Received: 4 January 2023 | Accepted: 28 February 2023

DOI: 10.1111/jpim.12669

CATALYST

JOURNAL OF PRODUCT INNOVATION MANAGEMENT pdma

Biocultural innovation: Innovating at the intersection of the biosphere and ethnosphere

Jarrod P. Vassallo[1] | **Sourindra Banerjee**[2] | **Jaideep C. Prabhu**[3]

[1]The University of Sydney Business School, The University of Sydney, Sydney, New South Wales, Australia

[2]Leeds University Business School, Maurice Keyworth Building, Leeds, UK

[3]Cambridge Judge Business School, University of Cambridge, Cambridge, UK

Correspondence
Jarrod P. Vassallo, The University of Sydney Business School, The University of Sydney, Sydney, NSW 2006, Australia.
Email: jarrod.vassallo@sydney.edu.au

Abstract

Scientists, economists, and politicians increasingly recognize that Indigenous peoples possess invaluable knowledge and practices that have the potential to drive innovation to solve critical global challenges. Indeed, thousands of important drugs—including lifesaving cancer treatments—have their origins in centuries old Indigenous knowledge and practices. Similarly, Indigenous practices have fueled the fast-growing regenerative agriculture industry that is able to yield windfall profits while sequestering carbon and enhancing biodiversity. Referred to in policy circles as *biocultural innovation*—a form of innovation that occurs at the intersection of the biosphere and ethnosphere—hundreds of diverse examples from a wide array of industries have been documented outside of the innovation literature. However, innovation scholars have yet to recognize or embrace biocultural innovation. We argue that this major oversight hinders practice and leaves untapped potential for solving issues such as slow or unsustainable economic growth, ecological decline, and inequality. To address this gap, we provide a clear definition of biocultural innovation, differentiate it from other innovation domains, and establish its conceptual foundations. Informed by economic theorizing that views the ethnosphere and biosphere as assets, we propose that these assets share four traits: *functionality*, *potentiality*, *vulnerability*, and *inseparability* ("*FPVI shared traits*"). Due to their immense biocultural diversity, we assert that these assets carry an "option value" representing enormous innovation potential that can be *converted*, *conserved*, or *constructed* to solve global challenges (the "*3Cs*"). We conclude by identifying promising avenues for future research on

We express our gratitude to Jared Harrison, Director of the Remote and Rural Enterprise (RARE) Program at the University of Sydney Business School, which has been partnering with Indigenous organizations and innovators for over a decade since it was founded by the late Richard Seymour. Our extensive discussions with Indigenous partners throughout Australia, facilitated by the RARE Program, and in India were instrumental in developing the ideas presented in this paper. Additionally, we appreciate the valuable feedback provided by David Oliver, Krithika Randhawa, Leanne Cutcher, and attendees at several conferences and seminars. We would like to extend a special thank you to the Editors-in-Chief, Charles Noble and Jelena Spanjol, for their invaluable input during the review process, as well as Fiona Crawford for her excellent copy editing support. All authors contributed equally to this paper's development.

biocultural innovation and a call for action on how to unlock economic and social value while supporting biocultural assets and Indigenous rights.

KEYWORDS

biocultural innovation, biosphere, ethnosphere, Indigenous peoples

1 | INTRODUCTION

Indigenous peoples[1] have long been a source of ideas for firms that innovate for economic and social value. As an example, McGonigle (2016) illustrates the case of Napo Pharmaceuticals, which developed a drug treatment for HIV derived from *Croton lechleri*, a flowering plant indigenous to Peru. Ethnopharmacologists developed this drug using Indigenous Amazonian peoples' knowledge of traditional medicines. Before its identification by Napo, the viscous dark-red sap of *C. lechleri*, locally known as "Dragon's Blood," was used in traditional medicine as a cicatrizant, an anti-inflammatory, an anti-microbial, an anticancer agent, and for digestive disorders. Napo also provided reciprocal benefits to the native community, re-planting deforested areas and providing at-cost medication to the local people. The case of Napo demonstrates what we call *biocultural innovation—a form of innovation that occurs at the intersection of the biosphere and ethnosphere*—and raises questions about its role within innovation practice, policy and scholarship.

Just as the biosphere refers to the sum total of all biological ecosystems (c.f., Dasgupta, 2021; Hutchinson, 1970), the ethnosphere refers to the sum total of human knowledge and experience, much of which is held by Indigenous peoples (c.f., Davis, 2002; Davis & Gagnon, 2021).[2] We argue that this rich diversity in natural and human capital, that is largely protected and managed by Indigenous peoples, represents immense innovation potential. Regrettably however, scholars and practitioners have often viewed Indigenous communities as passive beneficiaries or victims of new goods, services, processes, and business models, rather than seeing their potential as active (co-)creators (Hernandez et al., 2022; Karanasios & Parker, 2018). This is despite the profound impact of their knowledge to date. For example, beyond the case of Napo Pharmaceuticals, it is estimated that thousands of important drugs—including lifesaving cancer treatments—have their origins in centuries old Indigenous knowledge and practices (Gupta et al., 2005; McGonigle, 2016; Snively & Corsiglia, 2018). Similarly, Indigenous agricultural practices—agroforestry, crop rotations, intercropping, polyculture and water harvesting—have fueled the fast-growing regenerative agriculture industry, now worth $47 billion and able to yield high quality produce while sequestering carbon and enhancing biodiversity (Burgess et al., 2019). Beyond these examples, biocultural innovation is evident in a wide range of industries and practices including the fast-moving consumer goods (FMCG), finance, and housing sectors—as well as in approaches to criminal justice, weather forecasting, disaster risk reduction and infrastructure design (see Figure 1 for additional examples; IGWIA, 2022; Jayachandra, 2022; Jana, 1998; Maynard et al., 2008; Mukherjee, 2022; Nag et al., 2019; Sydney Institute of Agriculture, 2020; The Economist, 2018; Vicziany et al., 2017).

Practitioner points

- Biocultural innovation offers a transformative approach to problem-solving by tapping into the intertwined potential of the biosphere and ethnosphere, empowering Indigenous communities as co-creators and unlocking new opportunities for organizations, communities, and policymakers.
- Organizations looking to engage in biocultural innovation should focus on understanding the "*FPVI shared traits*" (*functionality, potentiality, vulnerability*, and *inseparability*) of biocultural assets and use the "*3Cs*" (*convert, conserve*, and *construct*) framework to unlock their innovation potential.
- Embracing biocultural innovation can redefine the innovation landscape, addressing gaps in pro-social and pro-environmental innovation fields, and unlocking untapped potential for sustainable growth, ecological renewal, and social wellbeing.

1.1 | Setting the context for biocultural innovation

With a view towards future possibilities, scientists, economists and politicians increasingly argue that Indigenous peoples—especially through their knowledge of, and role in, protecting the biosphere—are central actors in innovation with the potential to solve global problems that include

A. Cultural Burning, also known as firestick farming, is a traditional technique used by Indigenous communities in Australia and other parts of the world to reduce the destructive impact of bushfires. It involves the controlled use of fire to clear understory vegetation, which can help prevent larger, more destructive fires from occurring (Watson, 2019, 2020). Cultural burning requires a sophisticated understanding of land, technology, and practice and has been passed down through generations. It has been adopted by Indigenous communities in Australia, as well as the Mayans of Mesoamerica, the Chagga of East Africa, the Kayapo of Brazil, and the Anishinaabe of Northern Canada. In recent years, there has been growing demand for cultural burning among farmers and other landholders, leading to the creation of a new industry that benefits Indigenous communities.

B. The Indigenous Grasslands for Grain project, led by people on Gomeroi country in Australia, aims to leverage Indigenous ecological knowledge to grow, harvest, and process Indigenous grains that are significantly more nutritious (e.g., high in omega-3 fatty acids) and help regenerate ecosystems (e.g., by restoring biodiversity). The project combines ancient knowledge with modern technology to improve scalability and is being commercialized by Indigenous enterprises like BlackDuck Foods, which is working with Indigenous communities across the country to make these foods staples in the Australian diet (Sydney Institute of Agriculture, 2020). The project also helps strengthen Indigenous communities by promoting Indigenous leadership.

C. The East Kolkata Wetlands is a human-engineered ecosystem in India that covers 125 square kilometers and serves a variety of purposes, including fish farming, farming, and rice paddies. It is also the largest wastewater-fed aquaculture system in the world, treating half the sewage of a city with a population of 15 million people (Nag et al., 2019; Jana, 1998; Watson, 2020; Vicziany et al., 2017). The wetlands employ 60,000 farmers, produce 15% of the city's fish supply, and are home to over 3,000 tribal families. The fish farmers make use of traditional knowledge, such as the habits of plants and animals, to increase productivity and utilize natural pesticides. The success of the East Kolkata Wetlands has inspired similar projects in other parts of the world.

D. The Earth Bank of Codes is a project that aims to create an open library of biological data from the Amazon, including DNA sequences, that could unlock new lifesaving drugs or other useful applications (The Economist, 2018). The project uses smart contracts to track the use of the data and automatically distribute commercial royalties to the countries of origin. These royalties are expected to be redistributed to the Indigenous communities that protect these valuable ecosystems. Despite these positive intentions, it is currently unclear whether projects, including the Earth Bank of Codes project, are a form of biopiracy. It is important for innovation scholars to explore this issue and help find ways to ensure that data banking and bioprospecting are done ethically and fairly.

E. The EALAT project, initiated by the Association of World Reindeer Herders, aims to assess the vulnerability of reindeer herding and empower Indigenous peoples through the use of technologies like satellite imagery and Geographic Information Systems (Maynard et al., 2008). This collaboration between Indigenous communities and NASA allows for the co-production of knowledge for the sustainable development of the Arctic and enables reindeer herders to manage the movements and migrations of their herds in real-time, helping them adapt to changing weather and climate conditions and take advantage of better pasturelands.

F. The Wampis Nation is an autonomous territorial government established by the Indigenous peoples in the Peruvian Amazon in 2018 to defend their livelihoods from extractive industries (IGWIA, 2022). The governance of the Wampis Nation is based on a statute that outlines their vision for the future in areas like spirituality, education, language, and the recovery of ancestral place names. The autonomous government covers nearly 14,000 km2 (IGWIA, 2022). Similarly, in 2017, the *Guaraní of Charagua Iyambae* officially became Bolivia's first autonomous Indigenous farming community after years of fighting to regain their self-governance and territory (Marrie, 2019).

G. DJ Mahua is a company that produces Mahua, a traditional liquor made from the mahua tree (*Madhuca longifolia*), which grows in the forested plains of western, central, and eastern India. The mahua tree is considered the "Tree of Life" by Indigenous Peoples like the Santhal, Gond, Munda, and Oraon, who have lived in the area for the past 3,000 years and use its various parts for food, fuel, medicine, and even as currency (Mukherjee, 2022). DJ Mahua follows international quality standards while maintaining traditional production methods, providing livelihoods for tribal people and working to make Mahua a national heritage icon (Jayachandra, 2022). In recent years, Mahua has been recognized as an India-Made Liquor, increasing its acceptance among the general population (Mukherjee, 2022).

FIGURE 1 Biocultural innovations with practical and scholarly promise.

slow or unsustainable economic growth (Hickel, 2020; Priyadarshini & Abhilash, 2019; UNESCO, 2023b), widening inequalities (Graeber & Wengrow, 2021; Redvers et al., 2022), and potentially catastrophic ecological decline (Díaz, Settele, Brondízio, Ngo, Agard, et al., 2019; Díaz, Settele, Brondízio, Ngo, Guèze, et al., 2019; Reyes-García et al., 2019; Watson et al., 2021).

