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PERSPECTIVE

Guiding principles for transdisciplinary sustainability research and practice

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Abstract

1. Transdisciplinary sustainability scientists are called to conduct research with community actors to understand and improve relations between people and nature. Yet, research hierarchies and power relations continue to favour western academic researchers who remain the gatekeepers of knowledge production and validation.
2. To counter this imbalance, in 2018 we structured a multi-day workshop to co-design a set of principles to guide our own transdisciplinary, international and intercultural community of practice for biocultural diversity and sustainability. This community includes community collaborators, partner organizations, and early career and established researchers from Argentina, Bolivia, Canada, Germany, Mexico and South Africa. In 2021, we undertook online critical reflection workshops to share our research experiences and deepen our intercultural understanding of the application of the principles.
3. Through these exercises, we adopted seven principles for working together that include: honour self-determination and nationhood; commit to reciprocal relationships; co-create the research agenda; approach research in a good way: embed relational accountability; generate meaningful benefits for communities; build in equity, diversity and inclusion; and emphasize critical reflection and shared learning. We explain these principles and briefly highlight their application to our research practices.

4. By sharing these principles and associated practices, we seek to facilitate debate and spur transformations in how we conduct international and intercultural sustainability research. Our efforts also illustrate a strategy for on-going knowledge co-production as we cultivate safe and ethical spaces for learning together. Lessons learned may be particularly useful to those who engage in intercultural, collaborative research to advance sustainability transformations.

KEYWORDS
community-engaged scholarship, Indigenous Peoples, intercultural research, knowledge co-production, research principles, sustainability science, transdisciplinarity

1 | INTRODUCTION

Sustainability scientists have been called to engage equitably, respectfully and responsibly with collaborators and partnering organizations[1] to understand and improve relations between people and nature (Johnson et al., 2016; McGregor, 2021; Wong et al., 2020). When applying transdisciplinary approaches, sustainability researchers work with collaborators in civil society organizations, public and private sectors, and local, rural and Indigenous communities to collectively produce knowledge through "processes of reflection, formulating questions, selecting methods, collecting and analysing data, sharing, [and] learning" (Shackleton et al., 2023, p. 2). When done successfully, knowledge co-production can lead to policy and practice outcomes that better account for local and diverse values, perceptions and worldviews, and are more likely to be considered legitimate and credible by local people (Balvanera et al., 2020; Sala & Torchio, 2019). Working with community collaborators helps sustainability scientists avoid the harms of past research such as stigmatization of communities, disregard for community needs and knowledge exploitation (Poudrier, 2007; Smith, 2012).

Sustainability researchers apply a range of approaches and disciplines to bring local, traditional, Western and Indigenous knowledge systems[2] together in support of structural transformations for a sustainable future (Johnson et al., 2016; Tengö et al., 2014). Despite growth in academic-community collaborations, however, research hierarchies and power relations across disciplines, cultures and gender relations continue to favour western academic researchers who remain the gatekeepers of knowledge production and validation (Fletcher et al., 2021; Leach et al., 2018; Sala & Torchio, 2019; Tengö et al., 2017; Toomey, 2016). Community, experiential, and Indigenous knowledge can be ignored or tokenized, and community contributions are often inadequately acknowledged, compensated or reflected in research outcomes (Green & Johns, 2019; Harrison & Watson, 2012; Tengö et al., 2017). Bringing Indigenous and local knowledge into scientific assessments is important, challenging and evolving (Balvanera et al., 2020; IUCN, 2022), as scientific researchers have often "assume[ed] that knowledge is accessible and can be easily shared, ignoring the complexities around [I]ndigenous and local knowledge systems that are place-based, practical, oral, tacit—and has a local political context" (Tengö et al., 2017, p. 23). To address these concerns, academic and community collaborators have been encouraged to reflect on how their own positions of power within a research programme may affect outcomes (Lazrus et al., 2022; Toomey, 2016). These reflections encourage all research participants to periodically evaluate and learn from their research practices and become aware of cultural and disciplinary differences and influences (e.g. Sellberg et al., 2021; Taylor et al., 2016). This advice echoes the work of Indigenous scholars who have long suggested pathways for reflection before embarking on knowledge co-production (e.g. Cole, 2017; Ermine, 2007).

Within transdisciplinary sustainability research, concerns around how intercultural collaboration is best approached and practised have yet to be consolidated in the literature, few articles directly bring in the perspectives of community collaborators or offer specific guidance to help to decolonize dominant Western research processes (but see health researchers, Lokot & Wake, 2021). In this context, the purpose of this article is to (a) offer a co-designed and living set of principles for research practice to guide those working in and promoting transdisciplinary approaches to sustainability science and (b) illustrate a pathway for on-going, interactive knowledge co-production. The principles represent a consensus among diverse contributors across four continents of the global north and south, including natural and social scientists, representatives of non-governmental organizations, Indigenous mentors, and early and established researchers. This group brings both situated knowledge and rich research experiences across a broad spectrum of biocultural diversity and sustainability challenges and contexts. The guiding principles were generated as community collaborators and partner organizations worked together to form a community of practice under the auspices of the UNESCO Chair in Biocultural Diversity, Sustainability, Reconciliation and Renewal, established in 2018 at the University of Saskatchewan, Canada (for methodological details, see Supporting Information).

We identified seven principles that we believe are foundational to our ongoing work and may have broader applications to others who embark on transdisciplinary research and practice in sustainability. They emerged from discussion and consensus across the broad international, intercultural and transdisciplinary collective of which we are a part. The search for principles or guiding criteria for community-based and transdisciplinary research is not new (e.g.

Banks et al., 2013; Basta et al., 2021) and considered individually, some of these principles may even be viewed as common sense. Nevertheless, researchers have noted that scientists continue to ignore or overlook "the obvious" when working with Indigenous Peoples and local communities (Wilson, 2019), which can lead them to unintentionally engage in "misencounters" (Toomey, 2016). Because these principles emerged from the practice of diverse collaborators and partnering organizations working *internationally*, coupled with a commitment to on-going reflection and revision, we have confidence that they will have value across geographic and research contexts. We offer them to guide those interested in co-developing research protocols, practices, policies and knowledge mobilization activities with diverse communities.

