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# Enhancing participatory governance in biosphere reserves through co-creation of transdisciplinary and intergenerational knowledge

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In the context of the current global climate and biodiversity crisis, urgent action is needed to improve participatory and co-productive governance in territories under sustainability directives, such as biosphere reserves. These territories comprise a global network with the potential to apply and replicate sustainability actions, improve livelihoods, and boost climate change resilience while reducing impacts on the environment and the biodiversity in all continents. In the biosphere reserves network's 50 years of existence, progress and setbacks have been reported in different regions around the world, and there is an urgent need to envision alternative futures. In this contribution, we describe the results and reflections of our 'Open Academy' that enhanced the participatory governance in La Campana–Peñuelas Biosphere Reserve in Central Chile. We crossed the traditional assessment with the principles of transdisciplinary and intergenerational knowledge co-creation. The results show that the traditional performance assessment shows a generally poor performance and reveals the weaknesses of the governance system of the reserve's management. The extraction of water by mining and agroindustry, uncontrolled urbanization, wildfires, weak social participation, and low integration of indigenous communities are crucial issues for the performance of biosphere reserves. On the other hand, these territories have the potential as models toward post-extractive economies. Enhancing participatory governance, biosphere reserves shall serve as a) agents for configuring the future as an eco-social pact with the territory; b) pilot test areas for alternative futures; and c) places to promote the social collective as a conscious agent of the future.

## KEYWORDS

performance assessment, Lima Action Plan, sustainability transition, participatory mapping, transdisciplinary knowledge, post-extractivism, climate crisis

# 1 Introduction

The world is facing its sixth mass extinction, and all efforts are needed to cope with the climate and ecological crisis, crossed with geopolitical tensions, climate denialism, and neo-extractivism. This global challenge can be supported from different complementary participatory approaches such as the co-creation of transdisciplinary knowledge (Elliott et al., 2023; Reed and Egunyu, 2012) and intergenerational action (Zurba et al., 2022; Fang et al., 2023; Tàbara, 2023). These approaches must confront real-world challenges in current social, cultural, and political contexts worldwide, especially climate risk and the crossing of planetary boundaries (ISSC and UNESCO, 2013). Among these actions, sustainability transitions in specific territories must be promoted and their performance assessed (Avelino, 2017; Bilali et al., 2019; Winkler and Hauck, 2019), according to Agenda 2030 for the UN Sustainable Development Goals (SDGs). The scope of the sustainability transition must consider traditionally marginalized people—women, young people, and indigenous people—in particular (Peredo Parada et al., 2020; Walk et al., 2021).

The World Network of Biosphere Reserves (WNBR) plays a crucial role in this global challenge due to its spirit, geographical design, and extension, in addition to the explicit participatory governance that shall drive actions (Winkler and Hauck, 2019). These territories have the mandate to link climate change risks, disaster assessment (Cizungu et al., 2021; Ghanbari et al., 2021), and the evaluation of social–ecological resilience (Barraclough et al., 2021; Schultz and Lundholm, 2010).

Biosphere reserves (BRs), dependent on the UNESCO Man and the Biosphere (MAB) Programme, seek to reconcile the relationship between human societies and their environment, emphasizing the active role humans play as integral components of the environments they live in (Barraclough et al., 2023). For this, BRs must combine three essential and complementary functions: 1) conservation of natural and cultural diversity; 2) promotion of sustainable development; and 3) serving as spaces for research, continuous monitoring, education, and training (UNESCO, 1996). According to the Seville Strategy guidelines, BRs aim to become “models in the planning of the territory and places of experimentation for sustainable development” (UNESCO, 1996, p. 8). In its 50 years of existence, the program has undergone many vicissitudes and reorientations, among which the most important are the Seville Strategy in 1995 and the Lima Action Plan in 2016.

The Lima Action Plan (LAP) was prepared in 2016 within the framework of the Fourth MAB Congress that occurred in Lima, Peru. It encompasses a series of general and specific indications for BRs with the aim of improving their management to promote them as models for sustainable development.

The LAP includes specific guidelines for increasing communities’ participation in biosphere reserve management plans. In addition, it is increasingly recognized that the performance of biosphere reserves must be supported by community participation, especially vulnerable groups such as youths, indigenous people, and women (Elliott et al., 2023; Fang et al., 2023), with ‘participatory governance’ acting as a framework and governance program explicitly aimed at reconciling human–nature relationships to increase resilience to the climate crisis (Vasseur, 2023) and maintain ecosystem services in specific

territories such as BRs (Ruiz-Mallén et al., 2015). This type of participation can have an explicit territorial emphasis (Arango Espinal et al., 2020; Ledesma González, 2021; Vanelli and Ochoa Peralta, 2022) and can be enhanced with technical tools such as participatory mapping or ‘Participatory Geographical Information Systems (PGIS)’ (Huck et al., 2019).

