



ADVANCING SDG 4 THROUGH BIOCULTURAL SCIENCE EDUCATION: A PRISMA-GUIDED SYSTEMATIC LITERATURE REVIEW OF TRADITIONAL MEDICINE AND LOCAL KNOWLEDGE INTEGRATION

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ABSTRACT

Integrating traditional medicine and local cultural wisdom into science education is increasingly recognized as vital for fostering contextualized, inclusive, and sustainability-oriented learning. However, despite its potential to bridge scientific literacy with cultural identity and ecological stewardship, a significant gap remains in systematic syntheses examining how biocultural knowledge can be integrated into school science curricula. This study addresses this gap through a PRISMA 2020-guided Systematic Literature Review (SLR). A total of 21 peer-reviewed empirical articles published between 2019 and 2025 were selected from the Scopus database using a structured screening and eligibility protocol. Data were analyzed thematically across research characteristics, pedagogical applications, educational impacts, methodological trends, and contextual gaps. The findings reveal three dominant patterns: the prevalence of ethnobotanical knowledge as the primary domain of Traditional Ecological Knowledge (TEK), the integration of TEK with contemporary scientific inquiry, and the profound socio-cultural and spiritual drivers shaping traditional medicine practices. Geographically, research is heavily concentrated in Africa and Asia, highlighting regional engagement but revealing a lack of comparative international research. Furthermore, non-plant domains (animal and fungal TEK) remain significantly underrepresented. The review provides critical pedagogical implications for curriculum design, culturally responsive teaching, and sustainability-oriented science learning aligned with SDG 4 (Quality Education) and SDG 11 (Sustainable Cities and Communities), offering a structured five-point blueprint for contextual implementation in culturally rich regions such as Yogyakarta, Indonesia.

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Keywords: traditional ecological knowledge; science education; local wisdom; ethnomedicine; education for sustainable development, SDG 4; systematic literature review

INTRODUCTION

The global landscape of science education has shifted from decontextualized instruction to culturally responsive, place-based, and sustainability-oriented learning. This transition aligns directly with UNESCO's Education for Sustainable Development (ESD) 2030 framework and the United Nations Sustainable Development Goals, particularly SDG 4 (Quality Education)

and SDG 11 (Sustainable Cities and Communities). Engaging learners with authentic socio-environmental contexts through Indigenous and Local Knowledge (ILK) complements scientific literacy by instilling ecological stewardship and cultural identity. Among various forms of ILK, Traditional Ecological Knowledge (TEK) represents a foundational conceptual framework encompassing cumulative knowledge, practices, beliefs, and adaptive strategies developed by local communities through long-term environmental interaction (Berkes, 2017; Rani et al., 2025).

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Traditional medicine serves as one of the most tangible manifestations of TEK, offering rich biological, chemical, and ecological contexts for inquiry-based science learning.

In the Indonesian context, integrating local wisdom (*etnosains*) into formal science education has gained momentum alongside curriculum transformations such as *Kurikulum Merdeka* (Parmin et al., 2017; Atmojo et al., 2019; Hasibuan et al., 2023). Reconstructing community indigenous practices into scientific domain concepts enables students to develop critical thinking while preserving cultural heritage (Sudarmin et al., 2019; Zidny et al., 2020; Sumarni et al., 2022; Listiyani et al., 2025). However, while scholarly interest in ethnoscience and culturally responsive teaching has grown globally, existing synthesis literature remains broad or sector-specific. Previous reviews have predominantly focused on mental health intervention frameworks (Richardson & Waters, 2023), generic biocultural learning models in Latin America without systematic quantitative protocols (Garavito-Bermúdez, 2020), or general environmental ethnoscience within Indonesia (Murwitaningsih & Maesaroh, 2023; Sihombing et al., 2025; Budiarti et al., 2026).

A critical synthesis gap remains in how traditional medicine and local cultural wisdom function as interconnected biocultural assets within school STEM and biology instruction. Furthermore, no systematic review has yet synthesized global empirical evidence to directly inform regional curriculum operationalization, such as the *Projek Penguatan Profil Pelajar Pancasila* (P5) under Indonesia's *Kurikulum Merdeka* in culturally rich regions like Yogyakarta.