The paper is structured as follows. The following section presents the ethos of transdisciplinary research by positioning our team and explaining our methodological approach. We then explain the original five principles that guided our work, published following editorial review, by the Social Sciences and Humanities Research Council of Canada and the Canadian Commission for UNESCO in 2020 (Reed et al., 2020), and provide short case descriptions that illustrate their application. Next, we discuss key insights gained from periods of reflection in 2021 and illustrate how these insights led us to add two more principles. Our concluding remarks connect our work to contemporary practices in knowledge co-production and highlight the value of these principles for sustainability scientists seeking to make transformative social-ecological change.

1.1 | Positioning ourselves and our methodological approach

The authors are part of a transdisciplinary, international and intercultural community of practice (after Wenger, 1998) in sustainability and biocultural diversity, bound by a common passion and a desire to learn how to improve its practices. Our community of practice currently includes community collaborators from Indigenous Peoples and local communities[3] (see Hill et al., 2020) in the global north and global south, along with partnering organizations that support communities in these places.

We recognize "traditional and contemporary Indigenous knowledge, community leadership and support, and the community's ownership of knowledge" (Johnston et al., 2018, p. 2). Our collaboration seeks to establish conditions for "ethical space" that forms "when two [or more] societies, with disparate worldviews, are poised to engage each other" (Ermine, 2007, p. 193) through dialogue that pays attention to cultural differences, hidden values and intentions, and how these govern our behaviours (Ermine, 2007, paraphrased from 202 to 203). Further, we are committed to the six "Rs" of research with Indigenous Peoples: respect, responsibility, relevance, reciprocity, relational accountability and refusal (Johnston et al., 2018, p. 13). Learning from Indigenous scholars, we seek to decolonize our research approach by "negotiating research relationships, utilizing Indigenized methods, recognizing reciprocal capacity building, and crediting Indigenous knowledge" (McGregor, 2018, p. 132). In some of the countries where we work, such as Canada and South Africa, a seventh "R", reconciliation, requires researchers and research programs to respect and uphold the rights of Indigenous and traditionally disadvantaged peoples (Nobles et al., 2022; Wong et al., 2020).

Our methodological approach is characterized by critical and iterative reflection and shared learning, and a desire to elevate the voices of community collaborators in articulating theoretical premises and practical strategies of transdisciplinary research. Insights from knowledge holders within the community of practice are introduced with academic literature. This approach is consistent with practices of weaving knowledge systems (Dreise & Mazurski, 2018; Tengö et al., 2017) and with *Etuaptmumk* or "Two-Eyed Seeing" as proposed by Mi'kmaq Elder Albert Marshall (see Bartlett et al., 2012; Hatcher et al., 2009; M's-it No'kmaq et al., 2021)—both of which draw on the strengths of multiple knowledge traditions to better understand a context or phenomenon, to help alter power structures and support the empowerment of under-represented knowledge holders. We choose to apply collective and critical reflection and learning to our own work, to shape how we conceive and co-conduct research practice, and to contribute to broader sustainability transformations. Details of our methods, including the workshops conducted to develop and revise the principles, are provided in Supporting Information.

2 | THE ORIGINAL PRINCIPLES

2.1 | Principle #1: Honour self-determination and nationhood

The foundation of our work is a commitment to honouring the self-determination and nationhood of Indigenous Peoples and local communities. Indigenous Peoples have an inherent right to self-determination that does not require the endorsement or control of outside parties (United Nations, 2007). We acknowledge that past research has often undermined this right[4] and dismissed or ignored their rightful responsibilities. As we shift to understanding that Indigenous Peoples and some local communities are rights holders rather than simply "minorities, interest groups, or stakeholders" (von der Porten & de Loë, 2013), we correspondingly shift our lens towards such groups as shared responsibility holders, with their own governance protocols and traditional territories. Further, we understand that there is significant diversity in Indigenous authority and governance arrangements within and across countries (Díaz, 2007; McGregor, 2018). An Indigenous mentor (Johnston, 2019) explained that by using the language of "responsibility holders", we create a pathway for non-Indigenous and Indigenous Peoples to work together in the governance of research and practice. Honouring self-determination and nationhood supports recognitional and procedural equity (Leach et al., 2018) and the revitalization of Indigenous/traditional cultures, governance systems, language, and ways of being (Salomon et al., 2018).

CASE BOX 1 A virtual Indigenous circle

During the COVID-19 pandemic, in-person gatherings were severely restricted, an additional challenge when organizing meetings that respect Indigenous protocols. The World Virtual Indigenous Circle on Open Science and the Decolonization of Knowledge took place on November 12, 2020. It was organized by the UNESCO Chair in Community-Based Research and Social Responsibility in Higher Education and co-hosted by the Canadian Commission for UNESCO and the World Indigenous Nations Higher Education Consortium. Its format was designed by Dr. Lorna Wanósts'a7 Williams. The Circle featured nearly 20 Indigenous speakers and attracted some 300 registrants from around the world. Its purpose was to inform UNESCO's forthcoming recommendation on open science and, in turn, to ensure Indigenous Knowledge was included respectfully and with integrity and thereby reshape how institutions recognize and use it.

The webinar adhered to Indigenous protocols, opening and closing with prayers, songs and territorial welcomes from respected Elders and Knowledge Keepers. As one speaker reminded everyone, "Songs and prayers are a very important part of science." The format emulated a Talking Circle that encouraged respect, information-sharing, attentiveness and interconnectedness. Speakers and attendees expressed their recognition that the webinar marked a time for Indigenous Peoples to revisit who and where they are, who their ancestors are, and where their teachings come from in order to move forward in a positive way. They also expressed their appreciation for the use of the traditional Circle format and its ability to "bring out" Indigenous knowledge. While challenging to engage in Indigenous protocols through an online platform, its virtual character also helped towards the democratization and sharing of knowledge.

Dr. Lorna Williams aptly summed up the purpose of the Circle and its format it in her opening remarks: "We have gathered today in a circle, and we are here to shape what's in the middle: the bundle of knowledge that will guide the way in which Indigenous Peoples' knowledge is continued and created from all over the world."

Contributed by Eleanor Haine, formerly Program Officer for Natural Sciences, Canadian Commission for UNESCO, Canada; presently Policy Analyst Environment and Climate Change Canada.