This is in tune with parallel developments such as the co-creation of transdisciplinary and intergenerational knowledge and biosphere stewardship (Barraclough et al., 2021; Peña et al., 2020; Reed et al., 2023). Biosphere stewardship is especially urgent now, when planetary boundaries are already being crossed or are at the point of no return (Steffen et al., 2015; Murphy et al., 2021).

In this sense, more effective and affective modes of co-habitation in specific territories (Giraldo and Toro, 2020), such as biosphere reserves, are urgently needed since “territory is a material and symbolic at the same time, biophysical and epistemic, but above all it is a process of socio-cultural appropriation of nature and ecosystems that each social group carries out from its worldview or ontology” (Escobar, 2014), p 91).

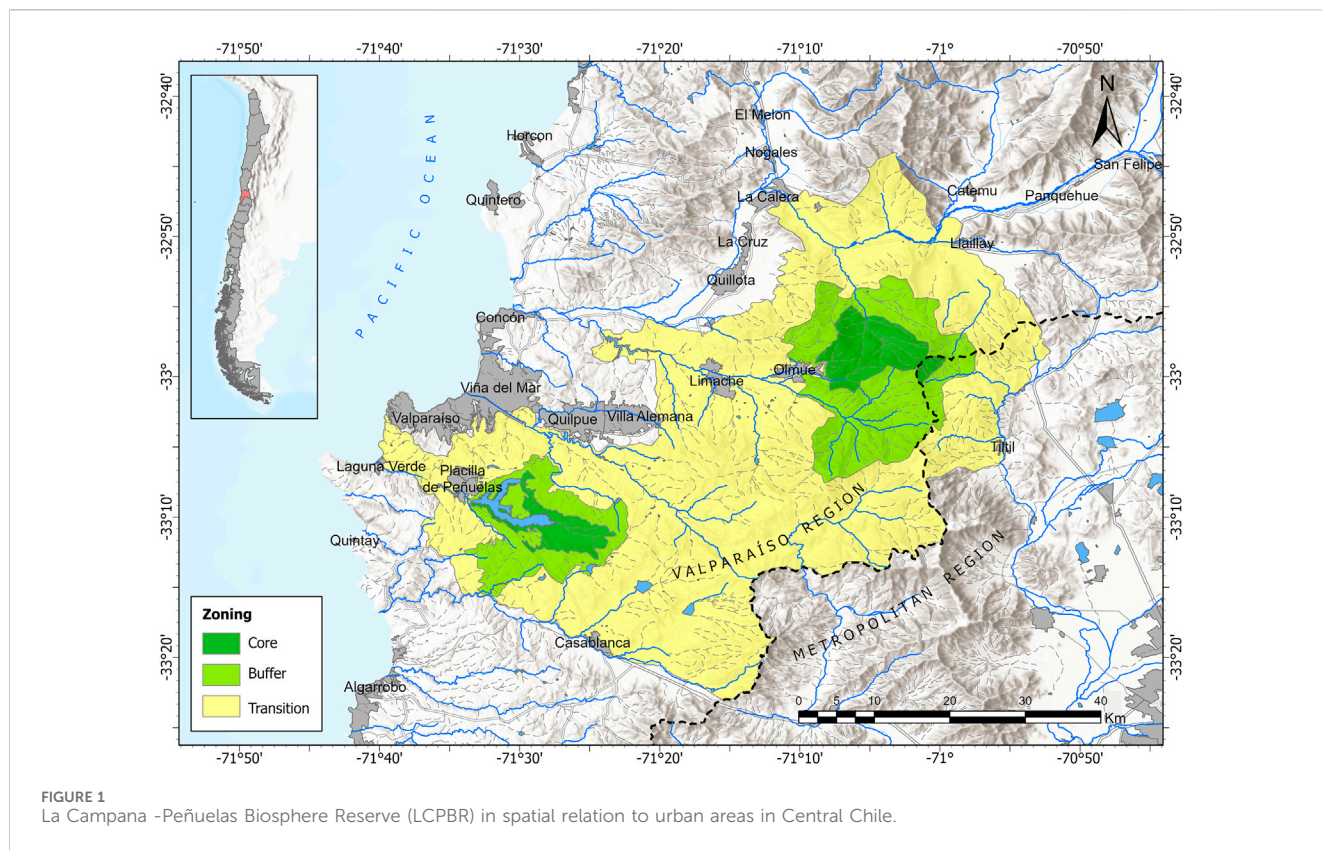
The aim of this paper is to describe the process of increasing participatory governance by engaging local people in assessing a biosphere reserve’s performance. It started with the ‘periodic review’ framework (Price et al., 2010; Reed and Egunyu, 2012), revised according to the Lima Action Plan guidelines, and assessed with several cohorts of youth activists and practitioners who participated in our ‘Open Academy’ offered between 2019 and 2023. We cross-referenced this assessment by employing new approaches within the participatory paradigm, creating an “ethical space” through “knowledge co-production” (Elliott et al., 2023; Reed et al., 2023). This aim was developed co-productively with the youth stakeholders of the La Campana–Peñuelas Biosphere Reserve, a territory with areas of high ecological values and intense environmental conflicts (Paulsen et al., 2019; Leguia-Cruz et al., 2021).