Economists view the biosphere and ethnosphere as assets with *innovation potential*, referred to as *option value*, due to the potential windfalls that can be unlocked through innovation processes (Dasgupta, 2021). This can be seen in the examples above, or perhaps more controversially in stevia, a once obscure herb discovered and used by the Guaraní peoples for centuries but now worth $492 million a year as a breakthrough sugar alternative (Wallace, 2019).[3] In the case of biocultural innovation, this option value is closely tied to the richness and extent of the ethnosphere and biosphere (i.e., biocultural diversity; cf. Maffi, 2007, 2018), specifically, (1) Indigenous knowledge itself (commonly referred to as traditional knowledge; Ludwig & Macnaghten, 2020) and the (2) the ecosystems that Indigenous peoples have inhabited and protected for millennia. Policymakers acknowledge the interconnection of these assets (i.e., biocultural assets) and advocate for innovative solutions that address the intersection between them. As stated in a UN report, traditional knowledge, particularly in relation to the natural world, has the potential to help modern society address major challenges from climate change to sustainable development (Marrie, 2019).

The process of synthesizing traditional knowledge, especially as it pertains to understanding the biosphere, with existing science has been referred to as biocultural innovation in policy circles (Swiderska et al., 2018). We define biocultural innovation as *the application of traditional knowledge to improve intergenerational wellbeing while minimizing the depletion of biocultural assets*.

Somewhat surprisingly, biocultural innovation has been widely documented in literature *outside* the field of innovation studies. For example, a review commissioned by the European Union identified 510 biocultural innovations that enhance food security, resilience, livelihoods, and biodiversity (Swiderska et al., 2018). These innovations include the revival of *parma*, a set of collective farming and knowledge-sharing practices that address climate challenges and labor shortages in the Himalayas, and the use of *Msinduzi* tree bark as a low-cost treatment for wounded livestock in Kenya. A recent review of 236 articles by Petzold et al. (2020), on innovations that have emerged from Indigenous knowledge to improve climate change adaption, classifies hundreds of these biocultural innovations into 11 categories. These range from physical infrastructure including climate resistance buildings (Mercer et al., 2012), to practices including improved natural disaster warning systems and forecasting (Chisadza et al., 2013), to financing and policy innovations including food sharing and social support schemes (Mavhura, 2017; Pearce et al., 2010).

Yet, theorization about biocultural innovation is either inadequate, or sits outside a clearly defined category. The term biocultural innovation was coined by Swiderska et al. (2018:1), but only appears in policy briefings and is not theorized beyond a rudimentary definition: "new ways of doing things that involve components of biocultural heritage, or traditional knowledge, and science." Likewise, literature that documents biocultural innovations uses cumbersome descriptors that limit its application to narrow spheres of influence. For instance, "types and examples of Indigenous knowledge used for climate change adaption" (Petzold et al., 2020:11), "biocultural approaches to conservation" (Gavin et al., 2015:140), or "ethnopharmacology" (McGonigle, 2016:217). These inadequacies are also reflected in the innovation literature that emphasizes either the pro-social *or* pro-environmental aspects of innovation without providing a clear conceptual space for the use of traditional knowledge in solving global issues. Consider the burgeoning interest in new forms of innovation. These include "green," "eco-" "sustainable" and "environmental" innovation on the one hand, and "frugal," "inclusive" and "social" innovation on the other, with the former emphasizing environmental problems, and the latter category emphasizing social problems. Moreover, scholarly streams on "Indigenous" and "Indigenous social" innovation (Peredo et al., 2019) prioritize the *intrinsic* value, or inherent worth, of Indigenous knowledge in the innovation process primarily "by" and "for" Indigenous peoples; over its *instrumental* value, or actionable potential in solving global challenges, especially beyond its Indigenous originators.[4]

This absence of adequate theorizing, not only results in a major conceptual gap, it also hinders practice. Policymakers acknowledge many unresolved practical challenges on how to integrate Indigenous knowledge into assessments and innovation processes that currently prioritize scientific knowledge (IPCC, 2022, p. 80); and little is known about how to effectively manage and scale up biocultural innovations, including how to do so equitably and fairly with their Indigenous originators. We argue that what is needed is unification around a construct that captures this unique form of innovation—and hence the innovation potential of the ethnosphere and biosphere—but with a focus on its application towards solving global problems.

The purpose of this *Catalyst* is to rectify these shortfalls through two contributions. First, we introduce the term biocultural innovation to an academic audience and define it in relation to other forms of pro-social or pro-environmental innovation. And second, we motivate research into biocultural innovation, emphasizing its role in solving global challenges and outlining promising future directions. Accordingly, this paper is structured as follows. First, presenting a novel framework, we explore the importance of innovation at the intersection of the biosphere and ethnosphere. Second, we define biocultural innovation and compare it to other forms of innovation. Finally, we discuss extant literature that falls under this category to identify promising future avenues of research that can inform practice.

2 | MOTIVATIONS AND FRAMEWORK

2.1 | Traits of biocultural innovation

Economists (Dasgupta, 2021) describe the ethnosphere and biosphere as "assets" (stocks), specifically forms of human and natural capital that provide "services" (flows).[5] We theorize these assets as having four shared traits. The first, *functionality*, refers to the first-order value that the biosphere and ethnosphere provide in the form of flows of services. The next two shared traits, *potentiality* and *vulnerability*, refer to the second-order (upside) value potential provided by the biosphere and ethnosphere, and the (downside) risks to this future value, respectively. The fourth, *inseparability*, refers to the blurred boundaries between them. We refer to these characteristics as '*FPVI shared traits*," and use them to motivate three types of biocultural innovation: (1) innovating to *convert* or unlock new value from biocultural assets (e.g., using traditional knowledge to develop a new lifesaving drug); (2) innovating to *conserve* or protect biocultural assets (e.g., developing smart contracts to compensate Indigenous communities for their knowledge and service, thus preventing further biocultural depletion); and (3) innovating to *construct* or restore the value of biocultural assets (e.g., using traditional knowledge to increase farming yields while regenerating the topsoil). We refer to these three types of biocultural innovation as the "*3Cs*" (see Figure 2). The following subsections outline these elements in more detail.

2.1.1 | Linking the biosphere and ethnosphere: "FPVI shared traits"

Functionality

The biosphere and ethnosphere serve a range of important services to humanity, which we refer to as *functionality*.

The biosphere is commonly recognized as serving humanity via three categories that contribute to well-being (Dasgupta, 2021; MA, 2005; MA, 2005; MA, 2005; MA, 2005). First, *provisioning services* include the provision of food, water, materials, biochemicals and even genetic information used for biotechnology. Second, *regulating and maintenance services* include maintaining clean air and water, decomposing waste, regulating pests and diseases, providing protection from natural disasters and regulating the climate. Third, the biosphere provides *cultural services* including spiritual experiences and identification with values, as well as education and instruction in societies. For example, the biosphere influences art and architecture, as well as social relationships and cultural diversity.

The ethnosphere also provides services to humanity. Díaz, Settele, Brondízio, Ngo, Agard, et al. (2019); Díaz, Settele, Brondízio, Ngo, Guèze, et al. (2019) categorize the services provided by Indigenous peoples, who together form the majority of the world's cultural diversity and thus the ethnosphere (UNESCO, 2023a), into five categories. First, they contribute by providing new *concepts*, in particular alternative values and worldviews that can influence societal views, values and practices more broadly. Second, they provide *protection* services, for example, preventing forest loss (Porter-Bolland et al., 2012). Third, and relatedly, they contribute by providing *sustainable use, management and monitoring* services. These include habitat management, the monitoring of wild species and the restoration of degraded ecosystems (Berkes, 2017; Reyes-García et al., 2019). Fourth, they provide *domestication* services, helping domesticate and maintain diverse crop and animal breeds (FAO, 2016). Fifth, they create new *ecosystems*, such as the hay meadows of Central Europe (Molnár & Berkes, 2018), or the multispecies forest gardens of Indonesia (Berkes, 2017).

Potentiality

The biosphere and ethnosphere—largely as a function of their immense biological and cultural diversity (known as biocultural diversity[6]; cf. Maffi, 2007, 2018)—have enormous option value and thus innovation potential, which we refer to as *potentiality*.

To illustrate the scope of this innovation potential, consider the option value of the biosphere for the pharmaceutical industry alone, which is estimated to be equal to the known medicinal value of natural products (Dasgupta, 2021). This medicinal value is immense, as approximately 61% of all pharmaceuticals—including 75% of anti-infectious disease drugs and 60% of all anticancer medications—have natural origins (Gupta et al., 2005), and global pharmaceutical sales averaged $890 billion per year from 2010 to 2020 (Statista, 2022).

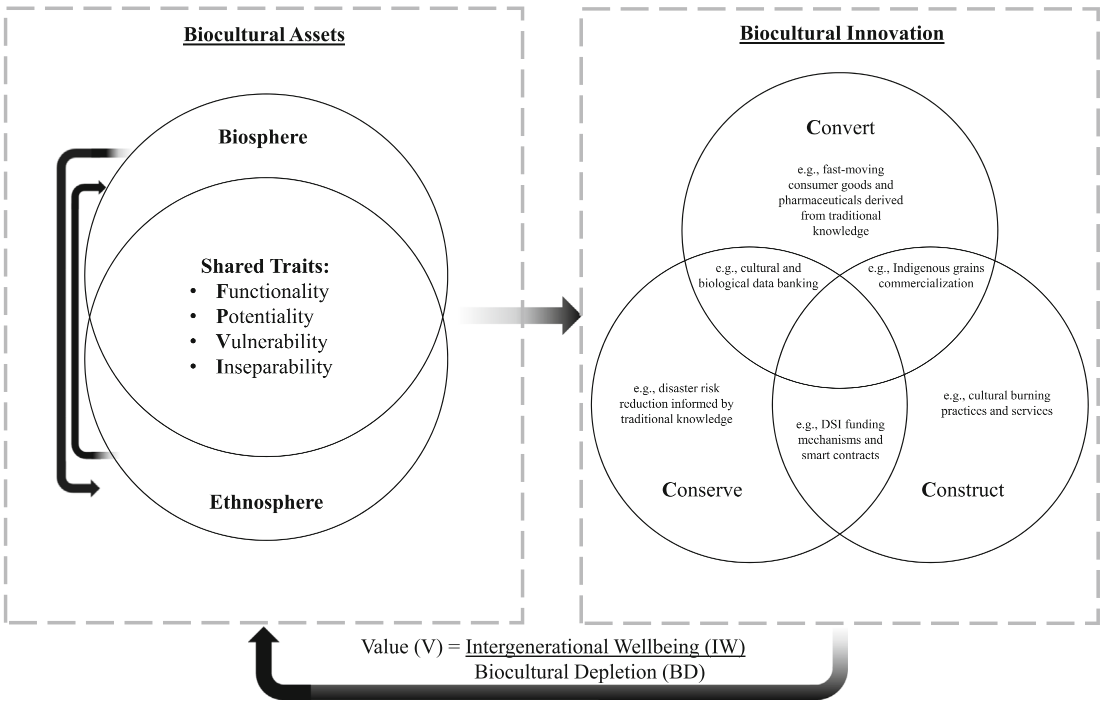

FIGURE 2 Biocultural innovation framework depicting value flows between, from and towards biocultural assets.

The ethnosphere also has significant innovation potential. The World Intellectual Property Organization (WIPO, 2016) estimates that much of the knowledge needed to unlock the potential of the biosphere for medicinal use and other innovations is held by Indigenous people. Furthermore, the World Bank (2022) reports that, although Indigenous peoples own, occupy or use just a quarter of the world's surface, they protect 80% of the planet's remaining biodiversity. Given that only about 6% of higher plants are estimated to have been screened for biological activity (Cámara-Leret & Bascompte, 2021; Verpoorte, 2000), what undiscovered benefits and innovations can the remaining 94% unleash for humanity?