Case Box 1 offers an example of respecting and foregrounding Indigenous governance protocols in a virtual setting. Honouring self-determination and nationhood is intentionally our first Principle; it is both a starting point and a constant underpinning to collaborative research endeavours.

2.2 | Principle #2: Commit to reciprocal relationships

Commitment to reciprocal relationships points to the importance of building relationships and friendships when beginning research with Indigenous Peoples and local communities (Johnston, 2019). Building both informal and formal relationships of trust, friendship and mutual respect requires significant time and effort (Tobias et al., 2013; Toomey, 2016). Informal approaches include learning about history and peoples in particular territories and learning about past experiences and present concerns (Toomey, 2016; Younging, 2018) as well as simply being present in the community beyond formal research time (Brock, 2019). These efforts can help establish informal community connections and enhance trust and friendships that are vital for working together. Additionally, securing champions who are knowledgeable about intra-community politics, demographics, and relationships is key (Friedrichsen, 2020; McGregor, 2018). Champions can help researchers navigate local protocols related to ceremony, youth engagement, gender relations, the role of Elders, as well as compensation and gift-giving, language, and appropriate sharing and curation of knowledge (McGregor, 2018; Noojmowin Teg Health Centre, 2003).

Increasingly, university research ethics boards require researchers to document benefits, risks and commitments for communities involved in research. Researchers may be required to establish formal relationships with community leadership, following local decision-making procedures and organizational structures. This often requires presentation and formal approval of the proposed research to the local council or authority before research can proceed (McGregor, 2018). For some communities, formal approval goes beyond university ethics requirement. Approval may follow the negotiation and signing of a research agreement between academic researchers and communities that sets out expectations for research conduct, data access and management, and knowledge sharing and credit. In parts of Latin America and Africa, some territorial governing authorities are developing biocultural protocols that provide guidelines for how researchers and agencies should engage with local communities, to ensure that outsiders undertake their work with the free, prior and informed consent of those communities and respect their rights to self-determination (CONABIO-GIZ, 2017; Girard et al., 2022).

Committing to reciprocal relationships also encourages researchers to support more creative opportunities to collect and share data (e.g. photos, popular theatre, and storytelling)—in ways that are culturally and locally appropriate and appealing to different groups within a community (e.g. Fernández-Llamazares & Cabeza, 2017; Hamer & Sutherland, 2014). Multiple forms of engagement may help raise the voices of under-represented groups (e.g. youth) and allow them to share ideas with their peers and other community members (see Case Box 2).

CASE BOX 2 Empowering youth through knowledge co-creation and sharing

Research focused on youth emerges from an understanding that youth are frequently underrepresented in territorial governance systems and often drawn away from their communities for higher education and employment. Permission to work with youth may require additional approvals from institutional ethics requirements and local authorities. Hence, building reciprocal relationships first is vital to determining research questions and methods that will engage youth and generate robust and meaningful results—in theory and on the ground. In Clayoquot Sound Biosphere Region (CSBR) on the west coast of Vancouver Island, Canada, a community food preservation program in 2018 helped residents build knowledge and skills to improve access to seasonal food from the region's Indigenous and local food systems. Community-based research identified that youth were particularly at risk of food insecurity, so the food preservation program was extended to Tla-o-qui-aht (ƛaʔuukʷiʔatḥ) Warrior group and Ucluelet Secondary School. Youth groups participated in co-designing and evaluating workshops tailored to their schedules and learning priorities, including food drying, canning, food preservation equipment operation, food cutting, food preservation science and teachings about the cultural importance of traditional food.

In the Indigenous territory of Lomerío, Bolivia, pre-research visioning workshops showed Lomerío´s leadership (CICOL) that youth wanted to participate in governance upon completing their professional career in the city. Leaders from Lomerio's 29 member communities voted to elect local young professionals as "Communal Caciques" to give them the opportunity to apply the skills and knowledge they had gained from being away. CICOL also requested the Bolivian Institute of Forest Research (IBIF) to establish forums for youth to discuss and solidify their proposals for living in the territory. Drawing on a research partnership between IBIF and the University of Saskatchewan, researchers facilitated knowledge exchange and helped CICOL meet a central commitment in its plan de vida (life plan): the integration of women and youth in territorial governance.

Research during the COVID-19 pandemic, required researchers, and graduate students in particular, to find creative ways to build the relationships necessary for community-engaged research. Mariana Campos Rivera used a digital ethnography approach to engage Indigenous youth from different communities in Oaxaca, southern Mexico in knowledge-sharing about traditional ecological knowledge. She provided an opportunity for on-going connection by launching a website (Table 1) to provide information relevant to youth needs and interests, such as details of events, digital resources, and funding opportunities. Because of the relationships she built during the research, the website continuously receives and incorporates feedback from youth, making it a living research product that adapts to their changing needs and interests.

Contributed by Majing Oloko, then PhD candidate, School of Environment and Sustainability, University of Saskatchewan, Canada; Marlene Soriano, Director, Inclusive Business and Socioeconomic Development Program, IBIF (Bolivian Institute of Forest Research), Bolivia; and Mariana Campos Rivera, then MES student, School of Environment and Sustainability, University of Saskatchewan, Canada.

2.3 | Principle #3: Co-create the research agenda

Co-creating the research agenda means that research objectives are determined according to the needs and interests of community collaborators. Co-creation is not new. Many successful co-created research agendas have been developed in the context of social-cultural movements, particularly in the context of decolonization and recognition of community-based systems of resource use and governance. For example, in Brazil, Mexico and Sri Lanka, researchers have been prompted by local peoples to examine the differences in agricultural and forestry land use systems brought by the transition from colonial to post-colonial or community-led approaches (Figueroa-Helland et al., 2018; Gunaratne et al., 2021). The frequency and timing of activities will vary by community (Reed & Peters, 2004). Involving local participants should promote learning and strengthen research and enhance their capacity to take up the results of the research with local leaders. The principle also requires research teams composed of community and academic collaborators to ask the community: who needs to know about the research findings, and how can research teams help support communication and uptake of knowledge gained? It is also challenging because of requirements that are placed on researchers to comply with norms or policies of funding agencies that may be at odds with practices of co-creating the research agenda. Wrestling with such questions as part of research co-design from the outset enables knowledge creation and mobilization to take place in a manner that is more meaningful and effective for communities. Case Box 3 provides a Canadian example of co-creating a research agenda.

