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## Ethnobiology's contributions to sustainability science

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**Abstract.** Progress towards the achievement of the Sustainable Development Goals (SDGs) is insufficient at a global scale. A thorough and interdisciplinary understanding of barriers and levers to sustainability, including synergies and trade-offs between SDGs, is utterly important but still limited. Ethnobiology is often advocated as a key discipline to address this research gap. We conducted a systematic literature review to explore (i) the visibility of ethnobiology within sustainability science, (ii) how ethnobiology understands the notion of sustainability, (iii) if ethnobiology literature on sustainability issues engages differently with non-academic knowledge and people compared to other types of ethnobiology research, and (iv) which SDGs are addressed (explicitly or implicitly) by ethnobiology. Our study reveals a minimal overlap between sustainability science and ethnobiology literature. The articles reviewed never mention the SDGs explicitly, but often address them implicitly. Reviewed ethnobiological articles addressed themes of relevance to almost all SDGs, especially the linkages between SDGs 1-3 and 15, but always implicitly. Biodiversity's understanding (SDG 15) provides the basis for culture and Indigenous and local knowledge and ensures communities' food security (SDG 2), health and well-being (SDG 3), and prosperity (SDG 1). We found that ethnobiology does not examine sustainability through the lens of the global sustainability agenda, and that knowledge coproduction processes are rarely reported. While ethnobiology demonstrates its relevance to address SDGs and contribute to transformative change, this potential is not fully realized because of a persisting decoupling between place-based research and global sustainability frameworks.

**Keywords:** Sustainable Development Goals, transdisciplinary approaches, nexus, biocultural paradigm, social-ecological systems, human-nature relationships.

## Introduction

The year 1992 witnessed the first global strategy for sustainable development at the United Nations Conference on Environment and Development in Rio de Janeiro, where 178 countries adopted sustainability action plans for the 21<sup>st</sup> century, Agenda 21 (UNCED 1992). A major step was achieved in 2015 at the UN Sustainable Development Summit in New York where 193 countries adopted the 2030 Agenda for Sustainable Development. Inspired by Agenda 21 and the Millennium Development Goals, 17 Sustainable Development Goals (SDGs) were adopted (UN 2000, 2015) with the aim to achieve “global sustainable development” defined as a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland 1987: 37) “by putting an end to poverty and hunger, and protecting the planet from degradation” (Scharlemann et al. 2020: 1574; UN 2015). As such, the SDGs integrate the three dimensions of sustainable development: social, economic, and environmental (Giddings et al. 2002).

In addition to these international efforts from decision-makers, a new science emerged to specifically address sustainability challenges: sustainability science, defined as “an emerging field of research dealing with the interactions between natural and social systems, and with how those interactions affect the challenge of sustainability” (Kates 2011). To do so, sustainability science aims to connect all research relevant to sustainability issues and to promote (i) interdisciplinary approaches to foster the analysis of coupled human-environment systems as well as (ii) transdisciplinary approaches to better engage non-academic stakeholders and knowledge in the effort of understanding sustainability issues and finding relevant solutions to these (Clark and Dickson 2003; Spangenberg 2011).

Despite these efforts, by 2019, only a handful of the 169 sub-targets of the SDGs were on track to being fulfilled while some, including climate change, biodiversity loss and inequalities, displayed negative trends (UN 2019). This situation illustrates the complexity of addressing systemic interactions and navigating between competing development agendas, and stresses the need for more place-based approaches able to foster locally relevant transformations (Messerli et al. 2019) and for more research on the interdependence between SDGs (Carlsen et al. 2022). Research and political decisions mainly focused on a single SDG or a single subset of SDGs while overlooking the trade-offs with other SDGs can result in negative side effects (Liu et al. 2018). Moreover, only focusing on the SDGs to tackle sustainability may be misleading. Vissen-Hamakers (2020) evidences that the SDGs neglect of animal health, welfare, and rights, and the importance of integrative governance to avoid trade-offs and enable synergies. Sterling et al. (2020) showed that SDGs’ current indicators did not really account for the well-being values of the inhabitants from Oceania. This result questions the adequation of SDGs to encompass the worldviews, ways of life and the particular and diverse knowledge systems of Indigenous Peoples and Local Communities (IP and LC) (Poole 2018).

It is now widely acknowledged the perspectives of IP and LCs and other peoples living in close relationships with nature are crucial to integrate to foster more just and sustainable futures (Carlsen et al. 2022; Scharlemann et al. 2020; UN 2019). Ethnobiology can offer untapped contributions towards this goal. The discipline can effectively provide evidence from concrete contexts, as well as theoretical and methodological tools to integrate people and place-based perspectives to research and action (Turner et al. 2022; Wolverton 2013). In particular, ethnobiology is inherently multi- and interdisciplinary, linking biology, ecology, anthropology, ethnography, archaeology, geography, linguistics, pharmacology, and even nutrition (Salick 2003; Wolverton 2013). Considering the diversity of disciplinary backgrounds of ethnobiologists, the discipline can also offer diverse, complementary lenses on current socio-environmental challenges (Wolverton 2013). Despite a historical focus on descriptive studies and challenges to establish strong theoretical

foundations, recent scholarship lays out ethnobiology's theoretical frameworks and hypotheses (e.g., Gaoue et al. 2017). Ethnobiology bridges scientific paradigms and approaches (D'Ambrosio 2014), has showcased examples of deep engagement with a diversity of actors, most importantly IP and LCs (McAlvay et al. 2021; Turner et al. 2022), and the epistemological, ontological, and normative challenges of knowledge integration are increasingly discussed (e.g., Ludwig and El-Hani 2020). Moreover, recent calls advocate for the decolonization of ethnobiology through the active contestation of colonialism, racism, and oppressive patterns and structures within institutions, projects, communities, and individual ethnobiologists themselves (McAlvay et al. 2021). These calls resonate with the International Society of Ethnobiology (ISE) Code of Ethics (2006) and align with the need for more inclusive, transdisciplinary research on sustainability (Hadorn et al. 2006; Ibarra et al. 2023; Messerli et al. 2019). Transdisciplinary research addresses complex problems through partnerships with a diversity of actors (e.g., Ibarra et al. 2023) and, as ethnobiology, requires integration of diverse knowledge systems.

