Ethnobiological Research by Local People/Methodological Approaches

Devyani Rajput, Rakhi Khabiya, Akanksha Dwivedi and G.N. Darwhekar

Correspondence

Devyani Rajput[1], Rakhi Khabiya[1,2], Akanksha Dwivedi[2*] and G.N. Darwhekar[2]

[1]Amity Institute of Pharmacy, Amity University, Gwalior, P. O. Box 474005, Madhya Pradesh, India.
[2]Acropolis Institute of Pharmaceutical Education and Research, Indore, P. O. Box 453771, Madhya Pradesh, India.

*Corresponding Author: akd.pharma@gmail.com

Ethnobotany Research and Applications 27:36 (20xx) - http://dx.doi.org/10.32859/era.27.36.1-18
Manuscript received: 27/08/2024 – Revised manuscript received: 02/09/2024 - Published: 02/09/2024

Research Methods and Methodology Reviews

Abstract

Background: Ethnobiological research undertaken by locals provides essential insights into the complex interactions between human populations and their surroundings. This review paper presents a synthesis of methodological approaches used in ethnobiological investigations involving local knowledge.

Methods: Drawing on a wide range of literature, the study evaluates participatory methods, ethnographic techniques, quantitative approaches, and mixed methods tactics used to reveal local ecological knowledge, resource management practices, and cultural perspectives on biodiversity.

Results: Through case studies from various ecological and cultural situations, we demonstrated the need of incorporating indigenous perspectives into ecological preservation and sustainable development projects.

Conclusions: The review addresses problems such as ethical concerns, difficulties with language, and access issues, as well as making ideas for further investigation. By developing collaborative alliances with local people and connecting traditional systems of knowledge in scientific studies, ethnobiological research can help to advance more holistic approaches to environmental protection and cultural preservation.

Keywords: Ethnobiological research, Local knowledge, Methodological approaches, Participatory methods and Ethnographic techniques

Background

The importance of the human aspect in conservation science is becoming more evident since it plays a crucial role in addressing both long-standing and emerging conservation challenges. In order to achieve success, it is crucial that solutions to these conservation issues are culturally suitable, as determined by their acceptance and execution by the local population who coexist with the species we aim to protect (Ladio 2017). Hence, it is imperative that we engage in the examination, comprehension, and appreciation of the indigenous population's understanding of their surroundings and their methods of handling it as seen in Figure 1 for its themes.

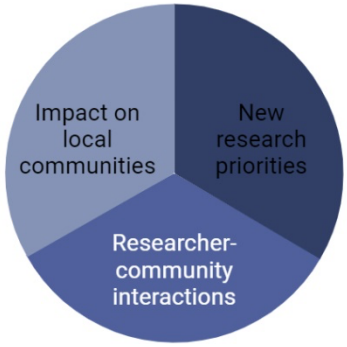

Figure 1. Schematic representation of three common themes in ethnobiology

The literature generally treats the recognition of ethnobiology's potential contribution in this setting as a parallel issue, with the discipline frequently being misunderstood or overlooked (Gaoue *et al.* 2021). Research on the human element in conservation identifies several interdisciplinary topics, including environmental anthropology, environmental sociology, human-environment geography, and environmental humanities. However, they fail to acknowledge ethnobiology as a crucial discipline within the domain of social conservation science. This suggests that ethnobiology needs further progress to successfully integrate the fields of biology and mathematics (Reyes-García V 2010).

To achieve this, ethnobiology must embrace the theory-inspired and hypothesis-driven approach that we have just suggested, aligning with the viewpoints of several authors during the last five decades. Furthermore, in order to enhance the rigor of the methodology, it is crucial for ethnobiology to adopt advanced methodological approaches, including new statistical modeling tools, while yet maintaining the effectiveness of qualitative methods that offer significant contextual information(Turner *et al.* 2022).

Ethnobiology is the scientific discipline that investigates the intricate relationships among human beings, living organisms, and cultural practices. Due to its interdisciplinary nature, the majority of ethnobiologists possess expertise in either biology, enabling them to confidently conduct interviews and inquire about the utilization of plants and animals in the environment, or anthropology, as they are inclined to study, identify, and document various plant and animal species (Gutiérrez-Santillán *et al.* 2019). The dual origin of ethnobiologists aligns with the mixed methodological culture of this field and has resulted in some methodological difficulties that it currently confronts. Ethnobiologists have been acquainted with a wide range of disciplines and analytical approaches for many years. These procedures are widely recognized and extensively documented in a series of exceptional books, and they are routinely employed in this discipline. Nevertheless, the majority of ethnobiological studies typically incorporate a greater number of tables as opposed to figures, and often exhibit a deficiency in statistical rigor(Alves and Souto 2011).The influential papers led to multiple investigations that sought to validate theories using conventional statistical methods, such as one-way analysis of variance, Student's t-test, and chi-squared test. Nevertheless, the majority of quantitative approaches in ethnobiology were constrained to utilizing metrics such as species significance indices.

The field of ethnobiology has achieved significant advancements due to the emergence of novel statistical techniques, including classification, ordination, and general linear models (Pfeifferand Butz 2005). Begossi (1996) introduced the ecological methodologies of diversity rarefaction approaches, which have gained widespread acceptance in ethnobotanical research. As a result, many studies have used rarefaction analysis to measure the abundance of plant knowledge in different local communities (da Silva *et al.* 2019). Although there has been improvement, the majority of quantitative ethnobiological methodologies are employed without a well-defined conceptual framework, which limits our comprehension of the mechanisms underlying plant utilization and selection. In a recent study, Gaoue *et al.* (2017) put out a compilation of 17 hypotheses in ethnobotany that can be tested. This work establishes a basis for the application of advanced statistical methods to improve ethnobiology as a scientific field. Currently, there is a growing although limited quantity of ethnobiological investigations that are based on certain hypotheses (Hidayati *et al.* 2015). Considering that most Ph.D graduates are more interested in jobs in industry rather than tenure-track teaching positions, and those ethnobiologists who do manage to secure academic positions usually join life sciences or ecology as well as evolutionary biology departments, it is essential for ethnobiological education to include a comprehensive toolkit for quantitative analysis(O'Neill *et al.* 2017). This toolset should encompass advanced statistical modeling methods in addition to traditional statistical analysis. Gaining

proficiency in these sophisticated analytical methodologies will enhance the competitiveness of ethnobiologists in the employment market and enable them to further our comprehension of how individuals choose plants and animals for utilization, therefore influencing their environment in a deliberate manner (Casagrande 2004). The limited uptake of contemporary statistical tools in ethnobiology can be attributed to their perceived intricacy and the requirement of utilizing syntax-based computer applications like R for conducting these studies. In addition, we hypothesize that providing a concise explanation of how these advanced methods can be applied in ethnobiology, offering practical instances where these methods can be used to investigate ethnobiological research inquiries, and supplying well-annotated seed R scripts that demonstrate the implementation of these methods will increase the probability of ethnobiologists adopting these new tools (Caron-Beaudoin and Armstrong 2019, Heinrich *et al.* 2009).

In this paper, we present a compilation of new techniques and approaches that can be used to conduct hypothesis-driven research in the field of ethnobiology. This involves the utilization of diverse statistical techniques in ethnobiology research, including generalized linear mixed-effect modelling, structure equation modelling, phylogenetic generalized least squares, community phylogenetic instruments social network analysis, species distribution modelling, geographical ecological tools, and predictive modeling (Silva and de Almeida 2022). Every quantitative method is exacerbated by a succinct discussion of its objectives, as well as the rationale and techniques used to assess ethnobiological hypotheses. Additionally, we give exemplar or foundational R scripts that demonstrate the practical application of these methods to real-world field data. We chose these quantitative methodologies for two primary reasons (Stagg and Dillon 2022). These strategies are frequently employed in the field of biological sciences. Acquaintance with these methods will enable ethnobiologists to effectively convey their scientific findings to a wider range of people. Furthermore, these techniques are especially valuable for evaluating ethnobiological hypotheses, allowing ethnobiologists to circumvent prevalent flaws in statistical data processing (Hanazaki *et al.* 2013, Gilmore and Eshbaugh 2011).

Methodological Approaches in Ethnobiological Research

Qualitative Methods

Obtaining a mechanistic comprehension of the reasons behind the selection of plants or animals by local populations is a significant inquiry for ethnobiologists. At the heart of ethnobotany investigations lies the comprehension of how and why the combined impact of plant/animal features and human attributes influences the knowledge and utilization of plants by local communities (Heinrich *et al.* 2009, Stagg and Dhillon 2022). The likelihood of a specific plant species and family being selected and used as medicine is affected by the socio-demographic traits of these people who are utilizing the plant, as shown by several empirical and theoretical research. For instance, certain plant species have a higher level of utilization by specific genders or age groups compared to others. Medicinal and food plants are chosen based on their chemical characteristics and, indirectly, their morphological characteristics. It is crucial to thoroughly explore these qualities in order to acquire a detailed understanding of how human civilizations have selected plants throughout history and in the present (Gaoue *et al.* 2017).

