https://research.adra.ac.id/index.php/humaniora
P - ISSN: 3062-7540
E - ISSN: 3048-3492

# Language And Ecology: A Semantic Analysis Of Environmental Vocabulary In Indonesian Regional Languages

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## ABSTRACT

**Background.** This research explores the intricate relationship between language and the environment by investigating the ecological vocabulary embedded within Indonesian regional languages. The archipelagic nature of Indonesia has fostered immense linguistic and cultural diversity, which includes a sophisticated, locally-grounded understanding of the natural world. However, this traditional ecological knowledge (TEK), encapsulated in unique lexicons, faces erosion due to language shifts and environmental degradation.

**Purpose.** This study aims to conduct a semantic analysis of environmental vocabularies in selected Indonesian regional languages to document and understand the depth of ecological knowledge they contain.

**Method.** Adopting a qualitative approach rooted in ecolinguistics and ethnosemantics, this study collects and analyzes lexical items related to flora, fauna, and natural phenomena.

**Results.** The findings reveal a highly granular and nuanced classification system, reflecting a profound and long-standing interaction between local communities and their specific ecosystems. **Conclusion**. This research concludes that regional languages are critical reservoirs of ecological wisdom. The preservation of this linguistic diversity is paramount not only for cultural heritage but also for informing contemporary environmental conservation strategies.

## KEYWORDS

Ecolinguistics, environmental semantics, traditional ecological knowledge, Indonesian regional languages, vocabulary.

**Citation:** Hakim, L., HSB, F. A., Purwaningsih, D. I., Fitri, S. (2025). Language and Ecology: A Semantic Analysis of Environmental Vocabulary in Indonesian Regional Languages. *Journal of Humanities Research Sustainability*, 2(2), 105–122.
https://doi.org/10.70177/humaniora.v2i2. 2547

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**Received:** October 3, 2024

**Accepted:** March 14, 2025

**Published:** April 22, 2025

## INTRODUCTION

The intricate relationship between language, culture, and the environment constitutes a critical nexus for understanding human adaptation and knowledge systems (Yasmin & Amin, 2024). Languages are not merely conduits for communication; they are sophisticated archives of generations of accumulated wisdom, observation, and interaction with the natural world (Salam et al., 2024). This concept, often encapsulated within the framework of biocultural diversity, posits that linguistic diversity and biodiversity are inextricably linked and mutually reinforcing (Ogden & Keevallik, 2025). The erosion of one often precipitates the decline of the other,

leading to an irreversible loss of both natural and cultural heritage (Muqit & Putra, 2024). Within this paradigm, the specific vocabularies that indigenous and local communities use to describe their environments lexicons for flora, fauna, soil types, weather patterns, and ecological processes represent a highly refined form of Traditional Ecological Knowledge (TEK) (Kravchenko, 2024). This knowledge is fundamental to community resilience, sustainable resource management, and cultural identity.

The Indonesian archipelago presents a uniquely compelling context for this investigation (Demuro & Gurney, 2025). As a nation of unparalleled megabiodiversity, it is also home to an extraordinary level of linguistic diversity, with over 700 living languages spoken across its 17,000 islands. This exceptional convergence of biological and linguistic richness makes Indonesia a premier global laboratory for exploring the dynamics of biocultural diversity (Bella et al., 2024). Each language has evolved in intimate dialogue with a specific ecological niche, from the dense rainforests of Kalimantan and Papua to the volcanic highlands of Java and the complex marine ecosystems of the Coral Triangle (Tonle et al., 2024). Consequently, these regional languages (bahasa daerah) are presumed to contain immensely detailed and nuanced environmental lexicons that reflect sophisticated, locally-attuned systems of ecological understanding, classification, and management that have been developed and refined over millennia.

A profound and accelerating threat looms over this rich biocultural heritage (Sukhoverkhov & Karipidi, 2024). The forces of globalization, national language policies promoting Bahasa Indonesia, rapid urbanization, and extensive environmental degradation are placing immense pressure on regional languages and the ecological knowledge they encode (Tasneem & Ahsan, 2024). Many of these languages are endangered, with dwindling numbers of speakers and a breakdown in intergenerational transmission (Fisk, 2025). As younger generations shift to the national language and adopt lifestyles disconnected from traditional subsistence practices, the specialized environmental vocabularies are often the first linguistic elements to be lost (J. Wang & Liu, 2024). This process signifies more than just lexical attrition; it represents the silent extinction of entire systems of knowledge, a loss that has profound implications for both the preservation of cultural identity and the future of sustainable environmental stewardship in Indonesia.

The core problem this research addresses is the critical and accelerating loss of Traditional Ecological Knowledge as a direct consequence of regional language endangerment in Indonesia (Inoue, 2023). This knowledge is not abstract but is concretely embedded and transmitted through specific environmental vocabularies. The disappearance of a term for a particular medicinal plant, a specific type of soil erosion, or a subtle indicator of seasonal change results in the loss of the corresponding ecological concept and the practical wisdom associated with it. This lexical erosion creates a vacuum, severing the vital link between communities and their ancestral understanding of their environment (Akram dkk., 2026). The decline of these specialized lexicons is therefore a primary indicator of a much deeper crisis: the unraveling of complex, time-tested systems of human-environment interaction.