## 2 Materials and methods

### 2.1 Study area

The La Campana–Peñuelas Biosphere Reserve (LCPBR) was designated as such in 1984, toward the end of the first wave of the WNBR’s expansion. At first, it encompassed 14,500 ha in two protected areas: the La Campana National Park and Lago Peñuelas National Reserve. In 2009, following the Seville principles, the LCPBR was enlarged to 240,000 ha, incorporating a new core of 1,000 ha (Cerro El Roble Natural Sanctuary), a buffer zone of 40,000 ha, and a transition zone of 186,000 ha into this new zoning scheme.

This vast territory is in the hinterland of the country’s most populated areas: the Santiago Metropolitan Area and the port of Valparaíso, with almost 9 million people living between them (Figure 1). It is important to consider the social–economic dynamics of this metropolitan area to understand the threats and potentials of the biosphere reserve. The LCPBR has a mixture of land uses, from urban, industrial, and agriculture areas to natural areas, including many that have been declared as “high ecological value areas” (HEVA) in a complex urban–rural–natural interface (Moreira-Muñoz et al., 2023). All biosphere reserves have the mandate of balancing three pillars:



environmental protection, improved quality of life, and the production of knowledge. In LCPBR, the overall protection of the environment and ecological services has historically been affected by landscape-scale threats like wildfires and urban sprawl, in a conflicting situation at the urban-forest interface. On the other hand, the territory of the LCPBR has also a long history of environmental activism and agency by *campesino* rural communities, indigenous peoples, scientists, and activists. Recent threats include major energy and railway infrastructure projects, which have prompted mass mobilizations and protests (Paulsen et al., 2019).

The LPBR is in the center of the “Mediterranean Central Chilean” global biodiversity hotspot (Figure 1). Specific assessments regarding its biota and the human-nature relationships are under way within the socioecological system framework, including the assessment of nature’s contributions to humans (Martinez-Harms et al., 2021) and ecosystem services (Cerdeira, 2013; Bidegain et al., 2019; Palliwoda et al., 2021).

## 2.2 Performance assessment

In its 50 years of existence, the MAB Programme has developed several protocols for assessing the performance of the units (BRs) that comprise the global network. One traditional assessment protocol is the ‘periodic review of biosphere reserves’ (Price et al., 2010; Reed and Egunyu, 2012).

The periodic review is a checklist of actions that has traditionally been used to compare how different units in different regions within a country or between countries cope with the MAB Programme’s

statutory mandate. Spain is the country that has one of the largest numbers of BRs, with 53 BRs. Consequently, the national MAB Committee has developed a specific protocol for assessing the performance of the BRs in a way that is comparable over time (Matar and Anthony, 2017; Castaño-Quintero et al., 2019; RERB, 2022).

This now needs to be in tune with the Lima Action Plan 2015–2025. For its part, the LAP must address the sustainable development goals (SDGs) (UNESCO/MAB, 2024). We adjusted this protocol according to the Lima Action Plan (2016–2025), which contains a comprehensive set of actions aimed at ensuring effective implementation of the MAB Strategy 2015–2025. It entails five areas of strategic action accompanied by objectives. These strategic lines are as follows: a) effective models for sustainable development; b) collaboration and networking; c) external partnerships and funding; d) communication, information, and data sharing; and e) effective governance. We crossed these strategic actions with the axes proposed by the Management Plan of LCPBR (Supplementary Tables S1, S2).

