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A systematic review of biocultural innovation: Challenges, potentialities and agendas for environmental futures

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Abstract: Biocultural diversity and heritage are areas threatened by the implications of the development agenda. They study the interdependent relationships between people and the biodiversity of Indigenous and Local community's territories. There are innovation practices related to biocultural memory, heritage, and diversity for rural development. This article systematically reviews the literature around the concept of Biocultural Innovation (BcI) following the PRISMA protocol. The databases Scopus, Web of Science, and Google Scholar were used to select the records between 2012 and 2023. Of the 71 records identified, a total of 33 documents met the exclusion/inclusion requirements, including 21 publication sources, 78 authors, 41 institutions, and 18 countries. Relevant case studies and programs that have promoted the application of BcI, particularly in the Global South, are also identified. A qualitative assessment is made to argue for the relevance of this concept based on its challenges and potential. Biocultural innovation is an emerging area of inquiry that provides elements to guide policymakers, research institutions and communities wishing to develop approaches to protect, sustain and revitalize rural place-based innovation. Finally, suggestions for future research are made.

Keywords: Biocultural innovation; Biocultural heritage; Biocultural diversity; Conservation; Systematic literature review.

Introduction

From plants to fungi and animals, biodiversity is being lost at a rate of hundreds to thousands of times (De Vos et al., 2014), alongside the rapid disappearance of Indigenous and local cultures, represented in their knowledge and languages (Swiderzka, 2009). Biological and cultural diversity are interdependent and inextricably linked (Poole, 2018). According to Bridgewater & Rotherham (2019, p302), Biocultural Diversity is "is a *dynamic, place-based, aspect of nature arising from links and feedbacks between human cultural diversity and biological diversity."* The biocultural lens focuses on diversity and heritage related to culture, linguistics, and biodiversity (Hanspach et al., 2020; Pretty et al., 2009). It can be seen as the interconnected space where the interlinks of societies and biodiversity merge, as well as the potential as plural elements to generate place-based well-being futures beyond the human-nature dichotomy that has been rooted in academic analysis and public policy design (Caillon

et al., 2017; Sterling et al., 2017). The concept of biocultural innovation (BcI) suggests interesting insights into how innovation is localized, co-created, and managed. This narrative is guided by values beyond growth and competitive advantage. However, most of the literature on biocultural innovation is sparse and vague. A systematic literature review is therefore needed.

The biocultural approach is nurtured by two concepts, biocultural diversity and biocultural heritage. Biocultural diversity is the "*dynamic, interdependent complex of relationships linking human populations, biodiversity, non-human species and their environments*" (Turner et al., 2016, p. 3). Also, for the Convention on Biological Diversity (CBD) Conference of the Parties (2018, p. 5) BcD is considered *"as biological diversity and cultural diversity and the links between them"*. More specifically, Diaz et al. (2015) define this diversity as "t*he total variety exhibited by the world's natural and cultural systems, explicitly taking into account the idea that culture and nature are mutually constitutive*" (p. 12).

It has also been extended through collaboration between indigenous peoples and research groups (Díaz et al., 2015). Biocultural heritage has been considered *"a holistic concept in which knowledge, biodiversity, landscapes and culture are interconnected and interdependent"* (Swiderzka, 2013b, p. 13), *"result from interactions between people and nature at a given time in a given place" (Bridgewater & Rotherham, 2019, p302),* and for CBD (2018, p6) is defined as *"the holistic approach of many indigenous peoples and local communities. This holistic and collective conceptual approach also recognizes knowledge as "heritage", thereby reflecting its custodial and intergenerational character. The cultural landscapes inscribed under the World Heritage Convention are examples of biocultural heritage*". This also draws more attention to the processual nature of culture, development, and human-environment relationships (Turner et al., 2016).

Based on Nemogá (2016), a reflection on research that includes biocultural diversity, the rights of local and indigenous communities and their cosmologies is crucial. The author suggests a series of barriers that biocultural approaches face from an innovation perspective, such as the legal and institutional norms, the emphasis on biodiversity inventories and measurements, the view of local communities as data providers, and the omission of science, technology, and innovation systems. Innovation needs to be rethought, taking into account its biological and cultural roots. According to Dutfield (2014), innovation needs to be understood very differently from the mainstream innovation literature, given the values of local communities and their distinct and diverse lifestyles and livelihoods. Thus, innovation is universal, but it is highly diverse in its place-based dynamics and occasionally challenges the development model (Jimenez et al., 2022; Maldonado-Villalpando & Paneque-Gálvez, 2022; Maldonado-Villalpando et al., 2022).

In this case, traditional and local knowledge is intrinsically intertwined with community-based innovations (Bajaj, et al. 2009; Macdonald et al., 2021). Nevertheless, in these processes, cultural and practical tensions emerge around the nexus of tradition and innovation (Ferreiro, et al. 2019), creating an opportunity to envision environmental futures (Granjou et al., 2017; Wyborn et al., 2020). Food, in particular, is a great representation of biocultural diversity; for many cultures, it has a deep meaning in terms of traditions, heritage, and relationship with the territory. They are rooted as a form of biological selection over centuries and millennia for human groups in interaction with biodiversity and its diversity. Then, their interactions in food systems are pathways for nutrition and sustainability, and also pathways for resilience to the threats of climate change, agriculture, development, and conservation policies (Swiderska et al, 2022).