The data sets used to assess these hypotheses often consist of species or participants as observations. To assess hypotheses accurately, it is essential to verify that the premise of independent observations is not broken. However, it is important to consider the prevalence of evolutionary connections among plant species and the existence of kinship, social affiliations, or spatial autocorrelation among human participants when accounting for non-independent observations (Popović *et al.* 2016, Chellappandian *et al.* 2012). Phylogenetic generalized least square (PGLS) methods are used to consider the evolutionary relationship between plant species and confirm the importance of phylogeny in determining the medicinal properties of plants. Utilizing subjects as unobserved variables in generalized mixed-effect of hierarchical models can successfully handle the problem of familial or genealogical relatedness among participants. Ethnobiology should recognize the importance of socio-relational links in the formation, modification, and spread of knowledge. The dynamics of local ecological knowledge are significantly influenced by social influence, social capital, and homophily (Caggiano and Weber 2023). Despite the crucial role that social contacts play in community dynamics, ethnobotanical literature frequently overlooks these interactions as influential factors in knowledge acquisition and subsequent behavior. Controlling for the influence of relationship effects is crucial when examining the impact of other factors on knowledge, such as human demographic variables or species physical and chemical traits. Social network analysis is a valuable tool in ethnobiology for comprehending the factors that influence the selection and utilization of plants or animals for sustenance, as well as for evaluating the methods through which knowledge is transmitted (Jones *et al.* 2024). Distinguishing between correlation and causation is a crucial topic in the fields of biology and social sciences. Nevertheless, establishing causation is unattainable by the utilization of conventional statistical techniques, which solely assess association. Identifying causal relationships becomes very difficult when dealing

with several predictor factors (Zent and Maffi 2009). Multiple predictors are rarely used in ethnobiological investigations, as researchers commonly prefer to use multiple one-way evaluations of variance instead of the theoretically more useful multiple regression. Structural equation modeling is a powerful method that allows for the analysis of interconnected hypotheses, making it possible to combine many predictors, some of which may be correlated, to demonstrate causation. Testing predictions to uncover generalizable principles is a crucial aspect of hypothesis testing and theory construction (Loch and Riechers 2021, Swanson and Ardoin 2021).

The primary objective of statistical analysis in ethnobiology is to test hypotheses by elucidating patterns in data. Alternatively, a more straightforward method of theory building involves evaluating the extent to which statistical models can be applied to data that were not utilized in the model's construction. Predictive modeling, also referred to as species distribution modeling, has predominantly been employed to construct species range maps that account for both present and future climate conditions. However, predictive modeling approaches can be included into other statistical models, including all the models discussed in this article (Odmell *et al.* 2019, Dufour *et al.* 2019).

Participant Observation

As previously said, while gathering information about individuals' experiences and opinions on a specific topic, one can directly inquire through the use of questionnaires and interviews. Pinheiro *et al.* note that while studying the relationship between individuals and their surroundings, many of the routine actions performed by people go unobserved by them (Deletre *et al.* 2012). Therefore, even if these individuals are inclined to disclose such actions, they frequently lack the ability to furnish dependable data on certain subjects. Observation-based research are significant in this context. Combessie argues that participant observation is a suitable method for making initial contact with a community since it provides the opportunity to investigate and understand its reality. Participant observation enables the collection of data regarding the daily activities of the community being studied (Agnoletti and Emanueli 2016). To accomplish this, the researcher must possess the ability to retain and recall the events witnessed and heard, and thereafter record them in a specific sequence, preferably in chronological order. A significant portion of the gathered data consists of qualitative information, specifically, field notes documenting various circumstances, photos, and records of discourse(de la Torre and Morelos-Juárez 2022). Participant observation and participatory research should not be confused as they have distinct objectives. Participant observation enables the researcher to acquire a deeper comprehension of the subject under investigation. However, it has limitations because it is impossible to watch every aspect of the phenomenon in a completely reliable manner (Ferreiraet al.2020). The observer must selectively choose which individuals, facts, and situations to focus on. Montenegro suggests that participant observation can be either comprehensive or marked by total objectivity. Full participation requires the investigator to fully connect with the local community and actively embrace its traditions and practices (Asprilla-Perea *et al.* 2020). This method also allows for an internal analysis of the seen reality, helping individuals to comprehend how a cultural aspect, based on widely accepted and authorized beliefs, adds to the comprehension of local plant life (Scholz and Binder 2011). Research undertaken through firsthand or participant observation follows a three-stage process, with each stage building upon the previous one in a sequential manner:

- The process of choosing and clearly stating difficulties "During this stage, the observer seeks out the problems and concepts that can provide the most comprehensive understanding of the organization being studied." When conducting an investigation, it is crucial for the investigator to carefully assess the reliability of informants and the characteristics of their comments, such as whether they are intentional or spontaneous. When encountering such situations, it is important to document all unique aspects pertaining to the observed phenomenon or provided information in the field diary, so that they can be thoroughly evaluated at a later time(Pérez-Rodríguez *et al.* 2023).
- The observer, who possesses knowledge of various problems, concepts, and temporary indicators, seeks to determine which ones are worth investigating as the primary focus of their study. This entails regulating the frequency and dispersion of these events (Anderson *et al.* 2021).
- Model construction In the last stage of field analysis, the individual findings are combined and incorporated into the overall model of the social systems or organization under study, or a particular aspect of that organization (Scholz and Binder 2011).

In our specific situation, this step is intended to give importance to the data collected on the relationship between individuals with plants. Initially, the observer has the ability to establish and delineate the connections that exist within the system. Subsequently, they have the ability to categorize the phenomena through an analytical procedure (Ferreira *et al.* 2020). Surprisingly, just a few ethnobiological studies exclusively use observation as its methodological technique. Investigators often require the integration of data obtained through participation plus data collected utilizing alternative methodological

approaches. Often, conflicting elements emerge and necessitate profound reflection and the formulation of questions to grasp what may appear to be a straightforward contradiction (Asprilla-Perea *et al.* 2020, Kidist 2023).

Semi-structured and Unstructured Interviews

Semi-structured interviews, as the name suggests, fall in between the two styles listed above. In this scenario, the investigator prepares some of the questions in advance before conducting field research. However, these questions are mostly adaptable, allowing for greater focus on any issues that may arise during the interview (Agnoletti and Emanueli 2016). The investigator may provide an overview of the topics beforehand and have a guide to help direct the interview. Semi-structured conversations are the best technique to use if it is not possible to interview the same informant again. This strategy's "open" element allows respondents to answer questions according to their own interpretations (Adeoye-Olatunde and Olenik 2021). It's crucial to understand that this strategy does not suggest that the investigator should give them complete freedom of speech. When the informants stray from the main subject of the interview, the interviewer should not abruptly interrupt them in order to preserve the focus of the study. According to Aguiar and Medeiros, in order to use this method, the investigator must conduct the interview themselves rather than assigning it to someone else because it requires in-depth knowledge of the subject (Chauhan 2022, Minhat 2015). Like an observation plan used for participant observation, a thorough interview guide must be created before the interview is conducted. A thorough list of the precise subjects, issues, questions, and topics that will be covered during the interview should be included in this guide. Therefore, it is essential that the guide be simple to use and effective in order to set up the structure of the interview and stop the interviewer from spending too much time focusing on some issues while ignoring others (Mestre *et al.* 2012).

Focus Group Discussions

Focus groups are employed as a data collection strategy that prioritizes the exchange of ideas and dialogue among a group of participants and the researcher. The effectiveness of this method depends on accurately defining a "focus" subject that will be analyzed by the group under the supervision of the investigator (de la Torre and Morelos-Juárez 2022). This technique can be employed to collect ethnobiological data for the following purposes:

- To generate hypotheses by analyzing the discussions among informants regarding a subject raised by the investigator;
- To obtain the group's explanations of the events, facts, or classifications that were identified all through the study; and
- When assessing strategies for gathering data, it is advisable to examine the utilization of group discussions as a supplementary way alongside other methodologies.

For instance, a focus group may comprise community people who actively participate in therapeutic methods to ascertain the importance of different ailment classifications (Tunon *et al.* 2016, Nugroho *et al.* 2023). The investigator must have discerning judgment when choosing this strategy and must consider the following suggestions:

- The ideal composition of the groupings should comprise individuals who are unfamiliar with each other and do not share any familial relationships (Shrivastava *et al.* 2023).
- Precise documentation of the data is necessary to facilitate the identification of each participant's distinct discourse plus the convergence of their discourses (Asprilla-Perea *et al.* 2020).
- It is important to regulate the workplace dynamics as those with a more dominant personality may hinder others or monopolize the conversation. This technique can be implemented in three distinct phases (Agnoletti and Emanueli 2016).