For all these reasons, ethnobiology could “contribute identifying lever and leverage points for enabling transformative change required for achieving more sustainable lifeways” (Turner et al. 2022:627). While ethnobiology's increasingly informs on systemic interactions for sustainability, divergences on understanding of sustainability, and on place-based transformations is improving rapidly on various fora (CBD, IPBES, IPCC, IUCN, etc.), the discipline is not yet recognised in academic and political discussions about sustainability (Argueta and Serrano 2021; Wolverton 2013) and its role to contribute to sustainability science remains largely unexplored.

Here, we explored the role of ethnobiology as a discipline finely tuned to study sustainability and some of the SDG interlinkages through a systematic review. Our study aimed at addressing four questions: 1) To what extent is ethnobiology visible in sustainability science? 2) How does ethnobiology research define sustainability? 3) Is there any difference between ethnobiology studies that deal with sustainability and those that do not in terms of inclusion of non-academic knowledge and people? 4) Do ethnobiology studies address (explicitly or implicitly) SDGs, and if so, which ones? On the basis of our analyses and results, we ultimately discuss how ethnobiology can contribute to sustainability science and mobilise knowledge to achieve the SDGs.

## Materials and Methods

### Literature searches

First, to assess ethnobiology visibility in sustainability science, we performed standardized literature searches in the Web of Science (WoS) that aimed at (i) capturing ethnobiological literature and sustainability science literature and (ii) assessing the overlap between the two. To do so, we processed searches based on words and expressions included in publications' titles, abstracts or author keywords, as well as searches based on specific journals and focused on the literature published between 2001 and 2022. For identifying the ethnobiological literature, two options were implemented, either in including or excluding ethnopharmacology and ethnomedicine literature (see Supplementary Material 1 for search scope and string). Similarly, two options were implemented to identify sustainability science (incl. SDG) literature. A first corpus, hereafter named ‘sustainability science *sensu stricto*’, was identified by searching all publications mentioning sustainability science in their title, abstract or keywords (see Supplementary Material 1). A second corpus, hereafter named ‘sustainability science *sensu lato*’, was constituted in gathering all publications of the 16 journals that were found to be the main contributors of sustainability science in Blanco et al. (in press) (see Supplementary Material 1 for search scope and string).

Second, to analyse how ethnobiological studies deals with sustainability issues, we gathered all articles published in the *Journal of Ethnobiology (JoE)* from January 2015 (year of officialization of the SDGs) to December 2022. While this corpus might not be fully representative of the diversity of ethnobiology literature (e.g., it only includes articles in English), JoE is one of the longest-standing, generalist, and leading journals in the field (Lepofsky et al. 2021). This search was performed on April 2023 and allowed us to identify a total of 280 articles published between 2015 and 2022 (Arrivabene et al., 2024). All articles were screened to only select those based on first-hand empirical data (in particular, editorials and literature reviews were excluded), resulting in a corpus of 211 articles.

### **Articles' full text screening**

To extract information from the 211 identified articles, we used a narrative synthesis exploratory approach based on keywords and full-text analysis (Dawson et al. 2021; Popay et al. 2006). Narrative synthesis is a process involving a wide range of questions, not just those necessary to test a particular hypothesis. Firstly, to evaluate the link between ethnobiology and sustainability, we searched for specific keywords throughout articles' full-texts: *ethno\** was used to identify the branches of ethnobiology mentioned in the articles and whether these branches were defined or not, and "*sustainab\**" and "*Sustainable Development Goals*" or "*SDGs*" were used to identify explicit references to sustainability, including whether the notion was defined or not. We also noted in which part of the text sustainability was presented or addressed. Secondly, each case study was classified according to its geographical location (continent and country) and associated economic context (based on the 2021 national or regional *per capita* income classification; World Bank 2021). Thirdly, to explore the transdisciplinary dimension of ethnobiological research, we identified at which stage of the research (study design, data collection/production, or result interpretation) researchers engaged with IP and LCs and other local actors. We also note whether the authors were associated to organizations from northern or southern countries, or whether they were members of IP and LCs, and the research methods used (i.e. qualitative or quantitative, such as participatory observation or surveys). Finally, to investigate how ethnobiology engages with SDGs, we identified in each article whether one or more SDGs were mentioned or addressed, either explicitly or implicitly. SDGs were coded as implicitly addressed when an article focused on a practice (or aspect of knowledge) concerning a topic included in the description of an SDG (UN 2015). When SDGs were addressed explicitly or implicitly, the corresponding sentences were copy-pasted from the articles onto the review grid. This grid was tested and corrected by all co-authors.

### **Data Analyses**

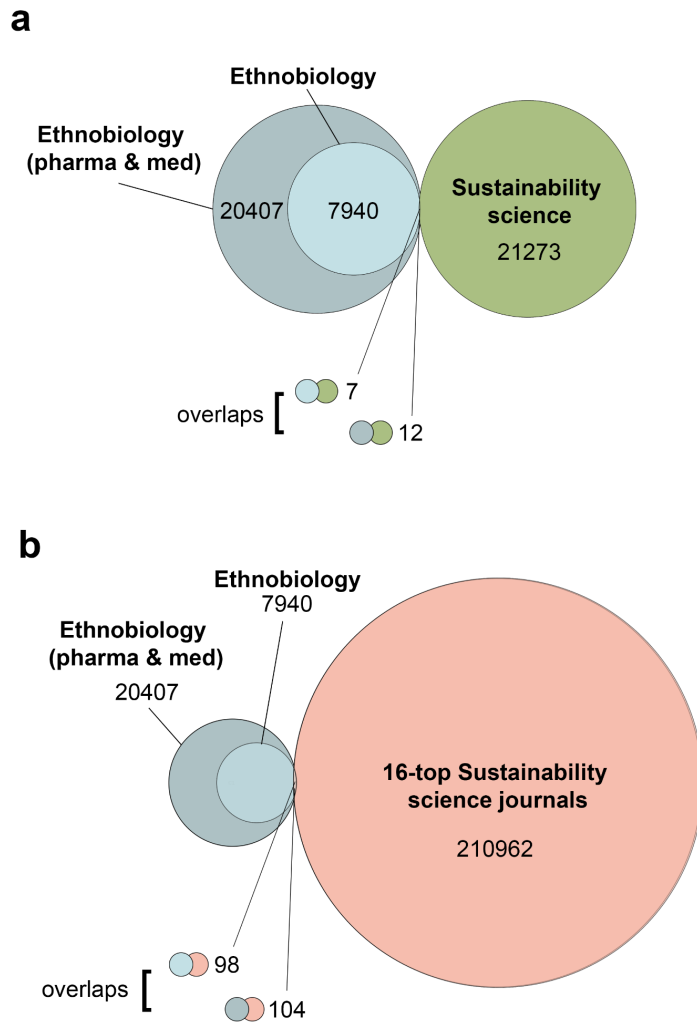
The interconnection between SDGs was studied through the quantification of articles addressing implicitly or explicitly one or more SDGs. With that, a chord diagram representing the links between the SDGs was created from a contingency table. A qualitative analysis of the content of the articles provided a more detailed understanding of this interconnection. To address our fourth research question on the approaches of studies mentioning sustainability, we used binomial Generalised Linear Models (GLMs) with the response variable as mention of *sustainab\** (presence/absence) and the explanatory variables as the origin of the authors, the different types of collaboration with IP and LCs and local actors, and different economic contexts of the countries studied (Supplementary Material 2). To reduce the occurrence of false positives due to the large number of GLMs performed, we performed Bonferroni corrections on the resulting p-values. As