Vulnerability

Despite their vast innovation potential, the ethnosphere and biosphere are being unsustainably depleted due to exploitation. We refer to this third trait as *vulnerability*.

In the biosphere, species extinction is accelerating—an estimated one million species of animals and plants are threatened with extinction, and natural ecosystems have declined by 47% on average relative to their earliest estimated states (Dasgupta, 2021; Díaz, Settele, Brondízio, Ngo, Agard, et al., 2019; Díaz, Settele, Brondízio, Ngo, Guèze, et al., 2019).

Similarly, language extinction, which is occurring at an alarming rate (Lewis & Simons, 2013), is a threat to traditional knowledge, and thus the ethnosphere. Over 30% of the world's 7400 languages are predicted to become extinct by the end of the century (Cámara-Leret & Bascompte, 2021). For example, a recent study found that only 58% of students in Papua New Guinea, compared to 91% of their parents, are fluent in Indigenous languages (Cámara-Leret & Bascompte, 2021; Kik et al., 2022). The vulnerability of the ethnosphere is also exacerbated by the ongoing marginalization of Indigenous peoples, who make up just 5% of the global population but 15% of the extreme poor, with life expectancies up to 20 years lower than non-indigenous people worldwide (World Bank, 2022).

Inseparability

Finally, the biosphere and ethnosphere are so intertwined, that as assets, they are inseparable. In fact, the coevolutionary relationship between biological and cultural diversity is well established in the natural sciences (Maffi, 2007). We refer to this high level of interaction as *inseparability* and can demonstrate it by revisiting the other three traits.

Regarding trait one (functionality), the services provided by the biosphere shape traditional knowledge and thus the services provided by the ethnosphere. Moreover, ethnosphere services influence broader humanity both directly (e.g., through new concepts, worldviews and products) and indirectly through their ability to shape the biosphere (e.g., through sustainable management of ecosystems).

Regarding trait two (potentiality), the options value—and thus innovation potential—of the biosphere is dependent on the ethnosphere (and vice versa). For example, a study published in *PNAS* analyzed three regions with high biocultural diversity, finding that, for each plant species, medicinal knowledge is unique to only one language (Cámara-Leret & Bascompte, 2021). Furthermore, while most plant species associated with linguistically unique knowledge are not threatened, most languages that report linguistically unique traditional knowledge are (Cámara-Leret & Bascompte, 2021). The authors conclude that "each Indigenous language is a unique reservoir of medicinal knowledge—a Rosetta stone for unraveling and conserving nature's contributions to people" (Cámara-Leret & Bascompte, 2021:1).

Regarding trait three (vulnerability), the fate of the biosphere is intertwined with that of the ethnosphere (and vice versa). Consider that Indigenous peoples own, manage, use or occupy 35%–40% of the remaining terrestrial areas with very low human interaction (Díaz, Settele, Brondízio, Ngo, Agard, et al., 2019; Díaz, Settele, Brondízio, Ngo, Guèze, et al., 2019). The ecosystems on these Indigenous lands are declining much less rapidly than elsewhere, and in many cases, the Indigenous management of these lands actively supports biodiversity through conservation and restoration (Díaz, Settele, Brondízio, Ngo, Agard, et al., 2019; Díaz, Settele, Brondízio, Ngo, Guèze, et al., 2019). The IPCC (2022:13) has "high confidence" that greater recognition of the rights of, and cooperation with, Indigenous peoples is integral to stabilizing and restoring ecosystems (IPCC, 2022:25); and that utilizing traditional knowledge can help prevent maladaptation and thus reduce the risk of adverse climate-related outcomes (IPCC, 2022:29).

Thus, to maximize utility to humanity, and the efficiency of nature informed innovation, we ignore the role, wellbeing and knowledge of Indigenous peoples at our collective peril. Conversely, a flourishing ethnosphere is also dependent upon a flourishing biosphere. Given their inseparability, we refer to both asset classes together as "*biocultural assets*," and thus to biocultural functionality, potentiality, vulnerability and inseparability. Upon considering how these "*FPVI shared traits*" represent the actual and potential stocks and flows of value to humanity from biocultural assets, three types of biocultural innovation emerge.

2.1.2 | Three types of biocultural innovation: The "3Cs" typology

Taken together, these traits raise important and urgent innovation related questions about how biocultural innovation—which depends heavily on the value (or health) of biocultural assets—can positively impact humanity. To address these questions, we propose that there are three types of biocultural innovation that involve converting, conserving or constructing the innovation potential, and thus options value, of biocultural assets. Together, we refer to these as the "*3Cs*" of biocultural innovation, and position it is a useful typology for categorizing individual biocultural innovations:

Innovating to convert (or unlock) value

How can new value at the intersection between the biosphere and ethnosphere be unlocked? With regards to the "FPVI shared traits" framework, this involves converting biocultural potentiality into useful innovations. For example, the Kaani tribe of India's traditional knowledge of the properties of *Trichopus zeylanicus* (known to them as "chathan kalanji," i.e., "Satan destroyer") was converted into a drug that effectively treats fatigue and stress (Suriyaprakash, 2022). Indeed, within drug discovery, it has been estimated that using traditional knowledge increases the efficiency of bioprospecting—screening of biological resources for the extraction of commercially important compounds—by over 400% (Cottrell, 2022). Beyond drug discovery, attempts to convert biocultural value are occurring in many industries, including agrochemicals, biofuels, functional foods, nutraceuticals and cosmeceuticals (Neimark, 2017).

Further, the latest Convention on Biological Diversity (CBD) agreement signed in Montreal (COP-15) provides a new a framework for the use of digital sequence information (DSI). DSI refers to digitized genetic information—that is, digitized biodiversity that come from forests and other rich ecosystems—which is frequently used to develop new products, but with returns seldom flowing back to the stewards of this biodiversity. In Montreal, a major deal was struck to develop a funding mechanism on DSI including the traditional knowledge held by Indigenous peoples associated with it. Hailed as a historic victory for Indigenous peoples and the Global South, this development provides new pathways for the development and proliferation of biocultural innovations aimed at converting value held in the biosphere and ethnosphere (Greenfield & Weston, 2022). Innovation scholars could contribute valuable insights on how to effectively implement and optimize these new approaches, mechanisms, and partnerships designed to convert of biocultural potentiality into useful innovations.

Innovating to conserve (or protect) value

How can the innovation potential that exists at the intersection of the biosphere and the ethnosphere be conserved (i.e., not depleted) to maximize its benefits for future generations? With regards to the "FPVI shared traits" framework, this involves reducing the vulnerability of both the ethnosphere and biosphere to save their functionality (the provision of services) and potentiality (by keeping options open). For example, to combat the roughly 75% of genetic diversity lost since the early 1900s, blockchain technologies are being developed and trialed to provide incentives and financial support for Indigenous communities to continue their important work—for example, safeguarding biodiversity from generation to generation—while maintaining their unique cultures (see Kochupillai et al., 2021; Peng & Huang, 2022). These biocultural innovations that blur the boundaries between traditional notions of innovation and conservation have immense value given that over one million of the earth's eight million or so plant and animal species are threatened with extinction (IPBES, 2019), with the ecosystem services provided to humanity by terrestrial species alone worth $75 trillion (IPCC, 2019) and Indigenous people protecting the vast majority of this biodiversity (Sobrevila, 2008).

These new biocultural approaches to conservation directly challenge "fortress conservation" (cf. Weston, 2021)—the dominant model based on the notion that natural areas flourish when free from human presence, that has contributed to the displacement of approximately 20 million people from their homelands among other human rights abuses (Weston, 2021). The latest CBD agreement (COP-15) now recognizes the critical role of biocultural innovations for the purpose of conservation by affirming the centrality of Indigenous peoples' knowledge, rights, practices, worldviews and innovations in its efforts to achieve global conservation targets (UNEP, 2022). Distinct from natural scientists, who focus on the health of ecosystems, innovation scholars are uniquely placed to contribute to understanding—and improving—the complex interactions among stakeholders that are emerging to conserve biocultural assets.

Innovating to construct (or restore) value

How can we use capital from the biosphere and ethnosphere without depleting, but instead improving, both spheres? Within the "FPVI shared traits" framework, this involves constructing greater biocultural functionality and potentiality. For instance, Watson (2019, 2020) documents a particular type of biocultural innovation that restores the value of biocultural assets. Cultural burning or firestick farming, can not only reduce the destructive impact of bushfires by approximately half where it is practiced, it also improves the health and productivity of the land, and the people who rely on it, including its Indigenous caretakers (Watson, 2019, 2020). Requiring an incredibly sophisticated understanding of land, technology and practice, this Indigenous pyrotechnology has been passed from generation to generation over millennia in communities including Australia's First Nations people, the Chagga of East Africa, the Kayapo of Brazil and the Anishinaabe of North America. Demand for cultural burning among farmers and other land holders is growing, spawning a new industry that is improving the health of the biosphere and strengthening Indigenous communities, and thus the health of the ethnosphere.

The latest CBD agreement (COP-15) aims to take "urgent action to halt and reverse biodiversity loss to put nature on a *path to recovery* for the benefit of people and planet" (UNEP, 2022:7). The agreement aims to place at least 30% of areas of degraded terrestrial, inland water, and coastal and marine ecosystems under effective *restoration* by 2030 (p. 9), while urging that actors do so by respecting Indigenous peoples and fostering their full and effective contributions in decision-making, including their free, prior and informed consent (p. 5). Far from leaving these degraded areas alone, this bold global initiative necessitates the creation of new organizational practices and complex interactions between stakeholders to create value: another area in which innovation scholars could apply their unique skills.

3 | DEFINITIONS AND DIFFERENTIATION

3.1 | Defining indigenous peoples and their knowledge

To formally define biocultural innovation, it is first necessary to define Indigenous peoples and traditional knowledge.

There are approximately 476 million *Indigenous people* globally (6.2% of the global population), representing 5000 different cultures and 90 countries. They speak the majority of the world's languages, each of which represents a complex system of knowledge (UNDP, 2021). Although there is no universally accepted definition of Indigenous peoples, the UN's International Labor Organization's Convention on Indigenous and Tribal People (1989) defines *Indigenous peoples* as those who descend from populations inhabiting a geographical region at the time of conquest, colonization or the establishment of present state boundaries, and who retain some or all of their own social, economic, cultural and political institutions (ILO, 1989: Article 1). Similarly, it defines *tribal peoples* as those whose social, cultural and economic conditions distinguish them from other sections of the national community, and whose status is in some way regulated by their own customs, traditions, special laws or regulations (ILO, 1989: Article 1). Further, self-identification as Indigenous or tribal is generally upheld as the fundamental criterion for one's membership to these groups (ILO, 1989; IPCC, 2022; Petzold et al., 2020; UNESCO, 2017). We use the term Indigenous peoples, but consider both groups in our conceptualization of biocultural innovation because Indigenous and tribal peoples share many common traits, especially the centrality of traditional knowledge.

Terms such as *traditional knowledge*, Indigenous knowledge, local knowledge and traditional ecological knowledge are used to describe the knowledge systems of indigenous, tribal and other "local" communities (see Petzold et al., 2020). These forms of knowledge are built by people who live and use the resources of a particular geographic location and have done so for a long time (Warren et al., 1995). In conceptualizing biocultural innovation as a legitimate area of study for innovation scholars, we favor the term traditional knowledge because of its widespread use in policy circles. For example, the World Intellectual Property Organization defines traditional knowledge as "knowledge, know-how, skills and practices that are developed, sustained and passed from generation to generation within a community, often forming part of its cultural or spiritual identity" (Drahos & Frankel, 2012:11; WIPO, 2022). This definition should not imply that traditional knowledge is static and unchanging; besides "vertical" intergenerational transmission, it evolves organically and "horizontally" in continued interaction with the environment and with others (see Saslis-Lagoudakis et al., 2014).