To address these empirical and pedagogical gaps, this systematic literature review addresses five central research questions: (1) What empirical, geographical, and thematic characteristics define studies integrating traditional medicine and local cultural wisdom into science learning? (2) How is Traditional Ecological Knowledge operationalized as pedagogical content, instructional resources, or learning contexts within science education? (3) What educational impacts, pedagogical benefits, and contextual challenges are reported in studies integrating traditional medicine into science learning? (4) What theoretical perspectives and methodological approaches characterize current research on biocultural integration in science education? (5) What contextual implications can be drawn from global evidence

to inform the development of sustainability-oriented science education in culturally rich regions such as Yogyakarta, Indonesia?

METHODS

This review adhered strictly to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement (Page et al., 2021). A comprehensive literature search was conducted in Scopus on September 5, 2025. Scopus was selected because it is a premier peer-reviewed multidisciplinary database that provides rigorous quality control, citation tracking, and extensive coverage of international science education, ethnomedicine, and ethnobiology literature.

The executed search syntax was structured as follows: TITLE-ABS-KEY (“traditional” AND “medicine” AND “local” AND “cultural”). Filters restricted records to Publication Years (2019-2025), Document Type (Article), Language (English), and Access (Open Access). The initial search yielded 1,507 records. After title and abstract screening, 659 records were evaluated, and 404 were sought for full-text retrieval. After removing non-retrievable reports and applying strict eligibility criteria (excluding theoretical reviews, book chapters, non-empirical briefs, and studies lacking pedagogical relevance), a final set of 21 high-quality empirical studies was included for in-depth thematic synthesis.

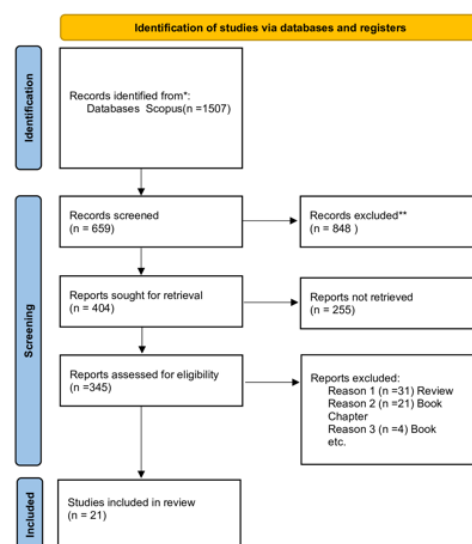


Figure 1. PRISMA 2020 Flowchart Illustrating Study Identification, Screening, Eligibility, and Inclusion Process (Generated Using <https://www.prisma-statement.org>)

To ensure screening objectivity and analytical rigor, two independent reviewers evaluated the eligibility of the retrieved records. Inter-reviewer agreement during full-text screening was quantified using Cohen’s Kappa coefficient (κ). The inter-rater reliability reached $\kappa = 0.82$, indicating strong consensus. The team resolved discrepancies during screening through structured discussion and adjudication by a third senior reviewer.

RESULTS AND DISCUSSION

Characteristics and Pedagogical Mapping of Included Studies

The 21 reviewed empirical studies represent diverse geographic regions, methodologies, and biological domains. Table 1 provides a structured summary of the primary empirical literature included in this systematic review.

Table 1. Summary of Reviewed Empirical Studies on Biocultural Integration (n=21)

No	Author & Year	Country	Publisher	Research Method	Main Findings	Educational Outcome
1	Nambiar & Mishra (2019)	India	Taylor & Francis	Qualitative Ethnography	Healer power is rooted in sacred callings and local networks.	Moral authority and socio-cultural framing in health units.
2	Maroyi (2023)	Kenya	AJFAND	Narrative Review	Pouzolzia mixta treats 48 diseases and is rich in flavonoids.	Empirical content for plant chemistry/ biology laboratory modules.
3	Packer et al. (2019)	Australia	Springer Nature	Action Research	Trust-building enables co-validation of customary medicines.	Framework for ethical community-school STEM collaboration.
4	Marques et al. (2023)	New Zealand	Taylor & Francis	Design Research	Rongoā healing gardens enhance cultural restoration.	Living outdoor laboratory model for place-based science inquiry.
5	Hailu et al. (2020)	Ethiopia	Springer Nature	Cross-sectional	85.9% of pediatric traditional medicine use driven by beliefs.	Highlights the need for community health literacy in science.
6	Zemedet et al. (2024)	Ethiopia	Springer Nature	Ethnobotanical Mixed	188 medicinal species recorded; threatened by deforestation.	Quantitative reasoning via ethnobotanical index calculation.
7	Nguyen et al. (2019)	Vietnam	Univ. Hasannuddin	Market Fieldwork	99 species sold in markets; high consensus for digestive care.	“Pasar Etnobotani” market inquiry activities for secondary science.
8	Alemu et al. (2024)	Ethiopia	Springer Nature	Ethnobotanical Mixed	134 plant species identified; leaves most utilized (47.3%).	Integrate conservation ethics and plant taxonomy into the module.
9	Howland (2020)	Kenya	Springer Nature	Ethnographic	Preference for indigenous care due to distrust of fake drugs.	Chemical safety, public health, and ethical literacy units.