Oral Histories and Narratives

This style is characterized by its lack of limitations and reliance on personal opinions, where communication occurs from an individual's point of view. Commonly employed in the field of sociology, the life history or oral history method can facilitate a deeper exploration of particular subjects while also separating itself from its usual autobiographical orientation (Pinheiro *et al.* 2020). The resultant documents are frequently classified as focal & case studies. These investigations are seldom employed in ethnobiological research, potentially because they lack crucial elements for understanding more extensive phenomena. Given the high level of adaptability of this technique, it is crucial to use caution in order to efficiently attain the required objectives (Bechler 2023). An optimal approach involves the investigator guiding the informants along the pertinent trajectories of their lives that align with the study's desired objectives. For example, in the field of ethnobotany, the focus of research could be an individual who possesses extensive expertise in the indigenous flora of a particular region (Wetselaar

et al. 2023). Due to its aim of depicting multiple aspects of the chosen character, this study will be constrained in terms of making generalizations. However, this study will clarify certain difficulties, such as how knowledge is passed between the interviewee and their group, or the origin of their learning in specific cultural areas (Rajabi-Moghaddam and Abbaszadeh 2024). Aside from the need of carefully choosing the most suitable methodologies and approaches for your study, it is crucial to consider the necessary materials and resources for successful fieldwork. An investigator must own a "optimal foundational kit" consisting of tools and resources to streamline, enhance, and organize their work while residing in the community (Grytsai *et al.* 2021, Al-Dabbagh *et al.* 2023).

Quantitative Methods

Structured Interviews and Surveys

In structured interviews, the stimulus delivered to each respondent must be the same, which means that already planned questions are posed to each informant regardless of previous contacts with the target group. This strategy necessitates that the investigators have complete knowledge of the most important issues that will be investigated (Adeoye-Olatunde and Olenik 2021). This style of interview restricts the interviewee's (or respondent's) responses; yet, it enables the codification/categorization of the answers and provides for speedier production of materials for analysis. In this particular form of interview, it is imperative that the interactions between the interviewer and each interviewee are conducted in a manner that ensures maximum similarity. It is important that any biases caused by factor such as the environment, circumstances, and timing are consistent for all interviewers (Williams 2015). Conversely, various conditions should not be mistakenly seen as the same occurrence. Questionnaires and/or forms are highly valuable instruments for conducting structured or semi-structured interviews due to this rationale (Coulter *et al.* 2024). According to many scholars, the utilization of questionnaires inherently establishes structuration; therefore, an interview is inherently structured when questionnaires are employed. However, there is occasionally a differentiation between the utilization of questionnaires and forms, based on the method by which the data is gathered (Priya *et al.* 2022). When data is gathered through face-to-face interviews where the interviewer records the information, it is referred to as a form. On the other hand, when the informant completes the data themselves, it is called a questionnaire. However, the utilization of forms requires additional time and incurs higher costs (Inbakaran and Kroen 2011). The limitations of these tools are accentuated to varying degrees depending on the nature of the questions posed or the manner in which they are presented. In Brazil, acquiring more precise information can be accomplished by requesting the interviewee's date of birth instead of their age. This phenomenon can be attributed to a cultural predisposition to describe age using imprecise terminology (Liu *et al.* 2022). The questions in the instruments can be classified as either open-ended or closed-ended, with each type having its own advantages and disadvantages, particularly in relation to statistical analysis. Open-ended questions afford interviewees greater autonomy in their responses since the interviewer refrains from offering predefined answers. For instance, a question like "Elaborate on the process of harvesting plants for firewood" allows for a more open and unrestricted response (Kinyua 2023). Closed-ended questions are valuable because they generate consistent responses that can be either dichotomous (yes or no, true or false) or multiple choice. For example, a dichotomous closed-ended question could be "Do you use plants for firewood?" whereas a multiple choice closed-ended question could be "Which of the following materials are used for cooking in your home?" The available options for fuel are firewood, gas, coal, bagasse, or manure (Wong 2006). According to multiple authors, there are also semi-open-ended inquiries that are designed to elicit concise responses, such as "How frequently do you collect firewood?" Therefore, depending on the questions they contain, questionnaires can potentially introduce significant study bias. Prior to its implementation, it is advisable to do a preliminary evaluation or pilot study of questionnaires and forms using a small sample size Mitchell and Rich 2020). This will help assure the quality, clarity, validity, and reliability of the instrument. Now we will examine Bernard's classification and explanation of the use of these instruments, along with their respective benefits and drawbacks (Cao *et al.* 2017).

(a) Face-to-face encounter forms are utilized during direct interactions between the investigator and interviewee. The investigator asks questions and notes the answers on a form, clarifies any uncertainties, and provides relevant remarks. These forms have the benefit of extracting information from individuals who may not normally offer it (such as illiterate, blind, or elderly individuals), while also guaranteeing that all questions are answered (Serafini et al.2015). Proficiency is required to effectively utilize this particular format, especially when dealing with intrusive or highly provocative inquiries. Nevertheless, personal interviews are both costly and time-consuming, and typically require a sample that accurately represents the population. Forms are extensively utilized in ethnobiological research, but they are frequently misidentified as "questionnaires" (Al Mhdawi *et al.* 2020).

(b) Questionnaires also referred to as self-administered assessments, can be dispatched via mail to the recipient's residence, educational institution, or workplace. This method is preferred since it allows the respondent to fill out the questionnaire

without the presence of an interviewer. Questionnaires are effective tools for gathering data, but their usefulness is limited by the possibility that respondents may not follow instructions or provide responses (Nor *et al.* 2009). By asking all interviews the identical questions, the investigator can prevent any misinterpretation. Furthermore, there may be inquiries of a more intricate nature, as well as inquiries that necessitate comparatively lengthier durations to respond to (Robinson *et al.* 2007). Questionnaires are employed to circumvent the interviewee's inhibition resulting from the presence of the interviewer or while dealing with sensitive or intrusive themes, such as the gathering of resources in unlawful regions and discussions on religious or sexual matters. Nevertheless, the utilization of questionnaires lacks control over the respondents' interpretations of the questions and the sequence in which they respond (Fidel 2008).

Consequently, a particular question may be read before the questions that came before it have been answered, thus impacting the responses to the prior questions. Questionnaires are rarely utilized by researchers in ethnobiological studies (Trabelsi *et al.* 2022).

Engaging Local Communities and Stakeholders

We aim to engage individuals and communities in actively participating in the design and delivery of services they receive, ensuring that their involvement is both significant and inclusive. By collaborating across the system, we strive to ensure that services are accessible and beneficial to all individuals(Guise *et al.* 2013).

To ensure the effectiveness of our ICS, we will prioritize the involvement of local individuals and communities in both our actions and decision-making processes. This will facilitate the inclusion of all those who desire to participate in the process of recognizing problems and contributing to the discovery of effective solutions that align with their preferences and address the needs of local communities. In order to effectively address health inequalities and the issues encountered by health and care systems, it is imperative to have the perspectives and different thinking of local individuals (Ferreira *et al.* 2017).

The core principle of our collaboration as an Integrated Care System (ICS) will be to prioritize learning from the local community and, if necessary, implementing changes to enhance the collaboration between health and care partners (Eleanor *et al.* 2017). This will involve breaking down barriers between services and ensuring seamless coordination of care for individuals and communities. This involvement will entail an ongoing exchange of ideas and feedback between the care service providers and the individuals receiving those services, with the aim of consistently enhancing the quality of care and involving individuals in receiving personalized care (Camden *et al.* 2015).

The active participation and inclusion of individuals is crucial for enhancing the availability and fostering trust and assurance in the healthcare services we offer. Our engagement will consistently be significant, carried out with cultural proficiency, and we will strive to synchronize engagement and participation throughout the system, considering individuals' priorities and experiences within the context of their lives, not solely their health issues(Woolf *et al.* 2016, Salsberg *et al.* 2015).

Opportunities for developing global ethnobiologies

This study introduces four different techniques that can be used to enhance the scalability of place-based ethnobiological research and data. Each pathway is appropriate for distinct sets of ethnobiological enquiries; however, all of them rely on the collection of research data that is firmly rooted in certain cultural contexts and geographical locations (Ladio 2017, Santoro *et al.* 2018). By promoting communication among all parties involved, we can facilitate the method of extending and addressing real-world problems and worldwide research and decision-making. Indigenous Peoples and local communities, despite their vast range of historical, cultural, and ecological characteristics, frequently encounter comparable risks and difficulties that jeopardize their means of subsistence and overall welfare (Turner 2022). These difficulties are often associated with persistent settler & extractive colonial rule, as well as environmental deterioration and depletion. The influence of ethnobiological research conducted at the local level is greatly enhanced when it is disseminated through scientific and popular publications, documentaries, innovative approaches, international discussions, & science-policy forums, affecting researchers and residents worldwide (Gaoue *et al.* 2021, Casagrande 2004).