3.2 | Defining and differentiating biocultural innovation

So far, we have described biocultural innovation above as a process that utilizes Indigenous and tribal people's traditional knowledge to help solve global problems, by converting, conserving or constructing the value of biocultural assets in a way that is more sustainable than existing alternatives. It follows that to accurately capture this phenomenon, our working definition of biocultural innovation should be solution oriented (i.e., *instrumental*), consistent with Indigenous people's worldviews (i.e., *holistic*), and concerned with the intergenerational stewardship of biocultural assets (i.e., *sustainable*). In line with these criteria, we adopt the following working definition: *biocultural innovation is the application of traditional knowledge to improve intergenerational wellbeing while minimizing the depletion of biocultural assets*. This definition encompasses several distinctions worth emphasizing. First, it is contingent on a specific input, *traditional knowledge*, and embraces all forms of innovation from new-to-context applications of traditional knowledge to novel recombinations of traditional knowledge with other resources (e.g., scientific knowledge) in the form of products, services, business models, processes, institutions, or social systems.

Second, by focusing on *application* attempts, we separate process from outcome, recognizing that attempts may fail or succeed, resulting in net-positive or net-negative outcomes. This distinction acknowledges that activities that fail to deliver value are also important.

Third, we focus on the *ratio* of benefits to costs—specifically the ratio of intergenerational wellbeing to biocultural resource depletion—because this provides an objective and measurable conceptualization of value that aligns with both Indigenous people's worldviews and notions of sustainability required to solve global problems. As examples see the "seven generations principle" of the *Kainenere'ko:wa* constitution of the Iroquois Confederacy (Horn-Miller, 2013), and the Māori's approach to decision making that considers impacts on *mokopuna's mokopuna*, literally "four generations hence" (Warne, 2015).

Given our working definition, as an output, the instrumental value of a given biocultural innovation can be represented as a ratio, which in turn is analogous to a cost–benefit ratio calculation (i.e., Σ Present value of Future Benefits/Σ Present value of Future Costs). Within a given context, this ratio can be used to compare the instrumental *value* (V) of a particular biocultural innovation with its alternatives:

$$V = \frac{IW}{BD}$$

where IW represents *intergenerational wellbeing* and BD stands for *biocultural depletion*. To operationalize this ratio for use in decision-making—say, to compare alternate innovation projects or policies—a range of valuation methods can be adapted. Of particular promise are those methods that use expanded timeframes and do not ignore or heavily discount costs that affect future generations. Regarding the numerator (IW) for instance, the OECD's Better Life Index provides a operationalizable measures that are increasingly adopted by policymakers (also see Arrow et al., 2012; Durand, 2015; Karacaoglu et al., 2019; Van Zanden et al., 2014). With regards to the denominator (BD), biocultural assets can be disaggregated into biosphere and ethnosphere components. Regarding the depletion (including the possibility of regeneration) of biosphere assets, a broad array of methodologies are available that rely on remote sensing, field observations, and interviews (etc.). IPBES's (2022) methodological assessment identifies over 50 approaches to valuation which are suitable to various contexts and units of analysis. When it comes to the depletion (or regeneration) of ethnosphere assets however, potential methodologies are less developed and are typically overly reductionist (refer to our discussion in Section 4). As such comprehensive approaches—see, for example, Gee et al. (2014)—should be developed further to operationalize the ethnosphere component of the denominator.

Although these literature streams provide blueprints for how each element of this ratio can be quantified, formal means of measuring the instrumental value of biocultural innovations should be developed with guidance from Indigenous communities to move away from purely market based depictions of value. Indeed, IPBES (2022) conclude that recognizing and respecting the worldviews, values and traditional knowledge of indigenous peoples leads to outcomes that are not only more inclusive, but that are also better for nature and society.

Incentivizing biocultural innovation with operationalized decision-making frameworks has real potential. At a firm level, LVMH, the luxury goods company, could readily expand its LIFE360 program—aimed at having a net positive impact on biodiversity (LVMH, 2021)—to include a focus on the ethnosphere, thus collaborating to innovate with and support Indigenous communities. At a policy level, it is possible for *gross ecosystem product* (GEP) calculations that currently guide planning, projects, transactions, monitoring, and evaluation in China to evolve into *gross biocultural product* (GBP) calculations. Consider if the Chinese government extended its already operational purchasing mechanism for buying regulating services from so called "two mountain businesses" that engage in restoration activities to also include businesses that specialize in biocultural innovation (see IPBES, 2022; Ouyang et al., 2020:316–317).

3.2.1 | Differentiating biocultural innovation

There is a rich and growing literature on more sustainable forms of innovation. As outlined in Table 1, these include innovation domains that prioritize benefits to society as a whole rather than for private individuals (social innovation); the inclusion and consideration of marginalized communities within the innovation process (inclusive innovation); bottom-up solutions for sustainable development and consumption (grassroots innovation); producing greater value while reducing environmental impact (sustainable innovation); doing these things with a focus on radical resource efficiency (frugal innovation); or with concern for future generations (responsible innovation). Beyond these pro-social and pro-environmental forms of innovation, scholars have also studied novelties developed and implemented by Indigenous peoples in accordance with their knowledge and worldviews, primarily for the benefit of their own communities (indigenous social innovation).

This range of definitions begs the question, "what makes biocultural innovation different from these innovation domains, and thus worth pursuing as a distinct research stream?" To answer this, we highlight three gaps that exist among existing domains and streams. First, most of them overlook traditional knowledge as a unique and important input worthy of focused scholarship. Rather, they either specify a focus on other important inputs or none at all. "Input centric" forms of innovation include frugal, jugaad, and inclusive innovation; while "input neutral" forms include eco-, sustainable, responsible, and social innovation (see Table 2). Traditional knowledge is distinct from other forms of knowledge (e.g., scientific knowledge) and involves distinct processes and ethical considerations. If this distinctiveness is largely ignored—e.g., more general inputs such as "less capital, energy, labor and time" (frugal innovation) or the "inclusion of the marginalized" (inclusive innovation) take precedence—we will continue to undermine our ability to learn from Indigenous peoples, instead unduly nudging them to be "more like us." Rather, giving precedence to traditional knowledge provides an opportunity to learn from the sector of humanity that represents its largest pool of diversity, a pool that may prove invaluable in an uncertain world. There is much to learn about sustainability from those who have thrived for thousands of generations relying solely on their own resources at nobody else's expense, who are less threatened by food shortages, who protect 80% of the Earth's biodiversity, or who are the least likely to leave a carbon footprint (Corry, 2011).

Second, even if traditional knowledge is central to other domains of innovation research (e.g., Indigenous social innovation), they emphasize the intrinsic value of such innovations over their instrumental value (i.e., their usefulness for humanity and the environment; see Table 2). For example, by limiting their focus to innovations created and implemented "by" and primarily "for" Indigenous peoples', Peredo et al. (2019:112) explicitly "exclude the development and application of innovations driven largely by organizations, governments and other actors outside of Indigenous communities." These exclusionary criteria ignore significant traditional knowledge-based innovations that could have a profound impact on social, environmental, or economic problems. Examples of such innovations include Restorative Justice and other novel forms of organizing developed by First Nations in Canada and New Zealand, or polyculture and other widely adopted regenerative agriculture practices that

TABLE 1 Definitions and dominant perspectives.

Innovation type	Definition	Dominant perspective	References
Biocultural innovation	"The application of traditional knowledge to improve intergenerational wellbeing while minimizing the depletion of biocultural assets."	Biocultural diversity and intergenerational wellbeing	This paper; Swiderska et al. (2018)
Indigenous social innovation	"A novelty informed by ancestral knowledge and practices, in some product, practice, technology or other phenomenon with social and cultural impact, developed and implemented by the Indigenous in accordance with their worldviews" (Peredo et al., 2019:112).	Indigenous worldviews and lived experience	Peredo et al. (2019)
Grassroots innovation	"A network of activists and organizations generating novel bottom-up solutions for sustainable development and sustainable consumption; solutions that respond to the local situation and the interests and values of the communities involved" (Seyfang & Smith, 2007:585)	Social movements and activism	Seyfang and Smith (2007)
Frugal/Jugaad innovation	"…the ability to 'do better with less resources for more people', i.e., to create significantly more value while minimizing the use of resources." (Prabhu, 2017:4)	Resource efficiency	Prabhu (2017)
Reverse innovation	"Innovations adopted first in poor (developing) economies before being adopted in advanced economies." (von Zedtwitz et al., 2015:14)	Adaptation across contexts	Govindarajan and Ramamurti (2011), Govindarajan and Trimble (2012), von Zedtwitz et al. (2015)
Social innovation	"Any novel and useful solution to a social need or problem, that is better than existing approaches and for which the value created accrues primarily to society as a whole rather than private individuals." (Phills et al., 2008:36)	Social impact	Phills et al. (2008)
Sustainable innovation	"Innovations in which the renewal or improvement of products, services, technological or organizational processes delivers not only improved economic performance, but also an enhanced environmental and social performance." (Bos-Brouwers, 2010:422)	Sustainable growth and triple-bottom line	Bos-Brouwers (2010), Carrillo-Hermosilla et al. (2010)
Responsible innovation	"…taking care of the future through collective stewardship of science and innovation in the present." (Owen et al., 2013:3)	Ethics and social responsibility	Owen et al. (2013)
Inclusive innovation	"…the development and implementation of new ideas which aspire to create opportunities that enhance social and economic wellbeing for disenfranchised members of society." (George et al., 2012)	Inclusion and social justice	George et al. (2012), Foster and Heeks (2013)
Eco-innovation	"…new products and processes which provide customer and business value but significantly decrease environmental impacts" (Fussler & James, 1996; cited in Kemp & Foxon, 2007)	Environmental impact	Fussler and James (1996), Kemp and Foxon (2007)

emerged from Indigenous communities in Latin America and Africa. Excluding such traditional knowledge informed innovations not only stifles our collective ability to value the services of Indigenous peoples for society and the environment, it also prevents the exploration of ethical gray-zones that urgently need attending. For example, how can Indigenous people share knowledge in ways that scale positive outcomes, while ensuring appropriate recognition and compensation for these services, and avoiding any further degradation of their wellbeing

TABLE 2 Biocultural innovation as a distinct domain.

	Biocultural innovation	Indigenous social innovation	Frugal /Jugaad innovation	Inclusive innovation	Sustainable/eco-innovation	Social innovation
Key input	Traditional knowledge from Indigenous and tribal peoples	Ancestral knowledge and practices of Indigenous peoples as innovators	Fewer capital, labor, energy, and time resource inputs	Knowledge from or about previously excluded groups	Wide-ranging/ input neutral	Wide-ranging/ input neutral
Key process	Wide-ranging/ process neutral	Development and implementation by and for Indigenous peoples	Improving efficiency of resource use	Removal of structural barriers that block opportunities	Wide-ranging/ process neutral	Wide-ranging/ process neutral
Value emphasis	Instrumental/ solution-oriented	Intrinsic/ phenomena-oriented	Instrumental/ solution-oriented	Instrumental/ solution-oriented	Instrumental/ solution-oriented	Instrumental/ solution-oriented
Evaluation metrics	Improved ratio of inter-generational wellbeing to biocultural depletion	Improved lives of Indigenous peoples and reaffirmation of their Indigenous ways of life	Improved ratio of value creation to resource use	Improved opportunities for social and economic wellbeing for disenfranchised	Improved ratio of value to customers/ businesses to environmental impact	Improved ratio of value to society versus to private individuals
Epistemological orientation	Mainly positivist	Mainly constructivist	Mainly positivist	Mainly positivist	Mainly positivist	Mainly positivist

and rights to self-determination? Only by using a more inclusive definition can we recognize and realize the instrumental importance of Indigenous peoples and their knowledge for solving global problems, especially beyond their immediate communities.