No	Author & Year	Country	Publisher	Research Method	Main Findings	Educational Outcome
10	Liufu et al. (2023)	China	Springer Nature	Ethnobiology Survey	Documented 51 feed and 62 ethnoveterinary species.	Expands TEK into ethnoveterinary and agricultural science.
11	Rahman et al. (2022)	Pakistan	Springer Nature	Ethno-ornithology	64 waterbird species used in traditional healing.	Broadens TEK to avian ecology and wildlife conservation.
12	Hove et al. (2019)	Zimbabwe	Johns Hopkins CCP	Field Action	98% chose circumcision when integrated with tradition.	Illustrates integration of modern medicine and local culture.
13	Misaki (2021)	Fr. Polynesia	Soc. Océanistes	Ethnography	Pragmatic and theological efficacy co-exist in healing.	Connects science learning to cultural-spiritual identity.
14	Chebii et al. (2020)	Kenya	Springer Nature	Mixed-Methods	High secrecy; practitioners lack legal awareness.	Policy literacy and IP rights (Nagoya Protocol) in STEM.
15	Manzoor et al. (2023)	India	Springer Nature	Ethnobotanical	110 species documented under commercial pressure.	Fosters ecological transition and community health inquiry.
16	Vinagre et al. (2019)	Portugal	Springer Nature	Ethnobotanical	105 plant taxa recorded in protected landscapes.	Regional biodiversity cataloging and botany instruction.
17	Pullen et al. (2021)	Liberia	Makerere Univ.	Qualitative In-depth	Spiritual idioms dominate local mental healthcare.	Comparative health systems and socio-scientific reasoning.
18	Liu et al. (2024)	China	Springer Nature	Fieldwork Mixed	55 animal-derived traditional medicines documented.	Introduces ethnozoology into zoology and pharmacology.
19	Bautista-González et al. (2022)	Mexico	Springer Nature	Mycological Ethno.	14 fungi and 6 lichens used medicinally.	Fills a critical research gap in mycology/lichenology teaching.
20	Miyamoto et al. (2021)	Fiji	Springer Nature	Field Regression	Social cohesion significantly drives sustainability ($p = 0.03$).	Links community solidarity to environmental conservation.
21	Awoke et al. (2025)	Ethiopia	Springer Nature	Mixed Ethnobotanical	Documented 122 species; habitat loss is a major threat.	Drives conservation action and in-situ garden initiatives.

Detailed Synthesized Thematic Clusters and Pedagogical Translations

To provide a rigorous analytical synthesis of the global corpus without relying on ASCII diagrams, the 21 empirical studies were catego-

rized into five interconnected thematic domains. Table 2 provides an overview of these synthesized clusters, mapping each thematic dimension to its pedagogical translation and its target science domain.

Table 2. Comprehensive Synthesis of Biocultural Thematic Clusters and Science Curriculum Integration

Thematic Cluster	Primary Empirical Focus (Selected Corpus Studies)	Pedagogical Translation & Instructional Strategy	Target Science Curriculum Domain
Cluster 1: Ethnobotanical Quantitative Frameworks	Nguyen et al. (2019); Alemu et al. (2024); Zemedede et al. (2024); Manzoor et al. (2023)	Field data collection, calculation of consensus indices (ICF, RFC, FL), and extraction of plant secondary metabolites.	Botany, Organic Chemistry, Plant Physiology, and Educational Mathematics (STEM)
Cluster 2: Co-Designed Outdoor Living Laboratories	Marques et al. (2023); Packer et al. (2019); Awoke et al. (2025)	School medicinal herb gardens (e.g., <i>Rongoā</i> models), indigenous elder co-teaching, soil pH testing, and microclimate measurement.	Ecological Science, Soil Chemistry, Agronomy, and Experiential Environmental Education
Cluster 3: Socio-Cultural, Spiritual, & Ethical Governance	Nambiar & Mishra (2019); Chebii et al. (2020); Howland (2020); Hove et al. (2019)	Socio-scientific issues (SSI) debates, the Nagoya Protocol, IP literacy, and toxicological testing for counterfeit herbal mixtures (“fake <i>jamu</i> ”).	Analytical Chemistry, Toxicology, Public Health Literacy, and Bioethics
Cluster 4: Biodiversity Conservation & Ecological Agency	Vinagre et al. (2019); Miyamoto et al. (2021); Awoke et al. (2025)	Mapping local biodiversity loss, assessing anthropogenic threats to flora, and linking community social cohesion to conservation stewardship.	Conservation Biology, Environmental Impact Assessment, and Education for Sustainable Development (SDG 11/15)
Cluster 5: Multi-Taxa “One Health” TEK Expansion	Rahman et al. (2022); Liu et al. (2024); Liufu et al. (2023); Bautista-González et al. (2022)	Inquiry into non-plant TEK including avian species, animal pharmacology, ethnoveterinary remedies, medicinal fungi, and lichen symbiosis.	Zoology, Avian Ecology, Mycology, Veterinary Science, and “One Health” Interdisciplinary Biology