The text is divided into five sections. The second section presents the methods based on the PRISMA protocol, the main research questions, and the literature generation. The next section notes the findings around the framing of the biocultural innovation construct. In particular, how the scientific and practitioner communities have used the concept, types of publications, institutional programs, main case studies, and definitions. The fourth section highlights the challenges and opportunities, followed by future research and policy agendas. Finally, the last section presents the conclusions of the review.

Methods

According to Kitchenhama (2009), a systematic review of the literature (SRL) is a rigorous method of synthesizing research findings. SRL involves the identification, selection, and critical appraisal of relevant research literature. The main aim is not only to summarise all existing evidence on a research question but also to support the development of evidence-based guidelines for practitioners. In this case, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) protocol was used.

The PRISMA statement consists of a checklist of 27 items and a four-stage flowchart (see Figure 1). This protocol aims to help authors strengthen the reporting process of a systematic review. Scientific literature and practitioner reports are relevant to the broad field of the biocultural approach. In particular, it is an area where international research organizations, universities, and community-based organizations are interested in promoting practices based on situated traditional and ancestral knowledge and heritage.

Research questions

This research aims to understand the development of the concept of biocultural innovation as an emerging element in environmental, social and conservation studies. To this end, the following three research questions were formulated

Q1 What is the number and type of publications per year?

The first objective is to determine the number and type of publications found, and then to generate a trend on the evolution of this concept in recent years.

Q2 What have been the main case studies and programs of research sharing and what has been their impact?

A particular focus will be placed on case studies and programmes to understand how this construct has been used in interactions on the ground. In particular, the type of biocultural innovation that has emerged from rural areas is expected to illustrate this concept to the audience.

Q3 How is bio-cultural innovation defined?

The final aim of the thesis is to provide an overview of definitions of biocultural innovation and the contexts in which they have been applied. To understand how the scientific and practitioner communities have approached the issue.

Literature body creation

The protocol for establishing the body of literature was based on searching for the term 'biocultural innovation' in three languages, Spanish, English, and Portuguese. For this purpose, the following scientific databases were used to broaden the search spectrum: Scopus,

Web of Science, and Google Scholar. The main search terms were ("biocultural innovation") ("innovación biocultural") ("inovação bioculturais") and ("biocultural heritage innovation").

Thus, the body of literature in this systematic review is the result of the following steps

A) Selection of documents, the result of the search carried out in Scopus, Web of Science, and Google Scholar.

B) Identification of duplicates is excluded. The bibliography found is checked to see if it is present in more than one database.

C) Application of inclusion/exclusion criteria. The documents resulting from the identification of duplicates are analyzed, excluding those that do not meet all the inclusion criteria.

D) Verification of included articles. In the final step, the literature is reviewed to confirm that it is in the context of biocultural innovation.

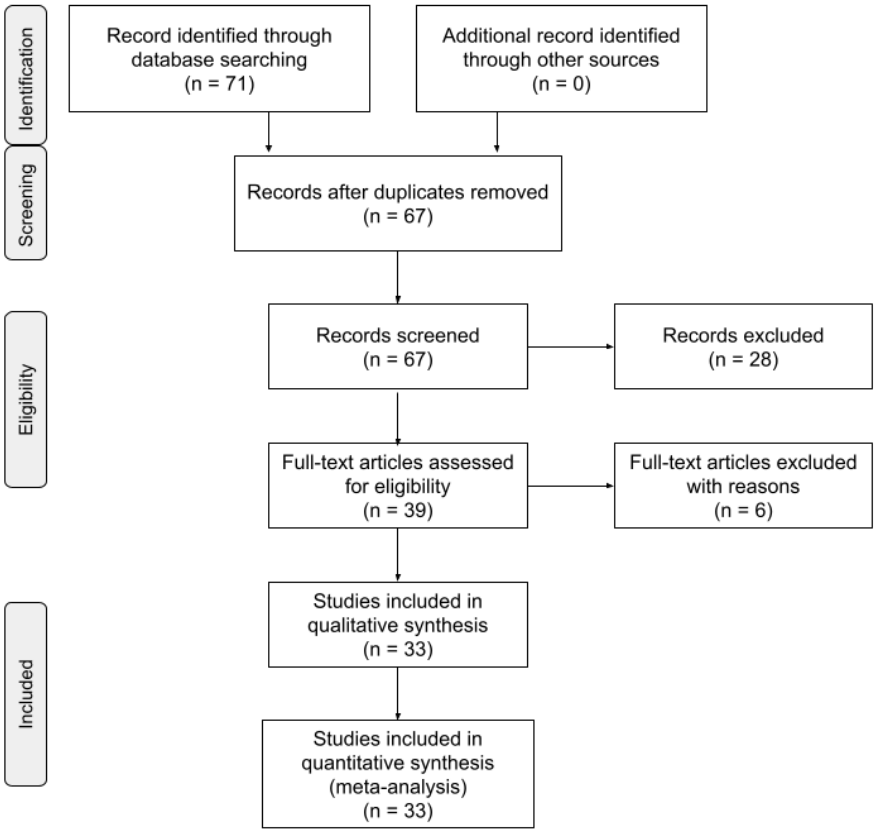
The following inclusion and exclusion criteria were established:

1. The term must be present in the title, abstract, or keywords of the publication.
2. Scientific articles, peer-reviewed book chapters, graduate theses and scientific reports were accepted.
3. They may be written in English, Spanish, or Portuguese.
4. The body of the text must be more than one page.
5. Have access to the full text of the document.