Engaging in these forums is crucial for formulating effective and fair policy solutions to tackle the climate issue and the decline of biocultural diversity. Global institutions and organizations can offer support to dialogic techniques, which encompass the utilization of art, literature, and other means of information mobilization. Global dialogues, involving the collaboration of scientists and Indigenous and local knowledge holders, can facilitate the integration of diverse knowledge systems across multiple geographical and temporal contexts (Saslis-Lagoudakis *et al.* 2015). They also allow for the recognition of universal patterns and shared characteristics in different biocultural contexts.

This aims to generate more comprehensive and applicable knowledge for policy-making, taking into account the specific circumstances, and ultimately improving the resilience and prosperity of communities (Heywood 2011). The employment of a various evidence-based strategy, such as multi-scale triangulation, is a common method. These study strategies entail deliberately exploring the connections and distinctions between knowledge systems, with a specific emphasis on how information from various scales and techniques can enhance, harmonize, and exchange ideas. Typically, these methods entail regular collaborations between ethnobiologists and Indigenous and local knowledge holders, with the goal of creating a comprehensive body of research that may effectively contribute to global leadership processes (Arrivabene *et al.* 2024). Several studies have offered qualitative evidence to educate policymakers on how changes in the environment or pollution affect the livelihoods of Indigenous Peoples and local communities. This evidence is gathered through the collection of local testimonies, personal accounts, the analysis of local governance frameworks, as well as the synthesis of detailed narratives to case studies around the world (Alves and Souto 2011).

Increasing the range by merging and organizing current ethnobiological information by aggregating published data to construct specialized databases and use descriptive statistics or advanced meta-analyses, the global value of Indigenous and local knowledge can be further enhanced (Da Silva *et al.* 2019). Open-access online databases have been created by compiling published data on cultural and environmental diversity. An example of such a resource is the Ethno-ornithology Global Atlas (EWA), which offers a comprehensive worldwide perspective on species that hold cultural significance (Sillitoe 2006). Another instance involves the comprehensive worldwide surveys on the protection of all palm species, which have meticulously recorded their ethnobotanical applications. The data collected in D-PLACE, an extensive database encompassing information on over 1400 human communities, functions as a demonstrative instance (Sillitoe 2006). The focus is on research that investigates the correlation between the environment and religious variety, the global distribution among human subsistence practices, including the factors that influence variations in land ownership worldwide. These datasets consist of location-specific evidence that has been georeferenced and verified through thorough ground-truthing. They integrate data from many sources that employ varied terminology, concentrate on varying time and space intervals, and explicitly consider spatial and historical relationships between groups (Njoroge 2010). The development and utilization of cross-cultural databases in anthropology, combined with ongoing endeavors to emphasize the potential of quantitative methods in ethnobiology, can provide guidance and inspiration for new research in global ethnobiology, while also complementing essential inductive approaches at all levels. Ethnobiological studies are increasingly using published data to uncover similarities and overall trends in people's experiences on a large regional level (Ludwig and El-Hani 2020). For instance, through collaborative research, a comprehensive worldwide analysis has been conducted on the biocultural methods employed by Indigenous Peoples and local communities to conserve pollinators. Additionally, a global summary has been compiled on the ethnophiles interactions between coastal communities and marine ecosystems (Berlin *et al.* 1999).

Additional instances of ethnobiological study include investigations into the worldwide ramifications of climate change on communities that rely on subsistence, as well as the consequences of insufficient documenting of Indigenous and local knowledge on the formulation of policies. Constructing and utilizing global databases is a complex task that requires careful consideration of associated challenges (Turner *et al.* 2022). An understanding of these limitations can help inform their usage, and they can serve as a catalyst for combining local case studies to draw culturally significant conclusions on a global scale, while maintaining a strong ethnographic foundation. Expanding study scope by utilizing multi-site and cross-cultural research design It is feasible to expand from a local to a regional and global level by adopting a multi-sited research design. This involves comparing observations and data acquired from different field sites using paired research methods (Wolverton *et al.* 2014). Multi-sited studies are connected by shared research inquiries, methods of gathering data, and analysis. Multi-sited research is commonly used to examine the variety and uniformity of different elements within ethnobiological systems over different periods and locations, and to deduce the factors that contribute to changes in time or distance. Inter-regional specific studies can exemplify cross-cultural commonalities by examining factors such as age, gender, career, and wealth (Santoro *et al.* 2015). Research is also undertaken on the synthesis of the floral, linguistic, and political backgrounds of neighboring social or ethnolinguistic communities. Additionally, investigations are carried out on the evolution and adjustment of medicinal plant utilization in the setting of migrations (Stepp *et al.* 2002).

Engaging in cross-cultural research enhances the comprehensiveness and complexity of ethnobiological data, while also aiding in the validation of hypotheses and the development of theories within the field. We propose to enhance these methods by developing multi-sited investigations that encompass wider spatial scales (Abbasi and Bussmann 2021). Designing multi-sited research on a regional or worldwide scale necessitates significant coordination and money. However, data gathering and analysis can be made easier by implementing consistent, data sovereign, and carefully crafted protocols.

Protocols designed for crosscultural research provide a convincing means of incorporating ethnobiology into global solutions (Casagrande 2004). The reason for this is that these protocols are frequently established on pre-established, wide-ranging domains or classifications that may be compared across different cultures. However, they are also built upon locally adjusted and culturally particular categories and measurements. While multi-sited studies have mostly used concepts and classifications based on Western scientific fields, there is an increasing number of multi-sited investigations led solely by Indigenous populations (Zimmerer 2001). An instance of this can be seen in the Kogi territorial diagnosis called "Shikwakala" (https://www.tchendukua.org/shikwakala). In addition, involving community people as collaborators in these studies helps promote equal collaboration & fairness, so ensuring responsible scaling up that does not needlessly reduce or remove culturally particular information. Expanding globally by incorporating geospatial analysis (Hidayati *et al.* 2015). Ethnobiologists are establishing partnerships with conservation biologists & geographers to methodically record and elucidate the varied ecological importance of Indigenous Peoples and local communities' land management techniques, encompassing both local and global scopes. Indigenous thinkers and scholars have always advocated for the worldwide significance of Indigenous stewardship (Hunn 2007). Geospatial analysis has increasingly been used to visually depict and quantify the role of Indigenous peoples or local communities in conserving global biodiversity. These advancements, grounded in the most reliable facts, are being utilized to bolster ongoing policy debates over the involvement of Indigenous Peoples in the preservation of world biodiversity. This data is being used to support the advocacy efforts of Indigenous Peoples in international discussions about the newly established Kunming-Montreal Global Biodiversity Framework of the Convention on Biological Diversity (Kuhnlein 2014). The data shows that Indigenous Peoples have rights to or control over more than 25% of the world's land, which overlaps with at least 37% of the remaining natural areas globally and 36% of the most ecologically intact forests. A recent study using geospatial analysis has found that a minimum of 60% of terrestrial mammal species, with reliable habitat data (Albuquerque *et al.* 2014), rely on Indigenous Peoples' lands worldwide. Additionally, these territories contribute to 30% of the global distribution range of non-human primates. Global studies have demonstrated that Indigenous Peoples' lands, despite being susceptible to biodiversity loss, have a greater number of species compared to protected areas of similar size. Additionally, these lands are as effective in mitigating deforestation. These findings have led to an increasing acknowledgement and interest in the specific methods, projects, and knowledge networks that promote the ecological well-being of these locations worldwide (Zimmerer 2001, Stepp 2000).

Data Analysis and Interpretation

Triangulation and Validation of Results

The selected processes for addressing a problem may not always provide the optimal option for dealing with a certain subject. Occasionally, the topic being studied has a high degree of intricacy that presents a significant obstacle to the researcher (Alele 2023). It is desirable for the methodologies chosen in these investigations to be consistently evaluated and analyzed, allowing the researcher to make more informed conclusions about interpreting the results. Recently, a number of authors evaluated the effectiveness of different approaches (see to Gaugris and Rooyen for example)(Oleinik 2011). Triangulation is a recommended strategy for planning research. The term "methodological procedures" refers to a collection of techniques used to investigate a certain research subject. In this work, we focus on methodological triangulation, which refers to the use of multiple methods either inside a single method or between two different ways. One example of the former technique is when several subscales are used to measure a single item in a questionnaire (Barnes and Vidgen 2005). On the other hand, the latter method involves combining a questionnaire and a semi-structured interview. During interviews, investigators can additionally organize guided tours to gather artefacts mentioned in the interviews and discover ethnospecies acknowledged by the community. This approach helps to prevent the overestimation of the number of species recognized by the scientific community and streamlines the classification of species found in the area(Sciberrar and Dingli 2023, Barnes and Vidgen 2006).