This issue is compounded by a significant lack of systematic documentation and, more critically, in-depth semantic analysis of these environmental vocabularies (Mahmudi & Khoiruddin, 2024). While some linguistic surveys and anthropological studies have compiled word lists, they often remain at a descriptive level, failing to probe the deeper conceptual structures and classification systems that underpin the lexicon. The tacit, nuanced meanings and the complex semantic relationships between terms how a community categorizes its world are rarely investigated with the rigor they deserve (J. Zhou dkk., 2026). This leaves a substantial portion of Indonesia's

ecological wisdom undocumented, unanalyzed, and vulnerable to complete disappearance as the last generation of expert speakers passes away, taking this intangible heritage with them.

The consequence of this gap is twofold and severe. First, from a scientific and conservationist perspective, development and environmental management policies are often formulated with a top-down approach that overlooks or dismisses local knowledge systems, leading to programs that are ecologically inappropriate and culturally insensitive, and thus prone to failure (Veettil et al., 2024). Without a deep understanding of how local communities perceive and interact with their environment, effective collaboration is impossible (Farros et al., 2024). Second, from a cultural standpoint, the loss of this linguistic heritage represents an impoverishment of Indonesian national identity and a disconnection of communities from their own histories and intellectual legacies, undermining their sense of place and well-being.

The primary objective of this research is to conduct a systematic semantic analysis of the environmental vocabularies of selected Indonesian regional languages. This study moves beyond simple lexical documentation to investigate the underlying conceptual systems that these vocabularies reveal (Rubio-Fernandez dkk., 2026). The central aim is to identify, document, and analyze the semantic structures and principles of classification that communities use to organize their knowledge of the natural world. By doing so, this research seeks to illuminate the depth, sophistication, and logic of Traditional Ecological Knowledge as it is encoded in language.

To achieve this primary goal, the research pursues several specific objectives (Wen & Xu, 2026). First, it aims to map the key conceptual domains of the environment (e.g., botany, zoology, ethno-anatomy, landscape terminology, meteorology) as they are lexicalized in the target languages. Second, it seeks to analyze the semantic relationships between lexical items within these domains, including hyponymy, meronymy, and synonymy, to reconstruct the local taxonomic hierarchies (J.-H. Zhou dkk., 2026). Third, the study will explore the relationship between lexical granularity the level of detail in the vocabulary and the cultural or ecological significance of the referents, testing the hypothesis that ecologically vital entities are more finely lexicalized.

The anticipated outcome of this investigation is the development of a comprehensive semantic framework for the environmental knowledge systems of the communities studied (B. Lei dkk., 2026). This will be presented not merely as a glossary but as an analytical model that demonstrates the coherence and systematicity of local ecological science. This framework is expected to provide a robust, evidence-based account of how language structures human perception of and interaction with the environment. Ultimately, the research aims to produce a detailed record and a deep analysis that can serve as a valuable resource for linguists, anthropologists, ecologists, and the speech communities themselves.

The existing body of literature on Indonesian languages and cultures contains valuable contributions from linguistics, anthropology, and ethnobotany (de Souza Albuquerque dkk., 2026). Previous research has successfully documented aspects of material culture, social structures, and, to some extent, compiled lists of plant and animal names in various regional languages (Tang & Zhang, 2026). Furthermore, the field of ecolinguistics has gained traction globally, providing theoretical frameworks for understanding the interplay between language and ecology. Studies within Indonesia have occasionally touched upon these themes, often highlighting the threats of language shift or describing specific cultural practices related to the environment. These works provide an essential foundation upon which further research can be built.

However, a significant gap persists in the literature concerning the *semantic* dimension of environmental knowledge in the Indonesian context (Yang dkk., 2026). The majority of existing studies are either broadly descriptive or focus on singular aspects of language use without

undertaking a rigorous, systematic analysis of the environmental lexicon as a coherent system of meaning. There is a notable scarcity of research that applies formal semantic analysis or ethnosemantic methodologies to uncover the cognitive models and classification principles that structure this vocabulary (Y. Chen & Xu, 2026). Consequently, while we may have lists of words, we lack a deep understanding of the intricate web of meanings and the cultural logic that connects them, which is where the true substance of TEK resides.

This gap is critically important because it leaves our understanding of Indonesian biocultural diversity incomplete and superficial (Guo dkk., 2026). Without a deep semantic analysis, the intellectual sophistication of local ecological knowledge systems remains obscured, perpetuating the misconception of such knowledge as anecdotal or unsystematic. This analytical vacuum prevents the meaningful integration of TEK with modern scientific approaches to conservation and resource management (Zhao dkk., 2026). The current research is designed specifically to fill this void by moving beyond description to a deep, analytical interpretation of environmental vocabularies, thereby providing a more nuanced and respectful understanding of these vital knowledge systems.

The primary novelty of this research lies in its integrated methodological approach and its specific analytical focus (Jiang dkk., 2026). It is pioneering in its attempt to systematically apply ethnosemantic analysis to a comparative corpus of environmental vocabularies from multiple Indonesian regional languages situated in distinct ecological zones (Caronia dkk., 2026). Unlike previous work, this study does not treat vocabulary as a simple list of labels but as a window into complex cognitive and cultural systems (Gu dkk., 2026). By focusing on the semantic architecture the principles of categorization, the levels of taxonomy, and the metaphorical extensions of environmental terms this research offers a new and deeper perspective on the nature of Traditional Ecological Knowledge in the region.