Records selection

A systematic review was performed to obtain the literature, following the previous steps. The database search was carried out on 19 February 2024 and covered the period from 2012 to 2023. Applying the first inclusion/exclusion criteria, 71 articles were selected that included "biocultural innovation" or "biocultural heritage innovation" in their abstract, title, or keywords. After applying the second, third, fourth, and fifth criteria, 32 documents were excluded. Finally, 6 documents were excluded because they were not related to the context of biocultural innovation. Therefore, 33 publications that met all the selection criteria were included in the qualitative synthesis. The following figure shows the document selection process for the qualitative synthesis.

Figure 1 - PRISMA Protocol



Source: Adapted from Moher et al., 2009.

Framing the concept of Biocultural Innovation

This section presents the synthesis of the 33 documents selected for the qualitative synthesis. Using the PRISMA protocol, 32 documents in English and 1 in Spanish were selected. In this case, there are 21 different sources, 78 authors from 41 institutions in 18 countries. In the following subsections, specific elements of the literature are presented. Parameters such as year frequency, publication type, source, authors, institutions, countries, case studies, programs, and definitions are key to understanding the flow of the BcI concept in the literature.

Year frequency and publication type

At the level of publications per year, it can be seen that since 2012 there are records of documents relevant to the SRL. The years with the highest number of publications are 2013 and 2018 (four publications) and 2016 and 2019 (five publications). The table below shows the number of documents published per year.

Table 1 -Publications by year.

Year	Publication	Total
2012	(Davidson-Hunt et al., 2012)	1
2013	(Asociación ANDES & IIED, 2013; Sera & Voeks, 2013; K. Swiderska, 2013a, 2013b)	4
2014	(Brandt, 2014; Dutfield, 2014)	2
2015	(Ludlow, 2015)	1
2016	(Asociación ANDES, 2016; Groh, 2016; Melo, 2016; Song, Zhang, Song, & Swiderska, 2016; Turner et al., 2016)	5
2017	(Martinez, 2017; Wekesa et al., 2017)	2
2018	(Kagawa-Viviani et al., 2018; Mukerjee, Sogani, Gurung, Rastogi, & Swiderska, 2018; K. N. Swiderska et al., 2018; Turner, Davidson-Hunt, & Hudson, 2018)	4
2019	(Aellen, 2019; Ekblom et al., 2019; Friedrichesen, 2019; Madden, 2019; Mardones, 2019)	5
2020	(Addae, 2020; Winkel et al 2020)	2
2021	(Kenterelidou and Galatsopoulou, 2021)	1
2022	(Reina-Rozo, 2022; Swiderska et al., 2022; Swiderska & Argumedo, 2022)	3
2023	(Andablo-Reyes et al., 2023; Svensonn et al., 2023; Vassallo et al, 2023)	3
	Total	33

In the last five years, from 2019 to 2023, 9 journal articles and 2 book chapters were published, representing almost 66% of the peer review records. Table 2 shows the type of publication reviewed.

Table 2 - Publication types

Publication Type	Publication	Total
Journal Article	(Andablo-Reyes et al., 2023; Brandt, 2014; Davidson-Hunt et al., 2012; Ekblom et al., 2019; Kagawa-Viviani et al., 2018; Kenterelidou and Galatsopoulou, 2021; Reina-Rozo, 2022; Svensonn et al., 2023; Swiderska, 2013b; Swiderska et al., 2022; Turner et al., 2016, 2018; Vassallo et al, 2023; Winkel et al 2020)	14
Report	(Asociación ANDES, 2016; Asociación ANDES & IIED, 2013; Dutfield, 2014; Mukerjee et al., 2018; Song et al., 2016; K. Swiderska, 2013a; K. N. Swiderska et al., 2018; Wekesa et al., 2017)	8
Thesis	(Addae, 2020; Friedrichesen, 2019; Groh, 2016; Madden, 2019; Mardones, 2019; Martinez, 2017; Melo, 2016)	7
Book chapter	(Aellen, 2019; Ludlow, 2015; Sera & Voeks, 2013; Swiderska & Argumedo, 2022)	4
	Total	**33**

Main programs and case studies

Regarding the second research question on the application of the construct in the field, two main research programs and several case studies were found. This review has identified ten case studies developed in the seven countries of the Global South (Mexico, Peru, Bolivia, Brazil, Kenya, India, and China) and two research programs from three countries, Canada, the United Kingdom and the United States. The following is a description of the two main programmes and the case studies that emerged from them.

Programs

Smallholder innovation for resilience (United Kingdom)

The first program is Smallholder Innovation for Resilience: Strengthening Biocultural Innovation Systems for Food Security in the Face of Climate Change (SIFOR). It was developed by the International Institute for Environment and Development (IIED) in the UK from 2012 to 2017. This program enabled farmers and organizations in four countries, including China, India, Kenya, and Peru, to strengthen innovation systems based on two pillars, the first being biocultural heritage and the second being traditional knowledge. This program identified three sets of biocultural innovations, technological, market, and institutional, and their case studies, in total over 500 BcIs were analyzed. These were largely endogenous and related to technology, while collaborative processes focused on institutional and market (Swiderska et al., 2018).

Through a strategy of South-South knowledge sharing, the program facilitates spaces for sharing and co-creation of methodologies and concepts. The latter to produce comparable and rigorous findings needed to influence policy debates on biocultural heritage and innovation, and on the other hand to foster grassroots initiatives. Finally, through its program,

SIFOR has been able to inform policy in several ways. First, with the ability to produce scientifically rigorous and comparable data through the baseline study and effectively influence policy both nationally and internationally in Peru (Asociación ANDES, 2016), China (Song et al., 2016), Kenya (Wekesa et al., 2017) and India (Mukerjee et al., 2018). Second, policymakers' field visits broadened their understanding of the critical role of farmers and landscape knowledge in conserving crop diversity for climate change adaptation. Third, the knowledge of the experts enabled the dialogue on intellectual property, which improved the understanding of these mechanisms and the proposal of an alternative system of Biocultural Heritage Indications (Swiderska, 2013a).