Bonferroni's correction is sometimes considered too conservative, we also performed Holm and Hommel corrections (Jafari and Ansari-Pour 2019). The various diagrams and statistical analyses were produced using R (R Core Team 2023), Rstudio (Rstudio Team 2023), and the *tidyverse* (Wickham et al. 2019), *circlize* (Gu et al. 2014), *ggplot2* (Wickham 2016), and *dplyr* (Wickham et al. 2023) packages.

## Results

### Visibility of ethnobiology in sustainability science

Standardized searches in the WoS resulted in an ethnobiology corpus of 7,940 publications published between 2001 and 2022, and totalized 20,407 publications when ethnopharmacology and ethnomedicinal literature was included. We identified a sustainability science corpus *sensu stricto* of 21,273 publications, and a sustainability science corpus *sensu lato* of 210,962 publications published over the same period of time. As illustrated in Figure 1a, there was virtually no overlap between ethnobiology and sustainability science *sensu stricto* corpuses: only seven articles were in the two corpuses, representing 0.033% of the sustainability science *sensu stricto* corpus (see Supplementary Material 1 for the references). Similarly, only twelve articles overlapped between the two corpuses when ethnopharmacology and ethnomedicinal literature was included (0.056% of sustainability science corpus). As illustrated in Figure 1b, ethnobiology was found to be poorly represented in sustainability science *sensu lato*, with a total of 98 papers (i.e., 0.046% of sustainability science *sensu lato* and 1.23% of the ethnobiological literature). Interestingly, this percentage was even lower when including ethnopharmacology and ethnomedicine literature (overlap of 104 papers, i.e., 0.049% of the sustainability science *sensu lato* and 0.51% of the ethnobiological literature), suggesting that this branch of ethnobiology is even less concerned with sustainability science.



**Figure 1.** Overlaps between ethnobiology and sustainability science literature. **A.** Ethnobiology and Sustainability science (*sensu stricto*), with sustainability science identified from keywords. **B.** Ethnobiology and Sustainability science (*sensu lato*) with sustainability science defined from its key contributing journals. The light blue circle displays the corpus of ethnobiology literature excluding ethnopharmacology (“pharma”) and ethnomedicinal (“med”) literature, and the dark blue circle represents the corpus of ethnobiology literature including them. The respective number of publications overlapping both corpora of literature is displayed at the intersection of each Venn diagram.

### The place of sustainability in ethnobiological research

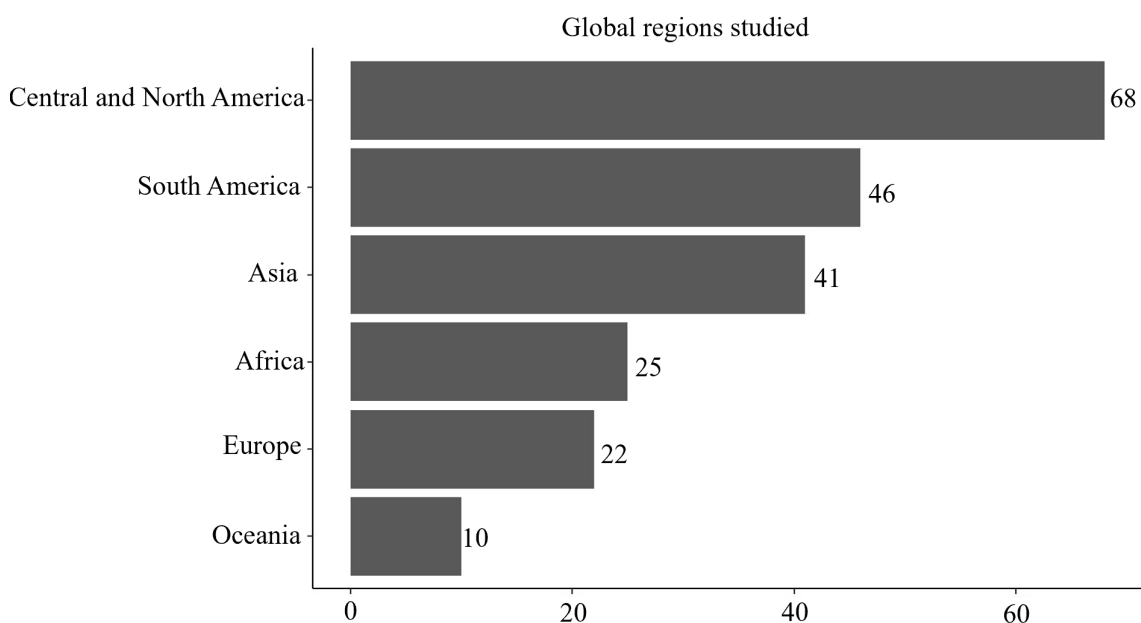
Ethnoscience were mentioned in 82.5% of the 211 articles (n=175), and the keywords “sustainability” or “sustainable” were mentioned in 47% of the reviewed JoE articles (n = 99). In most of these articles (n = 55, 26%), sustainability appeared in multiple parts of the text. Other articles mentioned the terms only in the introduction (n = 17) or the discussion (n = 11), where the term was only used to describe the context or implications of the research without further consideration. While the word “sustainable” was often used, its meaning was mostly used as a synonym of “long-lasting” (practices, livelihoods, plant and animal populations, economic development, etc.). Definitions or measurements of sustainability were explicitly mentioned in only six articles. Bodmer et al. (2020)