We applied a transdisciplinary approach to collaborate with the young participants and representatives of indigenous communities, participating in our ‘Open Academy on Biosphere Reserves’. Open courses were made available for participants and youth activists within the territory, as a *Cátedra participativa* (Figure 2) (Supplementary Tables S4, S5).

Different versions were held face-to face and online (especially during the pandemic). We were therefore able to adapt the Spanish assessment protocol applied for BRs. The performance was based on seven indicators: i) zoning; ii) institutional support; iii) participation; iv) management plan; v) conservation function; vi) developmental function; and vii) research (Supplementary Table S5).





FIGURE 2  
Social media announcement for the “Open Academy” and the online participatory mapping (illustration by Paulina Altamirano). See more announcements in [Supplementary Material](#).

## 2.3 Participatory Geographical Information Systems

The second stage consisted of the implementation of the online PGIS forms using the ArcGIS 123 Survey platform, a web-based tool that allows creating collaborative maps (Figure 2). PGIS uses a simple cartographic language that allows territorial information from diverse origins to be shared quickly. PGIS is considered a participatory practice best-suited to engaging people in the discovery of environmental conflicts and improving agency and the protection of ecosystem services in territories such as biosphere reserves (Ioki et al., 2019; Cusens et al., 2022). We also considered the positive aspect of environmental best practices in the territory (Leguia-Cruz et al., 2021; UNESCO/MAB, 2024).

## 2.4 Integration with current advances in knowledge co-creation

As discussed with young participants in the ‘Open Academy,’ we considered that the request of a ‘periodic review’ is insufficient to cope with the huge challenges that biosphere reserves currently face. In addition, specific current debates in environmental sciences and

sustainability need to enter the assessment and actionable knowledge for WNBR’s performance.

Thus, we explicitly searched for ideas and advances that relate to the mandatory framework of the BRs with current transdisciplinary knowledge co-creation approaches (Reed et al., 2023) and insights after the network’s 50 years of existence, as suggested by Barraclough et al. (2023).

## 3 Results

### 3.1 Performance assessment

A series of indicators and variables were assessed by intersecting the traditional ‘periodic review’ protocol with the guidelines of the Lima Action Plan and the management plan diagnosis (Supplementary Table S1). Results based on face-to-face activities and online surveying revealed communities’ poor perception of the BR’s performance. The BR performance assessment is framed according to seven indicators with three variables each, which cover most of the strategic actions established in the Lima Action Plan. The first indicator is **zoning**, which showed poor performance. An obsolete zoning plan is maintained, which also fails to acknowledge the

community's participation in the process of identifying areas of ecological value. Zoning models that incorporate concepts such as biological corridors to connect core areas with buffer zones have been proposed around the world, which are also interwoven with sustainable production areas in transition zones.

The second indicator assessed is the **management body**. In the case of LCPBR, the Management Committee is only composed by state departments, does not meet regularly, and does not include citizen participation. This is the point that influences a bad assessment result. Communities are the most accurate source for detecting relevant needs and prioritizing them; they have the most knowledge regarding the lack of resources and the relative urgency of the same and, consequently, are the ones called upon to make decisive contributions to environmental policy in matters that affect their environments and quality of life.

The third indicator is **organizational potential**, which receives the highest assessment and is the only indicator with positive performance. The local organization of the BR territory is marked by projects with high environmental impact presented in local municipalities. High-impact energy projects like a thermoelectric plant and a high-voltage line mobilized thousands of people in the territory's defense (Paulsen et al., 2019; Leguia-Cruz et al., 2021).

The fourth indicator assessed is the **management plan**, which is the document that establishes the objectives for the development of BRs within a 10-year horizon and must be updated and approved by the management committee. In this BR, this document is precisely in the middle of being updated, a process that has not been without problems due to low-community participation, especially among indigenous communities.

The fifth indicator is the **conservation function**. It was rated with medium performance, with a positive assessment of the National Forestry Service's (CONAF) work in the BR core areas, although conservation outside the protected areas does not guarantee the connectivity of sites of high ecological value, especially considering that the territory has mountain relief aspects that facilitate this option (Moreira-Muñoz et al., 2016).

The sixth indicator is the **development function**, which shows poor performance. Private enterprises neither participate in management nor consider the BR in its dissemination activities nor is there a bet on local development through declarations of origin, for example, as happens in European countries, where products are clearly identified with their territories of origin.