Challenges and Limitations Ethnobiological research undertaken by locals provides essential insights into the complex interactions between human populations and their surroundings

Expanding the cultural practices of ethnobiology to a global or regional level may alienate, marginalize, or suppress local viewpoints, challenges, and insights due to the fact that ethnobiology information is often dependent on specific time and space scales)(Ludwig and El-Hani 2020). Here, we discuss the main conflicts that have impeded ethnobiology's ability to expand its applications from local through global levels. We offer illustrations of current projects and activities that are broadening the impact of the field at both local and international scales (Albuquerque and Hanazaki 2009). Nevertheless, a significant obstacle arises when these initiatives are expanded to encompass bigger sample sizes for comparison

investigations. This hinders the ability of specific communities to lead and control the projects. In the Global North, Western scientists typically hold leadership roles and have significant decision-making power, primarily because of their financial capabilities, which allow them to fund and support large-scale projects (Ladio 2017).

According to Wolverton et al., power dynamics in the field of environmental archaeology, as well as in all areas of ethnobiology, lead to Western scientists telling the history of another group. This can potentially be harmful or serve the scientist's targets without benefiting the community (Maffi 2004). Several ethnobiological enquiries have been driven by a researcher's intellectual inquisitiveness or financial motivations, rather than the concerns of the community. Within our discipline, we prioritize the importance of theoretical and methodological rigor and progress (Reyes-Garcinia 2010). Nevertheless, it is crucial for any theories or practices to be globally applicable and align with and actively promote the significance of community-led research that pays close attention to local issues. Establishing genuine and collaborative alliances with Indigenous Peoples and local communities is crucial to ensure that worldwide ethnobiology is in harmony with the objectives and principles of the community (Albuquerque *et al.* 2013).

Furthermore, funding agencies have a crucial role in supporting efforts to enhance the worldwide significance of research conducted at local levels. By allocating strategic resources to support cross-disciplinary studies on "global ethnobiologies," which includes establishing dedicated funding methods, designing calls for long-term multifaceted projects, and providing seed funding for collaborative networks, we can effectively unlock the full global potential of ethnobiology (Junior 2020). Several research networks, which include the Programme for Ecological Change and Society and the Knowledge Action Networking of Future Earth, have been established to promote the incorporation of location-specific social-ecological study into global solutions. These networks can provide valuable insights and ideas to the wider field of ethnobiology (Wolverton *et al.* 2014). Another significant barrier relates to the notion of "open data" and the matter of data sovereignty. Academics involved in global comparative research, like the Forest Data Partnership, benefit from open-source data. Nevertheless, it has also resulted in challenges for Indigenous Peoples and local communities about their fundamental rights and control over data(Lopes 2017). The emergence of indigenous data sovereignty movements is a direct response to the promotion of responsible open data and the return of data that was previously appropriated from their community (referred to as #databack). Platforms like Mukurtu (https://mukurtu.org) offer public access to certain data while also using "graded access" codes to establish a platform that encourages courteous and reliable connections. Linguists have effectively employed comparable techniques within the DELAMAN repository network (https://www.delaman.org) to attain noteworthy outcomes (Fernández-Llamazares *et al.* 2024). This network enables extensive global comparative research while ensuring the protection of confidential, sacred, or otherwise sensitive data. An ethnobiology database with centralized and graded access could be beneficial. However, ethnobiologists must address and mitigate certain concerns, particularly the occasional conflict between "open" and "protected" material. It is imperative to highlight how access decisions shouldn't ever be exclusively established by external schoolwork, and that community engagement is significant for these endeavors. The LICCI Project actively incorporates Traditional Knowledge labels to solve these concerns by utilizing the open-source platform OpenTEK (https://opentek.eu/licci)(Hildebrand 2009). A number of ethnobiologists, who are responsible for managing biocultural collections at different institutions, are currently tackling the matter of open information and information sovereignty. An example of such a project is the Ethno-ornithological Global Atlas (EWA), which specifically concentrates on collecting and analyzing ethno-ornithological information, thereby making a valuable contribution to this endeavor. Developing guidelines for community oversight of gathering information, management, acquisition, and utilization is an ongoing and collaborative effort that requires extensive participation and constant consent (Hildebrand 2009). Ethnobiologists should acknowledge that community members often lack resources and face excessive burdens. Therefore, they should offer support when taking on supervisory roles. An effective strategy involves establishing community review boards or engaging with community members to establish guidelines for the sharing and utilization of data(Albuquerque *et al.* 2020). Nevertheless, this necessitates significant resources to support community members and enable their participation in scientific endeavors. It is imperative to acknowledge that not all communities will always be inclined to assume responsibility or engage in such endeavors, since they may have other more pressing societal issues to attend to (D'Ambrosio 2014). Without a doubt, any globally important tools for managing comparative ethnobiological data must adhere strictly to the fundamental principles of data sovereignty, known as Ownership, Control, Access, Possession (OCAP®). These principles include ethical guidelines such as providing compensation and redress, as well as recognizing the rights to intellectual property of Indigenous and local communities (Gaoue *et al.* 2021). Quantitative ethnobiology plays a vital role in scientific study, while studies on interactions between humans and the environment mostly depend on the collection and analysis of qualitative data. Quantitative studies show potential in shaping policy, but qualitative methods are generally better at capturing the comprehensive aspects of Indigenous and regional cultural systems that are challenging to convey through reductionist quantitative research (Albuquerque and Ferreira Junior 2017). Nevertheless, in qualitative investigations, there

are instances where comprehensive explanations of research designs and procedures are inadequate for subsequent comparisons.

The wide range of methodologies used in ethnobiology presents a barrier for the global applicability of ethnobiological data(Albuquerque *et al.* 2019). This is because knowledge gained from a specific location and culture may not necessarily be transferable or applicable on a larger scale. Even if the descriptions are adequate, discrepancies in the methods of data collection, reporting, or interpretation can hinder the ability to make large-scale comparisons and quantifications (Eldeen *et al.* 2006). However, the pursuit of measurable, universally applicable forms that may be easily incorporated into global datasets has certain methodological difficulties. These drawbacks encompass the possibility of displacing factual and contextually detailed case studies, disregarding exceptional cases, eradicating epistemological, cultural, and geographic distinctions, and amplifying crucial diversity and intricacy. It is crucial to recognize that these various approaches are complementary and can mutually enhance each other, with both quantitative and qualitative data working together synergistically(Fernández-Llamazares *et al.* 2024, Setchell *et al.* 2017).

Future Directions and Recommendations

In order to stimulate discourse within the scientific community regarding the field of ethnobiology during the next two decades, the following suggestions can be put into practice: Arranging global and cross-regional conferences and symposia centered on ethnobiology, extending invitations to distinguished specialists, up-and-coming scholars, and advocates from marginalized groups as well as local and traditional communities (Albuquerque *et al.* 2013). These meetings offer opportunities for research presentations and debates on theory and technique, as well as addressing political concerns and emergent difficulties. Moreover, incorporating sensory channels such as music, poetry, object exhibitions, and traditional art into our events is a means of bridging the divide between the scientific and traditional ecological knowledge (TEK) languages (Junior 2020). The objective is to create specialized working groups that focus on specific concerns mentioned here. These groups will consist of scholars from various institutions and locations who will come together to share knowledge, exchange experiences, and foster collaborations. Promoting the publication of scientific articles and books by researchers and offering accessible resources for non-experts to explore the topics discussed here (Hidayati *et al.* 2015). This will establish a strong basis for debates and encourage the development of fresh methods and perspectives. Facilitate the widespread distribution of academic papers in scientific journals that concentrate on the experiences of political groups related to the field of ethnobiology. Social movements undertake various acts and interpretations related to biodiversity (Albuquerque and Hanazaki 2009). Nevertheless, the need to compile these encounters into scholarly literature often impedes the widespread sharing of popular experiences and information. Facilitating the establishment of collaborative networks between researchers, institutions, Indigenous Peoples and Local Communities (IPLC), and Academic, Medical, as well as Multidisciplinary Centres (AMMC) through the use of online platforms that enable effective communication, resource sharing, and coordination of research endeavors (Svanberg *et al.* 2011). It specifically recognizes the impressive accomplishments of scientists representing economically disadvantaged countries who are making substantial contributions in the field of cultural biology. They are attaining enhanced efficiency with a reduced amount of resources. Organizing training sessions and seminars that especially address the practical components of ethnobiology, equipping researchers with the skills to effectively address the difficulties mentioned in this book.