Innovation in Small-Scale Food Systems (Canada)

The second program is entitled "Ethnobiological Design and Food System Innovation for Indigenous and Local Communities in Canada and Bolivia". It was developed from 2015 to 2020 and led by the Natural Resources Institute at the University of Manitoba. The program created the framework of biocultural design as a collaborative practice for community innovation. The main objectives were to (a) document the interrelationships between people and biological materials for food systems; (b) document food system innovation through case studies; (c) implement prototyping processes for food system innovation; and (d) develop recommendations for policies and programs to enable local food system innovation.

A key concept in this program is *biocultural design*, which refers to the intimate relationship people have with their territory and enables the creation of their plans, products, and services to meet locally defined needs (Davidson-Hunt et al., 2012). In this case, biocultural design is based on BcD and BcH, its conceptual pillars. The two study regions were rural areas in Bolivia and Canada. The first is located in the Central Valley of Tarija in southern Bolivia. In this region, two cases were developed studies related to the gastronomic heritage. The second region of the study was the rural area of Manitoba, specifically, cases were developed focused on craft breweries (Davidson-Hunt, Ulrich, & Muhajarine, 2019) and *manomin* (wild rice, *Zizania palustris L.*) harvest camp (Kuzivanova & Davidson-Hunt, 2017).

Case studies

Berimbau de barriga (Brazil)

Biocultural innovation cannot be seen as a concept limited to the sphere of indigenous communities. Historically, enslaved Africans and their descendants in the Americas have been active agents in these processes of innovation based on biocultural heritage and biodiversity. The case of the Brazilian berimbau de barriga illustrates the ethnobotanical and cultural roots of this single-stringed musical instrument, the key to the capoeira dance, which has its roots in West Africa. Sera and Voeks (2013) provide a historical and careful description of the travels of travellers who mentioned encounters with the Berimbau in Brazil and some countries in Africa.

Ethnobotanical knowledge plays a key role in the case of the Berimbau. This artefact is made almost entirely of biological components, especially plants. The basic elements are the Verga (Biriba - *Eschweilera ovata L*), the Cabaça (*Crescentia cujete L*), the Arame (metal wire), and are often accompanied by the Caxixi (seeds from *Heliconias sp or Job's tears, Coix lacryma-jobi L*) (Sera & Voeks, 2013). The growing interest in the Afro-Brazilian

martial arts, and dance of capoeira as a cultural heritage and its musical instruments have put pressure on biodiversity. This extraction process highlights the tensions between heritage and the pressure on biodiversity, especially in the Atlantic coastal rainforests, due to the extraction of Biriba for the construction of the Verga. However, this phenomenon has much less pressure than agriculture, livestock or mining activity in the area. Thus, this case of biocultural innovation represents the interrelationship between biocultural heritage and biodiversity, here as a musical instrument.

Zapatista Corn (México)

Innovation can be an instrument of resistance. In this case, the Zapatistas in the state of Chiapas (southwest Mexico) have developed the 'Zapatista maize' as a means of resistance to GMOs and as a response to new technologies (Brandt, 2014). In this context, a program of institutional and organizational biocultural innovations is emerging to confront the threat of GMOs on the territory of Indigenous communities who, according to their cosmogony, are peoples made of maize (Darling, 2020). The case in point is the Mother Seeds in Resistance from the Land of Chiapas Project (hereafter Mother Seeds) a joint action between the Zapatistas and the organization *Schools for Chiapas* (a non-profit based in San Diego). Brandt states that this is a valuable case study of biocultural innovation because Zapatista maize is "*a material-semiotic assemblage defined by the combination of new and old techno-cultural practices of seed saving, genetic testing, and agroecology-based political education*" (2014, p. 890). In this case, the Genetic testing kits are subverted as tools of the weak that would allow Zapatistas to know if GM markers are present in their crops and remove the offending plants if markers were found (Ibid, p. 887).

In this way, biocultural innovations could be processed to build a different future, one that can be possible for Indigenous communities that have been excluded from modern and colonial society. Zapatista bioculture cannot be reduced to Indigenous cultural practices alone, because it also stems from their political goals of autonomy in opposition to neoliberalism. Finally, Brandt concludes that Mother Seeds should be considered "*as an alternative to modern projects of purification: its aim is not to separate nature and culture, but rather to show how deeply they are intertwined - Zapatista corn provides the biocultural link between the Zapatistas' political project and their maize plants"* (2014, p. 876).

Potato Park in Pisaq (Perú)

The Parque de la Papa is an indigenous biocultural heritage site (Argumedo, 2008). This case study has been conducted since 2002 in the Sacred Valley of the Incas, near Pisaq (Peru). According to Swiderska (2013a, p. 1), "*the park has introduced several biocultural innovations that have strengthened biodiversity conservation, cultural identity, and livelihoods.*" In this regard, Asociación ANDES (2016) has identified several biocultural innovations applied by the Potato Park communities that contribute to both agricultural productivity and livelihood resilience, such as:

A) New technologies based on ancient agricultural technologies that reflect their role in risk reduction, which include changing the time and place of Chuño production and the creation of a community seed bank; B) Market innovations related to livelihood options derived from biocultural heritage and business opportunities for products and services, which include the development of collective microenterprises and informal collective trademarks; and C) Institutional innovations as new institutions and policies that promote the use of Indigenous

knowledge and the effective functioning of local institutions, which include the Potato Park Biocultural Heritage Territory model and biocultural protocols.