Third, while other forms of innovation are also instrumental, by emphasizing pro-social over pro-environmental outcomes (or vice-versa), they may use overly reductive conceptualizations of "value" that fail to consider important positive and negative externalities for both the biosphere *and* the ethnosphere over sufficiently long timeframes. This can lead to perverse outcomes.[7] On one extreme, pro-social value conceptualizations (e.g., frugal, bottom-of-the-pyramid, inclusive, and social innovation) may disregard negative environmental externalities, instead prioritizing value as largely social (and not even as a biproduct of natural capital). One example of this is the widespread promotion and use of single-serve packaging, such as sachets for shampoo and razor blades in base-of-the-pyramid markets. While these innovations have been lauded as successful frugal, bottom-of-the-pyramid, and inclusive innovations that provide an affordable, acceptable, and accessible product to the poor in the short run, pollution created by single-serve packaging innovations have had detrimental environmental consequences that may further impoverish local communities over the long run (Borchardt et al., 2020).

On the other extreme, when pro-environmental value conceptualizations (e.g., green, eco-, and sustainable innovation) are reduced to overly simple metrics such as reduced carbon emissions that overlook biocultural diversity (and otherwise endorse 'business-as-usual'), humanity and the ethnosphere in particular can suffer. For example, the rush for biofuel energy and carbon offsets in the name of 'green' innovation has led to food crises and land grabs among Indigenous and subsistence agricultural communities across the Global South (Buller, 2022). For instance, Eni, a major oil company, announced plans to sequester roughly 8 million hectares of land in Africa for tree plantations to meet its 'net zero' commitments and offset operational emissions—all while continuing to increase oil and gas production (Buller, 2022). Such 'sustainable' innovations have resulted in the forced expulsion of Indigenous peoples from their homes and the seizure of land from subsistence farmers for 'conservation' (Cavanagh & Benjaminsen, 2014). Ironically, offsetting schemes have also led to detrimental environmental impacts through the substitution of native biocultural diversity for mono-species plantations.

In sum, although the literature on more sustainable forms of innovation is broad, biocultural innovation represents a vital new field of innovation studies that champions the role of Indigenous peoples and their knowledge as instrumentally critical, while sidestepping many of the blind spots inherent within overly pro-social and pro-environmental innovation fields that disregard the entwinement of the biosphere and ethnosphere and its importance to humanity.

4 | AGENDA FOR FUTURE RESEARCH

To make the most of the potential offered by biocultural innovation, Table 3 presents a research agenda that we will now elaborate on. Biocultural innovation as outlined in this *Catalyst* provides a bottom-up approach to creating much needed global change. Despite having ancient roots, it is incredibly timely. Consider the *UN Environmental Programme*'s shared 2050 vision—supported by over 100 nations—to find ways for society to live in harmony with nature (UNEP, 2022), and radically new economic theorizing that recognizes that economy and society are embedded in the biosphere in ways that complement long held Indigenous views and approaches to innovation (Dasgupta, 2021). Indeed, beyond acknowledging the deeply intertwined relationship between cultural and biological diversity, the UN proclaimed 2022–2032 as the *International Decade of Indigenous Languages* to raise global awareness of their threatened status and of their importance for sustainable development (Cámara-Leret & Bascompte, 2021). Yet, despite the innovation potential of leveraging the immense diversity in the biosphere and ethnosphere to find new solutions to global issues, biocultural assets are in crisis. Ecosystems around the world are perilously close to "tipping points" in which biodiversity loss will irretrievably damage their capacity to benefit humanity to in new ways (Dasgupta, 2021). Further, Indigenous peoples who hold much of humanity's knowledge about the biosphere are increasingly marginalized, and their languages—and therefore deep reservoir of knowledge—is at risk of disappearing (Cámara-Leret & Bascompte, 2021; World Bank, 2022). It follows, therefore, that this *Catalyst* is an urgent call to action.

To heed this call, learning from the relative success (or failure) of existing biocultural innovations can inform *blueprints* for best practice attempts to solve pressing challenges. These represent promising research contexts. For example, innovation scholars may uncover novel insights from UNESCO's *Man and the Biosphere* (MAB) initiative that brings scientists and Indigenous peoples together to form Biosphere Reserves: a novel kind of 'Innovation Lab' designed to find new approaches to sustainable economic development while conserving biocultural diversity (UNESCO, 2023b). Likewise, innovation scholars can critically reflect on how communities such as India's Kaani tribe have funded community development through an organization that captures royalties from the ongoing commercial use of their traditional knowledge (Bijoy, 2007; Millum, 2010). Innovation scholars could also work with organizations like the *Union for Ethical Biotrade*, a partnership of 130 global companies and their local suppliers, to analyze their attempts to develop and implement firm-level action plans to benefit local communities and their ecosystems. Further, innovation scholars could form new opinions on how initiatives such as India's *Traditional Knowledge Digital Library* (TKDL), established to document traditional knowledge and protect it from exploitation, could be integrated with recent global DSI funding mechanisms (Greenfield & Weston, 2022) to promote more effective and ethical biocultural innovation practices. These and other contexts are ripe for study by innovation scholars.

To aid such endeavors, we suggest three broad areas of investigation outlined in Table 3. First, innovation scholars should document and create helpful new typologies of the various types of biocultural innovations and related processes that exist. As discussed, biocultural innovation is unique because it is a function of diversity—that is, biocultural diversity and thus the value of biocultural assets—rather than of just resource conversion efficiency (as with frugal innovation, for example). As such, beyond the *conversion* of biocultural assets into value, it also includes the *conservation* (and ultimately *construction*) of these assets, especially for use by future generations. This blurring of the boundaries between innovation as conventionally understood and new approaches to conservation offers new research opportunities. Understanding better approaches to forest conservation that merge advanced sensing technologies with Indigenous knowhow would fall within this blurring of boundaries. Further, identifying organizations that systematically do biocultural innovation well (with a focus on scale and replicability)—and determining why this is—is also of critical practical and scholarly importance. Researchers should be especially encouraged to explore biocultural innovation processes, antecedents and outcomes beyond typically studied industries such as medicine, chemistry, and pharmacology (Miller, 2015). Please refer to Section A of Table 3 for other relevant research questions on biocultural innovation processes.

Second, innovation scholars could help navigate a path forward in an increasingly polarized debate in which one person's *bioprospecting*—that is, the collection, research, and commercialization of biodiversity for new products (Neimark, 2017)—is another person's *biopiracy*—that is, the systematic theft of traditional knowledge and nature (Neimark, 2017). Wynberg (2023) outlines how *Access and Benefit Sharing* (ABS), a central approach to addressing biopiracy by protecting biodiversity and strengthening the

TABLE 3 Future research directions.

Topic and research questions	Concepts and theories that can be utilized
A. Biocultural innovation processes *Organizational perspective* 1. **Typology of innovations and processes.** Building on the "3Cs" and "FPVI shared traits" frameworks, what are the various types of biocultural innovations and related processes that exist? What characteristics and factors contribute to the success or failure of biocultural innovations? How do these differ across contexts? 2. **Business models.** What new or existing business models are most effective for capturing value in biocultural innovation? Value for whom? What trade-offs exist and how can these be navigated? How should traditional knowledge be integrated into innovation processes that currently prioritize scientific knowledge? 3. **Scaling and replication.** What organizations are particularly effective at scaling and replicating biocultural innovations and why? How do firms develop the capabilities necessary for successful biocultural innovation? *Community and institutional perspective* 4. **Policy and governance.** What role do policy and governance mechanisms play in facilitating or hindering biocultural innovation? What barriers to biocultural innovation currently exist and how can they be overcome? 5. **Community dynamics.** How do communities of practice form and operate within biocultural innovation processes? How do communal biocultural innovation practices feed back into organizational biocultural innovation practices (and vice-versa)? 6. **Funding.** What forms of funding are suited to fostering biocultural innovation? To what extent does this differ for biocultural innovations aiming to convert, conserve, or construct biocultural asset value?	Business model innovation (Zott & Amit, 2010) Dynamic capabilities (Eisenhardt & Martin, 2000; Teece et al., 1997) Barriers to innovation (Hadjimanolis, 2003; Vassallo et al., Forthcoming) Communities of practice (Brown & Duguid, 1991) Social practice theory (Reckwitz, 2002)
B. Ethics of biocultural innovation *Organizational perspective* 7. **Risks and challenges.** How can firms effectively manage the risks and challenges associated with open innovation and co-creation processes involving indigenous communities to develop biocultural innovations (e.g., issues related to intellectual property and cultural appropriation)? 8. **Free, prior and informed consent.** How can firms effectively commercialize and scale biocultural innovations while ensuring the ongoing free, prior and informed consent of their Indigenous stakeholders? *Community and institutional perspective* 9. **Community governance.** What are the most effective ways for Indigenous communities to benefit from their traditional knowledge and biocultural assets in the context of biocultural innovation? How can biocultural innovation be designed and managed to maximize benefits to local communities and the environment? 10. **Protection of rights.** How can the intellectual property rights of Indigenous communities be protected and respected in the pursuit of biocultural innovation? How can digital sequence information (DSI) be managed and used so that Indigenous peoples benefit from biocultural innovations that utilize their knowledge and services?	Open innovation (Chesbrough & Crowther, 2006; Randhawa et al., 2016) Co-creation (Prahalad & Ramaswamy, 2004) Biopiracy (Wynberg, 2023) Bioprospecting (Millum, 2010) Hyperownership (Safirin, 2004)
C. Quantifying biocultural innovation *Organizational perspective* 11. **Quantifying and sharing value.** How can firms quantify the value of biocultural assets and traditional knowledge in the development of new goods and services? How is (versus should) this value be shared with Indigenous communities and other stakeholders? 12. **Options value.** How can the options value (i.e., innovation potential) of biocultural assets be valued? How can real options reasoning be applied to managing biocultural innovation portfolios? 13. **Biocultural investment multipliers.** What are the output multipliers for investment into various types of biocultural innovation? To what extent is there a	Real options reasoning (Kaufmann et al., 2021; Klingebiel & Adner, 2015; Myers, 1977) Spending multipliers (Batini et al., 2022) Social return on investment (Lingane & Olsen, 2004). Geospatial and big data for good (Chandy et al., 2017; Vassallo et al., 2019).

(Continues)

TABLE 3 (Continued)

Topic and research questions	Concepts and theories that can be utilized
tradeoff between investment into biocultural innovation and an economy's strength?	Intergenerational wellbeing (Arrow et al., 2012; Karacaoglu et al., 2019)
Community and institutional perspective	
14. **Community impacts.** What are effective methodologies for measuring the positive and negative impacts of biocultural innovation on Indigenous communities and their ecosystems? How can existing SROI approaches be modified to quantify the impacts of biocultural innovations?	
15. **Levels of analysis.** Are there particular types of impact at different levels of analysis that are distinctive and relevant to biocultural innovation? How can these impacts be quantified, especially using available geospatial and big data?	
16. **Intergenerational wellbeing.** How can intergenerational wellbeing be measured within the context of biocultural innovation and the value of the biosphere and ethnosphere?	

rights of Indigenous peoples, has created more problems than it seeks to resolve: it remains disconnected from, and ignorant of the struggles faced by Indigenous peoples, and instead serves as a mechanism to justify 'business as usual' in which benefits are highly skewed towards industry partners who have market dominance. To remedy this, innovation scholars could explore how the ABS approach and resultant *Benefit Sharing Agreements* (BSAs) could be improved, especially under institutional developments including the UN's *Post-2020 Global Biodiversity Framework* and the recent COP-15 agreement that seek to ensure that the 'traditional knowledge, innovations and practices of Indigenous peoples guides decision-makingto realize a world living in harmony with nature' (UNEP, 2022:5). Please see Section B of Table 3 for other relevant research questions on the ethics of biocultural innovation.