Advocating for the utilization of several languages, particularly native and local languages, in the domain of ethnobiology, on a worldwide scale as well as within local communities (Simbiak *et al.* 2019). This will allow our field to enhance the portrayal of Indigenous Peoples and Local Communities (IPLC) as well as Afro-descendant, Indigenous, & Tribal Peoples (AMMC) on a worldwide level. To increase ethnobiological research and address global challenges, it is important to foster collaboration with ethnobiologists and researchers from various disciplines, such as social anthropology, human geography, linguistics, botany, zoology, and agronomy. This collaboration allows for the incorporation of multiple perspectives and expertise (Simbiak *et al.* 2019). Facilitating the communication of evidence-based recommendations from scientists to non-technical policymakers in the political realm. It is essential to provide training to environmental agents and managers so that they can effectively recognize and value social-ecological systems and advocate for impactful public policies. Promoting fairness and fairness can be accomplished by regularly practicing analytical reasoning, cooperating in work groups, and exchanging information and insights within the framework of ethical principles that challenge racism, sexism, colonialism, and heteronormativity (Weckerlw *et al.* 2018). Contribute to bolstering the rights and endeavors of Indigenous Peoples and Local Communities (IPLCs), either through scientific progress or by backing organized social movements and engaging in government decision-making processes. Examining the diversity of life and civilizations across many geographical locations and historical periods, including varied terrestrial and aquatic ecosystems (such as mountains, deserts, woods, and polar

regions) as well as remote tropical islands, holds great significance, especially for developing and emerging nations (O'Neill *et al.* 2017). These ideas seek to promote in-depth and comprehensive conversations within the field of science regarding ethnobiology. Their goal is to promote advancement in the theoretical approaches and practical aspects of this research field, besides advocating for the integration of traditional/local knowledge into broader socio-environmental issues. In essence, these recommendations seek to improve our comprehension of the world we reside in as inhabitants of this planet (Holloway and Bryant 1986, Wyndham *et al.* 2011).

Conclusion

Ethnobiology is the scientific discipline that investigates the relationships between human beings and the living organisms present in their surroundings. This includes the examination of plants (ethnobotany) & animals (ethnozoology), along with the indigenous people's understanding of the ecological trends and procedures in their environment (ethnoecology). Additionally, it analyses the process by which traditional management methods are formed by collective behaviors that arise from self-organized patterns or in reaction to external stimuli. The field has faced persistent challenges in establishing coherent research directions and theoretical frameworks. It is imperative to pursue this in order to progress in this field and to generate crucial educational and professional prospects that are vital for its sustainability. Ethnobiology has progressed from basic accounts of plant and animal utilization and understanding to examining the rationale and mechanisms behind the choices made by particular communities in their selection of plants. Recent advancements involve proposals for theoretical inquiries and practical experimentation. This review aims to integrate advanced statistical approaches that can be employed by ethnobiologists to test theories and hypotheses. We contend that ethnobiologists should embrace these overlooked sophisticated instruments. Structural equations modeling, evaluation of social networks, and phylogenetics provide opportunities for investigating new research questions. This will facilitate the integration of ethnobiology to cultural evolution, quantitative sociology, or community ecology.

Declarations

List of abbreviations: ICS-Integrated Care System; OCAP-Ownership, Control, Access, Possession; TEK-Traditional Ecological Knowledge; IPLCs-Indigenous Peoples and Local Communities; AMMC: Academic, Medical, as well as Multidisciplinary Centres

Ethics approval and consent to participate: Not Applicable.

Consent for publication: Not applicable

Availability of data and materials: All the supporting data available in the article.

Competing interests: The authors declared no competing of interest.

Funding: No funding was received for the work.

Author contributions: Rakhi Khabiya and Akanksha Dwivedi- Design of the Draft
Devyani Rajput-Framing of the manuscript
G. N. Darwhekar and Akanksha Dwivedi- Proof reading of the manuscript
All authors read and approved the final manuscript.

Acknowledgements

The authors express gratitude to Amity University and Acropolis Institute of Pharmaceutical Education and Research for providing digital support for fetching data related to the topic.

Literature cited

Abbasi AM and Bussmann RW. 2021. Medicinal, Nutritional, and Spiritual Significance of Plants in Bhutan: Their Biodiscovery Potential and Conservation Status. In Ethnobiology of mountain communities in Asia. Springer: 1-25.

Adeoye-Olatunde OA, Olenik NL. 2021. Research and scholarly methods: Semi-structured interviews.Journal of The American College of Clinical Pharmacy 4(10):1358-1367.

Agnoletti M, Emanueli F. 2016. Biocultural Diversity in Europe. Environmental History 5:1-69.

Al Mhdawi MK, Motawa I, Rasheed HA. 2020. Assessment of risk management practices in construction industry. in The 10th International Conference on Engineering, Project, and Production Management.Architecture 421-433.

Al-Dabbagh J, Younis R, Ismail N. 2023. The currently available diagnostic tools and treatments of scabies and scabies variants: An updated narrative review. 102(21):e33805.

Albuquerque UP and Ferreira Junior WS. 2017. What do we study in evolutionary ethnobiology? Defining the theoretical basis for a research program. Evolutionary Biology 44: 206-215.

Albuquerque UP and Hanazaki N. 2009. Five problems in current ethnobotanical research—and some suggestions for strengthening them. Human Ecology 37: 653-661.

Albuquerque UP, Borba do Nascimento AL, Chaves LS, Feitosa IS, Brito de Moura JM, Gonçalves PHS, Henriques da Silva R, Cristina da Silva T, Ferreira Júnior WS, Araújo EL. 2019. How to partner with people in ecological research: Challenges and prospects. 2019. Perspectives in Ecology and Conservation 17(4): 193-200.

Albuquerque UP, Ludwig D, Feitosa IS, Brito de Moura JM, Medeiros PM, Goncalves PHS, Silva RH, Silva TC, Goncalves-Souza T and Junior WSF. 2020. Addressing social-ecological systems across temporal and spatial scales: a conceptual synthesis for ethnobiology. Knowledge Technology and Innovation 48: 557-571.

Albuquerque UP, Ramos MA, Paiva de Lucena RF and Alencar NL. 2014. Methods and Techniques Used to Collect Ethnobiological Data. In Methods and techniques in ethnobiology and ethnoecology: 15-27.

Albuquerque UP, Silva JS, ampos JLA, Sousa RS, Silva TC and Alves RRN. 2013. The current status of ethnobiological research in Latin America: gaps and perspectives. Journal of Ethnobiology and Ethnomedicine 9: 72.

Alele, F. 2023. Triangulation of data. In An Introduction to Research Methods for Undergraduate Health Profession Students.

Alves RR, Souto WM. 2011. Ethnozoology in Brazil: current status and perspectives. Journal of ethnobiology and ethnomedicine 7:1-19.

Anderson CL, Reynolds TW, Biscaye P, Patwardhan V, Schmidt C. 2021. Economic benefits of empowering women in agriculture: Assumptions and evidence.The Journal of Development Studies 57(2):193-208.

Arrivabene A, Lasic L, Blanco J, Carrière SM, Ladio A, Caillon S, Porcher V and Teixidor-Toneu I. Arrivabene, A., 2024. Ethnobiology's Contributions to Sustainability Science. Journal of Ethnobiology: 1-14.

Asprilla-Perea J, Díaz-Puente JM, Martín-Fernández S. 2020. Evaluation of wild foods for responsible human consumption and sustainable use of natural resources. Ambio 11(6):687.

Barnes SJ and Vidgen RT. 2005. Data triangulation in action: using comment analysis to refine web quality metrics. ECIS 2005 Proceedings: 24.

Barnes SJ and Vidgen RT. 2006. Data triangulation and web quality metrics: A case study in e-government. 2006. Information and Management 43(6): 767-777.

Bechler C. 2023. Automatic Transcription of Northern Prinmi Oral Art: Approaches and Challenges to Automatic Speech Recognition for Language Documentation.Theses and Dissertations--Linguistics 51.

Berlin B, Berlin EN, Ugalde JCF, Garcia-Barrios LE, Puett JD, Nash RJ and Gonzalez-Espinoza M. 1999. The Maya ICBG: drug discovery, medical ethnobiology, and alternative forms of economic development in the Highland Maya Region of Chiapas, Mexico. Pharmaceutical Biology 37(1): 127.

Caggiano H, Weber EU. 2023. Advances in qualitative methods in environmental research. Annual Review of Environment and Resources 48(1):793-811.

Camden C, Thomas KS, Nguyen T, Graham E, Thomas A, SpruJ, Morris C and Russell. 2015. Engaging stakeholders in rehabilitation research: a scoping review of strategies used in partnerships and evaluation of impacts. Disability and Rehabilitation 37(15): 1390-1400.

Cao Q, Schniederjans DG, Schniederjans M. 2017. Establishing the use of cloud computing in supply chain management.Operations Management Research 10:47-63.

Caron-Beaudoin E, Armstrong CG. 2019. Biomonitoring and ethnobiology: Approaches to fill gaps in indigenous public and environmental health. Journal of Ethnobiology 39(1):50-64.

Casagrande DG. 2004. Ethnobiology lives! Theory, collaboration, and possibilities for the study of folk biologies.Reviews in Anthropology 33(4):351-370.

Chauhan RS. 2022. Unstructured interviews: are they really all that bad?Human Resource Development International 25(4):474-487.