ANDES also uses the Inca graphic as a conceptual framework in the context of the Potato Park research activities because *"it still represents the paradigm that communities use to define their future... this worldview is the source of solutions to the problems that affect us"* (Asociación ANDES & IIED, 2013, p. 12). Meanwhile, Martinez (2017) offers an in-depth analysis of the potential compatibility and/or conflicts of an open-source seed model developed by the Quechuas communities in the park as an alternative to the dominant legal regime on seed privatization. The Chuño seeds in this case, have been identified as BcI (Swiderska & Argumedo, 2022), Because, they combine material and immaterial aspects such as genes, knowledge, and culture (Sievers-Glotzbach et al., 2021)

Mijikenda people at Kenya Coast (Kenya)

This case serves to build climate resilience in five Mijikenda communities (southeastern Kenya) by exploring traditional knowledge-based innovations developed by farmers in response to socio-economic and climatic challenges (Wekesa et al., 2017). The forest and agricultural lands serve as areas of biocultural heritage, which have traditionally united communities through cultural cohesion. This case study was conducted by the Kenya Forestry Research Institute (KEFRI) at its Coast Eco-Regional Research Programme headquarters.

The objective of the case study was to *"identify and disseminate a) traditional knowledge-based innovations that enhance productivity and b) conditions that foster vibrant and resilient traditional knowledge-based innovation systems"* (Wekesa et al., 2017, p. 4). Some BcIs have been identified as follows: A) technological innovations, such as the combination of modern and traditional tillage practices to increase productivity and the domestication of various wild forest plants to increase income; B) market and livelihood innovations, such as the Rabai cultural village and village banking; and C) social and institutional innovations, such as the free exchange of seeds, the establishment of cultural centres, and the revival/preservation of customary laws and practices.

The work of Groh (2016) analyses the factors that hinder and facilitate biocultural innovations. In particular, some aspects related to the impact of gender and age on the ability to innovate were studied. The author concludes that older people show the highest awareness and participation in biocultural innovations, while young people are increasingly isolated. Gender discrimination is socially reinforced and limits women's resilience to climate change by reducing their access to agricultural inputs, markets, capital, leadership positions, and information. Despite its importance, biocultural innovation is weakened by several elements, including religion, modern culture and education, youth migration, and recent climate change impacts (Wekesa et al., 2017).

Biocultural innovation concept definition

Innovation from a biocultural perspective has been seen as a collective process of doing new things based on cultural and biological heritage. In this context, local communities (Peasant, Indigenous, and Afro-descendant) are not only knowledge holders but also innovators. It needs to be understood differently from the mainstream innovation literature, especially the neoliberal perspective. This has focused on quantitative rationality and has been driven by profit based on a hegemonic economic system. BcI is now seen as practical, sustainable, and locally and globally relevant.

In this context, Dutfield (2014) argues that the innovation processes led by indigenous and local communities have specific characteristics that distinguish them from the hegemonic narrative of innovation, in particular three main elements are highlighted: a) they are largely endogenously generated and primarily local in origin; b) they are primarily collective and individual attribution is rarely sought, even if an individual was instrumental in achieving the final part of the process; and c) conventional innovation tends to be quantified based on statistical units of measurement and comparison that make little sense to indigenous peoples. These latter characteristics are key to considering a broad definition of biocultural innovation.

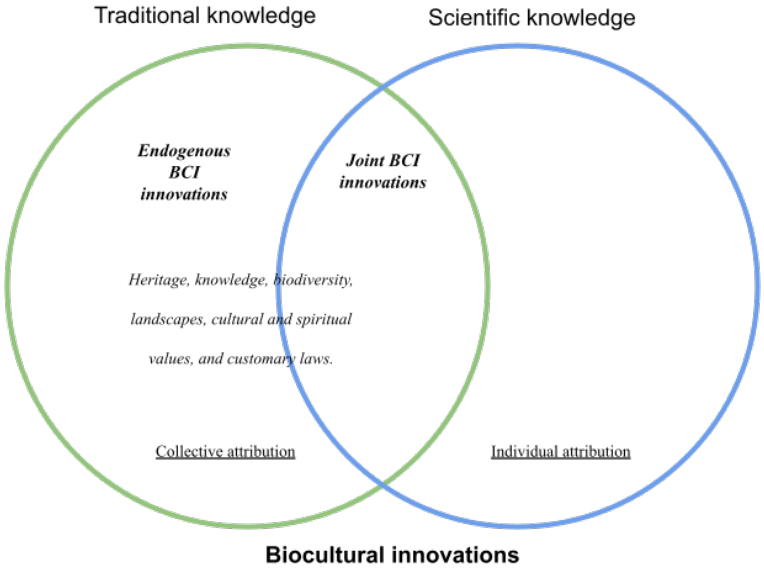
Several definitions have been found. The main similarities between them are primarily: the interaction of local and academic knowledge, cultural and spiritual values, traditional norms, and based on biodiversity. Dutfield (2014, p. 4) offers a first draft to rethink the concept of innovation in place-based environments: *"Innovation is about combining different elements (pieces of knowledge, new and old ideas, customary practices, different techniques, biological materials or artefacts, etc.)"*. Most of the definitions found are related to the SIFOR program, while there is one definition related to the Biocultural Design program. This means that the epistemological space in which BcI has been developed is mainly related to the objectives of SIFOR's partner organizations in four countries. In particular, the definition provided by Asociación ANDES was the most cited in the documents reviewed, problematizing the mainstream narrative. The definitions found are listed below in chronological order.