Third, there is a promising avenue for future research in the operationalization of biocultural innovation and its outcomes, particularly through the consideration of holistic costs and benefits over sufficiently long timeframes. In Section 3.2, we propose a ratio that, if accurately operationalized with available data, could enable researchers, policymakers, and other essential stakeholders to quantify the value of biocultural innovations and motivate their development and adoption. Building on existing methodological approaches would facilitate this. Consider the denominator, *biocultural depletion*. Given that biosphere depletion is relatively easy to quantify (with much environmental data now available) compared with ethnosphere depletion, researchers and analysts will need to find better proxies for the latter. Crude proxies for the health of the ethnosphere (or value of ethnosphere assets) have included linguistic diversity; conventional measures of human capital (e.g., income, health or education metrics); or conventional measures of natural capital (e.g., biodiversity, the rate of forest regeneration; see Marrie, 2019:5). However, these approaches either abstract away the unique needs and values of Indigenous peoples' or reduce the ethnosphere to the equivalent of the biosphere. More comprehensive frameworks—see, for example, Gee et al. (2014)—should be developed further to operationalize biocultural innovation and its outcomes. Moreover, *intergenerational wellbeing*—our proposed numerator—has recently been operationalized within economics and policy circles (see Arrow et al., 2012; Durand, 2015; Karacaoglu et al., 2019; Van Zanden et al., 2014). These measures can be refined further with guidance from Indigenous communities to quantify the value of biocultural innovations. Section C of Table 3 outlines other relevant research questions on quantifying biocultural innovation.

In conclusion, we argue that the time for a scholarly focus on biocultural innovation is now. We hope that by rallying around biocultural innovation and further developing the frameworks provided, innovation scholars inspired by this *Catalyst* will share in our mission to unlock economic and social value while supporting biocultural assets and Indigenous rights.

ACKNOWLEDGMENT

Open access publishing facilitated by The University of Sydney, as part of the Wiley - The University of Sydney agreement via the Council of Australian University Librarians.

FUNDING INFORMATION

None.

CONFLICT OF INTEREST STATEMENT

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

ETHICS STATEMENT

The authors affirm that there are no known financial conflicts of interest or personal relationships that may have influenced the findings presented in this paper.

Furthermore, this conceptual paper adheres to the ethical standards established by the respective professional codes of conduct for each author. The authors accept full responsibility for the integrity of the research, and in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

ORCID

Jarrod P. Vassallo https://orcid.org/0000-0002-3096-0227
Sourindra Banerjee https://orcid.org/0000-0001-5171-2612
Jaideep C. Prabhu https://orcid.org/0000-0002-8919-9567

ENDNOTES

[1] We capitalize the "*I*" in Indigenous to highlight the wide variety of distinct populations who can offer unique perspectives that have been historically silenced. This distinguishes "Indigenous innovation" from "indigenous innovation," the latter used to refer to "local" invention.

[2] In this paper, we limit our definition of the ethnosphere to the sum total of human knowledge and experience held by Indigenous peoples because the world's 6000 to 10,000 cultures were all originally Indigenous (Barsh, 1999), and collectively Indigenous peoples comprise the vast majority of the world's cultural diversity, including creating and speaking most of its languages (UNESCO, 2023a). See also terms such as logosphere and noosphere (see Maffi, 2007).

[3] Sadly, despite introducing western scientists and companies to this otherwise obscure herb, the Guaraní have not been compensated for their intellectual property.

[4] The authors' conversations with dozens of Indigenous people engaged in biocultural innovation overwhelmingly highlight these individuals' desires not just for self-determination and an Indigenous resurgence, but also to share their innovations in a fair and equitable way with the broader community to solve pressing societal challenges.

[5] While respecting that some readers may question this economic approach, the debate on whether and how to value these assets is not new (Buller, 2022), and we are unable to reconcile the spectrum of viewpoints that exist. Nevertheless, we agree with the UN's position that "if we do not value and account for nature in decision-making, it will continue to be lost" (IPBES, 2022:4). We extend this logic to include the ethnosphere, and join calls to explicitly account for the wide-ranging stocks and flows of biocultural assets in decision-making to ensure justice, sustainability, and intergenerational equity (IPBES, 2022).

[6] Biocultural diversity in turn is a function of raw biocultural richness, as well as land and population features and extent (see Loh & Harmon, 2005).

[7] Consider arguments that corporations are "externalizing machines" that by design, constantly pursue mechanisms for profit maximization by evading the true costs of economic activities (Buller, 2022).

REFERENCES

Arrow, Kenneth J., Partha Dasgupta, Lawrence H. Goulder, Kevin J. Mumford, and Kirsten Oleson. 2012. "Sustainability and the Measurement of Wealth." *Environment and Development Economics* 17(3): 317–53.

Barsh, Russel. 1999. *The World's Indigenous Peoples*, 1–12. Lethbridge, MB: Department of Native American Studies, University of Lethbridge.

Batini, Nicoletta, Mario Di Serio, Matteo Fragetta, Giovanni Melina, and Anthony Waldron. 2022. "Building Back Better: How Big Are Green Spending Multipliers?" *Ecological Economics* 193: 107305.

Berkes, F. 2017. *Sacred Ecology*. Abingdon: Routledge.

Bijoy, C. R. 2007. "Access and Benefit Sharing from the Indigenous Peoples' Perspective: The Tbgri-Kani Model." *Law, Environment and Development Journal* 3: 1.

Borchardt, M., N. O. Ndubisi, C. J. C. Jabbour, O. Grebinevych, and G. M. Pereira. 2020. "The Evolution of Base of the Pyramid Approaches and the Role of Multinational and Domestic Business Ventures: Value-Commitment and Profit-Making Perspectives." *Industrial Marketing Management* 89: 171–80.

Bos-Brouwers, Hilke Elke Jacke. 2010. "Corporate Sustainability and Innovation in SMEs: Evidence of Themes and Activities in Practice." *Business Strategy and the Environment* 19(7): 417–35.

Brown, John Seely, and Paul Duguid. 1991. "Organizational Learning and Communities-of-Practice: Toward a Unified View of Working, Learning, and Innovation." *Organization Science* 2(1): 40–57.

Buller, Adrienne. 2022. "The Value of a Whale: On the Illusions of Green Capitalism." In *The Value of a Whale*. Manchester, UK: Manchester University Press.

Burgess, P. J., J. Harris, A. R. Graves, and L. K. Deeks. 2019. *Regenerative Agriculture: Identifying the Impact; Enabling the Potential. Report for SYSTEMIQ*. Bedfordshire, UK: Cranfield University.

Cámara-Leret, Rodrigo, and Jordi Bascompte. 2021. "Language Extinction Triggers the Loss of Unique Medicinal Knowledge." *Proceedings of the National Academy of Sciences* 118(24): e2103683118.

Carrillo-Hermosilla, Javier, Pablo Del Río, and Totti Könnölä. 2010. "Diversity of Eco-Innovations: Reflections from Selected Case Studies." *Journal of Cleaner Production* 18(10–11): 1073–83.

Cavanagh, C., and T. A. Benjaminsen. 2014. "Virtual Nature, Violent Accumulation: The 'Spectacular Failure' of Carbon Offsetting at a Ugandan National Park." *Geoforum* 56: 55–65.

Chandy, Rajesh, Magda Hassan, and Prokriti Mukherji. 2017. "Big Data for Good: Insights from Emerging Markets." *Journal of Product Innovation Management* 34(5): 703–13.

Chesbrough, Henry, and Adrienne Kardon Crowther. 2006. "Beyond High Tech: Early Adopters of Open Innovation in Other Industries." *R&D Management* 36(3): 229–36.

Chisadza, B., M. J. Tumbare, I. Nhapi, and W. R. Nyabeze. 2013. "Useful Traditional Knowledge Indicators for Drought Forecasting in the Mzingwane Catchment Area of Zimbabwe." *Disaster Prevention and Management.* 22: 312–25.

Corry, Stephen. 2011. *Tribal Peoples: For Tomorrow's World: A Guide*. London, UK: Freman Press/Read Books.

Cottrell, Clifton. 2022. "Avoiding a New Era in Biopiracy: Including Indigenous and Local Knowledge in Nature-Based Solutions to Climate Change." *Environmental Science & Policy* 135: 162–8.

Dasgupta, Partha. 2021. *The Economics of Biodiversity: The Dasgupta Review*. London, UK: Hm Treasury.

Davis, Wade. 2002. *Light at the Edge of the World: A Journey Through the Realm of Vanishing Cultures*. Washington, DC: National Geographic Society.

Davis, Wade, and Jean-Paul Gagnon. 2021. "Democracies in the Ethnosphere: An Anthropologist's Lived Experiences of Indigenous Democratic Cultures." *Democratic Theory* 8(2): 118–38.

Díaz, Sandra Myrna, Josef Settele, Eduardo Brondízio, Hien Ngo, Maximilien Guèze, John Agard, Almut Arneth, et al. 2019. *The Global Assessment Report on Biodiversity and Ecosystem Services: Summary for Policy Makers*. Bonn, Germany: IPBES.

Díaz, Sandra, Josef Settele, Eduardo S. Brondízio, Hien T. Ngo, John Agard, Almut Arneth, Patricia Balvanera, et al. 2019. "Pervasive Human-Driven Decline of Life on Earth Points to the Need for Transformative Change." *Science* 366(6471): eaax3100.

Drahos, Peter, and Susy Frankel. 2012. *Indigenous Peoples' Innovation: Intellectual Property Pathways to Development*. Canberra, ACT: ANU Press.

Durand, Martine. 2015. "The OECD Better Life Initiative: How's Life? and The Measurement of Well-Being." *Review of Income and Wealth* 61(1): 4–17.

Eisenhardt, Kathleen M., and Jeffrey A. Martin. 2000. "Dynamic Capabilities: What Are they?" *Strategic Management Journal* 21 (10–11): 1105–21.

FAO. 2016. *The State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B. Rischkowsky and D. Pilling. Rome, Italy: FAO.

Foster, Christopher, and Richard Heeks. 2013. "Conceptualising Inclusive Innovation: Modifying Systems of Innovation Frameworks to Understand Diffusion of New Technology to Low-Income Consumers." *The European Journal of Development Research* 25(3): 333–55.

Fussler, Claude, and Peter James. 1996. *Driving Eco-Innovation: A Breakthrough Discipline for Innovation and Sustainability*. London, UK: Pitman Publishing.

Gavin, Michael C., Joe McCarter, Aroha Mead, Fikret Berkes, John Richard Stepp, Debora Peterson, and Ruifei Tang. 2015. "Defining Biocultural Approaches to Conservation." *Trends in Ecology & Evolution* 30(3): 140–5.

Gee, Graham, Pat Dudgeon, Clinton Schultz, Amanda Hart, and Kerrie Kelly. 2014. "Aboriginal and Torres Strait Islander Social and Emotional Wellbeing." *Working Together: Aboriginal and Torres Strait Islander Mental Health and Wellbeing Principles and Practice* 2: 55–68.

George, Gerard, Anita M. McGahan, and Jaideep Prabhu. 2012. "Innovation for Inclusive Growth: Towards a Theoretical Framework and a Research Agenda." *Journal of Management Studies* 49(4): 661–83.

Govindarajan, Vijay, and Ravi Ramamurti. 2011. "Reverse Innovation, Emerging Markets, and Global Strategy." *Global Strategy Journal* 1(3–4): 191–205.