The seventh indicator is the **logistic support function** (environmental education and research), which scores in the medium performance range. This value is entirely attributed to the work done by academia in terms of research on various topics and connections to the community through open courses and training. One particularly important issue is the long-term monitoring of socioecological conditions in biosphere reserves, understanding the importance of academia's participation, which must be integrated with community interests and, in this way, gain a closer perspective of territorial reality.

## 3.2 Participatory mapping

By means of collaborative mapping (PGIS), we could detect and plot environmental conflicts in and around the LCPBR; and we could also register environmental best practices in the territory.

### 3.2.1 Environmental conflicts

From the results obtained through the online collaborative map of environmental conflicts, a total of 114 environmental conflicts were identified within and around the LCPBR (Figure 3). The effects of the mining extractivism represent the main problem at the regional level. The impacts generated by mining activity correspond mainly to the existence of tailing dams, the effects generated on the contamination of aquifers and soil, and their consequences on biodiversity.

Water-related conflicts and water extractivism represented the second most relevant socio-environmental issue at the regional level (Arancibia and Jeldes, 2023; Panez-Pinto et al., 2018). Participants indicated that these are due to the effects of droughts and climate change but, above all, to the problems generated by the dispossession of water under an obsolete water code, which has created a water market that excludes many rural inhabitants and denies the human right of access to water.

The water problem is also connected to the dynamics of urban growth due to the increase in the leisure plots (*parcelas de agrado*) that have generated an overexploitation of groundwater through the construction of wells. The problems of urbanization are related to the rapid urban growth toward the urban periphery that affects various areas of high environmental value located on the urban fringes, also increasing the risk of wildfires (see also (Moreira-Muñoz et al., 2023)). The dynamics of urban growth can be explained by the construction of social housing complexes in areas on the urban periphery as well as the rapid advance of informal settlements (*campamentos*).

Participants recognized that urban problems are directly linked to the weakness of urban land-use planning instruments such as communal and regional regulatory plans, which have permitted the expansion of urban development in the detriment of natural spaces and at the same time have not considered the voice of local communities or participatory processes.

Conflicts are also reported due to the effects of urbanization on the filling of streams with debris and the construction of road infrastructure that tends to increase vehicular traffic and fragment areas of high biodiversity value.

A third area in which the connection between water and other problems is reflected is in the consequences generated by the consumption of water by the citrus and avocado agroindustry. In this way, it can be identified that the water problem is of a transversal nature, joining other diverse issues at the regional level (Panez-Pinto et al., 2018).

Finally, energy projects were also recurrently mentioned by the participants such as projects like the Cardones–Polpaico power transmission line, the Los Rulos thermoelectric plant in Limache, and the energy companies present in the Quintero–Puchuncaví area.

All of these environmental conflicts go hand in hand with processes forced by the state in line with private companies, with little or no citizen participation and fewer participatory governance protocols that include more vulnerable groups such as women, children, rural, and indigenous communities.

### 3.2.2 Environmental good practices

From this experience, a series of environmental best practices were also discovered (see also (Leguia-Cruz et al., 2021)), such as the following:

- a) Educational, outreach, and community engagement activities, including meetings, forums, and open classes.