Firstly, Swiderska (2013) offers the BcI definition concerning Biocultural Heritage Innovation. The author, later in her following research documents published by her abandoned the direct link of Heritage with Biocultural Innovation. The definition can be found as:

"new knowledge, resources, skills and practices, or new combinations of these, that serve to: (a) strengthen and sustain agrobiodiversity, especially local seed systems, livelihoods and the material and spiritual well-being of communities; (b) adapt to and mitigate risks from global impacts, especially those of climate change...". "As such, they are dynamic, continuous, open, adaptive and gender-sensitive, integrating the creativity of people and nature." (2013b, p. 13).

Asociación ANDES and IIED suggest that biocultural innovation goes beyond traditional knowledge-based innovation, as BcI *"results from the interaction of all elements of biocultural heritage - knowledge [traditional and external], biodiversity, landscapes, cultural and spiritual values, and customary laws"* (2013, pp. 2-3). In 2016, *"the interaction between traditional knowledge and science"* was added to the definition of BcI (p. 7). Meanwhile, Swiderska et al. (2018) add that BcI is *"at least 50% derived from the former [scientific knowledge]"* (p. 1). In this case, there is an ecology of knowledge expressed in the interweaving between a) traditional knowledge, which refers to the knowledge of Pachamama *"that the land provides in terms of agroecosystems and indicators of climate change impacts",* and b) external or scientific knowledge, which is *"situated in the broader framework of biocultural heritage"* (Swiderska, 2013, pp. 12-13). Thus, traditional knowledge and scientific knowledge are interrelated in the BcI conceptual framework.

Figure 2 - BcI conceptual framework



According to Asociación ANDES (2016, p. 14), biocultural innovations are typically:

- Developed with a higher proportion of traditional knowledge than scientific knowledge;
- Holistic - i.e. provide multiple benefits to people and biocultural systems;
- Policy relevant - provide new policy models based on customary law and BcH, and strengthen Indigenous rights and control over BcH;
- Significant - make a significant difference to livelihoods and BcH; new to the local area, but not necessarily unique globally;
- Make people proud of their BcH;
- Respond to climate change impacts but also address other socio-economic needs; and
- Benefit multiple people/be scalable.

Song et al, from the case of China, define biocultural innovations as: *"new technologies or ways of doing things. Innovations arise in two main ways. 'Internal' (or 'endogenous') innovations arise from interactions between components of the biocultural heritage, and 'joint' (or 'collaborative') innovations arise from interactions between traditional knowledge and science"* (2016, p. 10). From the case of Kenya, Ongugo, cited in Groh, defines it as *"the totality of all traditionally based knowledge and cultural practices, whether explicit or implicit, that are practised by communities in adapting to climate change and that are used in managing socio-economic and environmental facets of life, guided by the wisdom of the community's ancestors*" (2016, p. 3). Finally, Davidson-Hunt et al. (2017) from the BcD program offer the following definition as a framework about globalised change and well-being:

"new or traditional knowledge, resources, skills, institutions, products, services and other practices that use biodiversity to support well-being in response to globalised change and that undergo a process of socialisation through which they move from the realm of individual creativity to become part of a society's range of responses to globalized change" (2017, p. 1).

In terms of the typology of BcI, there are three main areas in which these are materialized, such as technological, market, and institutional innovation. However, in other case studies, these biocultural innovations are not clear in terms of innovation typology. Dutfield (2014) is aware of the tendency to downplay the role of innovation communities in favour of individuals, who get most of the credit, as the hegemonic innovation dynamic. This author points to the problematic issue of how innovations in indigenous and local communities tend to be seen as informal, collective, and anonymous achievements, as opposed to those generated by individuals (2014).

Discussion

The concept of biocultural innovation is an emerging term within the biocultural approach. Based on the interpretation of the 33 records identified, the use of this concept has been described as a new way of doing things by indigenous and local communities, and its practice has been rooted in agriculture as a key activity for communities worldwide. An analysis of the records therefore shows that BcI has links to fields such as conservation, communication, design, music, history, geography, heritage, environmental studies, and law, among others. The latter reflects the complexity of the concept in both academic research and practitioner/community work. However, it is important to consider the challenges and potential of this framework for future research.

Challenges

The challenges related to the BcI concept are mainly related to rights, intellectual property, social factors, elite bias, replicability, globalized consumption, and knowledge asymmetry. Firstly, the ANDES Association identifies a key challenge related to rights, as they are key elements for the resilience of the biocultural system. In particular, rights related to land and traditional knowledge are fundamental (Asociación ANDES & IIED, 2013). For Ludlow (2015), the regulation of research on agricultural organisms is key. For this author, *"care must be taken in the creation of legal protections to ensure that there is space for traditional innovation. Otherwise, legal tools aimed at protecting tradition may themselves stifle genetic change, both modern and traditional"* (2015, p. 122).

Patenting is another challenge related to intellectual property rights (IPR) and the definition of the community itself (Ekblom et al., 2019). Dutfield (2014) affirms that patenting is largely based on a convenient fiction: the process breaks down both invention and the invention itself into discrete units that can be attributed to individuals and bought, sold and licensed. In this case, BcI faces the challenge of being embedded in national and international intellectual property laws. The Indigenous varieties that have been developed and conserved by the communities in the Potato Park as biocultural innovations are not eligible for protection under an IPR regime because they do not fulfill the technical characteristics (distinctness, uniformity, and stability). In other words, they have not been considered as innovations

by the scientific-centralized IPRs approach, maintaining and fostering the innovation gap (Martinez, 2017, p. 91).