Theme 1: Dominance of Ethnobotanical Frameworks and Mathematical-Scientific Integration

Ethnobotanical research represents the primary domain of biocultural literature, accounting for over 52% (n=11) of the total corpus (e.g., Vinagre et al., 2019; Manzoor et al., 2023; Alemu et al., 2024; Zemedede et al., 2024; Awoke et al., 2025). The synthesized studies show that indigenous communities maintain extensive empirical knowledge of plant taxonomy, use of plant parts, and preparation techniques. From a pedagogical perspective, the true power of ethnobotanical TEK lies in its ability to bridge qualitative community wisdom with quantitative mathematical-scientific analysis.

Primary studies often use mathematical agreement metrics to quantify traditional know-

ledge, including the Informant Consensus Factor (ICF), which Nguyen et al. (2019) used in Vietnamese traditional markets, achieving values up to 0.97 for digestive treatments. ICF measures the uniformity of knowledge among informants using the following equation: $(Nur - Nt) / (Nur - 1)$, where *Nur* represents the number of use citations for a specific disease category, and *Nt* is the number of taxa used. Relative Frequency of Citation (RFC) and Use Value (UV) were employed in Ethiopian and Himalayan ethnobotanical surveys (Alemu et al., 2024; Manzoor et al., 2023) to establish the cultural importance of plant species. Fidelity Level (FL) was applied by F. Rahman et al. (2022) to evaluate species specificity for treating particular ailments.

In secondary science classrooms, integrating these ethnobotanical metrics transforms

passive biology lectures into active, interdisciplinary STEM investigations. Students perform real-world data processing, compute statistical consensus indices from field interviews, and evaluate chemical properties (e.g., secondary meta-

bolites like flavonoids and tannins documented in *Pouzolzia mixta* by Maroyi, 2023). Table 3 outlines how ethnobotanical research components map directly onto secondary science learning competencies.

Table 3. Pedagogical Translation Matrix: Ethnobotanical Field Indicators to Secondary Science Competencies

Ethnobotanical Indicator / Metric	Field Scientific Meaning	Secondary Science Learning Competency	Interdisciplinary STEM Link
Plant Part Preference (e.g., Leaves 47.3%)	Identifies plant anatomical organs richest in active compounds.	Botany & Organ Physiology (Photosynthesis, Stomata, Secondary Metabolites)	Biology & Chemistry
Informant Consensus Factor (ICF)	Measures community agreement on medicinal efficacy.	Data Analysis, Statistical Probability, & Informant Sample Consensus	Biology & Mathematics
Fidelity Level (FL) %	Quantifies species-specific treatment usage.	Pharmacology, Dosage Calculations, & Specificity Testing	Chemistry & Statistics
Threat Index / Deforestation Loss	Evaluates anthropogenic pressure on local flora.	Ecology, Ecosystem Conservation, & Environmental Impact Assessment	Biology & Environmental Science

Theme 2: Co-Designed Living Laboratories and Place-Based Outdoor Inquiry

The synthesis highlights that biocultural knowledge cannot be effectively transmitted through abstract textbook reading alone; it requires place-based, experiential learning environments. Marques et al. (2023) demonstrated that establishing cross-cultural *Rongoā* (Māori healing) gardens in urban landscapes creates outdoor “living laboratories” that restore cultural identity while fostering environmental health. Similarly, Packer et al. (2019) emphasized that participatory action research between indigenous elders and school STEM educators enables co-designed learning activities rooted in mutual trust and reciprocal validation.