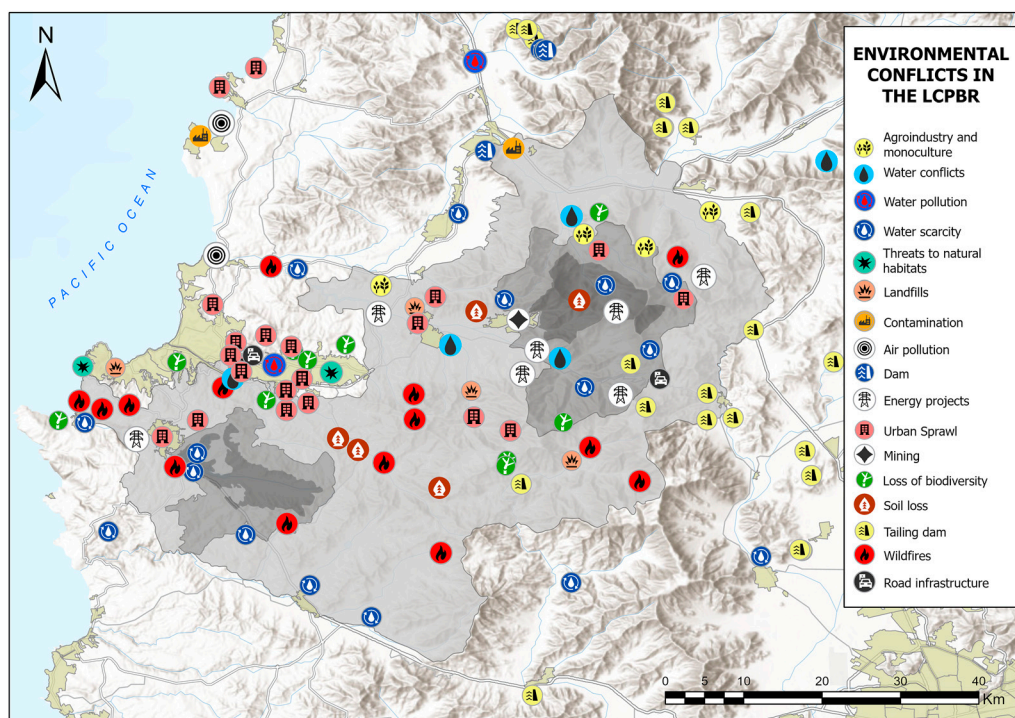


FIGURE 3 Environmental conflicts by means of participatory mapping in La Campana–Peñuelas Biosphere Reserve, Central Chile.

- b) Recovery of natural areas through cleanup actions.
- c) Recovery of cultural practices related to craftsmanship, which has a close relationship with the natural area traditional farmers are located in, such as wicker weavers, spinners, and instrument makers.
- d) Activities for the contemplation of nature through hiking and photographic walks.
- e) Artistic-cultural activities, which involve children and young people in socioenvironmental issues through theater.
- f) Reforestation and risk mitigation, especially those linked to forest fires, which are part of the threats commonly encountered by natural commons.
- g) Practices of territorial control and declaration of natural parks by citizens, where young environmentalists have been camping for more than a year to generate opposition to the installation of high-rise buildings in areas considered to be “high-ecological value areas” (HEVA).
- h) Spatial analysis through the creation of maps of the affected territories and the generation of surveys that allow the identification and location of natural common goods and the construction of re-appropriation strategies. See also [Supplementary Table S6](#).

### 3.3 Envisioning knowledge co-creation

Participants and activists created the slogan “*We Are Biosphere Reserve*”, and we detected a deep understanding of the challenge of

inhabiting a BR in the context of the climate crisis. We also recovered several co-creation” practices for biocultural diversity and sustainability as a “transdisciplinary, intercultural, and intergenerational community of practice” (Reed et al., 2023); see also Leguia-Cruz et al. (2021).

We cross-referenced our findings and experiences with the principles of transdisciplinary and intergenerational knowledge co-creation (Reed et al., 2023) (Figure 4).

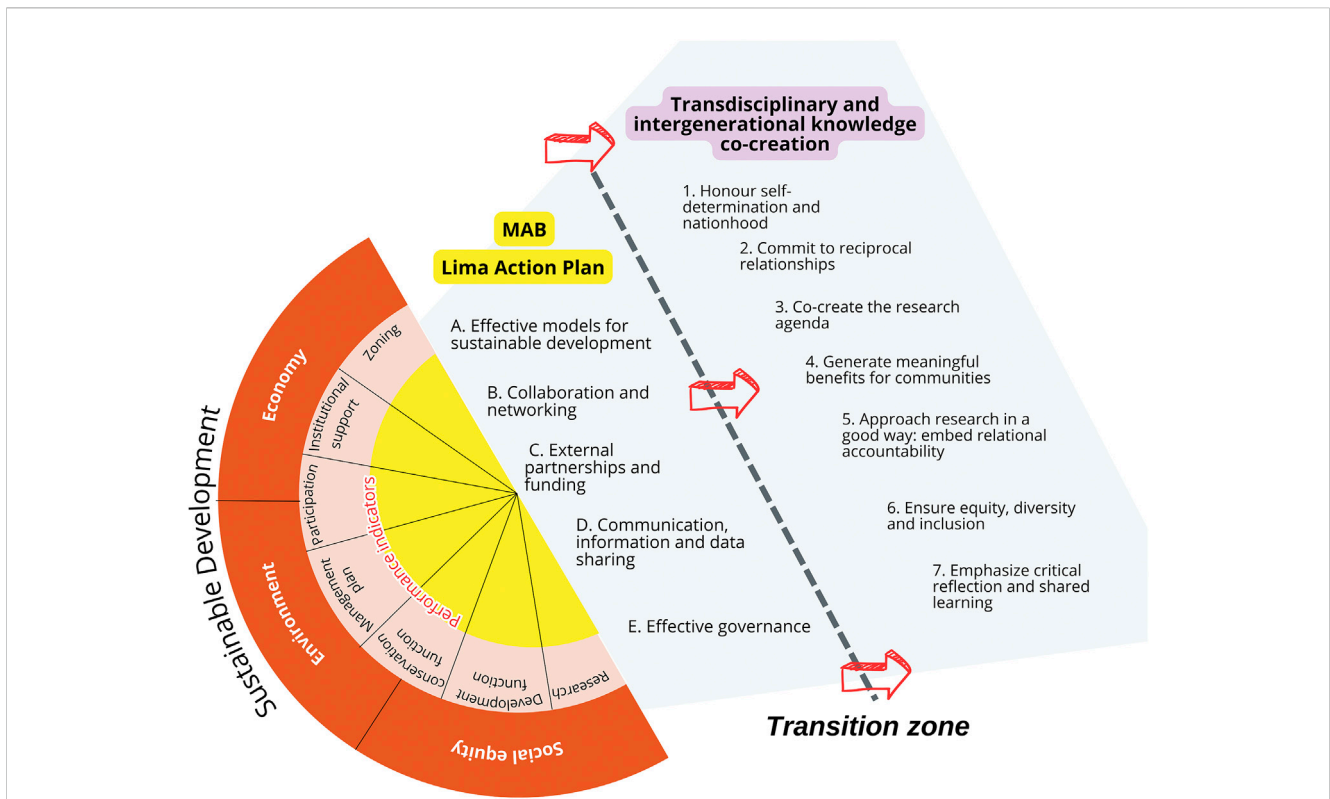
#### 1. Honor self-determination and nationhood