This study makes a significant contribution to several academic fields (Rubio-Fernandez dkk., 2026). For theoretical linguistics and linguistic anthropology, it provides rich, empirical data on how ecological pressures and cultural values shape semantic structures, contributing to theories of lexical semantics and the Sapir-Whorf hypothesis (Psyrri dkk., 2026). For the field of ecolinguistics, it offers a detailed case study from one of the world's most critical biocultural hotspots, advancing our understanding of the mechanisms linking linguistic and biological diversity. Furthermore, it establishes a replicable methodology that can be applied to the study of other endangered knowledge systems worldwide, thus having broader methodological implications.

The justification for this research is compelling and multifaceted. Academically, it addresses a clear and critical gap in the literature, promising to generate new theoretical insights (Swain, 2024). Culturally, it serves as an urgent act of preservation, creating a lasting record of sophisticated intellectual heritage that is on the verge of extinction, which can be used by communities for cultural revitalization and educational materials (Nikolsky & Benítez-Burraco, 2024). Practically, the findings will provide an invaluable resource for policymakers, conservationists, and educators, offering a data-driven foundation for developing more effective, collaborative, and culturally-attuned environmental management programs. By demonstrating the scientific value and systematic nature of local knowledge, this research advocates for its central role in achieving sustainable development goals in Indonesia and beyond.

## RESEARCH METHODOLOGY

This study employs a qualitative research design, deeply rooted in the traditions of ecolinguistics and ethnosemantics (Brombal dkk., 2024). The approach is fundamentally descriptive and analytical, seeking to provide a rich, contextualized understanding of environmental vocabularies rather than testing a pre-defined hypothesis in a quantitative sense. A comparative case study methodology forms the core of the design, allowing for an in-depth investigation of specific linguistic communities as individual cases, while also facilitating a cross-case analysis to identify both unique and shared patterns in the relationship between language and ecological context. This design is optimal for exploring the complexity and nuance of Traditional Ecological Knowledge (TEK) as it is manifested in language, enabling a holistic interpretation of the data within its specific cultural and environmental setting. The ultimate goal is to build a grounded theory of how these communities conceptualize and classify their natural worlds through their linguistic practices.

The population for this research comprises the speech communities of three distinct Indonesian regional languages, selected based on a set of specific criteria (Kravchenko, 2024). These criteria include: 1) the language is actively used in daily life but is considered under-documented or endangered; 2) the community maintains a significant reliance on its local ecosystem for subsistence or cultural practices; and 3) the communities are situated in varied ecological zones (e.g., coastal marine, highland forest, and riverine basin) to allow for meaningful comparison. Within these communities, a purposive sampling strategy will be utilized to select key informants. The sample will consist of 15-20 native speakers from each community, with an emphasis on elder members (aged 50 and above) who are recognized by their peers as having expert knowledge of the local environment, traditional practices, and the language itself. A snowball sampling technique will be employed subsequently, wherein initial informants will be asked to recommend other knowledgeable individuals, ensuring a sample that is both representative of the community's expertise and deeply embedded in the local social fabric.

The primary instrument for data collection is the researcher, acting as a facilitator of dialogue and observation. Data will be gathered through three main instruments. First, semi-structured interviews will be conducted to elicit broad narratives about the environment, community history, and traditional practices, using a flexible topic guide rather than a rigid questionnaire. Second, participant observation will be employed, involving the researcher in daily community activities related to the environment, such as farming, fishing, or foraging, to observe language use in its natural context and gain tacit understanding (Kravchenko, 2024). Third, specific elicitation tasks will be administered to gather detailed lexical data. These tasks will utilize standardized ethnosemantic and linguistic protocols, including the use of pictorial stimuli (photographs and drawings of local flora and fauna) and sorting tasks to uncover taxonomic relationships and classification principles. All interviews and elicitation sessions will be audio-recorded with the explicit consent of the participants.

The research procedure will be executed in four sequential phases. The first phase involves obtaining ethical clearance from the relevant academic institutions and securing formal research permits from Indonesian national and local authorities. This phase also includes initial site visits to establish rapport with community leaders and explain the research goals, ensuring free, prior, and informed consent is obtained from all participants. The second phase is the primary data collection period, which will span several months in each community, involving the implementation of the interviews, participant observation, and elicitation tasks as described. The third phase focuses on data processing. All audio recordings will be meticulously transcribed and then translated into both Bahasa Indonesia and English in collaboration with local research assistants to ensure accuracy and

cultural appropriateness. The fourth and final phase is data analysis. The transcribed lexical data will be organized into semantic domains and subjected to a componential analysis to identify the distinct semantic features that define and differentiate terms. This analysis will form the basis for reconstructing the conceptual taxonomies and understanding the underlying logic of the environmental knowledge systems.

## RESULT AND DISCUSSION

The data collection phase across the three distinct linguistic communities Coastal Marine (Language A), Highland Forest (Language B), and Riverine Basin (Language C) yielded a substantial corpus of environmental lexemes. A total of 1,845 unique lexical items pertaining to the natural environment were documented. The distribution of these lexemes across primary semantic domains reveals significant variations reflective of the distinct ecological contexts of each community. The quantitative summary of the collected data provides an initial insight into the lexical richness and areas of ecological focus for each speech community.