Chellappandian M, Mutheeswaran S, Pandikumar P, Duraipandiyan V, Ignacimuthu S. 2012. Quantitative ethnobotany of traditional Siddha medical practitioners from Radhapuramtaluk of Tirunelveli District, Tamil Nadu, India. Journal of Ethnopharmacology 143(2):540-547.

Coulter J, Whichello C, Heidenreich S, Hauber B, Michaels-Igbokwe C, Cappelleri JC, Peyrani P, Presa JV, Venkatraman M, Schley K. 2024. From Qualitative Research to Quantitative Preference Elicitation: An Example in Invasive Meningococcal Disease. The Patient 17(3):319-333.

D'Ambrosio U. 2014. Theoretical reflections on ethnobiology in the third millennium. Contributions to Science 10(1): 49-64.

da Silva TC, de Medeiros PM, Hanazaki N, da Fonseca-Kruel VS, Hora JSL, de Medeiros SG. 2019. The role of women in Brazilian ethnobiology: challenges and perspectives. Journal of ethnobiology and ethnomedicine 15(1):1-11.

de la Torre S, Morelos-Juárez C. 2022. Primate Conservation Efforts and Sustainable Development Goals in Ecuador, Combining Research, Education and Capacity Building.Animals (Basel) 12(20):2750.

Deletre M, Gaisberger H, Arnaud E. 2012. Agrobiodiversity in perspective - A review of questions, tools, concepts and methodologies. Report prepared for Bioversity International and IRD-Sud Expert Plantes. Appendix: "List of neglected and underutilized species (NUS) in the inter-tropical zone" 1-78.

Dufour S, Rodríguez-González PM, Laslier M. 2019. Tracing the scientific trajectory of Eldeen IMS, Effendy AW and Tengku-Muhammad TS. 2016. Ethnobotany: Challenges and future perspectives.Research Journal of Medicinal Plants. 10(6-7): 382-387.

Eleanor JS, Betley E, Sigouin A, Gomez A, Toomey A, Cullman G, Malone C, Pekor A, Arengo F, Blair M, Filardi C, Landrigan K, and Porzecanski AL. 2017. Assessing the evidence for stakeholder engagement in biodiversity conservation. Biological Conservation 209: 159-171.

Fernández-Llamazares A, Teixidor-Toneu I, Armstrong CG, Caviedes J, Ibarra JT, Lepofsky D, McAlvay AC, Molnar Z, Moraes RM, Odonne G, Poe MR, Bahraman AS and Turner NJ. 2024. The global relevance of locally grounded ethnobiology. Journal of Ethnobiology and Ethnomedicine 20(1): 53.

Ferreira AF, Zimmermann H, Santos R, Wehrden HV. 2020. Biosphere reserves' management effectiveness—a systematic literature review and a research agenda. Biodiversity Conservation and Sustainability—Current Challenges and Opportunities 12(14):5497.

Ferreira V, Barreira AP, Loures L, Antunes D, Panagopoulos T. 2020. Stakeholders' engagement on nature-based solutions: A systematic literature review. Sustainability 12(2): 640.

Fidel R. 2008. Are we there yet?: Mixed methods research in library and information science. Library & Information Science Research 30: 265–272.

Gaoue OG, Coe MA, Bond M, Harti G, Seyler BC, Mcmillen H. 2017. Theories and Major Hypotheses in Ethnobotany. Economic Botany 71(3):269-287.

Gaoue OG, Moutouama JK, Coe MA, Bond MO, Green E, Sero NB, Bezeng BS, Yessoufou K. 2021. Methodological advances for hypothesis-driven ethnobiology. Biological Reviews Cambridge Philosophical Society 96(5):2281-2303.

Gilmore MP, Eshbaugh WH. 2011. From researcher to partner: ethical challenges and issues facing the ethnobiological researcher. Ethnobiology 2011:51-63.

Grytsai O, Myrgorodska I, Rocchi S, Ronco C, Benhida R. 2021. Biguanides drugs: past success stories and promising future for drug discovery. European Journal of Medicinal Chemistry 15(224):113726.

Guise JM, O'Haire C, McPheeters M, Most C, Labrant L, Lee K, Barth Cottrell EK, Graham E. 2013. A practice-based tool for engaging stakeholders in future research: a synthesis of current practices. Journal of Clinical Epidemiology 66(6):666-74.

Gutiérrez-Santillán TV, Albuquerque UP, Valenzuela-Galván D, Reyes-Zepeda F, Vázquez LB, Mora-Olivo A, Arellano-Méndez LU. 2019. Trends on mexicanethnozoological research, vertebrates case: a systematic review. Ethnobiology and Conservation 8(1):1-39.

Hanazaki N, Herbst DF, Marques MS, Vandebroek I. 2013. Evidence of the shifting baseline syndrome in ethnobotanical research. Journal of Ethnobiology and Ethnomedicine9:(75)1-11.

Heinrich M, Edwards S, Moerman DE, Leonti M. 2009. Ethnopharmacological field studies: a critical assessment of their conceptual basis and methods. Journal of Ethnopharmacology 124(1):1-17.

Heywood VH. 2011. Ethnopharmacology, food production, nutrition and biodiversity conservation: towards a sustainable future for indigenous peoples. Journal of Ethnopharmacology 137(1): 1-15.

Hidayati S, Franco FM, Bussmann RW. 2015. Ready for phase 5-current status of ethnobiology in Southeast Asia. Journal of ethnobiology and ethnomedicine 11:1-18.

Hildebrand EA. 2009. The utility of ethnobiology in agricultural origins research: Examples from Southwest Ethiopia. 2009. Current Anthropology 50 (5): 693-697.

Holloway RG, and Bryant Jr VM, 1986. New directions of Palynology in Ethnobiology. Journal of Ethnobiology 6(1): 47-65.

Hunn, E. 2007. Ethnobiology in four phases. Journal of Ethnobiology 27(1): 1-10.

Inbakaran, C. and A. Kroen. Travel Surveys–Review of international survey methods. in Australasian Transport Research Forum. 2011.Australasian Transport Research Forum 2011 Proceedings 1-15.

Jones BLH, Santos RO, James WR, Costa SV, Adams AJ, Boucek RE, Coals L, Cullen-Unsworth LC, Shephard S, Rehage JS. 2024. New directions for Indigenous and local knowledge research and application in fisheries science: Lessons from a systematic review. Fish and Fisheries 25(4): 647-671.

Júnior WSF. 2020. Reflections on the theoretical advance in ethnobiology: are we pointing to the wrong direction?E thnobiology and Conservation 9: 1-8.

Kidist S. 2023. The Role and Significance of Domestic Adoption as a Cultural Practice of Raising Children in Sebeta-Awas District of Oromia Regional State, Ethiopia.Norwegian University of Science and Technology 1-76.

Kinyua RF. 2023. Quantitative Research Designs, a Review of Extant Literature.Journal of Technology & Socio-Economic Development2223-9227.

Kuhnlein HV. 2014. How ethnobiology can contribute to food security. Journal of Ethnobiology 34(1): 12-27.

Ladio AH. 2017. Ethnobiology and research on Global Environmental Change: what distinctive contribution can we make? Ethnobiology and Conservation 6(7):1-8.

Liu D, Wu L, Luo J, Li S, Liu Y, Zhang C, Zeng L, Yu Q, Zhang L. 2022. Developing a Core outcome set for the evaluation of antibiotic use in Prelabor rupture of membranes: a systematic review and semi-structured interview. Frontiers in Pharmacology 13:1-15.

Loch TK, Riechers M. 2021. Integrating indigenous and local knowledge in management and research on coastal ecosystems in the Global South: A literature review.Ocean and COastal Management 212:1-13.

Lopes SF. 2017. The other side of Ecology: thinking about the human bias in our ecological analyses for biodiversity conservation. Ethnobiology and Conservation 6: 1-24.

Ludwig D and El-Hani CN. 2020. Philosophy of ethnobiology: Understanding knowledge integration and its limitations. Journal of Ethnobiology 40(1): 3-20.

Maffi L. 2004. Maintaining and restoring biocultural diversity: the evolution of a role for ethnobiology. Advances in Economic Botany 15: 9-35.

Mestre JI, Rossi PC, Torrens M. 2012. The assessment interview: A review of structured and semi-structured clinical interviews available for use among Hispanic clients.Guide to Psychological Assessment with Hispanics 33-48.

Minhat HS. 2015. An overview on the methods of interviews in qualitative research.International Journal of Public Health and Clinical Sciences 2(1):210-214.

Mitchell AJ, Rich M. 2020. Business School Teaching of Research Methods–A Review of Literature and Initial Data Collection for Undergraduate Business School Students.The Electronic Journal of Business Research Methods 18(2):100-114.

Njoroge GN. 2010. Science and Technology, Ethnobiology and Development: Relevance of Traditional Knowledge in the Growth of Natural Products Industry and Sustainable Environmental Management. Journal of Agiculture, Science and Technology 12(2): p. 3-19.