The inhabitants of the LCPBR participating in the ‘Open Academy’ include community collaborators, university students, early career researchers, senior scientists, practitioners, and indigenous people. None of them played a lead role in the lectures, establishing a horizontal relationship and a respectful plurality of perspectives. This allowed “a pathway for non-indigenous and indigenous people to work together in the governance of research and practice” ((Reed et al., 2023) p. 1096).

#### 2. Commit to reciprocal relationships

We encouraged each participant to build formal and informal relationships based on trust, friendship, and mutual respect. Although this is an immaterial aspect that is not easy to share outside the practice group, a simple example is the writing of papers in which researchers share authorship with local practitioners (Leguia-Cruz et al., 2021). This includes an intergenerational





**FIGURE 4** Conceptual model linking the traditional assessment of biosphere reserve’s performance with current approaches such as transdisciplinary and intergenerational knowledge co-creation. Note that the “Transition zone” shall be a process rather than a area.

practice since “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” ((Reed et al., 2023) p. 1098).

3. Co-create the research agenda

The consultation process for elaborating the Reserve’s Management Plan took place as the lectures developed in the middle of the pandemic. We participated in several sessions marked by tensions and contrasting visions but ultimately managed to move forward with the reserve management plan, with online sessions where forging trust is even more difficult. This is in line with transdisciplinary participatory processes occurring now within a decolonial framework across Latin America, recognizing “community-based systems of resource use and governance” (Reed et al., 2023, p. 1098).

4. Generate meaningful benefits for communities

The lectures helped build social capital inspired by Agenda 2030 and the SDGs. Several participants in the lectures were already engaged *a posteriori* in local policy-making. The economic benefits included a certain amount of capacity building to apply for state financing projects.

5. Approach research positively: embed relational accountability

Alliances were strengthened during lectures, and ongoing NGOs and practitioners’ groups were able to reinforce not only just knowledge but also a joint energy and spirit to continue specific territorial struggles. Furthermore, groups that, at times, hold different political or activist positions were able to bring their positions closer by means of recognition of shared goals. Some of the groups derived from or inspired in the lectures are the municipal environmental committees (*Comités Ambientales Comunes*, CAC) and the plurinational firefighting committees (*Mesa Plurinacional Contra Incendios*).

6. Ensure equity, diversity, and inclusion

In various lectures where indigenous peoples participated, sessions would begin or end with greetings in their own language, and all participants listened or participated with respect and affection, with an open-minded attitude of learning dialog among knowledges (Eschenhagen, 2021). The same was the case with participants attending lectures with their children (in the absence of alternative family care) or with their companion animals, such as guide dogs.