measured the sustainability of wild meat hunting by monitoring wild meat species' population trends. In Benner et al., an important aspect of sustainability was “intergenerational access to [a] resource” (2021:223). In Peacock and Quitmyer (2016) sustainable practices were those having “patterns of relatively long duration”, and this was also the case in Rautio et al. (2016) where sustainable harvest was identified as allowing long-term presence of a harvesting practice. Powell (2016) mentioned demographic changes, abandonment of farming activities, and farmer-led management as key aspects of sustainability of the agrarian system studied, and Lemonnier and Arnaud defined sustainability of agrarian systems as “the ability of [...] societies to maintain a lifelong balance between their food needs and the environmental carrying capacity, without reciprocal damage (even enhancing the environment for future generations) [...], and particularly with regards to their demographic growth” (2022:111). Another 36 articles supported their statements on sustainability by citing external references, and one article authored by Parra et al. (2019) referred to the Agenda 2030 sustainability framework (UN 2015).

Sustainability is not mentioned in the aims and scope of any of the leading ethnobiology journals (Journal of Ethnobiology, Journal of Ethnobiology and Ethnomedicine, Etnobiología, Economic Botany, Ethnobotany Research and Applications). One aspect of sustainability, namely biodiversity conservation, is mentioned in the aims and scope of the Ethnobiology and Conservation journal, the Asian Journal of Ethnobiology, and the Revue d’Ethnoécologie, yet this represents a narrow aspect of sustainability.

### Research partnerships and transdisciplinarity in ethnobiology

In order to have a glimpse at collaborations established during research, we analysed co-authorship composition of the reviewed articles and compiled reported partnerships by IP and LC. The 211 articles published in JoE mainly focused on South, Central, and North America (Figure 2). The countries studied were of high 40.5% (n=85), upper/middle 33.8% (n=71), lower/middle 20% (n=42), and low income 5.7% (n=12). Authors were mainly based in institutions in the global North (Table 1).





**Figure 2.** Number of geographical regions studied among the 211 articles included in the review. articles from Central and North America are from the USA (27), Mexico (23), and Canada (18).

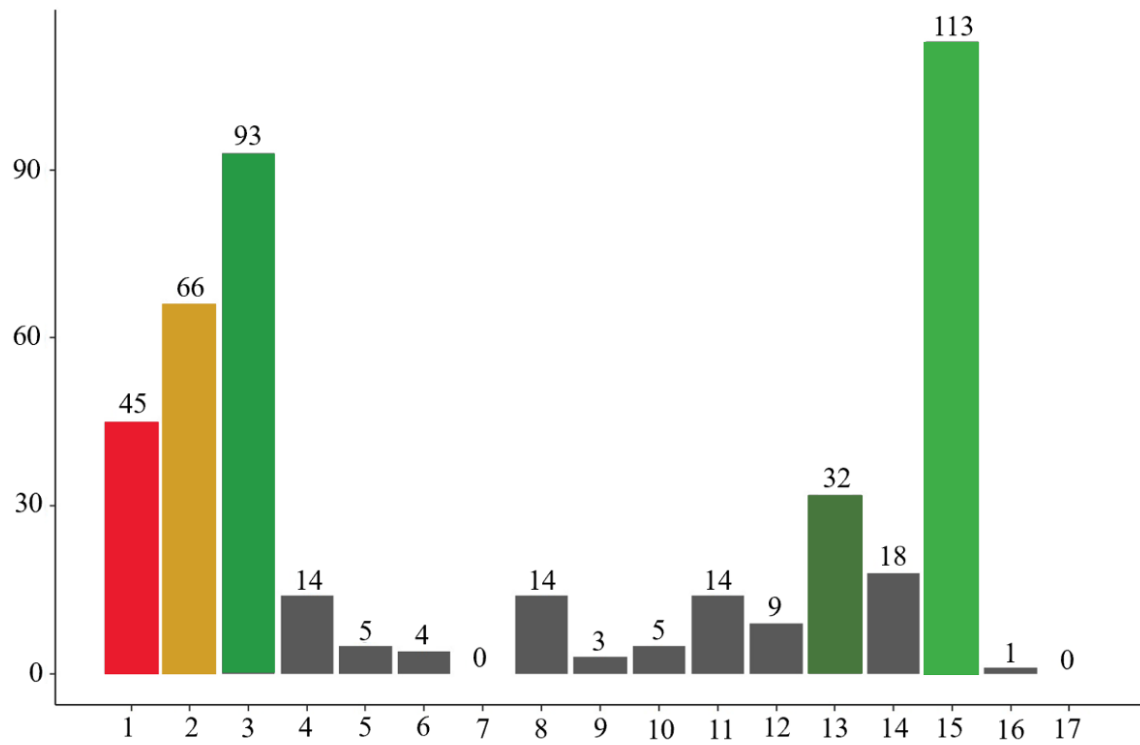
**Table 1.** Collaboration between South and North authors and with IP and LCs.

<b>Authors</b>	<b>Proportions in % (n = articles)</b>
North	62.6 (n = 132)
South	15.2 (n = 32)
Both	22.3% (n = 47)
<b>Co-construction and collaborative approach with local actors and IP and LCs</b>	
IP and LC co-authors	4.7% (n = 10)
Study design	5.7 (n = 12)
Method level and/or results interpretation	14.2 (n = 30)
Data collection	23.1 (n = 49)

Collaborations with IP and LCs were mostly motivated by data collection (23.1%, Table 1) and rarely effective for designing research (5.7%). The articles mentioning sustainability were not significantly different from those that did not in terms of authors' origin, types of collaboration with IP and LCs and local actors, or economic context of the studied countries (Supplementary Material 2).