2.4 | Principle #4: Generate meaningful benefits for communities

Research should provide relevant and meaningful benefits to the communities with whom academics partner (Royal Roads University, 2018). When research is based on reciprocal relationships, is co-designed

TABLE 1 Putting principles into practice.

Principle	Explanation	Examples
1. Honour self-determination and nationhood	Although it emerges from recognizing the rights of Indigenous Peoples, the act of honouring the self-determination of all peoples is an important foundation for many research relationships Learn about pre-existing treaties and recognize the roles of non-Indigenous Peoples in maintaining treaty commitments Where we conduct research on the traditional territories of others, we engage respectfully in ceremonies, traditions, and teachings that help us understand worldviews, values, culture, and perspectives	A full report of an online Indigenous circle is available here A video recording of the webinar can be viewed here
2. Commit to reciprocal relationships	Build both informal and formal relationships by adhering to local structures and building relationships built on trust, friendship and mutual respect for example Follow local decision-making procedures; provide time for consultation prior to research to ensure research is understood and desired	See the award-winning website created to support knowledge exchange among Indigenous youth in Mexico here
3. Co-create the research agenda	Researchers and community collaborators jointly set conditions for the research from setting objectives to managing data and sharing the results	See the Anishinaabeg food security exhibit here
4. Generate meaningful benefits for communities	Adherence to Principles 1, 2 and 3 will significantly increase the likelihood of meaningful benefits being generated for partner communities These benefits can come in multiple forms, including such as building economic (financial capital), building social capital (through dialogue), undertaking skills training, and enhancing local knowledge to feed into local policy making	Learn more about the Payun Matru Cooperative, Mendoza, Argentina by viewing this link
5. Approach research in a good way: embed relational accountability	Indigenous scholars and collaborators explain that research is relationship. It involves working together in respectful, reciprocal, and responsible relationships and alliances. Relationships may extend beyond those of individuals directly involved in the research. Relational accountability requires self-awareness, critical reflection, extended timelines, and adaptation when research or community activities take unexpected turns	To find out more about Nama peoples' climate vulnerability modelling, review this link
6. Ensure equity, diversity and inclusion	Ensuring EDI requires consideration of how systemic barriers, unconscious bias, and racism influence all stages of research design and practice	A transdisciplinary research training partnership has drawn attention to how language can include or exclude potential collaborators Find the operating principles for TRANSECTS here
7. Emphasize critical reflection and shared learning	This principle requires committing to continuous collaborative efforts to reflect and learn from experience	The vulnerability, health and climate change project in Eastern Cape South Africa illustrated the benefits that come from on-going social learning exercises. Find a copy of the handbook here Find documentaries here

with and is accountable to community collaborators, there is a higher likelihood that the research activities and the knowledge shared will generate meaningful, tangible, and intangible benefits to community collaborators and partners, and broader members.

Benefits can be wide ranging and come in various forms. Some may be designed at the outset of research, while others may be emergent, but all should be tied to local, on-the-ground needs and realities and therefore align with the interests, needs, values and worldviews of the communities where research takes place. Research grants can often help "level the capacity playing field" (von der Porten & de Loë, 2015, p. 141), such as by paying local people to serve as research guides and assistants (Gearhead & Shirley, 2007) or providing financial or logistical support for community-organized events. Where capacity building of youth is desired, researchers can provide specific training such as in environmental change and monitoring (Adams et al., 2014; Robson et al., 2019; Wolfe et al., 2007). Research can also be designed in such a way that it supports on-going local dialogue and intergenerational knowledge exchange to inform local decision-making and enhance

CASE BOX 3 Co-creating the research agenda in lake of the woods Anishinaabeg

Miijim: Traditional foods of the lake of the woods Anishinaabeg (Miijim: Anishinaabe Gaabi Inanjiged Zaaga'iganiing) was an exhibit and public engagement programme in Canada supporting food security co-curated by Phyllis Pinesse of Iskatewizaagegan Independent First Nation, Lori Nelson of the Lake of the Woods Museum, and Iain Davidson-Hunt of the University of Manitoba.

The development of the exhibit and programme was undertaken by a design team that included community research partners and Elders, curatorial and public education staff of the museum and university researchers. The audience identified was both Indigenous and settler residents of northwestern Ontario to create a space for dialogue and exchange through public engagement. Panels were developed in both English and Anishinaabemowin, drawing from textual sources gathered through research projects (Elders statements, illustrations, photos, and archival materials) and based on a design developed by the team. A youth from the community with video production skills developed two short videos about contemporary harvest practice from the water and the land guided by the team.

During the six-week exhibit, weekly programmes were held during which community members and Elders demonstrated cooking with Anishinaabe foods; discussed the importance of water and land for their foods and medicines; and, provided opportunities for people to learn skills related to food processing and preparation. In its first run, the exhibit attracted several thousand visitors and since then has continued to be requested by regional museums, schools and Indigenous organizations. At the requests of Indigenous organizations, the panels were later produced as a digital booklet that provided information on language, food security and nutrition programmes.

Contributed by: Iain Davidson-Hunt, University of Manitoba, Canada.

CASE BOX 4 Generating meaningful benefits in Argentina

La Payunia Provincial Reserve is located in Mendoza province in Argentina. As is the case for other protected areas created in the 1980s, the participation of local people in the design and establishment of the Reserve was very limited. In 2005, some inhabitants of La Payunia asked the Provincial Department of Renewable Natural Resources for technical advice in order to develop an alternative source of income, while reducing conflicts between domestic livestock and wild guanaco (*Lama guanicoe*) populations.

The Payun Matru Cooperative was set up to implement live shearing of guanacos and link conservation with improving the economic situation for local people. The cooperative also aimed to preserve local culture and encourage young people to remain in the area. Technical and scientific advice was sought with camelid experts from the National Research Council (CONICET). This initiative resulted in a long-lasting cooperation with researchers and students.