A better understanding of how biocultural innovations have been developed and could be strengthened is a particular challenge, especially the role of women and youth. In some cases they are strongly associated with seed systems (Swiderska et al., 2018; Swiderska & Argumedo, 2022), in others, they are excluded from activities due to cultural norms (Mukerjee et al., 2018). Groh (2016) suggests that youth participation in the BcI process is declining. Western contact has challenged and eroded the strong biocultural relationships developed over centuries between communities and their environment, and their innovation ecosystems have been weakened and lost (Maldonado-Villalpando & Paneque-Gálvez, 2022; Swiderska et al., 2022). One of the examples of this erosion is the case of Hawaii, where knowledge and practices have been lost (Kagawa-Viviani et al., 2018).

A central challenge with environmental, economic, and socio-cultural implications appears to be the ease with which elite bias (unintended or otherwise) can be built into and perpetuated through a project to create new regimes of access and exclusion (Turner, et al. 2018; Winkel et al., 2020). These authors identify the market-oriented valorization of biocultural heritage as challenging because it can embody a neoliberal ideal of competition through the 'marketised relationships that position cultural heritage as a resource' (Coombe & Weiss, 2015 cited in Turner et al., 2018, p. 31).

Also, concerns such as climate change and deforestation can affect the potential for continuity of biocultural diversity, and heritage in the future (Groh, 2016; Turner, et al. 2016), as in the case of Berimbau in Brazil. While biocultural diversity advocates may welcome the growing interest within mainstream development circles, the findings suggest that a cautious and critical stance is essential (Turner, et al. 2018). This reveals tensions within the biocultural valorization discourse around over-representation, quality, and what defines innovation, tradition, and development (Turner, et al. 2018).

Another element is the replicability and scale-up of innovations, which are so tied to local cultural and spiritual values, as well as social, environmental, and economic conditions, that their replication or transfer to another location would simply be impossible (Dutfield, 2014). Biocultural heritage is becoming weaker in all communities analyzed in the SIFOR program, except the potato park (Swiderska et al., 2018). Repositioning biocultural heritage as a resource in this context is an inherently political process, reflecting tensions over self-representation, local identity, and access to resources (Turner, et al., 2016).

Potentialities

This review has identified several potentials related to the possibility of its flourishing in the academic, community, and policy fields. Some of these are the co-production of knowledge, global food security and sovereignty, local cultural values linked to shared spaces, novel institutions such as biocultural heritage territories, and the open approach as common. Biocultural innovations have the potential to build other futures from an indigenous perspective, such as the Zapatista maize case (Bradt, 2014) and the Quechua potato park (Asociación ANDES, 2016). In this sense, local infrastructures, activities, and practices are embedded in epistemological and ontological community frameworks that promote biocultural innovation (Groh, 2016; Asociación ANDES, 2016).

Knowing dialogues, as a potential process of traditional and academic knowledge, is a perspective presented in some case studies, especially those of SIFOR. The Potato Park is an

example of knowing ecologies, creating a space for the synergy of traditional knowledge from rural communities and explicit knowledge from research institutions. At the level of inter-community exchange, there is potential for the dissemination and exchange of traditional knowledge. Many traditional practices and innovations have proven to be pioneering and effective. The scientific community should be sensitized to the role of farmers as a peer group with valuable ancestral knowledge, rather than being seen only as recipients of external scientific knowledge (Mukerjee et al., 2018) or data providers (Nemogá, 2016). Recognizing the key role of traditional knowledge in scientific practices (McIntyre et al., 2009).

BcI contributes to global food security by maintaining and enhancing genetic diversity in climate-constrained environments (Swiderska et al., 2018). One of the best BcI practices is participatory plant breeding (PPB), especially in the case of Yunnan (Song et al., 2016). Cultural values also play an important role in binding communities, facilitating the sharing of ideas at the community level through various traditional rituals and festivals, and ensuring the transmission of traditional knowledge and biodiversity conservation (Wekesa, et al., 2017). Reciprocity, solidarity, identity, balance and collectivity with the human, natural and spiritual worlds have been found to drive experimentation and are intrinsic to innovation activities (Swiderska et al, 2018).

Biocultural heritage areas are another potential. The potato park as a BhT provides a powerful tool to maintain the interrelated cultural, social, biological, and territorial pillars for communal innovation (Swiderska et al., 2018). The restoration of biocultural heritage is also a process that, in some cases, makes new relationships visible. Kagawa-Viviani et al. (2018) offer a vision of restoration in relation to four indigenous plants in Hawaii, the Kalo (*Colocasia esculenta*), the 'Uala (*Ipomoea batatas*), the Kö (*Saccharum officinarum*) and the 'Awa (*Piper methysticum*), through different activities such as Workshops, education, outreach; festivals of (re)connection; and community networks of information and resource exchange/sharing.

An open approach is emerging as a model for BcI. Different knowledge systems and alternative property rights regimes are seen as possibilities (Martinez, 2017). There are three main elements to consider biocultural innovations from an open approach: a) they are collaborative, b) they aim to meet social needs, and c) participation is voluntary. This new perspective could promote the idea of considering biocultural heritage as a common good (González, 2015). Finally, embracing BcI could redefine the innovation landscape, address gaps in the field of socio-ecological systems research and innovation, and unlock the potential interlinks of the biosphere and ethnosphere for an environmental perspective of the future (Vassallo et al., 2023).