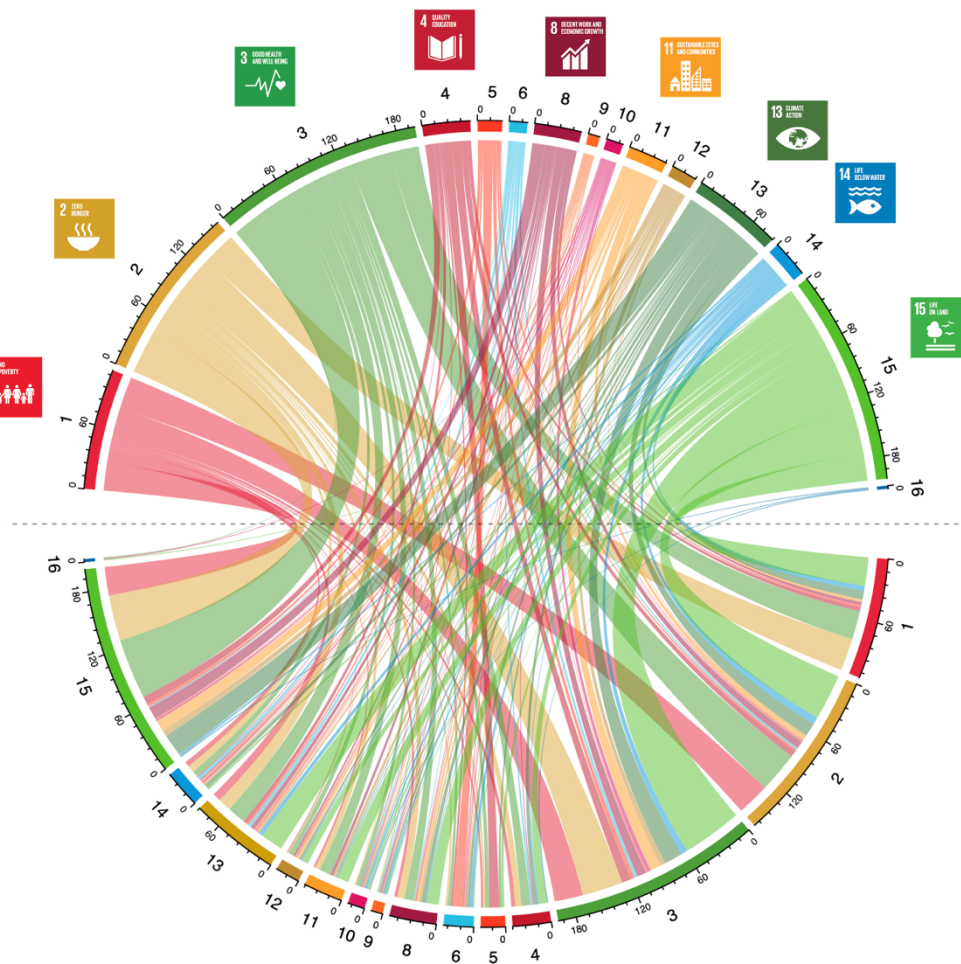
### **Ethnobiology research implicit connections with SDGs**

The SDGs were never mentioned explicitly, but 176 articles (83%) focused on research topics corresponding to SDG themes. In total, we found 436 mentions of subjects concerning one or several SDGs (Arrivabene et al., 2024). The most frequently addressed SDGs were life on land (SDG 15, 53.6%), good health and well-being (SDG 3, 44.1%), zero hunger (SDG 2, 31.3%), and no poverty (21%; Figure 3). SDGs 7 and 17 (affordable and clean energy, and partnerships for the goals, respectively) were never addressed and the remaining SDGs are addressed in a few number of articles (Figure 3).



**Figure 3.** Number of articles implicitly addressing each SDG through their research topics.

Frequently addressed SDGs were often addressed together in the same studies (Figure 4). In particular, SDGs 1,2 and 3 were often addressed together and with SDG15. Climate action (SDG 13) was also frequently addressed alongside good health and well-being (SDG 3).



**Figure 4.** Chord diagram showing the interlinkage amongst SDGs through their implicit mentions. The SDG numbers are on the outer rim and icons show the most common SDGs; the numbers between the SDGs and the diagram are the co-occurrences of the implicit mentions between the SDGs; the width of links between SDGs represents the number of shared implicit SDGs per article.

Reviewed articles provided information on the use and management of terrestrial and marine biodiversity (SDG 15, 53.6%,  $n = 113$  and, to a much lesser extent, SDG 14, 8.5%,  $n = 18$ ) by IP and LCs and other holders of place-based knowledge for all aspects of daily life: food (SDG 2, 31.3%,  $n = 66$ ), medicine and religious ceremonies (SDG 3, 44.1%,  $n = 93$ ), construction, and subsistence (hunting, gathering, fishing, agroecological systems, SDG 1, 21.3%,  $n = 45$ ). Articles evidenced that people-dependent biocultural landscapes are not only a set of plant varieties, animal breeds, wild species, but are complex social-ecological systems intentionally created, maintained, and used by different cultural groups. For example, interconnections with plants were found to support the Inuit Community’s culture of Makkovik in Nunatsiavut (Labrador, Canada). The Makkovimiut Aunt Ellen Andersen stated, “Tell them about our plants... All of our plants, what we have, any of them. They’re all important.” (eg., Oberndorfer et al. 2017:459). The Ch’orti Maya of southern Guatemala use the word “mut” to refer to spirits and also birds. “*No’n kab’ijnu ke’ kamut a’xin tichan* [We believe that our spirit goes up above]” (Hull 2005:85). Birds hold semi-divine values as it can bridge the cognitive gap between this world and otherworld beings. They can bear rains (positive events, when the

flycatchers sings, the Ch'orti say “*wati 'x wati 'x*”, “it is now coming, it is now coming,” (Hull and Fergus 2017:609) and sunlight, but also sickness, disasters, or death (by “*ajb 'a 'xmut*”, “sorcerer-birds”; Hull and Fergus 2017:608).

Many articles emphasised the need to transmit and protect ILK and other forms of place-based knowledge, in particular through children's education (e.g., Marlett 2019; Stampella 2016; SDG 4). ILK, transmitted orally and emerging from individual and collective experience, were shown by reviewed articles to be crucial to the sustainable management of resources, hence to people's food security, health, and well-being (SDGs 2 and 3). Several articles also reported on the stances of caring, respect, and affection that some people maintain with their environment (e.g., Clarke 2016; Thornton et al. 2019). Some places and species were highlighted to hold symbolic values associated with myths, stories, or spiritual entities, breaking from a sole extractivist vision (e.g., Echeverri-Sanchez 2021; Shrestha and Medley 2016). Through this connection and dependence on ecosystems, coupled with ILK, many articles advocated that IP and LCs and other knowledge holders should actively be included in global decision-making for biodiversity conservation (linking SDGs 1, 2, 3 and 15).