Since 2006, guanaco roundups have been planned and carried out by Cooperative members and researchers, merging community development with scientific research. Over time, the guanaco captures have become 'open air labs', enabling IUCN´s Animal Welfare Protocol for guanaco captures to be developed and many young scientists to be trained. Cooperative members improved their management and shearing methods and have become experts on guanaco management with high animal welfare standards. Several members were hired by producers from Patagonia to share their expertise on guanaco management. In 2012, a public-private consortium was established between the Payun Matru Cooperative, the CONICET, the National Institute for Industrial Engineering (INTI) and the local Municipality of Malargüe, and was awarded funding to develop the technology needed to support the establishment of a guanaco fibre value chain, which included the installation of a fibre processing plant for the Cooperative to use and benefit from.

Contributed by: Gabriela Lichtenstein, Independent Researcher at the National Institute of Latin American Anthropology and Thought, Argentina.

social cohesion (Sarigumba et al., 2023; Shackleton et al., 2023). Ensuring knowledge from research is mobilized to the right audience may also confer significant benefits. For example, the European Union (EU) refused honey from Mexico under its Zero Genetically Modified Organisms (GMO) policy. However, by using molecular techniques, researchers demonstrated that traces of GMO found in the honey were not 'ingredients', but rather, 'components' and therefore the honey complied with EU regulations. Effective knowledge mobilization prevented devastating economic losses across Maya communities (Gómez González, 2016; Villanueva-Gutiérrez et al., 2014).

Case Box 4 illustrates how building relationships led to meaningful benefits in Mendoza province, Argentina. While some material benefits were realized in the form of employment and management improvements, less tangible, but equally important, benefits also took the form of local capacity enhancement and recognition of local people as experts in their territory.

2.5 | Principle #5: Approach research in a good way: Embed relational accountability

Transdisciplinary research is ultimately about building and nurturing relationships; researchers are now expected to enter a research relationship with a significant amount of self-awareness, critical reflection and self-evaluation about how knowledge is generated, and what research methodologies may be suitable (Barrett, 2013; Castleden et al., 2012, 2017; Datta, 2018; Smith, 2012). Indigenous Peoples and scholars in Canada and their allies describe this as research being done "in a good way" (e.g. Johnston et al., 2018; Peltier et al., 2020; Stiegman & Castleden, 2015), while researchers in other contexts have described this in the context of procedural equity (e.g. Leach et al., 2018). For non-Indigenous scholars, the phrase "in a good way" may appear vague; however, it represents the best translation for ethical and equitable research practice across multiple Indigenous languages and contexts. Research that accounts for relationships requires researchers to be mindful of the impact of their actions and assumptions before, during, and following fieldwork (International Society of Ethnobiology, 2006; Toomey, 2016). Indigenous scholars and collaborators speak to the need to work together in respectful, reciprocal, and responsible relationships and alliances, and to be accountable for the network of relationships within which researchers work (M's-it No'kmaq et al., 2021).

Relational accountability requires researchers to consider relationships beyond those between individual collaborators. M's-it No'kmaq et al. (2021, p. 845) remind readers that "Indigenous Peoples have lived within relationships of all forms of life since time immemorial, gathering deep understanding of the place, interconnections, and processes" while Lazrus et al. (2022, np) note that "non-Indigenous scientists who partner with Indigenous knowledge-holders must understand, support, and be accountable to a broader set of responsibilities than that to which they may be accustomed". Johnston et al. (2018:14) explain the connections researchers enter once they engage with communities:

> Relational accountability is not just about the researcher being responsible to a research participant; it holds the family and community of those two people, and all their other relations, accountable for the research being done in a good way. A researcher must take personal responsibility for the knowledge shared […], as well as for the new knowledge that arises….Indigenous research is about relationships and responsibilities. As such, research participants also hold responsibilities.

Working with a sense of humility, bravery, wisdom *and humour* will enhance research relationships (Noojmowin Teg Health Centre, 2003). Researchers working in Indigenous and non-Indigenous communities must also reflect and adapt (Nelson, 1991; Reed & Peters, 2004; Toomey, 2016); they will inevitably make mistakes and should therefore be prepared to make changes throughout research processes. Researchers should also be conscious of the local culture and be aware of, and sensitive to, the ebbs and flows of community life and community capacity. This includes remembering that community participants also have full lives and enter in research partnerships voluntarily. Researchers who require formal decisions to be made by community collaborators, must provide them sufficient time to consider implications of the research prior to making decisions, according to the tenets of free, prior and informed consent (Zurba et al., 2019). Furthermore, in many communities—Indigenous and non-Indigenous alike—research activities will pause during times of major celebration, crisis, or grief (Martin, 2003). Hence, good community-engaged research is not to be rushed. Case Box 5 describes how adaptation during the research process can build robust results for communities.

CASE BOX 5 Relational accountability supports adaptation of research with the Nama peoples in South Africa

In 2018, a group of researchers and practitioners from Canada, the United States, and South Africa embarked on a journey with the Nama peoples in Kuboes, South Africa, near the Richtersveld World Heritage Site, to understand their climate vulnerabilities and create an early action plan for adaptation. The team consisted of researchers from South African National Parks (SANParks), the Agricultural Research Council of South Africa, the University of Western Cape, and the Resilience Institute (Canada), and five post-school learners from the Kuboes village.

As a starting point, the team followed the Local Early Action Plan (LEAP) process developed by the Resilience Institute with Indigenous tribes in Canada. The LEAP process starts with a series of educational workshops and dialogues. The dialogues provide the opportunity to hear participants' observations, concerns and ideas for resilience building. During these engagements, many of the Nama community members agreed that adaptation planning was necessary but requested that the team consider working with them to implement an early action while the longer-term planning occurred. Water quality and quantity was already a major concern for the community and with drought only expected to worsen where they live in the arid zone of South Africa (Samuels et al., 2022), the local community knew that water capture units were desperately needed.

Responding to the community's request for an early adaptation strategy, the team re-designed the initiative to include purchasing, installing, and training local community members to maintain water capture units. By the end of the pilot, three water capture units were installed at the Kuboes School in tandem with conducting additional climate change education sessions and a vulnerability assessment with over 400 households. We also fostered a successful model for learning while doing.

Contributed by Laura S. Lynes, President, the Resilience Institute, Canada.