Govindarajan, Vijay, and Chris Trimble. 2012. "Reverse Innovation: A Global Growth Strategy that Could Pre-Empt Disruption at Home." *Strategy & Leadership* 40: 5–11.

Graeber, David, and David Wengrow. 2021. *The Dawn of Everything: A New History of Humanity*. New York: Farrar, Straus, Giroux.

Greenfield, Patrick, and Phoebe Weston. 2022. *Cop15: Key Points of the Nature Deal at a Glance*. Accessed January 2, 2023. https://www.theguardian.com/environment/2022/dec/19/cop15-key-points-of-nature-deal-at-a-glance-aoe

Gupta, Ranjan, Bjarne Gabrielsen, and Steven M. Ferguson. 2005. "Nature's Medicines: Traditional Knowledge and Intellectual Property Management. Case Studies from the National Institutes of Health (NIH), USA." *Current Drug Discovery Technologies* 2(4): 203–19.

Hadjimanolis, Athanasios. 2003. "The Barriers Approach to Innovation." In *The International Handbook on Innovation*, edited by L. V. Shavinina, 559–73. Oxford, UK: Elsevier Science.

Hernandez, Jessica, Julianne Meisner, Lara A. Jacobs, and Peter M. Rabinowitz. 2022. "Re-Centering Indigenous Knowledge in Climate Change Discourse." *PLOS Climate* 1(5): e0000032.

Hickel, Jason. 2020. *Less Is More: How Degrowth Will Save the World*. London, UK: William Heinemann.

Horn-Miller, Kahente. 2013. "What Does Indigenous Participatory Democracy Look Like: Kahnawa: Ke's Community Decision Making Process." *Review of Constitutional Studies* 18: 111.

Hutchinson, G. Evelyn. 1970. "The Biosphere." *Scientific American* 223(3): 44–53.

IGWIA. 2022. *The Wampis Nation—The First Indigenous Autonomous Government in Peru*. Accessed September 9, 2022. https://www.iwgia.org/en/peru/3265-wampis-nation-peru

ILO. 1989. *C169—Indigenous and Tribal Peoples Convention, 1989 (No. 169)*. Accessed October 5, 2022. https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C169

IPBES. 2019. *Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn: IPBES Secretariat.

IPBES. 2022. *Summary for Policymakers of the Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn: IPBES Secretariat.

IPCC. 2019. "Summary for Policymakers." In *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*. Geneva, Switzerland: The Intergovernmental Panel on Climate Change (IPCC).

IPCC. 2022. *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Cambridge: Cambridge University Press.

Jana, B. 1998. "Sewage-Fed Aquaculture: The Calcutta Model." *Ecological Engineering* 11(1–4): 73–85.

Jayachandra, Abhilash. 2022. Mahua Takes a Global Stroll. *Burum Collective*. BBC. Accessed March 11, 2022. https://www.burumcollective.com/opinion20/mahuaflowers

Karacaoglu, Girol, Jacek Krawczyk, and Anita King. 2019. *Intergenerational Wellbeing and Public Policy*. Singapore: Springer Singapore.

Karanasios, Konstantinos, and Paul Parker. 2018. "Explaining the Diffusion of Renewable Electricity Technologies in Canadian Remote Indigenous Communities through the Technological Innovation System Approach." *Sustainability* 10(11): 3871.

Kaufmann, Carsten, Alexander Kock, and Hans Georg Gemünden. 2021. "Strategic and Cultural Contexts of Real Options Reasoning in Innovation Portfolios." *Journal of Product Innovation Management* 38(3): 334–54.

Kemp, René, and Tim Foxon. 2007. "Typology of Eco-Innovation." *Project Paper: Measuring Eco-Innovation* 5(1): 10–23.

Kik, Alfred, Martin Adamec, Alexandra Y. Aikhenvald, Jarmila Bajzekova, Nigel Baro, Claire Bowern, Robert K. Colwell, et al. 2022. "The World's Hotspot of Linguistic and Biocultural Diversity under Threat." *bioRxiv*. Accessed April 20, 2022. https://doi.org/10.1101/2021.04.12.439439

Klingebiel, Ronald, and Ron Adner. 2015. "Real Options Logic Revisited: The Performance Effects of Alternative Resource Allocation Regimes." *Academy of Management Journal* 58(1): 221–41.

Kochupillai, Mrinalini, Ulrich Gallersdörfer, Julia Köninger, and Roman Beck. 2021. "Incentivizing Research & Innovation with Agrobiodiversity Conserved in Situ: Possibilities and Limitations of a Blockchain-Based Solution." *Journal of Cleaner Production* 309: 127155.

Lewis, P., and Gary F. Simons. 2013. "The World's Languages in Crisis: A 20-Year Update." In *Responses to Language Endangerment. In Honour of Mickey Noonan*, edited by E. Mihas, B. C. Perley, G. Rei-Doval, and K. M. Wheatley, 3–19. Amsterdam: John Benjamins.

Lingane, Alison, and Sara Olsen. 2004. "Guidelines for Social Return on Investment." *California Management Review* 46(3): 116–35.

Loh, Jonathan, and David Harmon. 2005. "A Global Index of Biocultural Diversity." *Ecological Indicators* 5(3): 231–41.

Ludwig, David, and Phil Macnaghten. 2020. "Traditional Ecological Knowledge in Innovation Governance: A Framework for Responsible and Just Innovation." *Journal of Responsible Innovation* 7(1): 26–44.

LVMH. 2021. *LVMH Unveils its "Biodiversity" Commitments and Strengthens its Partnership with UNESCO with a Project in the Amazon*. Accessed March 3, 2023. https://www.lvmh.com/news-documents/news/lvmh-unveils-its-biodiversity-commitments-and-strengthens-its-partnership-with-unesco-with-a-project-in-the-amazon/

MA – Millennium Ecosystem Assessment. 2005. In *Ecosystems and Human Well-Being, IV: Multiscale Assessments*, edited by D. Capistrano, K. C. Samper, M. J. Lee, and C. Randsepp-Hearne. Washington, DC: Island Press.

MA – Millennium Ecosystem Assessment. 2005. In *Ecosystems and Human Well-Being, II: Scenarios*, edited by S. R. Carpenter, P. L. Pingali, E. M. Bennet, and M. B. Zurek. Washington, DC: Island Press.

MA – Millennium Ecosystem Assessment. 2005. In *Ecosystems and Human Well-Being, III: Policy Responses*, edited by K. Chopra, R. Leemans, P. Kumar, and H. Simmons. Washington, DC: Island Press.

MA – Millennium Ecosystem Assessment. 2005. In *Ecosystems and Human Well-Being, I: Current State and Trends*, edited by R. Hassan, R. Scholes, and N. Ash. Washington, DC: Island Press.

Maffi, Luisa. 2007. "Biocultural Diversity and Sustainability." In *The SAGE Handbook of Environment and Society* 267–77. London: SAGE Publishing.

Maffi, Luisa. 2018. "Biocultural Diversity." In *The International Encyclopedia of Anthropology*, edited by H. Callan, 1–14. https://doi.org/10.1002/9781118924396.wbiea1797

Marrie, Henrietta. 2019. "Emerging Trends in the Generation, Transmission and Protection of Traditional Knowledge." *Presentation to the 18th Session of the UN Permanent Forum on Indigenous Issues.* New York. https://www.un.org/development/desa/indigenouspeoples/wp-content/uploads/sites/19/2019/04/TK-Emerging-trends-in-the-generation-transmission-and-protection-of-TK-final-paper.pdf

Mavhura, Emmanuel. 2017. "Building Resilience to Food Insecurity in Rural Communities: Evidence from Traditional Institutions in Zimbabwe." *Jàmbá: Journal of Disaster Risk Studies* 9(1): 1–9.

Maynard, N. G., P. Burgess, P. Oskal, A. Turi, J. M. Mathiesen, I. G. E. Gaup, B. Yurchak, V. Etylin, and J. Gebelein. 2008. *Eurasian Reindeer Pastoralism in a Changing Climate: Indigenous Knowledge and NASA Remote Sensing*. NASA Technical Reports Server (NTRS).

McGonigle, Ian Vincent. 2016. "Patenting Nature or Protecting Culture? Ethnopharmacology and Indigenous Intellectual Property Rights." *Journal of Law and the Biosciences* 3(1): 217–26.

Mercer, Jessica, Ilan Kelman, Björn Alfthan, and Tiina Kurvits. 2012. "Ecosystem-Based Adaptation to Climate Change in Caribbean Small Island Developing States: Integrating Local and External Knowledge." *Sustainability* 4(8): 1908–32.

Miller, James S. 2015. "The Realized Benefits from Bioprospecting in the Wake of the Convention on Biological Diversity." *Washington University Journal of Law & Policy* 47: 51.

Millum, Joseph. 2010. "How Should the Benefits of Bioprospecting be Shared?" *Hastings Center Report* 40(1): 24–33.

Molnár, Z., and F. Berkes. 2018. "Role of Traditional Ecological Knowledge in Linking Cultural and Natural Capital in Cultural Landscapes." In *Reconnecting Natural and Cultural Capital: Contributions from Science and Policy*, edited by M. L. Paracchini, P. C. Zingari, and C. Blasi, 183–93. Luxembourg: Publications Office of the European Union.

Mukherjee, Sugato. 2022. *Mahua: The Indian Liquor the British Banned*. Accessed May 19, 2022. https://www.bbc.com/travel/article/20221121-mahua-the-indian-liquor-the-british-banned

Myers, Stewart C. 1977. "Determinants of Corporate Borrowing." *Journal of Financial Economics* 5(2): 147–75.

Nag, Subir Kumar, Saurav K. Nandy, Koushik Roy, U. K. Sarkar, and B. K. Das. 2019. "Carbon Balance of a Sewage-Fed Aquaculture Wetland." *Wetlands Ecology and Management* 27(2): 311–22.

Neimark, Benjamin D. 2017. "Bioprospecting and Biopiracy." In *The International Encyclopedia of Geography: People, the Earth, Environment and Technology*. Chichester, UK: John Wiley & Sons.

Ouyang, Zhiyun, Changsu Song, Hua Zheng, Stephen Polasky, Yi Xiao, Ian J. Bateman, Jianguo Liu, et al. 2020. "Using Gross Ecosystem Product (GEP) to Value Nature in Decision Making." *Proceedings of the National Academy of Sciences* 117(25): 14593–601.

Owen, Richard, Jack Stilgoe, Phil Macnaghten, Mike Gorman, Erik Fisher, and Dave Guston. 2013. "A Framework for Responsible Innovation." *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society* 31: 27–50.

Pearce, Tristan, Barry Smit, Frank Duerden, James D. Ford, Annie Goose, and Fred Kataoyak. 2010. "Inuit Vulnerability and Adaptive Capacity to Climate Change in Ulukhaktok, Northwest Territories, Canada." *Polar Record* 46(2): 157–77.

Peng, Yixiao, and Wenyi Huang. 2022. "Using Blockchain Technology and Sharing Culture to Promote Sustainable Forest Management in Tribal Communities." *Journal of Environmental and Public Health* 2022: 1–12.

Peredo, Ana María, Murdith McLean, and Crystal Tremblay. 2019. "Indigenous Social Innovation: What Is Distinctive? And a Research Agenda." In *Handbook of Inclusive Innovations*, edited by G. George, T. Baker, P. Tracey, and H. Joshi, 107–28. Cheltenham, England: Edward Elgar Publishing Limited.

Petzold, J., N. Andrews, J. D. Ford, C. Hedemann, and J. C. Postigo. 2020. "Indigenous Knowledge on Climate Change Adaptation: A Global Evidence Map of Academic Literature." *Environmental Research Letters* 15(11): 113007.