## 7. Emphasize critical reflection and shared learning

Continuous collaborative efforts included the common commitment to address environmental conflicts. In this sense, the environmental activists' participation in the lectures helped better inform and elaborate reports for formal court battles. These processes began prior to the establishment of the lectures, but during or after this practice, the case against a thermoelectric project was won, and the power lines project escalated to the Supreme Court, which ultimately ruled in favor of the local community, emphasizing the values of the biosphere reserve.

## 4 Discussion

The performance of biosphere reserves has traditionally been assessed on a top-down basis by regional or national committees. Assessing the performance in a participatory way by integrating the community is a first step toward more effective and affective governance (Price, 2017; Giraldo and Toro, 2020). We attempted to put forward the limits of the assessment approach by envisioning an integration of approaches that will potentially foster rapid advances toward sustainability and climate resilience in the different territories where the WBRN operates. We took principles from transdisciplinary and intergenerational knowledge co-creation for this transformation to operate (Fang et al., 2023; Reed et al., 2023). In this context, biosphere reserves shall serve as a) agents for configuring the future as an eco-social pact with the territory; b) pilot test areas for alternative futures by means of participatory territorial governance; and c) places to promote the social collective as a conscious agent of the future (Miguélez López, 1997; Moreira-Muñoz et al., 2019; Vanelli and Ochoa Peralta, 2022).

Participatory governance based on transdisciplinary and intergenerational knowledge co-creation has the potential to spread worldwide associated with the UNESCO's MAB Programme and its World Network of Biosphere Reserves. In this sense, biosphere reserves and their territorial design can serve as the models that societies need to make the transition toward post-extractive economies, abandoning unlimited economic growth as a policy objective (Acosta, 2017; Brand et al., 2017; Murphy et al., 2021). This is especially appealing to rich nations if they want to cope with achieving the boundaries of a safe and just space for Earth systems (Hickel, 2019).

Some challenges detected for making fruitful progress toward sustainability are as follows: effective communication, stakeholder engagement, participatory governance, and funding (Price, 2017). We need to better recognize stewardship actions (Chan et al., 2016) and promote a governance framework for healing the human-nature relationship (Ives et al., 2017). This needs to occur in accordance with the political processes affecting Latin America and the regional neo-extractive political and economic impulses affecting mainly energy, mining, and water. We, therefore, need a better understanding of the "tension between regulatory models and the predominant governance patterns in Latin America" (Zurbruggen, 2011, p. 38).

## 5 Conclusion

Biosphere reserves, dependent on the UNESCO MAB Programme, seek to reconcile the relationships between human societies and their environments, emphasizing humans' active role as integral components of the environments they live in.

After 50 years of existence of the MAB Programme and the World Network of Biosphere Reserves, there is still a long path ahead toward participatory governance that incorporates the principles of transdisciplinary knowledge co-creation and intergenerational care practices for climate adaptation and livelihoods. Biosphere reserves shall serve as a) agents for configuring the future as an eco-social pact with the territory; b) pilot test areas for alternative futures by means of participatory territorial governance; and c) places to promote the social collective as a conscious agent of the future. Several insights are worthy of consideration for improving participatory governance in BRs, including transformations toward post-capitalist economic models, to respect the planetary boundaries of a safe and just space for Earth systems.

### 5.1 CODA

When working on the final revision of this manuscript, the worst wildfire in Chilean history affected more than 9,000 ha of the La Campana-Peñuelas Biosphere Reserve. The fire took the lives of 136 people and thousands of organisms that shared this territory. Climate risk becomes a devastating reality, demonstrating that participatory governance is more urgent than ever. On the other hand, on May 14, 2024, the Biosphere Reserve Management Committee has been reactivated and for the first time in decades it includes civil society and indigenous stakeholders in decision-making, inaugurating a new era of participatory governance of the biosphere reserve.

### Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding author.

### Ethics statement

Ethical approval was not required for the studies involving humans because all participants involved in the study freely enrolled in the biosphere reserves' courses. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements because all participants involved in the study freely signed up in the biosphere reserves' courses. Written informed consent was not



obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article because surveyed data are anonymous and in pictures, no person is identifiable.

## Author contributions

ML-C: writing—original draft, data curation, formal analysis, investigation, methodology, and visualization. CC: conceptualization, supervision, validation, and writing—review and editing. NO-C: writing—review and editing, formal analysis, investigation, visualization, software. PM-Q: writing—review and editing, methodology, conceptualization, formal analysis, and validation. AM-M: writing—original draft, conceptualization, funding acquisition, supervision, and validation.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fenvs.2024.1266440/full#supplementary-material>

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