Selecting venues and processes that are appropriate for the community, such as holding a communal meal or talking circle may be more comfortable for an Indigenous or other traditional community than a typically western setting for engaging (von der Porten & de Loë, 2013). Silence and gratitude can also be important to the process, especially when someone shares from the heart (Noojmowin Teg Health Centre, 2003; Vásquez-Fernández et al., 2018). Doing research in a good way requires researchers to maintain strong and meaningful connections with community members throughout. This extends to communicating results and outcomes back to the community in ways that are culturally relevant and in formats that are accessible and useful to community members (Kushnir, 2021; McGregor, 2018), even if they are not counted as academic outputs. This may mean doing so prior to finalizing theses or academic papers.

Special attention should be paid to how data are maintained and shared, with participants' well-being paramount (Nuu-chah-nulth Tribal Council, 2008). Vasseur and McDermott (2019, p. 270) explain how researchers bringing Indigenous and western scientific knowledge systems together must ensure that "(i) appropriate Indigenous Research Ethics approval [is secured], (ii) true and open consent …is sought before …research begins, and [that] (iii) data [are] returned to the People … for the protection and preservation of Indigenous knowledge". In Canada, First Nations have established the principles of Ownership, Control, Access and Possession (OCAP),[5] calling on researchers to operationalize these with communities with whom they work (First Nations Information Governance Centre, 2020). An international network of Indigenous and non-Indigenous scholars and practitioners has generated similar principles of Collective Benefit, Authority to Control, Responsibility and Ethics (CARE) to guide research practice (Carroll et al., 2020). Community ownership of research results can be encouraged by creating opportunities for community members to contribute to findings and associated outputs, including explicit acknowledgement or co-authorship and naming the products or projects resulting from research (Zurba et al., 2019), and ensuring that data are coming back to the community in ways that are fully accessible and understandable.

2.6 | Visualizing the research principles as an interwoven knot

We visualized the principles as a set of five, interconnected principles that form an interwoven, non-hierarchical knot. The image draws on both Indigenous and Western traditions to demonstrate the interconnectedness among cultures and worldviews (Figure 1). Both the colours selected for the image and the circles depicting each principle, gesture to the Medicine Wheel used by Anishinaabeg, Niitsitaapi, Nêhiyawak and other Indigenous Peoples in North America. The knot itself is a variation on the traditional Celtic symbol which has no beginning or end point, signifying the eternity of life. This symbolism was agreed upon through

FIGURE 1 A visualization for principles guiding international and intercultural research (design by P. Friedrichsen) originally published in Reed et al., 2020, reprinted with permission.

respectful, reciprocal and ongoing discussion. It supported our need to learn and work together to co-create and share knowledge with the understanding that collaboration is a means to transform research relationships and practices that advance sustainability (Longboat, 2022).

3 | EXPANDING THE PRINCIPLES

Following the initial development of the guiding principles, we continued to reflect on our practices. In 2021, we engaged in collective systematic reflection and learning through a series of workshops that reinforced key principles and added two new ones: 'on-going reflection and learning' and 'ensuring equity, diversity and inclusion' (for details, see Supporting Information). Our revised illustration embeds the two new principles around the core circle as they intersect with each of the individual principles in an iterative fashion (Figure 2).

3.1 | Reinforcing the original principles

Across the community of practice, there was broad support for the principles and their framing. Colleagues from community-based organizations and research institutions in Latin America reinforced that ensuring reciprocal relationships (#2) and meaningful benefits (#4) were particularly important when they worked with local communities in their region, arguing that collaboration must be developed with a corresponding commitment to endogenous development and project design. They explained how common it is for

FIGURE 2 An enhanced visualization for principles guiding international and intercultural research (illustrated by M. Campos Rivera, based on the design by P. Friedrichsen).

projects to be carried out and implemented by external institutions without properly consulting or including communities in the process. Such an approach results in a dependence on external agents and a lack of ownership and participation by communities themselves. Maintaining a commitment to grassroots projects and initiatives has important implications for who starts and guides the conversation when communities and external actors collaborate on research or in practice.

Community collaborators also challenged the researchers to mobilize the principles by compiling a suite of cases, methodologies or techniques that document success and failures. They argued that communities must decide which approach may be more effective for them. An open access repository of detailed cases that is readily understandable and accompanied by data and tools could help them become better aware of the advantages and disadvantages of a specific approach. Community collaborators suggested that having access to this information might encourage local people to participate in projects being proposed by government or external organizations at the outset. Collaborators saw a role for the training of graduate students in techniques that support community-engaged learning. Others stressed that if we are serious about knowledge co-production, we need to create opportunities for community collaborators to become directly involved in traditional academic spaces. This includes academics inviting community collaborators to participate in academic symposia, serve as student mentors, participate in conferences, co-author academic papers, engage university leaderships in shaping future research agendas and themes, and work to break down systemic barriers including financial costs, institutional norms and prejudices, and logistical challenges.

3.2 | Expanding the principles

3.2.1 | Principle #6: Ensure equity, diversity and inclusion

As our community of practice grew, so too did we learn the significance of new elements. First, we began to explore how our understanding (or lack of understanding) of systemic barriers, unconscious bias, and racism have influenced research design and practice (UNESCO, 2017). Funding agencies and research programs in some countries (e.g. South Africa, Canada) now track indicators of "equity, diversity, and inclusion" (EDI[6]) and some require researchers to take specific measures to ensure that research teams are diverse, design is inclusive, and outcomes are equitable (e.g. Social Sciences and Humanities Research Council of Canada, 2022). This includes a range of practices including team composition, role and workload distribution, inclusion and attribution of knowledge, opportunities for knowledge mobilization, networking, training for highly qualified personnel, and monitoring of progress and success. At the same time, we know, and must recognize, that concerns for EDIs are not formalized in all of the places and contexts where our collaborators live or work. This creates challenges for how EDI thinking might be brought into the kinds of intercultural, collaborative research that can underpin transdisciplinary sustainability science.

Interestingly, how academics use language was raised as a key EDI issue (see also, Baker & Vasseur, 2021). Language can serve to separate rather than bridge collaborators, and thereby becomes an unintended barrier to welcoming diversity among team members, ensuring inclusive design, and securing and communicating equitable outcomes. For example, despite being international in scope, our community of practice still operates primarily in English. Although most, if not all, our members have some functionality in English, for many, English is an additional language. Hence, they may not have the full range of vocabulary or the comfort to speak up in a group setting.