Living laboratories allow students to engage in multi-sensory scientific inquiry across several domain topics. In Soil Science and Chemistry, they analyze soil pH, organic matter, and moisture retention in plots cultivated with traditional medicinal herbs versus commercial crops. In Plant Morpho-Anatomy and Taxonomy, they examine leaf morphology, root structures, and the reproductive biology of native medicinal flora in situ (Awoke et al., 2025). In Ecological Interactions and Microclimates, they observe pollinator

behavior, plant-fungal mycorrhizal associations, and microclimate variations in biodiversity-rich herbal gardens (Bautista-González et al., 2022).

Theme 3: Socio-Cultural, Spiritual, and Ethical Governance Dimensions

Traditional medicine operates within intricate socio-cultural, spiritual, and governance frameworks that distinguish it from conventional Western biomedical instruction (Nambiar & Mishra, 2019; Misaki, 2021). The reviewed literature indicates that healing practices are frequently intertwined with spiritual authority, ancestral callings, and sacred natural sites (Pullen et al., 2021). Ignoring these cultural-spiritual drivers creates epistemological resistance among indigenous and rural students.

Furthermore, the synthesis highlights critical governance and legal issues that serve as authentic contexts for Socio-Scientific Issues (SSI) instruction. First is Intellectual Property Rights and Secrecy. Chebii et al. (2020) found that traditional medicine practitioners in Western Kenya operate under high secrecy because legal frameworks do not protect their indigenous intellectual property. Science curricula can incorporate discussions on the Nagoya Protocol, access-and-

benefit-sharing (ABS), and ethical bioprospecting (Buck & Hamilton, 2011). Chemical Safety and Counterfeit Drugs are also highlighted. Howland (2020) and Hung (2020) documented growing community distrust toward fake biomedical drugs and adulterated herbal mixtures (“fake *jamu*”). In chemistry education, this provides an authentic entry point for teaching analytical testing, label verification, solvent extraction, and toxicological safety. Regarding Biomedical Integration, Hove et al. (2019) demonstrated that integrating biomedical safety into traditional cultural camps in Zimbabwe achieved a 98% acceptance rate, showing that modern scientific safety and cultural traditions can coexist harmoniously.

Theme 4: Biodiversity Loss, Threats, and Conservation Stewardship

A recurring theme across global empirical studies is the rapid depletion of biocultural assets due to habitat destruction, deforestation, agricultural expansion, and over-commercialization (IP-BES, 2019; Manzoor et al., 2023; Alemu et al., 2024; Awoke et al., 2025). Traditional ecological knowledge is inherently vulnerable to extinction as local ecosystems degrade.

Integrating TEK into school science transforms abstract environmental conservation concepts into active community stewardship. When students map local medicinal plant degradation and document community conservation practices, they develop ecological agency. As Miyamoto et al. (2021) established in Fiji, community social cohesion is significantly correlated with environmental conservation success ($p = 0.03$). Science education grounded in biocultural conservation fosters both ecological literacy and civic responsibility, directly supporting SDG 11 (Sus-

tainable Cities and Communities) and SDG 15 (Life on Land).

Theme 5: Multi-Taxa Expansion Beyond Plant-Centric Knowledge

While ethnobotany dominates current literature, the synthesized corpus reveals critical, underrepresented non-plant TEK domains that offer transformative potential for holistic biology and One Health education:

Ethno-ornithology and Wildlife Ecology: Rahman et al. (2022) documented 64 waterbird species utilized in traditional healing in Pakistan. Translating ethno-ornithology into secondary biology introduces bird migration patterns, wetland ecology, and wildlife conservation ethics.

Ethnozoology and Animal Pharmacology: Liu et al. (2024) identified 55 animal-derived traditional medicines among the Gelao people in China. Ethnozoological instruction bridges animal physiology, comparative anatomy, and awareness of zoonotic disease.

Ethnoveterinary and Agricultural Science: Liufu et al. (2023) surveyed 51 feed plants and 62 ethnoveterinary species used for local livestock in Hakka communities. Ethnoveterinary units illustrate sustainable animal husbandry and natural veterinary pharmacology.

Ethnomycology and Lichenology: Bautista-González et al. (2022) documented 14 medicinal fungi and 6 lichen species among Yuman communities in Mexico, providing rare empirical materials for fungal taxonomy, spore biology, and lichen symbiosis.

Table 4 provides a structured breakdown of this multi-taxa “One Health” framework, detailing how each biological domain bridges indigenous knowledge with secondary science topics.