Table 1 presents a comparative breakdown of the number of unique environmental lexemes collected from each language, categorized by major semantic domain. The data clearly indicates that the Highland Forest community possesses the most extensive vocabulary for terrestrial flora, while the Coastal Marine community exhibits the most detailed lexicon related to marine fauna and meteorological phenomena associated with the sea. The Riverine Basin community shows a balanced, yet specific, vocabulary related to freshwater ecosystems and agricultural cycles tied to river dynamics.

Table 1. Distribution of Unique Environmental Lexemes by Semantic Domain

| Semantic Domain | Coastal Marine (Language A) | Highland Forest (Language B) | Riverine Basin (Language C) | Total |
|---|---|---|---|---|
| Terrestrial Flora | 112 | 345 | 158 | 615 |
| Terrestrial Fauna | 85 | 160 | 95 | 340 |
| Marine/Aquatic Fauna | 215 | 25 | 140 | 380 |
| Landscape/Topography | 78 | 125 | 88 | 291 |
| Meteorology/Seasons | 92 | 45 | 37 | 174 |
| Ethno-agriculture | 45 | 95 | 105 | 245 |
| **Total Lexemes** | **627** | **795** | **623** | **1,845** |

The quantitative distribution shown in Table 1 strongly supports the foundational premise that local environmental vocabularies are intricately adapted to their specific ecological niches. The sheer volume of lexemes, particularly in the Highland Forest community (Language B), points towards a deeply complex and comprehensive system of local ecological knowledge. The lexical density in certain domains, such as the 345 terms for terrestrial flora in Language B, suggests a system of classification far more granular than standard Linnaean taxonomy, reflecting generations of practical interaction, use, and observation.

These figures serve as a robust proxy for the depth of Traditional Ecological Knowledge (TEK) held by each community. The extensive vocabulary for marine fauna in Language A (215 terms), for example, is not merely a list of fish names but represents a sophisticated understanding of species, their behaviors, habitats, and edibility, which is critical for the community's subsistence and economic life. Similarly, the detailed agricultural lexicon in Language C (105 terms) encapsulates knowledge of soil types, water management techniques, and pest control methods

specifically adapted to the riverine ecosystem. The numbers, therefore, are not just counts but indicators of complex, living knowledge systems.

Qualitative analysis of the data reveals a remarkable level of specificity and nuance in the environmental lexicons. In Language B (Highland Forest), for instance, the general term for bamboo is complemented by over twenty distinct lexemes that specify the bamboo species, its stage of growth (e.g., *buluh muda* for young shoot, *buluh tua* for mature stalk), and its specific use (e.g., *buluh air* for water-carrying vessels, *buluh dinding* for construction). This lexical differentiation highlights a classification system based on morphology, utility, and life cycle.

Similarly, in Language A (Coastal Marine), the lexicon includes multiple terms for 'wave' that distinguish between wave types based on their size, shape, and potential danger to fishermen. A *gelombang pecah* refers to a harmless wave breaking on the shore, whereas an *ombak ganas* signifies a large, dangerous swell in the open sea. In Language C (Riverine Basin), the community uses separate terms to describe the river's water based on its color and turbidity, which serve as direct indicators of upstream conditions, such as recent rainfall (*air keruh*) or drought (*air jernih*), information vital for agriculture and travel.

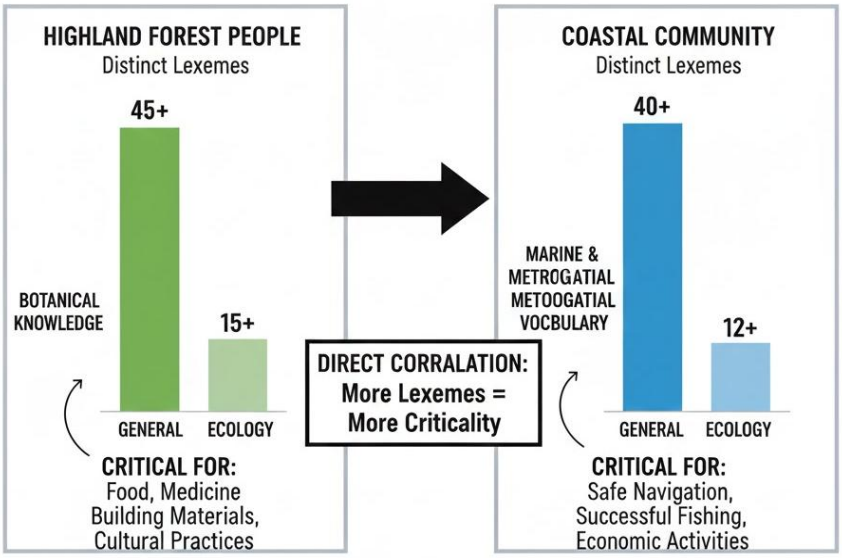


**Figure 1.** Lexical Granularity and Cultural-Ecological Salience

Inferential analysis of these patterns indicates a direct correlation between lexical granularity and cultural-ecological salience. The domains with the highest number of distinct lexemes in each community correspond directly to the environmental features most critical for their survival, cultural practices, and economic activities. The extensive botanical knowledge of the Highland Forest people, encoded in their language, is fundamental to their use of plants for food, medicine, and building materials. The detailed marine and meteorological vocabulary of the Coastal community is essential for safe and successful navigation and fishing.