Additionally, academics continue to speak with jargon-laden terms that are not commonly understood even across academic disciplines let alone across academic-community 'cultures'. Workshop participants reminded academics to better explain key terms, particularly for international collaborators not in academia. For example, the idea of 'knowledge co-production', now commonly used by academics working in English, is often not well understood by practitioners or academics for whom English is an additional language. For many, transdisciplinarity is not commonly understood; the idea of community-engaged research might be a better description. Such observations reinforce that we all need to take care with the words we use when working across sectors, languages and cultural contexts. Featuring local terms and language in the written and oral products created with collaborators may also support the critical task of Indigenous language recognition and revitalization (Redvers et al., 2023). As discussed in Case Box 6, attention to language—local and academic—is part of engaging in careful and responsible communications. Although some may argue that "EDI" emerges from all principles, we have maintained this as a distinct principle so we remain vigilant about how our research practices affect opportunities or generate barriers for participants.

CASE BOX 6 Engaging in careful and responsible communications to embrace diversity and respectful inclusion

The establishment of a transdisciplinary research training partnership among researchers and practitioners in Argentina, Canada, South Africa, Germany, and Ukraine required us to develop a series of operating principles to guide our emerging community of practice. The principle of "Employ careful, responsible, and responsive language and communication" was explained in this way:

> Communication is more than simply providing information. We are a broad community of practice where partners come from different cultural traditions, institutions, and languages. We need to engage in communication carefully and responsibly, attending to communication media, styles and languages to ensure all partners understand our intentions and our actions. We understand that we may need to spend time unpacking our language as our words contain unconscious bias that may not be mutually understood. We are keen to learn new "languages" and ways of expressing or understanding sustainability challenges. While we operate primarily in English, we recognize that sometimes our use of language can be hurtful and/or exclusive. As we learn about these instances, we will modify our language accordingly. For example, we reject the use of "targets" and "targeting", we employ the terminology of "shared responsibility holders" instead of "stakeholders", and we replace "focus groups" with "sharing circles" or "workshops". TRANSECTS Operating Principles 2022.

Addressing "equity, diversity and inclusion" involves more than counting the diversity of research teams. Attention to language can help us rethink old habits that exclude or marginalize, and build more inclusive structures and processes where diverse groups can work together more effectively.

Submitted by Maureen G. Reed, University of Saskatchewan.

3.2.2 | Principle #7: Emphasize critical reflection and sharing

Participants also stressed the value of on-going critical reflection and shared learning – something that was implied by our efforts but missing from the set of principles. An important feature of the international and cross-cultural community of practice that we are building is that community actors, practitioners, and researchers in each locality have different expectations associated with community-engaged or transdisciplinary research. Their experiences, and on-going feedback, again underscored the need to provide information in plain language and in highly accessible formats.

CASE BOX 7 Co-creating knowledge through continuous communications, sharing and social learning in South Africa

Regular and continuous communication, knowledge sharing and learning are critical for achieving engaged, transdisciplinary research. Recognizing this, a team of researchers working on a vulnerability, health and climate change project in the rural Eastern Cape, South Africa, designed an integrated process to ensure on-going engagement and conversation between ourselves (the researchers) and the local communities.

We built on traditionally practiced meeting formats. This resulted in three levels of interaction within communities: individual (with the chiefs and other community leaders); through a community selected 'social learning group', and via a large community imbizo (a gathering coordinated by the chief). Social learning group meetings were held once a month, while the imbizos were hosted twice per year, and included a start-up meeting where the communities were invited to name the project. The project became known as 'Jongphambili Sinethemba' [looking forward we have hope], a concept which combined ideas from the two communities where we worked. The imbizos provided culturally based entertainment centred around the project themes as well as a platform for information sharing, and included a pre-meeting soccer match, drama, poetry, song, dance and more formal feedback using posters summarizing the work undertaken by both the research team and the social learning group. The final imbizo involved a theatre production ['Vukani!' {Wake up!}] that included two youth from each community, led by professional actors and a producer.

Lastly, we held a provincial workshop in which the key speakers were members of the social learning group. This engagement process was designed to support individual and community level adaptation to the myriad of stressors affecting rural people's lives. It unfolded in an emergent and flexible way as the project progressed, requiring open-minded and reflexive facilitation by the research team. One of the benefits to social leaning members was the receipt of a Rhodes University certificate for completion of a 'problem solving course'—a course they had a hand in designing.

Contributed by: Sheona Shackleton, University of Cape Town, South Africa.

This information can then be taken up by community organizations working with local change agents to ensure that project ideas or project results are based on or respond to community-specific contexts, needs and experiences. The continuous cycle of reflection and learning is exemplified in the South African example in Case Box 7.

4 | DISCUSSION AND CONCLUSION

Our work builds on the idea that processes of knowledge co-production create "more than just knowledge; they develop capacity, build networks, foster social capital and implement actions that contribute to sustainability" (Norström et al., 2020, n.p.). It demonstrates the application of one pathway to knowledge "co-productive agility" described by Chambers et al. (2022, p. 2) as "exploring diverse agendas [that] brings actors together through processes that foster mutual understanding and respect for a plurality of perspectives." The principles are explicitly produced from iterative and interactive deliberations involving academic researchers, graduate students and early career researchers, community collaborators, practitioners and partnering organizations from six countries in the global north and south, with the intention to support "pathways towards a sustainable future" (Norström et al., 2020, n.p.). By adopting key principles to guide how we conduct research, we aim to contribute to transformative change towards sustainability (see summary in Table 1).

Through a series of case boxes, we offered examples of practices that exemplify the principles; however, we do not intend to prescribe specific practices because they must be tailored to local conditions. In our community of practice, some collaborators have formalized research protocols that direct researchers, while others have not. Due to a commitment to honour our collaborators, the set of interwoven principles that we present here has been deliberately built, and refined, through exercises in knowledge sharing and critical reflection. Throughout the paper, we have consciously brought together the contributions of our collaborators with academic scholarship in participatory and transdisciplinary research. Although our own research is rooted in sustainability, biocultural diversity, and reconciliation with Indigenous Peoples and local communities, the principles may also be relevant to those tackling a broad range of topics and working with groups of local people in rural, urban, or peri-urban settings, especially those who engage in intercultural, collaborative research, including students and early career researchers who rarely receive such training in their research programs and degrees (Holden et al., 2019). It is conceived as a living document, requiring us to regularly revisit our assumptions and refine our research practices.