Phills, James A., Kriss Deiglmeier, and Dale T. Miller. 2008. "Rediscovering Social Innovation." *Stanford Social Innovation Review* 6(4): 34–43.

Porter-Bolland, Luciana, Edward A. Ellis, Manuel R. Guariguata, Isabel Ruiz-Mallén, Simoneta Negrete-Yankelevich, and Victoria Reyes-García. 2012. "Community Managed Forests and Forest Protected Areas: An Assessment of their Conservation Effectiveness across the Tropics." *Forest Ecology and Management* 268: 6–17.

Prabhu, Jaideep. 2017. "Frugal Innovation: Doing More with Less for More." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 375(2095): 20160372.

Prahalad, Coimbatore K., and Venkat Ramaswamy. 2004. "Co-Creation Experiences: The Next Practice in Value Creation." *Journal of Interactive Marketing* 18(3): 5–14.

Priyadarshini, Priya, and Purushothaman Chirakkuzhyil Abhilash. 2019. "Promoting Tribal Communities and Indigenous Knowledge as Potential Solutions for the Sustainable Development of India." *Environmental Development* 32: 100459.

Randhawa, Krithika, Ralf Wilden, and Jan Hohberger. 2016. "A Bibliometric Review of Open Innovation: Setting a Research Agenda." *Journal of Product Innovation Management* 33(6): 750–72.

Reckwitz, Andreas. 2002. "Toward a Theory of Social Practices: A Development in Culturalist Theorizing." *European Journal of Social Theory* 5(2): 243–63.

Redvers, Nicole, Yuria Celidwen, Clinton Schultz, Ojistoh Horn, Cicilia Githaiga, Melissa Vera, Marlikka Perdrisat, et al. 2022. "The Determinants of Planetary Health: An Indigenous Consensus Perspective." *The Lancet Planetary Health* 6(2): e156–63.

Reyes-García, Victoria, Álvaro Fernández-Llamazares, Pamela McElwee, Zsolt Molnár, Kinga Öllerer, Sarah J. Wilson, and Eduardo S. Brondizio. 2019. "The Contributions of Indigenous Peoples and Local Communities to Ecological Restoration." *Restoration Ecology* 27(1): 3–8.

Safirin, Sabrina. 2004. "Hyperownership in a Time of Biotechnological Promise: The International Conflict to Control the Building Blocks of Life." *American Journal of International Law* 98(4): 641–85.

Saslis-Lagoudakis, C. Haris, Julie A. Hawkins, Simon J. Greenhill, Colin A. Pendry, Mark F. Watson, Will Tuladhar-Douglas, Sushim R. Baral, and Vincent Savolainen. 2014. "The Evolution of Traditional Knowledge: Environment Shapes Medicinal Plant Use in Nepal." *Proceedings of the Royal Society B: Biological Sciences* 281(1780): 20132768.

Seyfang, Gill, and Adrian Smith. 2007. "Grassroots Innovations for Sustainable Development: Towards a New Research and Policy Agenda." *Environmental Politics* 16(4): 584–603.

Snively, Gloria, and John Corsiglia. 2018. "Indigenous Science: Proven, Practical and Timeless." In *Knowing Home: Braiding Indigenous Science with Western Science (Book 1)*, edited by G. Snively and W. L. Williams, 89–104. Oak Bay, BC: University of Victoria.

Sobrevila, C. 2008. *The Role of Indigenous Peoples in Biodiversity Conservation: The Natural but Often Forgotten Partners*. Washington, DC, USA: The World Bank.

Statista.com. 2022. *Global pharmaceutical sales*. Accessed June 3, 2022. https://www.statista.com/statistics/272181/world-pharmaceutical-sales-by-region/

Suriyaprakash, Timmakkondu Narasimman Kuppusami. 2022. "Intellectual Property Rights: Bioprospecting, Biopiracy and Protection of Traditional Knowledge-An Indian Perspective." In *Intellectual Property*, edited by S. L. Prabu and T. N. K. Suriyaprakash. IntechOpen.

Swiderska, Krystyna, Alejandro Argumedo, Yiching Song, Rastogi Ajay, Nawraj Gurung, and Chemuku Wekesa. 2018. *Biocultural Innovation: The Key to Global Food Security?* London, UK: IIED Briefing Paper-International Institute for Environment and Development.

Sydney Institute of Agriculture. 2020. *Native Grains from Paddock to Plate: Study of the Economic, Environmental and Social Sustainability of an Ancient System in a Modern Context*. Accessed May 20, 2022. https://www.sydney.edu.au/content/dam/corporate/documents/faculty-of-science/research/life-and-environmental-sciences/sia-native-grains-paddock-to-plate.pdf

Teece, David J., Gary Pisano, and Amy Shuen. 1997. "Dynamic Capabilities and Strategic Management." *Strategic Management Journal* 18(7): 509–33.

The Economist. 2018. *The Economist. Sequencing the World*. January 23. Accessed May 23, 2022. https://www.economist.com/science-and-technology/2018/01/23/sequencing-the-world

UNDP. 2021. *10 Things We Should all Know about Indigenous People*. Accessed June 2, 2022. https://stories.undp.org/10-things-we-all-should-know-about-indigenous-people#!

UNEP. 2022. *Kunming-Montreal Global Biodiversity Framework*. Accessed December 21, 2022. https://www.cbd.int/doc/c/e6d3/cd1d/daf663719a03902a9b116c34/cop-15-l-25-en.pdf

UNESCO. 2017. *Local and Indigenous Knowledge Systems*. Accessed May 1, 2022. http://unesco.org/new/en/natural-sciences/priority-areas/links/related-information/what-is-local-and-indigenous-knowledge

UNESCO. 2023a. *Indigenous Peoples*. Accessed May 18, 2022. https://en.unesco.org/indigenous-peoples

UNESCO. 2023b. *Man and the Biosphere (MAB) Programme*. Accessed December 16, 2022. https://en.unesco.org/mab

Vassallo, Jarrod P., Sourindra Banerjee, Hasanuzzaman Zaman, and Jaideep C. Prabhu. forthcoming. "Design Thinking and Public Sector Innovation: The Divergent Effects of Risk-Taking, Cognitive Empathy and Emotional Empathy on Individual Performance". *Research Policy*.

Vassallo, Jarrod P., Jaideep C. Prabhu, Sourindra Banerjee, and Ranjit Voola. 2019. "The Role of Hybrid Organizations in Scaling Social Innovations in Bottom-of-the-Pyramid Markets: Insights from Microfinance in India." *Journal of Product Innovation Management* 36(6): 744–63.

Verpoorte, Robert. 2000. "Pharmacognosy in the New Millennium: Leadfinding and Biotechnology." *Journal of Pharmacy and Pharmacology* 52(3): 253–62.

Vicziany, Marika, Dhrubajyoti Chattopadhyay, and Somenath Bhattacharyya. 2017. "Food from Sewage: Fish from the East Kolkata Wetlands and the Limits of Traditional Knowledge." *Journal of South Asian Studies* 40(3): 619–44.

Von Zedtwitz, Max, Simone Corsi, Peder Veng Søberg, and Romeo Frega. 2015. "A Typology of Reverse Innovation." *Journal of Product Innovation Management* 32(1): 12–28.

Wallace, Eric. 2019. *The Indigenous Tribes Fighting to Reclaim Stevia From Coca-Cola*. Accessed December 2, 2022. https://www.atlasobscura.com/articles/where-is-stevia-from

Warne, Kennedy. 2015. *Uncle Tangaroa and the Mokopuna*. https://www.nzgeo.com/stories/uncle-tangaroa-and-the-mokopuna/

Warren, D. M., L. J. Slikkerveer, D. Brokensha, and W. H. Dechering. 1995. *The Cultural Dimension of Development: Indigenous Knowledge Systems*. London: Intermediate Technology Publications.

Watson, Julia. 2019. *Lo-TEK, Design by Radical Indigenism*. Cologne, Germany: Taschen.

Watson, Julia. 2020. *Julia Watson Presents Lo-Tek | The World Around*. Accessed May 3, 2022. https://www.youtube.com/watch?v=BAblFYr0NF0&t=213s

Watson, Julia, H. Abukhodair, N. Ali, A. Robertson, H. Issaoui, and C. Sun. 2021. "Design by Radical Indigenism: Equitable Underwater and Intertidal Technologies of the Global South." *SPOOL* 8(3): 57–74.

Weston, Phoebe. 2021. *Campaign Launched to Protect 80% of Amazon at Key Environment Summit*. The Guardian. Accessed November 15, 2022. https://www.theguardian.com/environment/2021/sep/08/marseille-summit-indigenous-people-best-keepers-of-their-lands-aoe.

WIPO. 2016. *Intellectual Property and Traditional Medical Knowledge*. Accessed June 20, 2022. https://www.wipo.int/publications/en/details.jsp?id=3871

WIPO. 2022. *Traditional Knowledge*. Accessed June 20, 2022. https://www.wipo.int/tk/en/tk/a

World Bank. 2022. *Indigenous Peoples*. Accessed July 6, 2022. https://www.worldbank.org/en/topic/indigenouspeoples#1

Wynberg, Rachel. 2023. "Biopiracy: Crying Wolf or a Lever for Equity and Conservation?" *Research Policy* 52(2): 104674.

Van Zanden, Jan Luiten, Joerg Baten, Marco Mira d'Ercole, Auke Rijpma, Conal Smith, and Marcel Timmer. 2014. *How Was Life?: Global Well-Being since 1820*. Paris: OECD Development Centre.

Zott, Christoph, and Raphael Amit. 2010. "Business Model Design: An Activity System Perspective." *Long Range Planning* 43(2–3): 216–26.

AUTHOR BIOGRAPHIES

Dr. Jarrod P. Vassallo is a lecturer of social innovation and entrepreneurship at the University of Sydney Business School, University of Sydney. He received his PhD from Judge Business School, University of Cambridge. His research is focused on how socially and environmentally oriented innovations, entrepreneurs and enterprises can contribute to the 17 UN Sustainable Development Goals (SDGs). His research has been published in journals including *Research Policy* and the *Journal of Product Innovation Management*, and he has developed a strong pipeline of research papers in conjunction with world-leading academics.

Dr. Sourindra Banerjee is an Associate Professor of Marketing at Leeds University Business School, University of Leeds, UK. He received his PhD from Judge Business School, University of Cambridge and was a visiting scholar for a year at the Marshall School of Business, University of Southern California, Los Angeles. His research has been published in *Journal of Marketing, Research Policy, Journal of Product Innovation Management, Management International Review, Journal of Business Research, International Marketing Review*, and *Journal of Management Inquiry*.

Prof. Jaideep C. Prabhu is a professor of marketing, Jawaharlal Nehru Professor of Indian Business and Enterprise, and the director of the Centre for India & Global Business at Judge Business School, University of Cambridge. He has a PhD from USC and a BTech from IIT Delhi. His research interests are in marketing, innovation, strategy, and international business. He has published in *Journal of Marketing, Journal of Marketing Research, Marketing Science, Proceedings of the National Academy of Sciences (PNAS)*, and *JPIM*, among other leading journals. He is the co-author of *Jugaad Innovation: Think Frugal, Be Flexible, Generate Breakthrough Growth*, described by *The Economist* as "the most comprehensive book yet" on the subject of frugal innovation; *Frugal Innovation: How to do More with Less*, which won the CMI's Management Book of the Year Award 2016; and *How Should a Government Be? The New Levers of State Power*, published in 2021.

How to cite this article: Vassallo, Jarrod P., Sourindra Banerjee, and Jaideep C. Prabhu. 2023. "Biocultural Innovation: Innovating at the Intersection of the Biosphere and Ethnosphere." *Journal of Product Innovation Management* 40(5): 610–629. https://doi.org/10.1111/jpim.12669