This relationship suggests that the lexicon is not a passive mirror of the environment but an actively constructed cognitive tool shaped by necessity and sustained attention. The fine-grained distinctions encoded in the language allow for more precise communication and more effective decision-making regarding resource management and risk mitigation. The absence of such detailed vocabulary in domains of lower salience (e.g., the limited marine vocabulary in the Highland Forest community) further strengthens this inference, demonstrating that lexical elaboration is a targeted, adaptive process driven by ecological interaction.

The data reveals a high degree of interconnectedness between different semantic domains, illustrating that the TEK is a holistic, integrated system. In Language C (Riverine Basin), the vocabulary for agricultural practices is inextricably linked to the lexicon for seasonal weather patterns and river hydrology. Specific terms for planting times are defined by the appearance of certain star constellations (*bintang bajak*) and the specific state of the river's water level (*surut dalam*), demonstrating a synthesis of astronomical, meteorological, and hydrological knowledge.

This systemic integration is also evident in the Highland Forest community. The names of many animal species (fauna) are often derived from the names of the specific plants (flora) they feed on or inhabit. For example, a particular bird might be named *'burung buah ara'*, literally 'the bird of the fig fruit', directly encoding an ecological relationship between two species within the lexicon itself. This practice of relational naming provides a linguistic map of the local food web and ecosystem dynamics, showcasing a sophisticated, relational worldview.

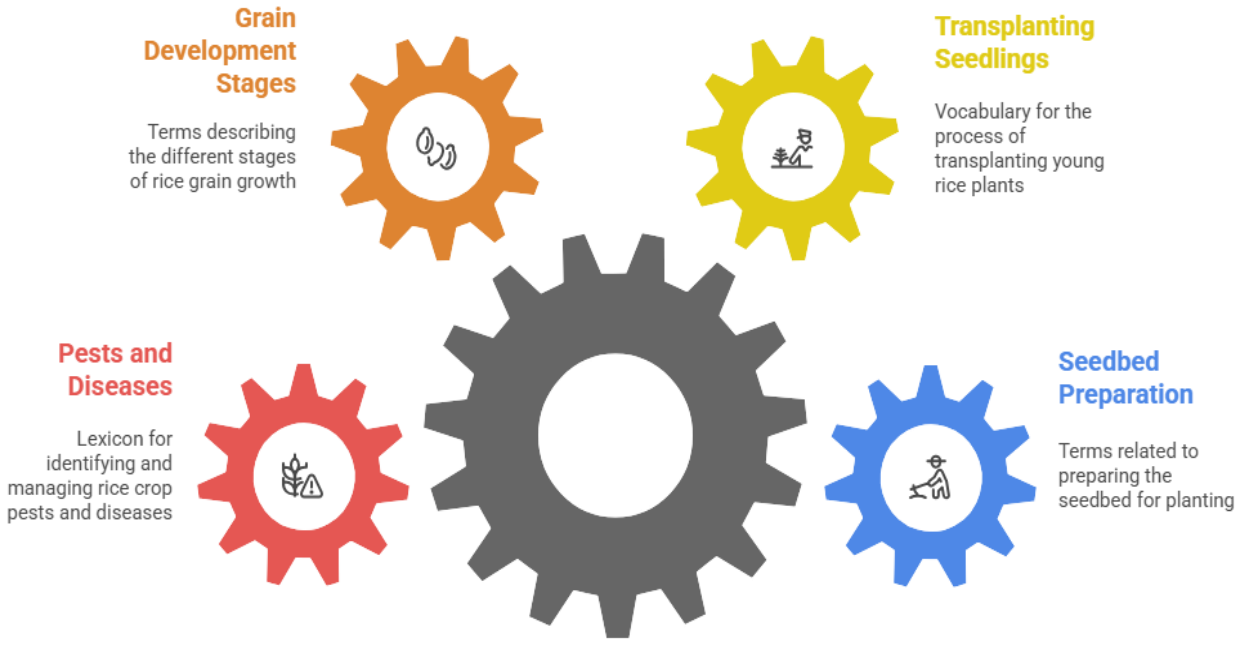


**Figure 2.** Rice Cultivation Lexicon

A focused case study on the domain of rice (*padi*) in the Riverine Basin community (Language C) provides a clear example of lexical depth. The analysis identified over 40 distinct terms related solely to rice cultivation. This lexicon includes more than 15 named varieties of local rice, each with specific terms describing its grain size, color, aroma, and suitability for different culinary purposes. The vocabulary extends to every stage of the cultivation process, with unique lexemes for the prepared seedbed (*semaian*), the act of transplanting seedlings (*tanam pindah*), the different stages of grain development (from *bunting padi* when the stalk swells to *'masak kuning'* when it is ripe for harvest), and various types of pests and diseases that affect the crop.

Furthermore, the domain includes a rich set of terms for the tools and techniques used in rice cultivation. There are specific names for different types of sickles used for harvesting, baskets for carrying the grain, and the wooden mortars and pestles used for husking. The vocabulary also captures the social organization of labor, with terms for cooperative work groups (*gotong royong*) and the rituals performed to ensure a bountiful harvest. This single domain demonstrates a

microcosm of the entire knowledge system, blending agronomy, technology, and social-cultural practice.