Our efforts also meet the call for "new approaches to research, integrated with action" by drawing on peoples' own lived experiences and expertise into…research" (Leach et al., 2018, p. 11). We seek to both deepen understanding and contribute to knowledge co-production by engaging with community collaborators and elevating their contributions in research outputs, including publications such as this. The visualization of the principles serves as a boundary object to facilitate debate and spur transformations in how we conduct sustainability research. Our commitment to its periodic review is in line with the call for "better monitoring and evaluation of co-production practices, and in particular practices that can capture complexity and manage for emergent outcomes" (Norström et al., 2020, n.p.). We have deliberately not introduced an evaluation framework or a specific concept of success. Rather, we seek to enhance the legitimacy of research outcomes through collaborative reflection and learning in which multiple (scientific, local, and Indigenous) perspectives are brought together with equal consideration.

We agree with Chambers et al. (2022, p. 2) that "collaborative knowledge and action-making processes are key to achieving just, creative and durable transformations". These processes require us to address power relations when building research frameworks (Leach et al., 2018). We recognize that too often scholars and granting agencies to which they apply continue to set the terms of research, well in advance of the research itself—setting up budgets or determining codes of conduct, without directly engaging with research collaborators or having them set the parameters for the research. We support calls now being made of funding agencies to promote knowledge co-production processes that directly engage and give voice to community collaborators as theorists and co-authors, and to make future funding and research practice more equitable (African Climate and Development Initiative and Centre for Sustainability Transitions, 2022).

Our pathway to co-productive agility seeks to cultivate safe and ethical spaces for learning as described by Ermine (2007) and Chambers et al. (2022). Specifically, paying close attention to the cultural differences that shape our ideas and behaviours, demonstrating deep respect for different knowledge traditions, and elevating the diverse voices of our collaborators have become central to our community of research practice. Additionally, we consider it vital to translate the lessons we learn into training strategies for emerging researchers and practitioners. Further work together will demonstrate how we can help raise marginalized agendas or question dominant ones, and navigate pathways that may, ironically, simultaneously support and conflict with one another. In forging winding and possibly crooked pathways for knowledge co-production, we seek to transform research practices in sustainability scholarship at home and, with collaborators, around the world.

AUTHOR CONTRIBUTIONS

Maureen G. Reed and James P. Robson conceived the ideas, designed the methodology, and led the writing. Mariana Campos Rivera, Francisco Chapela, Iain Davidson-Hunt, Eleanor Haine, Anthony Blair Dreaver Johnston, Gabriela Lichtenstein, Majing Oloko, Michelle Sánchez Luja, Sheona Shackleton, Marlene Soriano, Fermín Sosa Peréz and Liette Vasseur participated in at least one workshop. Authors contributed case boxes, to multiple drafts of the paper, and gave final approval for publication. The author order reflects the leading contributions by Maureen G. Reed and James P. Robson, followed by the names of all contributing authors in alphabetical order by last name. As this research was focused on improving our own research practice, it was exempt from securing a Research Ethics certificate.

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CONFLICT OF INTEREST STATEMENT

We have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

This manuscript does not use data.

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ENDNOTES

[1] Many terms have been used such as research partners and practitioners. We have opted for "community collaborators" and sometimes "academic collaborators" throughout this paper to signify individuals, with the word "partners" reserved for the organizations for which they work.

[2] We adopt Hill's et al. (Hill et al., 2020: 11) description of Indigenous and local knowledge systems as "bodies of integrated, holistic, social and ecological knowledge, practices and beliefs pertaining to the relationship of living beings, including people, with one another and with their environments."

[3] We agree with Hill et al. (2020), that the key to defining Indigenous Peoples is those who self-identify: "Indigenous [P]eoples include communities, tribal groups and nations, who self-identify as [I]ndigenous to the territories they occupy, and whose organization is based fully or partially on their own customs, traditions, and laws…. Local communities are groups of people who maintain intergenerational connection to place and nature through livelihood, cultural identity, worldviews, institutions and ecological knowledge." (Hill et al., 2020: 9). Since our work began prior to this publication, we have followed the 'statement of coverage' contained in the Indigenous and Tribal Peoples Convention (C169) to consider 'local communities' as groups not necessarily called Indigenous or tribal but who have had a longstanding presence in a place or territory, who share similar social, cultural, and economic conditions that distinguish them from other sections of the broader community or society in the country where they reside, whose status is regulated wholly or partially by their own customs or traditions, and/or whose livelihoods are closely connected to local lands, ecosystems and associated goods and services.

[4] All countries participating in the work of the Chair are signatories of the United Nations Declaration on the Rights of Indigenous Peoples that acknowledges the distinctive rights of Indigenous Peoples.

[5] The three main groups of Indigenous Peoples in Canada are First Nations, Métis, and Inuit. According to the First Nations Information Governance Centre, "OCAP® is an expression of First Nations jurisdiction over information about their communities and its community members. As such OCAP® operates as a set of specifically First Nations—not Indigenous—principles." Therefore, it is important to be cautious about the applicability of these principles to other Indigenous, traditional, and local peoples.

[6] We recognize that this terminology is evolving and frequently different within and across countries. For example, in Canada IDEA for Inclusion, Diversity, Equity, Accessibility is increasingly being employed, while in the United States, both DEI (Diversity, Equity and Inclusion) and JEDI (Justice, Equity, Diversity and Inclusion) are also used. Scholars in Australia report that Indigenous Peoples criticize and reject the term "inclusion" as it implies that Indigenous Peoples are to be 'included' within western frameworks, standards, and norms, thereby perpetuating colonial, racist, and unjust institutions (Simone Bignall, Jumbunna Institute for Indigenous Education and Research, University of Technology Sydney, pers. Comm. January, 2021).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Table S1. Description of community of practice workshops.

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