Urban contexts were also addressed by the reviewed articles (e.g., Chan et al. 2016; Svendsen et al. 2016; SDG 11), which highlighted the importance of access to nature to people's well-being. For example, community gardens were found to contribute to individual and community resilience by promoting food security and by providing places and resources for gardeners to face social, economic, and environmental challenges (research addressing simultaneously SDGs 2, 3, 11 and 15; Hong and Zimmerer 2022).

When mentioned, climate change (SDG 13) was often described as detrimental to biodiversity (SDGs 14-15) and therefore to people's access to resources (affecting financial autonomy, food security, and health and well-being SDGs 1, 2 and 3; e.g., Konchar et al. 2015; Zahn et al. 2018). Furthermore, many studies emphasised reports of climate changes from IP and LCs: Aqylbek Qapchan, from the Kazakh pastoralists in western Mongolia, sings “*Zher quaryp zhyldan zhylgha öngi ketip. Zhyl sayyn quangshylyq bolyp zhatyr*” [Every year a drought takes place. Year by year the land is losing its color] (Post 2019:383).

## Discussion

This review confirms the contributions of ethnobiology to sustainability thinking, as announced and advocated by Ladio (2017), Turner et al. (2022), and Albuquerque et al. (2024) among others, but also highlights a persisting gap between ethnobiology and sustainability science. We yet acknowledge certain limitations in this study. First, our standardized searches relied on specific sets of keywords to capture sustainability science and ethnobiological literature and on the WoS database. As a consequence, relevant publications that are not indexed in the WoS or that did not use certain keywords were disregarded. A more exhaustive – yet also more time consuming – search strategy could be envisioned to further explore the links between ethnobiology and sustainability issues, in particular by considering other sources of academic and non-academic productions. Second, our qualitative analysis was based on publications from the JoE that is one specific journal among the many that would be relevant to ethnobiological research. As a result, the biases towards English publications and North and Central America could have been lower if other ethnobiology journals (e.g., Journal of Ethnobiology and Ethnomedicine, or the Latin-America oriented Etnobiología journal edited by the Mexican Ethnobiology Association) were integrated in our scope. In sum, our results could be refined via a more inclusive and exhaustive literature search strategy. Notwithstanding these

limitations, our main results rely on the analysis of a large number of papers that allowed us to point at trends in ethnobiological research. While discussing our key results, we draw in the following paragraphs four levers that could help ethnobiology gain visibility in sustainability science and further engage with sustainability challenges.

### **A paradoxical gap between ethnobiology and sustainability science**

A paradox emerged from this literature review that echoes with previous research. On one hand, we found that ethnobiology concretely engages with sustainability and associated SDGs (half of the reviewed articles in JoE mentioned the term *sustainability* and 83% of them focus on research topics that could inform one or several SDGs), suggesting the potential key role of ethnobiology towards sustainability (as stated by Carrière (2021), Ladio (2017), Turner et al. (2022), Albuquerque et al. (2024) and others). This result is not surprising given the discipline's history of engagement for sustainable development and recognition of IP and LCs rights. The collective Declaration of Belem (1988) as well as the work of many individual ethnobiologists was key to develop concepts for the CBD. It is also aligned with the two recent phases of ethnobiology that focus on aspects of sustainable transformations as addressed by the SDGs (e.g., biodiversity conservation, climate action, social justice, equality, Wolverson 2013; McAlvay et al. 2021). Yet, on the other hand, we evidenced a major gap between ethnobiological literature and sustainability science literature. This gap is even more paradoxical when we consider sustainability science agenda and its overlap with the one of ethnobiology. In particular, sustainability science focuses on the intricate relationships between human societies and the environment, aiming to jointly embrace biophysical and socio-economic dynamics in order to fully understand the functioning and evolution of so-called 'social-ecological systems' and to find pathways towards sustainability (Clark & Dickson 2003). This first broad goal strongly echoes the ethnobiological agenda that aims to overcome the traditional Nature-Culture divide and untangle the mutual interactions between IP and LCs and their nature. Aligned with this goal, both sustainability science and ethnobiology emphasise the importance of strong interdisciplinary approaches, i.e. collaborations between disciplines that rely on different epistemologies such as the social sciences and the natural sciences (e.g. for sustainability science, see Spangenberg 2011). Ethnobiologists, who *per se* are at the intersection between the two domains of sciences, would therefore be particularly relevant to sustainability science. Last, non-academic knowledge systems including knowledge from IP and LCs are increasingly recognized by sustainability science who invests large efforts towards their integration (e.g. Camara-Leret & Dennehy 2019). Similarly, place-based approaches and transdisciplinary perspectives based on the co-construction of projects are now widely advocated in sustainability science (Balvanera et al. 2017). Given the expertise of ethnobiologists on collaborations with IP and LCs and on local knowledge systems, it is once again surprising that ethnobiology and sustainability science have not already met.

Different hypotheses can be formulated to explain this gap. A first explanation might be linked to the fact that the concepts of sustainable development and now sustainability are Western-based concepts rooted in a capitalistic ethos that is away from the perspectives of many IP and LCs and other knowledge holder groups (Van Hulst and Beling 2012). Indeed, IP and LCs have long questioned the paradigm of economic growth that is embedded in the SDGs and demanded alternative models to better face the current socio-environmental challenges that affect them disproportionately (Fernández-Llamazares et al. 2021; Rights and Resources Initiative 2019). For example, IP and LCs have emphasised the importance of recognizing and integrating relational worldviews in order to go beyond the Nature-Culture dualism that is increasingly considered at the very origin of present socio-environmental crises (Escobar 2011; Van Hulst and Beling 2012). A second explanation might be related to a gap in the scales at which ethnobiology and sustainability science mainly operate. The

former mainly investigates local scales, at the level of a bundle of villages, for example (Ladio 2017). On the contrary, while the latter acknowledges the potential of place-based research, its main focus is on regional to global levels, promoting multiple level approaches to deal with global sustainability problems such as climate change and biodiversity erosion (Rockström et al. 2009; Smit and Skinner 2002). While closing this gap would be feasible (Turner and al. 2022; Fernández-Llamazares et al. *in review*), it is also highly challenging at a methodological stance. Finally, the lack of overlap between sustainability science and ethnobiology might be explained by the fact that ethnobiology borrows theoretical and methodological tools from other disciplines, in particular anthropology and biological sciences, and struggles to produce its own theories and methods (e.g., Ferreira Júnior 2020). As a consequence, we might assume that sustainability science is not aware of ethnobiology or disregards it as a discipline but integrates its approaches and themes via anthropology and biological sciences.

