discovery, education, intercultural dialogue, and technological innovation. Rather than framing language preservation solely as a cultural responsibility, this review proposes that it should also be recognized as an investment in humanity's shared intellectual and ecological future.

5. Conclusion

The disappearance of the world's languages represents one of the most significant cultural transformations of the twenty-first century. While language loss has traditionally been examined through the lenses of cultural heritage and linguistic

documentation, the interdisciplinary evidence synthesized in this review suggests that its implications may extend to ecological knowledge, conceptual diversity, technological innovation, and future scientific inquiry.

This review has brought together findings from linguistics, cognitive neuroscience, anthropology, ethnobiology, philosophy of language, artificial intelligence, and language policy to develop two complementary conceptual frameworks: Neurolinguistic Ecosystem Theory (NET) and the Linguistic Triage Protocol (LTP). NET proposes that linguistic diversity may function as a valuable component of humanity's broader knowledge ecosystem and offers a set of empirically testable hypotheses for future research. LTP provides a multidimensional framework intended to support more transparent and evidence-informed language-conservation decision-making under conditions of limited resources.

Importantly, the arguments presented in this review should not be interpreted as demonstrating that language extinction inevitably produces irreversible reductions in humanity's cognitive capacity. Rather, the available evidence suggests that linguistic diversity preserves multiple knowledge traditions, conceptual perspectives, and ecological understandings that may contribute to scientific discovery, cultural resilience, and technological innovation. The extent to which these broader relationships operate remains an important question for future empirical research.

The growing influence of artificial intelligence further reinforces the importance of linguistic diversity. AI technologies have the potential either to deepen existing linguistic inequalities or to become powerful tools for language documentation, education, and revitalization. Achieving the latter outcome will require ethical collaboration among researchers, governments, technology developers, and the communities whose languages are being preserved.

Ultimately, language preservation should not be viewed solely as an effort to protect the past. It is equally an investment in the future—one that safeguards humanity's intellectual diversity, strengthens cultural resilience, supports ecological knowledge, and expands opportunities for scientific and technological innovation. By integrating evidence across disciplines, this review aims to encourage future research, informed policymaking, and community-centered action that recognizes linguistic diversity as a shared global resource worthy of sustained protection.

6. Limitations and Future Research

6.1 Limitations

This review should be interpreted in light of several limitations. First, the study adopts an integrative literature review methodology rather than a systematic review or meta-analysis. Although this approach is appropriate for theory development and interdisciplinary synthesis, it does not provide statistical estimates of effect sizes or causal relationships. Consequently, the conclusions presented here should be

understood as conceptually informed interpretations of the available literature rather than definitive empirical findings.

Second, the proposed Neurolinguistic Ecosystem Theory (NET) has not yet been subjected to direct empirical testing. The framework integrates evidence from multiple disciplines to generate theoretically grounded hypotheses regarding the broader significance of linguistic diversity. Future empirical studies will be required to evaluate the explanatory power, reliability, and generalizability of these propositions across different linguistic and cultural contexts.

Third, the Linguistic Triage Protocol (LTP) remains a preliminary conceptual decision-support framework. Although its multidimensional structure is informed by existing scholarship on language vitality, ecological knowledge, and language policy, the assessment dimensions and scoring criteria require validation through pilot implementation, expert consultation, and collaboration with indigenous and minority-language communities.

Fourth, the review relies primarily on English-language academic literature. While this approach enabled broad interdisciplinary synthesis, it may have excluded valuable scholarship published in other languages. Future reviews incorporating multilingual literature could provide a more comprehensive understanding of language preservation across diverse regions.

Finally, language endangerment is influenced by complex historical, political, economic, and cultural factors that cannot be fully captured within a single conceptual model. Accordingly, NET and LTP should be regarded as complementary frameworks that contribute to ongoing scholarly discussion rather than comprehensive explanations of all dimensions of language loss.

6.2 Future Research

The conceptual frameworks proposed in this review create several opportunities for future investigation.

Future research should:

- empirically evaluate the theoretical propositions of NET using qualitative, quantitative, and longitudinal research designs;
- examine whether greater linguistic diversity contributes to measurable differences in ecological knowledge preservation, innovation, or cognitive flexibility;
- pilot the Linguistic Triage Protocol within different linguistic communities to assess its reliability, validity, and practical usefulness for language-planning agencies;
- investigate how artificial intelligence can support community-led language revitalization while respecting ethical principles, indigenous data sovereignty, and cultural ownership;

- develop standardized indicators for assessing cognitive distinctiveness and ecological knowledge within endangered-language communities;
- explore interdisciplinary collaborations among linguists, neuroscientists, anthropologists, AI researchers, policymakers, educators, and indigenous communities to strengthen evidence-based language-conservation strategies.

Collectively, these research directions will enable the theoretical propositions advanced in this review to be examined through rigorous empirical investigation and refined in response to emerging evidence.

Table 1. Linguistic triage protocol (LTP): Five evaluation dimensions.

Dimension	Purpose	High Priority (Score = 5)
Language Vitality	Degree of endangerment and intergenerational transmission	Fewer than 100 fluent speakers with no active transmission to children
Cognitive Distinctiveness	Presence of uncommon grammatical, semantic, or conceptual features	Linguistic structures rarely documented elsewhere
Ecological Knowledge	Extent of unique environmental, medicinal, or traditional knowledge	Well-documented ecological knowledge unavailable in neighboring languages
Revitalization Feasibility	Community capacity and institutional support	Active community participation, educational programs, and policy support
Network Connectivity	Relationship with neighboring linguistic communities	Language serves as a bridge connecting multiple minority-language communities

Note. See Section 2.2 for the full scoring rubric and implementation workflow.

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