Table 4. Multi-Taxa “One Health” Biocultural Learning Framework

Biological Domain	Empirical Target (Corpus Source)	Indigenous Ecological Knowledge (TEK) Focus	Secondary Biology & Chemistry Integration Topic	Interdisciplinary “One Health” Connection
Ethnobotany	188 Plant Taxa (Zemede et al., 2024)	Herbology, plant collection seasons, traditional preparation	Plant anatomy, organ systems, secondary metabolites (flavonoids, alkaloids)	Plant biodiversity, sustainable agriculture, and herbal medicine safety
Ethnozoology	55 Animal Taxa (Liu et al., 2024)	Faunal medicinal usage, traditional animal tracking and habitat knowledge	Animal physiology, comparative anatomy, vertebrate taxonomy	Zoonotic disease prevention, animal welfare, and wildlife trade ethics

Biological Domain	Empirical Target (Corpus Source)	Indigenous Ecological Knowledge (TEK) Focus	Secondary Biology & Chemistry Integration Topic	Interdisciplinary “One Health” Connection
Ethno-ornithology	64 Waterbird Taxa (Rahman et al., 2022)	Avian medicinal use, seasonal migration observations, wetland lore	Ornithology, ecosystem service evaluation, wetland conservation	Migratory bird conservation, aquatic ecosystem health, and avian flu risk
Ethnomycology & Lichenology	14 Fungi & 6 Lichens (Bautista-González et al., 2022)	Fungal foraging, bio-indicator licensing, traditional mushroom preparation	Fungal kingdom taxonomy, spore reproduction, mycorrhizal symbiosis	Soil microbiome balance, forest ecology, and fungal biochemical discovery
Ethnoveterinary	62 Veterinary Species (Liufu et al., 2023)	Livestock health maintenance, natural feed formulations, herbal pest repellents	Applied veterinary biology, agricultural biochemistry, animal nutrition	Antibiotic stewardship, organic livestock farming, and sustainable food systems

Contextual Application: Five-Point Curriculum Blueprint for Indonesia’s Kurikulum Merdeka

To operationalize these synthesized global insights within regional educational policy, this review proposes a structured five-point curriculum blueprint specifically tailored for Indonesia’s *Kurikulum Merdeka*, targeting culturally rich regions such as Yogyakarta. This blueprint seamlessly embeds biocultural assets into the *Projek Penguatan Profil Pelajar Pancasila* (P5) and core secondary biology/chemistry competencies. The first is the *Kebun Jamu* Living Laboratory (School Medicinal Garden). Schools establish living herbal gardens featuring local medicinal species (e.g., *Curcuma longa*, *Zingiber officinale*, *Kaempferia galanga*). Students create QR-coded plant tags linked to digital modules that include scientific taxonomy, active phytochemical compounds, and traditional usage narratives. The program also includes a *Pasar Etnobotani* Field Inquiry. Students conduct structured fieldwork in local traditional markets (*Pasar Tradisional*) to interview herbal traders, catalog medicinal flora, and compute Informant Consensus Factor (ICF) and Relative Frequency of Citation (RFC) values using school algebra and statistics skills. One Health & Ethnoveterinary Integration expands Biology modules to include local livestock care, exploring how traditional plant remedies maintain animal health and mitigate zoonotic risks without overreliance on synthetic chemicals. In Governance, Chemical Safety, and Ethical Literacy, chemistry and socio-scientific units incorporate laboratory testing for heavy metals and synthetic adulterants in commercial herbal extracts (“fake *jamu*”), while

discussing intellectual property protection under the Nagoya Protocol. Moreover, student learning is evaluated using Biocultural Performance-Based Assessment through authentic rubrics assessing scientific inquiry, statistical data processing, community interview ethics, and cultural stewardship contributions.

CONCLUSION

This systematic literature review shows that integrating traditional medicine and local wisdom into science education provides a robust pathway to advance SDG 4 (Quality Education) and SDG 11 (Sustainable Cities). Synthesizing 21 empirical studies demonstrates the versatility of TEK in promoting quantitative reasoning, place-based inquiry, ethical socio-scientific reflection, and multi-taxa ecological awareness. The proposed five-point blueprint offers an actionable pathway for embedding biocultural assets into Indonesia’s *Kurikulum Merdeka*. Future research should focus on multi-taxa learning environments and longitudinal studies measuring the impact of ethnoscience instruction on student scientific literacy, cultural identity, and environmental stewardship.

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