There is therefore a critical challenge for ethnobiology to become more visible in the grand agenda of sustainability. In the following sections, we draw pathways towards this goal.

### **Pathway #1: Ethnobiology can support IP and LCs sustainability agendas**

Ethnobiology often refers to sustainability but rarely discusses the concept or explicitly addresses how IP and LC conceptualise it. Better understanding of values and interests of competing development agendas and understanding transformations in concrete contexts are grand challenges unveiled by the Global Sustainable Development Report (UN 2019; Messerli et al. 2019). Ethnobiology can help address both. The divergence between development agendas and IP and LCs views on the present socio-environmental crisis are well known to ethnobiologists. For example, ethnobiological research evidenced that national and international sustainability policies were often maladapted to local cultures and place-based knowledge systems, while being sometimes even harmful to biodiversity (Sterling et al. 2017; Ludwig and El-Hani 2020; Fernández-Llamazares et al. 2021; Teixidor-Toneu et al. 2023). To avoid such caveats, ethnobiology can provide contextualised evidence of transformations, including local impacts of global change (e.g., Konchar et al. 2015) and relevant local adaptation strategies (e.g., Woodmansee 2023). For a long time, several Indigenous representatives have been declaring that the relational models established with Nature on the part of global societies are profoundly destructive (Rights and Resources Initiative 2019) and ethnobiologists have been sensible to these calls (e.g., Declaration of Belem 1988). Ethnobiologists also acknowledge that IP and LCs are in an open process of reconstitution, strengthening, and advancement (McAlvay et al. 2021). Due to the strong asymmetries of power and inequalities inherited from colonial and racist practices, continued by capitalism, and rooted in global society and in science itself to this day, these premises have been repeatedly disregarded (Ladio 2020). Such asymmetries are also suffered by place-based knowledge holders in Europe (Molnár et al. 2023). Given the recognised place of sustainability in ethnobiology research, ethnobiologists could explicitly address IP and LCs sustainability conceptualisations and indicators (e.g., Sterling et al. 2017, 2020). IP and LC ethical guidelines, embedding feelings and emotions, often reflected in myths and legends, constitute the vehicle that ensures the maintenance of biodiversity (Aillapan and Rozzi 2004; Garibaldi and Turner 2004). Ethnobiology is at the forefront of increasing the visibility of place-based knowledge holders and cultures that can serve as inspirational sources for sustainability transitions for food security, health, well-being, and the economy of communities and peoples at a global scale.

### **Pathway #2: Ethnobiology can make meaningful contributions to the SDGs**

The reviewed articles evidenced that ethnobiology addresses SDGs themes but in an implicit manner. Without falling into “SDG-washing” (Dangles and Struelens 2023), more explicit linkages of ethnobiological research with sustainability and the SDGs would reinforce its visibility in the grand

agenda of sustainability. Through its focus on the holistic approaches of people-nature relationships, place-based knowledge, local livelihoods, and well-being, ethnobiology has potential to address SDGs with a new lens as well as provide critical feedback towards some of the SDGs (Eisenmenger et al. 2020). By respectfully bridging understanding between different ontologies and explicitly addressing the SDGs while recognising that sustainability science goes way beyond the SDGs, ethnobiology would enable global sustainability strategies to be linked with local and Indigenous cultures and their knowledge systems. For example, IP and LCs and other place-based knowledge holders stress the need to maintain networks of life in order to achieve transformative change (Alarcón-Cháires and Toledo 2018). Widely recognised co-evolutionary relationships between cultural and biological diversity translate in an indivisible cultural whole of knowledge, values, and worldviews held and transmitted across and within generations (Gorenflo et al. 2012; Orlove et al. 2023; Posey 1985). The study of these interlinkages – which are at the core of ethnobiology – can be highly relevant to the understanding of SDG nexus configurations (Poole 2018).

Another lesson learned by ethnobiology for transformative change is that there is no single way of perceiving the non-human world, managing it, or protecting it (Ludwig and El-Hani 2020). For example, the cognitive and ethical positioning of place-based knowledge holders studied by ethnobiology on how landscapes are managed and protected can contribute to transformative change. Landscapes are social-cultural constructions, products of different management intensities, which include tolerance, protection, enhancement, and cultivation or breeding, and depend directly on the cosmologies of the societies that manage them (Casas et al. 2017). Landscapes are not only ecological and social formations, but also depend on epistemic and linguistic dimensions; that is, on beliefs, rituals, art, land-use norms, knowledge, and innovations developed and transmitted over time (Alarcón-Cháires and Toledo 2018; Hunn 2014) together leading to holistic social and ecological or biocultural well-being (Comberti et al. 2015; Sterling et al. 2017; Caillon et al. 2017). Terrestrial and water landscapes have been domesticated through human practices tending to maintain environmental diversity, redundancy, and the renewal of ecological cycles by adapting to the changing conditions of their surroundings (Levis et al. 2018; Ferrara et al. 2021). However, these practices were often delegitimized by scientific and Western-centred visions, resulting for example in the exclusion of IP and LCs from protected areas or the prohibition of place-based holders for the sake of the preservation of a certain idea of “Nature” and the achievements of SDGs 15 and 17 (Reis et al. 2014; Molnár et al. 2023). People’s role in the construction of sustainable landscapes has not been taken into account; in fact, anthropogenic processes have been stopped by emptying them of their cultural uses and practices. In this sense, numerous examples of landscapes considered by science as “wild” largely result from human action over hundreds or thousands of years (Casas et al. 2017; Ellis et al. 2021; Fletcher et al. 2021; Levis et al. 2018; Reis et al. 2018). Demystifying the paradigm of “pristine landscapes” (Reis et al. 2014; Odonne et al. 2019) and fostering an alternative vision through which IP and LC are important stewards of their environment (West et al. 2018) can contribute to transformative change by producing research that integrates governance, well-being, action, economy, and place-based knowledge (Ibarra et al. 2023; Messerli et al. 2019).