Nor FM, Egbu C, and Arif M. 2009. Knowledge sharing in quantity surveying firms in Malaysia-How the literature review informs the research approach. in POSTGRADUATE RESEARCH CONFERENCE.

Nugroho HYSH, Indrajaya Y, Astana S, Murniati, Suharti S, Basuki TM, Yuwati TW, Putra PB, Narendra BH, Abdulah L, Setyawati T, Subarudi, Krisnawati H, Purwanto, Saputra H, Lisnawati Y, Garsetiasih R, Sawitri R, Putri IASLP, Setiawan O. 2023. A chronicle of Indonesia's forest management: a long step towards environmental sustainability and community welfare.Diversifying Forest Landscape Management Approaches 12(6):1238.

O'Neill AR, Badola HK, Dhyani PP, Rana SK. 2017. Integrating ethnobiological knowledge into biodiversity conservation in the Eastern Himalayas. Journal of ethnobiology and ethnomedicine 13:1-14.

Odmell C, Mamimine PW, Kudakwashe C. 2019. Methodological complexities in the study of health tourism: A study of the appropriation of indigenous herbal sexual stimulants and fertility enhancers in Zimbabwe (A review paper).Cogent Social Sciences 5(1):1-14.

Oleinik A. 2011. Mixing quantitative and qualitative content analysis: Triangulation at work. Quality & Quantity 45(4): 859-873.

Pérez-Rodríguez G, Ortiz-Solorio CA, Gutiérrez-Castorena MD. 2023. Ethnopedology, its evolution and perspectives in soil security: A review. Soil Security 100121.

Pfeiffer JM, Butz RJ. 2005. Assessing cultural and ecological variation in ethnobiological research: the importance of gender. Journal of Ethnobiology 25(2):240-278.

Pinheiro S, Mota NB, Sigman M, Fernández-Slezak D, Guerreiro A, Tófoli LF, Cecchi G, Copelli M, Ribeiro S. 2020. The history of writing reflects the effects of education on discourse structure: implications for literacy, orality, psychosis and the axial age.Trends in Neuroscience and Education 21:100142.

Popović Z, Matic R, Bojovic S, Stefanovic M, Vidakovic V. 2016. Ethnobotany and herbal medicine in modern complementary and alternative medicine: An overview of publications in the field of I&C medicine 2001–2013. Journal of Ethnopharmacology 181:182-192.

Priya GL, Rajeshkumar S, Gomathi AS, Sindhu R. 2022. A comprehensive survey of data collection methods and tools for research novices. in AIP Conference Proceedings. AIP Conference Proceedings 2444(1):1-10.

Rajabi-Moghaddam M, Abbaszadeh H. 2024. Evaluation of prognostic factors of head and neck squamous cell carcinomas in Iranian patients: A narrative review. Journal of Oral Health and Oral Epidemiology 13(2):45-48.

Reyes-García V. 2010. The relevance of traditional knowledge systems for ethnopharmacological research: theoretical and methodological contributions. Journal of Ethnobiology and Ethnomedicine 6(32):1-12.

Robinson DT, Brown DG, Parker DC, Schreinemachers P, Janssen MA, Heugen M, Wittmer H, Gotts N, Promburom P, Irwin E, Berger T, Gatzweiler F and Barnaud C. 2007. Comparison of empirical methods for building agent-based models. Journal of Land Use Scienc 2(1):31-55.

Salsberg J, Parry D, Pluye P, Maridis S, Herbert CP and Macaulay AC. 2015. Successful strategies to engage research partners for translating evidence into action in community health: a critical review. 2015. Journal of Environmental and Public Health 1: 191856.

Santoro FR, Nascimento ALB, Soldati GT, Junior WSF and Albuquerque UP. 2018. Evolutionary ethnobiology and cultural evolution: opportunities for research and dialog. 14: 1-14.

Saslis-Lagoudakis CH, Ronsted N, Clarke AC and Hawkins JA. 2015. Evolutionary approaches to ethnobiology. In Evolutionary Ethnobiology. Springer: 59-72.

Scholz RW, Binder CR. 2011. Environmental literacy in science and society: from knowledge to decisions.Cambridge University Press 1-21.

Sciberras M and Dingli A. 2023. Research Analysis—Triangulation Approach. In Investigating AI Readiness in the Maltese Public Administration 568: 31-32.

Serafini EJ, Lake JB, Long MH. 2015. Needs analysis for specialized learner populations: Essential methodological improvements. English for Specific Purposes 40:11-26.

Setchell JM, Fairat E, Shutt K, Waters S and Bell S. 2017. Biosocial conservation: Integrating biological and ethnographic methods to study human–primate interactions. International Journal of Primatology 38: 401-426.

Shrivastava V, Mishra S, Mishra A. 2020. Exploring the Possible Applicability of Yagya in present time: a review.Ayurveda evam Samagra Swasthya Shodhamala 2(2):1-28.

Sillitoe P. 2006. Ethnobiology and applied anthropology: rapprochement of the academic with the practical. Journal of the Royal Anthropological Institute 12: S119-S142.

Silva JG, de Almeida Caetano R. 2022. Sampling bias in ethnobotanical studies on medicinal plants conducted in local markets. Journal of Ethnobiology 42(1):20-30.

Simbiak M, Supriatna J, Walujo EB, Nisyawati.2019. Current status of ethnobiological studies in Merauke, Papua, Indonesia: A perspective of biological-cultural diversity conservation. Biodiversitas Journal of Biological Diversity 20(12).

Simon Dufour, Rodríguez-González Patricia Maria, Laslier Marianne. 2019. Tracing the scientific trajectory of riparian vegetation studies: Main topics, approaches and needs in a globally changing world. The Science of the Total Environment 25(653):1168-1185.

Stagg BC, Dillon J. 2022. People, Planet, Plant awareness is linked to plant relevance: A review of educational and ethnobiological literature (1998–2020). Plants People Planet 4(6):579-592.

Stepp JR, Wyndham FS and Zarger RK, 2002. Ethnobiology and biocultural diversity: Proceedings of the Seventh International Congress of Ethnobiology. University of Georgia Press.

Stepp JR. 2000. Mountain ethnobiology and development in Highland Chiapas, Mexico. Mountain Research and Development 20(3): 218-219.

Svanberg I, Luclaj L, Pardo-De-Santayana M and Pieroni A. 2011, History and current trends of ethnobiological research in Europe: 189-212.

Swanson SS, Ardoin NM. 2021. Communities behind the lens: A review and critical analysis of visual participatory methods in biodiversity conservation. Biological Conservation 262:1-15.

Trabelsi O, Souissi MA, Scharenberg S, Mrayeh M, Gharbi A. 2022. YouTube as a complementary learning tool in times of COVID-19: Self-reports from sports science students. Trends in Neuroscience and Educationm29:100186.

Tunon H, Kvarnström M, Lerner H. 2016. Ethical codes of conduct for research related to Indigenous peoples and local communities–core principles, challenges and opportunities.Ethics in Indigenous Research - Past Experiences, Future Challenges 57-80.

Turner NJ, Cuerrier A, Joseph L. 2022. Well grounded: Indigenous Peoples' knowledge, ethnobiology and sustainability. People and Nature 4(3):627-651.

Weckerle CS, Boer HJ, Puri RK, Tinde van Andel, Bussmann RM and Leonti M. 2018. Recommended standards for conducting and reporting ethnopharmacological field studies. Journal of Ethnopharmacology 210: 125-132.

Wetselaar P, Lobbezoo F, de Vries R, Mehta SB, Opdam NJM, Loomans BAC. 2023. Developing diagnostic criteria for tooth wear, a preliminary beta version based on expert opinion, and a narrative literature review. Journal of Oral Rehabilitation 50(10):1030-1042.

Williams C. 2015. Designing survey methods to evaluate the undeclared economy: a review of the options.Sheffield University Management School, University of Sheffield 1-20.

Wolverton S, Nolan JM and Waquar A. 2014. Ethnobiology, political ecology, and conservation. Journal of Ethnobiology 34(2): 125-152.

Wong MW. 2006. Satisfying all stakeholders in evaluating the feasibility of public-private partnership projects: A structural equation model approach. Semantic Scholar 1-10.

Woolf SH, Zimmerman E, Haley A and Krist A. 2016. Authentic engagement of patients and communities can transform research, practice, and policy. Health Affairs 35 (4): 590-594.

Wyndham FS, Lepofsky D, and Tiffany S. 2011. Taking stock in ethnobiology: where do we come from? What are we? Where are we going? Journal of Ethnobiology 31(1): 110-127.

Zent s, Maffi L. 2009. Final report on indicator No. 2: methodology for developing a vitality index of traditional environmental knowledge (VITEK) for the project Global Indicators of the Status and Trends of Linguistic Diversity and Traditional Knowledge. Terralingua 1-112.

Zimmerer KS. 2001. Report on geography and the new ethnobiology. The Geographical Review 91(4): 725-734.