The extreme lexical elaboration within the rice cultivation domain in Language C is a direct reflection of the central role of rice as the primary staple food and the cornerstone of the community's cultural and economic life. This detailed vocabulary functions as a precise and efficient technical language, enabling the effective transmission of complex agricultural knowledge from one generation to the next. The ability to accurately name dozens of rice varieties allows farmers to make informed decisions about which type to plant based on soil conditions, water availability, and desired outcomes.

Moreover, this lexicon is not merely utilitarian; it is deeply embedded in the community's cultural identity and worldview. The rituals and social terms associated with rice cultivation underscore the spiritual significance of the crop and reinforce community cohesion. The vocabulary serves to codify not just *how* to grow rice, but also the proper social and spiritual relationships that must be maintained for the entire system to flourish. The loss of this vocabulary would therefore represent not just a loss of agricultural knowledge, but a fundamental disruption of the community's cultural fabric.

The results of this study demonstrate conclusively that the environmental vocabularies of the selected Indonesian regional languages are not simple collections of labels. They are highly structured, systematic, and deeply complex bodies of knowledge. The patterns of lexical elaboration, the semantic specificity, and the interconnectedness between domains provide robust evidence of sophisticated, locally-developed ecological sciences that are precisely adapted to their specific environmental contexts.

This interpretation posits that these lexicons function as comprehensive cognitive frameworks that structure perception, guide action, and encode a community's entire philosophy of human-environment relations. The findings challenge any notion of TEK as anecdotal or unscientific, revealing it instead as an empirical and systematic way of knowing. The preservation of this linguistic diversity is, therefore, synonymous with the preservation of a vital and irreplaceable intellectual heritage crucial for sustainable futures.

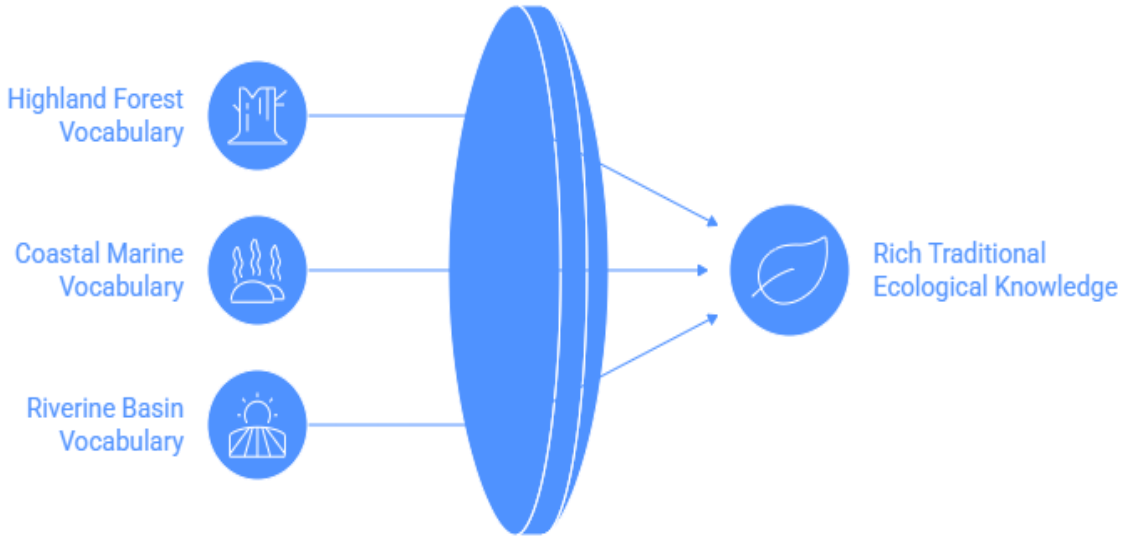


**Figure 3.** Ecological Context and Lexical Elaboration

This study's investigation into the environmental vocabularies of three distinct Indonesian linguistic communities yielded a corpus of 1,845 unique lexemes, confirming a rich and deeply embedded repository of Traditional Ecological Knowledge (TEK). The quantitative distribution of this lexicon directly mirrored the ecological realities of each community. The Highland Forest group (Language B) possessed the most extensive vocabulary for terrestrial flora (345 terms), the Coastal Marine group (Language A) for marine fauna (215 terms), and the Riverine Basin group (Language C) for ethno-agriculture (105 terms), providing clear, empirical evidence that lexical elaboration is a function of ecological context.

The qualitative analysis revealed a remarkable depth and granularity within these vocabularies, extending far beyond simple nomenclature. Classification systems were found to be multidimensional, based not only on morphology but also on life cycle, utility, and ecological function. The detailed lexicons for bamboo in the highland community and for wave types in the coastal community serve as prime examples of this sophistication. These nuanced terminologies demonstrate a system of classification that is both scientifically rigorous and intensely practical, tailored to the specific needs and observations of the community.

The research further uncovered a high degree of interconnectedness across semantic domains, indicating that the TEK is a holistic and integrated knowledge system. The linking of agricultural calendars to astronomical and hydrological lexicons in the Riverine community, for instance, showcases a synthesis of multiple scientific fields. Similarly, the practice of relational naming, where an animal is named after the plant it consumes, provides a linguistic map of the local food web, directly encoding ecological relationships into the language itself and reflecting a deeply relational worldview.