The way forward and the future agendas

As Kagawa-Viviani et al. (2018) note, there is a need for a research and policy agenda that pursues a decolonizing approach to innovation in rurality. Growing from more participatory methods can provide a way forward for mutually beneficial exchanges between researchers and communities. The need to include and respect different forms and sources of expertise is key (Kagawa-Viviani et al., 2018). Recognizing community biocultural innovation systems, their role in complementing science, and their collective spirit is crucial for sustainability (Song et al., 2016). There is also a need for a better understanding of how biocultural innovations have developed and could be strengthened through more inclusive

and collaborative research agendas between academics, practitioners, and communities (Vassallo et al., 2023).

New methodologies and tools for research and dissemination of biocultural innovations are key to involving local communities in the research process, such as farmer-to-farmer (ANDES, 2016) or the use of radio, as in the Mijikenda communities. The exchange of traditional knowledge and technologies between communities and case studies can strengthen and energize biocultural innovation (Macdonald et al., 2021). The way forward in terms of research is to have a strong dialogue between scientists and people (Swiderska et al., 2022).

National and international policies are a second agenda for strengthening the future of BcI. Some policies that affect biocultural innovation are represented by the Convention on Biocultural Diversity (in particular Article 8j); the Nagoya Protocol; the International Treaty on Plant Genetic Resources for Food and Agriculture; the FAO Committee on World Food Security; the Commission on Genetic Resources for Food and Agriculture (CGRFA); the UN Framework Convention on Climate Change; and the UN Declaration on the Rights of Indigenous Peoples. These mechanisms could be spaces for promoting collaborative innovation by local communities. For example, the Convention on Biocultural Diversity refers to the knowledge, innovations, and practices of Indigenous and local communities that embody traditional lifestyles, and requires Parties to "respect, conserve and maintain" them. However, the Nagoya Protocol only uses the term traditional knowledge, without delving deeply into the processes of change generated by communities and recognizing that local communities are active actors in innovation.

Policies that protect traditional knowledge and local innovation should be implemented globally, including Kenya's Traditional Knowledge Act and the FAO Treaty provisions on the protection of farmers' rights over traditional knowledge and genetic resources. Traditional community institutions and resource management systems should be strengthened to stem the loss of traditional knowledge and associated genetic resources (Kagawa-Viviani et al., 2018). To embody the framework of BcI as common, science, technology, and innovation policies need to be transformed to recognize local communities as cognitive subjects, knowledge producers, and innovators (Nemogá, 2016). Intellectual property policies also need to be transformed to consider traditional knowledge as a collective commons and protect it Concerns raised by changing human-nature relationships from biopiracy. Finally, BcI could be an agenda for research and policy design towards an environmental future (Granjou et al., 2017; Wyborn et al., 2020).

Conclusions

This text provides elements to guide policymakers, research institutions, and communities wishing to develop approaches to protect, sustain and revitalize rural place-based innovation. This literature review has found 33 sets of data, led by 45 authors registered in 23 institutions from 13 different countries. It also found two main research programs and several case studies, corresponding to cases developed in communities located in the Global South, while the main researchers of the programs come from the Global North. This may represent a gap in terms of who led the research programs, their objectives, and where they carried out the case studies. An exception is the SIFOR program, which has a collaborative research process where local institutions led the case studies.

Biocultural innovation is an emerging area of research but has a long history of local practice. It has been understood as the socio-ecological process of weaving traditional

knowledge and science for rural well-being, in particular for Indigenous and local communities' desires and needs (Tengö et al., 2017). It is found that the integration of both has evolved into a codification that has been seen as necessary for institutions to be formally recognized as valuable and useful. The review found more literature associated with practitioners than with scientific journals. It may be that this is more of a practitioner's perspective on research institutions.

At the conceptual level, there are two main definitions, the more commonly used being based on the SIFOR project and becoming the standard. Then, the different perceptions of the term 'innovation' in terms of the dominant IPR approach and ST&I policy are a challenge. Meanwhile, little attention has been paid to innovations coming from marginalized sectors in rural areas that have been excluded from the hegemonic development model, such as Indigenous peoples, Campesinos or the African diaspora. Their contribution to food sovereignty, well-being, livelihoods, and biodiversity remains unexplored. Some of these include community seed registers, biocultural protocols, and participatory plant breeding.

Although cultural and spiritual values promote BcI as reciprocity and solidarity, some cultural norms can be a barrier to innovation, such as the caste system in the case of the Central Himalayas and the exclusion of women and youth from the innovation process in the case of the Mijikenda communities. A critical reflection needs to be promoted to consider biocultural innovations as commons. Indeed, it is vital to return to discussions of the commons and its management practices in the innovation literature, to influence the design of public policies for the safeguarding of the rights of ethnic-peasant communities related to knowledge and its use. The latter supports the political and philosophical ontologies related to the community's practices of the creation and use of knowledge. To promote BcI, it is necessary to face its challenges, mainly related to rights, intellectual property, social factors, elite bias, replicability, globalized consumption, and knowledge asymmetry.

But also to build on its emerging potentialities, such as global food sovereignty or the novel institutions of biocultural heritage territories. Overall, the challenges and potentialities need to be framed by research agendas that are more inclusive and decolonized. In terms of policy agendas, mainly related to IPRs and ST&I, a shift is needed. Consideration needs to be given to what promotes and enhances the rights of local communities and their ontologies. Finally, this concept is relevant for communities and academia to develop strategies to conserve biocultural diversity and heritage in this world, especially in the area of rural development.

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