### **Pathway #3: Ethnobiology should emphasise its transdisciplinary approaches**

Transdisciplinary approaches are central to sustainability science and ethnobiology has an inherent and long-standing experience of collaborations with IP and LCs, and of reflections on how to promote inclusive and equitable partnerships in a post-colonial world. Transdisciplinary approaches whereby researchers across disciplines from the Global South and North and IP and LCs partner and together identify problems, build teams, establish common language and goals, conduct and communicate research are needed for sustainable transformations and fairer understandings of nature-

people relations (Hadorn et al. 2006; Ibarra et al. 2023; Jerneck et al. 2011; Molnár et al. 2024) and calls for the decolonisation of ethnobiology advocate similar research practices (McAlvay et al. 2021). With all the difficulties and processes against them, coming from a history of marginalization, exclusion, and anti-dialogue, IP and LCs and other place-based knowledge holders are claiming interculturality and the time has come to elaborate new alternative and open pathways to sustainable development with them (Argueta and Serrano 2021; Molnár et al. 2023). Our results show that ethnobiology still faces challenges to overcome systemic biases inherited from colonialism as the majority of articles are written by authors from the economic Global North, with Central and North America as the main regions of study (Figure 2, Table 1). While this may well be a bias stemming from our data sample reflecting membership of the Society of Ethnobiology, similar observations have been made in sustainability science (Dangles et al. 2022) and botany (Park et al. 2023). Formal research collaborations with IP and LCs and local actors are still limited (Table 1, although they agree to share their knowledge) and remain most important in data collection, while collaborations for project or study co-construction are rare (just over 5% of the articles). IP and LC members rarely participate in publications as co-authors. This is perhaps because the formulation of the decolonising phase of ethnobiology is very recent and might still be getting momentum (McAlvay et al. 2021).

We call for ethnobiologists to assess and address testimonial and hermeneutical injustice towards IP and LCs and other place-based knowledge holders in their research practice (Fricker 2007). The first occurs when prejudice causes a listener (scientist, technician, government) to grant a deflated level of credibility to a speaker. The second occurs when a gap in collective interpretive resources puts IP and LCs and other place-based knowledge holders at an unfair disadvantage when it comes to making sense of their social experiences. These biases result in the construction of ignorance because they imply a loss for science and for the advancement of human knowledge (Maffia 2007). In other words, the omission of the place-based ways of thinking to address the environmental crisis is not only not inclusive, but also narrows the horizons of possible, multicultural solutions and understanding of complex systems. Thus, in order to fully contribute to sustainability research and action, it is urgent to continue to support IP and LCs and other place-based knowledge holders with epistemic and social justice (e.g., Ludwig and El-Hani 2020; Molnár et al. 2023). As ethnobiologists, we have the responsibility to uphold the voices of IP and LCs and other place-based knowledge holders, for example by including them in knowledge coproduction processes, accompanying their social and territorial demands, and continue to call for policy directions that help promote the maintenance and restoration of place-based actions and viewpoints as sources of social-ecological resilience and inspiration (Declaration of Belem 1988; Ibarra et al. 2023; Ignace et al. 2023; McAlvay et al. 2021).

#### **Pathway#4: Active participation in sustainability I**

A vast array of international events and groups now exist with direct and indirect links with sustainability science, and ethnobiologists could further engage with these. Ethnobiologists played a key role in the Convention on Biological Diversity by contributing to reports on status and trends of IP and LC knowledge (e.g., CBD 2003), participating in Conferences of the Parties to the CBD, specifically organising side events on Article 15 and 8j (“Traditional Knowledge, Innovations and Practices”), and contributing to the CBD Nagoya protocol in 2010 and the CBD code of ethics (which drew from the ISE Code of Ethics). The strength of ethnobiology is identified as bringing understanding about the indissociable links between biological and cultural diversity, yet to be widely acknowledged by Governments when formulating their sustainability policies (exceptions exist, e.g., Ecuador, New Zealand; Chapron et al. 2019). Yet, ethnobiology as a disciplinary field still very seldom engages in sustainability discussions. The review presented here provides a glimpse of the



importance of ethnobiology to sustainability thinking. Our results show that ethnobiology adds the empirics of fieldwork and local voices that have been largely invisible in sustainability discussions, at least until recent work for and emerging from the IPBES assessments (e.g., IPBES 2019; Hill et al. 2021). Ethnobiologists have helped integrate Indigenous and Local Knowledge into IPBES assessments (Brondízio et al. 2021; Tengö et al. 2017). However, we could more actively engage with this and other sustainability fora, by applying to be part of IPBES co-authoring teams as well as reviewing assessment drafts. As a case point, the IPBES Nexus assessment that has recently been reviewed addresses the interlinkages among the Sustainable Development Goals related to biodiversity on land and in the oceans, water and food security, and health in the context of climate change and climate action. Our review shows that the topic of the assessment falls completely within ethnobiology's research agenda. While review applications are now closed, ethnobiologists could use the assessment when published as a guide to fill nexus knowledge gaps.

## Conclusions

While sustainability issues have gained an audience from many disciplines over the last decades, we investigated in this study the specific contribution of ethnobiological research to sustainability science and to research on the sustainable agenda's goals. Through standardized literature searches, we showed that ethnobiology literature is poorly connected to the large body of literature in sustainability science. Despite this apparent disconnect, a qualitative analysis of a sample of ethnobiology literature evidenced that ethnobiological research does effectively engage with sustainability issues and SDGs, yet in an implicit manner. We also found that research in ethnobiology rarely reports engagement with IP and LCs and other local stakeholders in the formulation of their research questions and in their study design. Overall, our findings confirm the unique yet understated contribution of ethnobiology to sustainability science and to research on SDGs. Four pathways are finally drawn to reinforce the place of ethnobiology in this grand sustainability agenda: ethnobiology research could explicitly address sustainability and the SDGs, further develop and report its transdisciplinary approaches, and ethnobiologists could more often actively participate in sustainability fora.

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