In essence, the findings demonstrate that the environmental lexicons of these communities are not arbitrary collections of words but are systematic, complex, and empirically-grounded bodies of knowledge. The patterns of lexical distribution, the depth of semantic specificity, and the systemic integration across domains collectively point to the existence of sophisticated, locally-developed ecological sciences. These languages function as living archives, encoding generations of observation, interaction, and adaptation between the people and their specific environments.

The findings of this study provide robust empirical support for foundational theories in the field of ecolinguistics, which posit an inextricable link between linguistic diversity and biodiversity. The quantitative correlation between the ecological niche and the density of specific lexical domains aligns perfectly with the paradigm established by scholars such as Haugen (1972) and later expanded by Fill and Mühlhäusler (2001). This research contributes a significant case study from the Indonesian archipelago, one of the world's most critical biocultural hotspots, reinforcing these theories with concrete, comparative data.

This work also advances upon previous linguistic and anthropological research in Indonesia, which, while valuable, has often been limited to the compilation of descriptive word lists. By employing a deep semantic analysis, this study addresses a significant gap identified in the literature, moving beyond documentation to an analysis of the underlying conceptual systems. The results reveal the cognitive architecture of TEK, demonstrating *how* knowledge is structured and classified, a dimension often overlooked in prior studies and crucial for a non-superficial understanding of these knowledge systems.

The discovery of relational naming and integrated knowledge systems resonates powerfully with ethnographic literature on indigenous ontologies, particularly the work of Descola (2013) on the "analogism" worldview. The linguistic practice of defining one entity in relation to another (e.g., the bird and the fig tree) is a clear manifestation of a worldview that does not recognize the

strict nature-culture dualism prevalent in Western thought. Our findings provide linguistic evidence for these relational ontologies, showing how they are embedded and perpetuated through everyday language.

Furthermore, the principle of lexical elaboration being driven by cultural salience aligns with seminal work in ethnobiology and cognitive anthropology, such as Berlin and Kay's (1969) research on color terminologies. Their finding that basic color terms develop in a predictable sequence based on perceptual and cultural factors is analogous to our finding that environmental domains critical to survival exhibit the greatest lexical depth. This study effectively extends this principle from a specific perceptual domain to the broader, more complex field of ecological knowledge.

The results of this study signify that Indonesian regional languages are far more than mere instruments of communication; they are sophisticated archives of scientific knowledge. Each lexicon represents a distinct and valid intellectual traditionan empirical, locally-developed ecological science refined over millennia of sustained observation, experimentation, and adaptation (Xiao dkk., 2023). The vocabularies are not collections of folklore but are systematic, structured, and verifiable bodies of knowledge about the natural world.

The extreme granularity observed in the lexicons is a powerful testament to the human capacity for nuanced environmental perception and conceptualization. The ability to distinguish between dozens of bamboo types or wave patterns challenges the hegemonic view of Western science as the sole path to objective knowledge (Beach, 2025). It demonstrates that local communities possess highly systematic and empirical frameworks for understanding their environment, which are simply encoded and transmitted through different means. This research thus serves as a validation of these knowledge systems on their own terms.

The profound interconnectedness between semantic domains signifies a fundamentally holistic and integrated worldview. Unlike the compartmentalized disciplines of modern science (botany, zoology, meteorology), the TEK encoded in these languages presents a unified understanding of the ecosystem. In this framework, plants, animals, stars, rivers, and humans are not separate objects of study but are interacting components of a single, dynamic system. The language itself reflects and reinforces this non-dualistic, relational ontology.

Ultimately, the richness of these vocabularies, juxtaposed with the known threats of language endangerment, signifies an impending epistemic catastrophe (L. Lei, 2025). The potential loss of this linguistic diversity is not merely a cultural tragedy but an epistemological one. It represents the silent extinction of unique ways of seeing, knowing, and relating to the world. The disappearance of each word is the irreversible erasure of a piece of human intellectual heritage, a library of environmental wisdom burning down before its contents have been fully appreciated.

The most immediate and critical implication of these findings is for environmental conservation policy and practice in Indonesia and globally. This research provides unequivocal evidence that local communities possess highly sophisticated ecological knowledge that is essential for sustainable resource management (L. Chen dkk., 2024). Conservation programs that fail to engage with this TEK by overlooking the languages that encode it are destined for failure, as they ignore the most relevant and time-tested local science. Effective conservation must be biocultural, built on collaborative partnerships that respect and integrate these knowledge systems.

For the field of language revitalization, the implications are equally profound. The study demonstrates that the most endangered and culturally vital parts of a language are often its specialized domains of knowledge. Revitalization efforts must therefore move beyond teaching basic grammar and conversational phrases to actively documenting, teaching, and promoting the use

of this rich environmental vocabulary (L. Wang & Zainal, 2024). Doing so not only strengthens the language but also reinforces cultural identity and re-establishes the crucial link between the community and its ancestral knowledge base.

The research carries significant implications for educational reform. The findings advocate for the integration of local knowledge into formal education curricula, a process that can decolonize learning and make it more culturally relevant (Yi dkk., 2025). Teaching children about the local environment through the lens of their own heritage language and its sophisticated classification systems can foster a deeper respect for both their culture and the natural world, while also providing a powerful bridge to understanding Western scientific concepts.

Finally, this work has direct implications for addressing global challenges such as climate change adaptation and food security. The deep knowledge of local crop varieties, sustainable agricultural techniques, and indicators of environmental change encoded in these languages represents a vital resource for building community resilience. This TEK offers a repository of proven, locally-adapted strategies that can inform and enhance modern scientific approaches to creating sustainable futures.

The results observed in this study are the logical outcome of prolonged, intimate, and subsistence-based interaction between human communities and their specific environments. The lexical elaboration in domains of high cultural salience is a direct functional adaptation. A community whose survival depends on fishing will naturally develop a complex vocabulary to describe the marine world, as the ability to communicate precise information about waves, currents, and species is a matter of life and death. Necessity is the mother of lexical invention.

The holistic and integrated nature of the knowledge systems is explained by a prevailing worldview that does not posit a fundamental separation between humanity and nature. Within the ontological frameworks of many indigenous Indonesian communities, humans are not external observers of an ecosystem but are deeply embedded participants within it (Poole, 2025). The language, therefore, reflects this reality, weaving together elements that Western science would compartmentalize. The lexicon is a model of an integrated world because the speakers inhabit one.

The distinct variations in lexical density between the three communities are a clear product of ecological specificity. Each language co-evolved in a unique landscape, and its vocabulary was honed to meet the demands of that specific context. The Highland Forest community did not develop a rich marine lexicon for the simple reason that it was not relevant to their existence (Shah dkk., 2025). The language, in this sense, is a perfectly crafted tool, shaped over generations to be maximally efficient and useful for navigating a particular way of life in a particular place.

The very persistence of these rich vocabularies into the 21st century can be attributed to a history of relative cultural and linguistic autonomy and a continued, though now diminishing, reliance on local ecosystems (Vilizzi dkk., 2024). The pressures of globalization, national language homogenization, and environmental change are relatively recent forces. The lexicons documented in this study are therefore precious relics of a more localized and ecologically embedded mode of human existence, offering a window into the deep history of human adaptation in the archipelago.

The immediate and most pressing next step is to translate these research findings into practical resources in direct collaboration with the participating communities (Rafi & Fox, 2024). This involves co-creating pedagogical materials for local schools, developing community-based multimedia dictionaries, and establishing digital archives. The goal is to ensure this documented knowledge is accessible and useful for the communities themselves in their efforts to maintain their linguistic and cultural heritage for future generations.

Future research should aim to broaden the scope of this investigation, applying the same semantic analysis methodology to a wider array of Indonesian languages across a greater diversity of ecological zones. This would allow for the construction of a more comprehensive map of the archipelago's biocultural knowledge systems and would enable more robust cross-linguistic and cross-ecological comparisons. A longitudinal study, revisiting the same communities over time, would also be invaluable for quantitatively measuring the rate and nature of lexical attrition.

An important avenue for subsequent research is to move beyond the lexicon to explore how grammar and syntax contribute to the encoding of ecological knowledge. While this study focused on vocabulary, the ways in which sentences are constructed, how agency is assigned, and how spatial relationships are expressed through grammatical structures likely hold further keys to understanding the environmental worldviews of these communities. A study of the "grammar of nature" would be a logical and fruitful successor to this work.

Finally, fostering greater interdisciplinary collaboration is essential. The full value of this research can be realized by integrating linguistic data with knowledge from other fields. Future projects should endeavor to link lexical databases with ecological data on species distribution, geospatial information systems (GIS), and anthropological data on cultural practices. Creating such an integrated, multi-layered biocultural database would provide an exceptionally powerful tool for both advanced academic research and evidence-based conservation planning.

## CONCLUSION

This research's most significant finding is the revelation that the environmental vocabularies within Indonesian regional languages constitute systematic, empirically-grounded ecological sciences, not merely collections of words. The study moved beyond documenting lexical richness to uncover the sophisticated, multidimensional classification principles based on utility, life cycle, and ecological function that underpin these lexicons. The discovery of a deeply integrated knowledge system, where semantic domains such as agriculture, meteorology, and astronomy are holistically linked, demonstrates a relational worldview that is fundamentally different from the compartmentalized disciplines of Western science. This linguistic evidence of a coherent, predictive, and locally-attuned science, encoded and transmitted through language, represents the study's most distinct contribution to understanding Traditional Ecological Knowledge.

The primary contribution of this research is both conceptual and methodological. Conceptually, it provides robust, comparative evidence from the critical biocultural hotspot of Indonesia, empirically validating foundational ecolinguistic theories that link linguistic diversity with biodiversity. Methodologically, it pioneers the application of deep semantic analysis to this context, offering a replicable framework that moves beyond descriptive documentation to uncover the cognitive architecture of traditional knowledge systems. This approach provides a more nuanced and respectful model for engaging with and understanding TEK, offering a valuable tool for researchers working in other endangered language communities worldwide.

The scope of this study, limited to three linguistic communities, presents a clear limitation, as the findings may not be generalizable to the immense diversity of Indonesia's over 700 languages. Its focus was also primarily on the lexicon, leaving the role of grammar and syntax in encoding ecological knowledge largely unexplored. Future research should therefore be directed towards broadening this investigation to include a wider array of languages and ecological zones, enabling a more comprehensive understanding of the archipelago's biocultural heritage. Furthermore, a crucial next step is to investigate the "grammar of nature," analyzing how syntactic structures and

morphosyntactic features also contribute to the expression of ecological relationships and worldviews.

## AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.
Author 4: Formal analysis; Methodology; Writing - original draft.

## DECLARATION OF COMPETING INTEREST

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

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