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Indigenous and Local Communities' initiatives have transformative potential to guide shifts toward sustainability in South America

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Addressing current environmental crises requires a fundamental shift in our relationship with nature. Indigenous Peoples and Local Communities can guide diverse pathways towards sustainable and just futures, rooted in ancestral knowledge and relational values that challenge the *status quo*. Indigenous knowledge and practices, however, are still largely underappreciated, not being recognized as agents of transformative change. Inspired by the Seeds of Good Anthropocenes approach, this research identifies types of initiatives driven by Indigenous Peoples and Local Communities. Through hierarchical cluster analysis of 127 initiatives from Ecuador, Peru, and Colombia, six groups of initiatives are revealed. Three out of these six groups, i.e., Empowering, Reconnecting people and nature, and Intercultural and ancestral education (named here as *I-Seeds*), apply knowledge co-design processes led by Indigenous Peoples and Local Communities and have higher transformative potential. Such initiatives also implement amplification strategies of scaling deep that catalyze profound shifts in values and mindsets beyond the *I-Seed*. This study draws attention to the importance of Indigenous Peoples and Local Communities and their (retro)innovations to foster sustainability transformations.

Worldwide ecological, social, and economic crises have brought to light the unsustainable pathways globalized societies are locked in ref. 1. Shifting these pathways requires fundamental transformative changes in how societies relate to nature and address increasing inequalities guided by new visions of sustainable and just futures².

Sustainability scholars have emphasized the need to identify opportunities for transformative change^{3–5} and understand the agency of different actors to pursue transformations^{6,7}. The project “Seeds of Good Anthropocenes” (<https://goodanthropocenes.net>) has collected information on more than 500 local sustainability initiatives, projects, movements, or new ways of acting that are contributing to the creation of futures that are just and sustainable (i.e. *seeds*)⁸. These *seeds* are currently marginal but, under the proper conditions, might catalyze larger sustainability transformations⁸ as demonstrated by the increasing empirical research on *seeds*^{9–11}. Key attributes of the *seeds* have been documented based on variables such as the

challenges they address, their innovative aspects, their contribution to the Sustainable Development Goals, or the amplification mechanisms used to increase their impact (e.g.^{12–15}). Further, although some efforts have been placed in co-producing positive scenarios that include Indigenous perspectives (e.g.^{15–18}), little attention has been placed on analyzing initiatives specifically led or catalyzed by Indigenous Peoples and Local Communities (IPLC) and their contribution to sustainability transformations¹⁹. This gap is of particular relevance in sustainability science, where there is an explicit attempt to be ontologically and epistemologically inclusive to understand and foster transformations^{20–22}.

Although Indigenous Peoples represent only 5% of the global population, they influence land management across at least 28% of the Earth's surface, which covers about 40% of all terrestrial protected and intact areas²³. While nature declines globally at rates unprecedented in human history, nature managed by IPLC faces growing pressure, but generally degrades at a

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slower rate compared to other areas²⁴. Recent global efforts, such as the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES²⁴) and the newly adopted Kunming-Montreal Global Biodiversity Framework (GBF, COP15), have emphasized the critical role of IPLC in promoting pathways toward just and sustainable futures^{25,26}. However, IPLC continue to face challenges to be fully recognized as agents of transformative change for sustainability in the scientific¹⁹ and decision-making arenas^{27,28}. In fact, a wide range of local sustainability initiatives led or catalyzed by IPLC are mostly overlooked by the global scientific community, policy-makers, and society at large^{19,29}.

In this paper, we explored biocultural initiatives, projects, or organizations led by or involving collaboration with IPLC (hereafter “initiatives”) to uncover *I-Seeds*. *I-Seeds* refer to IPLC-led initiatives that bring about innovations coming from ancestral cultures (or retro-innovations) and that show transformative features. Retro-innovations refer to certain elements of historical (or *retro*) practices, ideas, or technologies that can become drivers for new (innovative) ideas³⁰. This has also been referred to as “pockets of the past” in research on *seeds* (e.g.¹⁶). To do so, we collected 127 initiatives from Ecuador, Peru, and Colombia; all Latin American countries with extraordinary biological^{31,32} and cultural diversity³³. We identified types of initiatives and unraveled their transformative potential, understood as the latent capacities for generating a fundamental shift toward sustainability³⁴, using the frameworks of *values, rules, and knowledge (vrk)*^{35,36} and amplification strategies^{12,37}. By applying an analytical approach rooted in Western science frameworks, we seek to highlight the fundamental role of IPLC’s ancestral knowledge, rules, and values to trigger (retro)innovations that might lead to sustainable and just futures that are, otherwise, mostly overlooked in current transformation scientific discourses.

Results

The sample of initiatives cover a wide variety, spanning from those that intend to reverse the loss of cultural diversity (81% of the initiatives) and biodiversity (80%)—with many aimed at addressing both cultural and biodiversity loss (64%)—and most of them holding relational values (98%). The most reported outcomes by the initiatives included spreading

knowledge and methods (72%), biodiversity conservation measures (69%), the preservation and promotion of local products and traditions (69%), or community education (67%). Table S1 in Appendix provides an overview of the outcomes and characteristics of the initiatives.

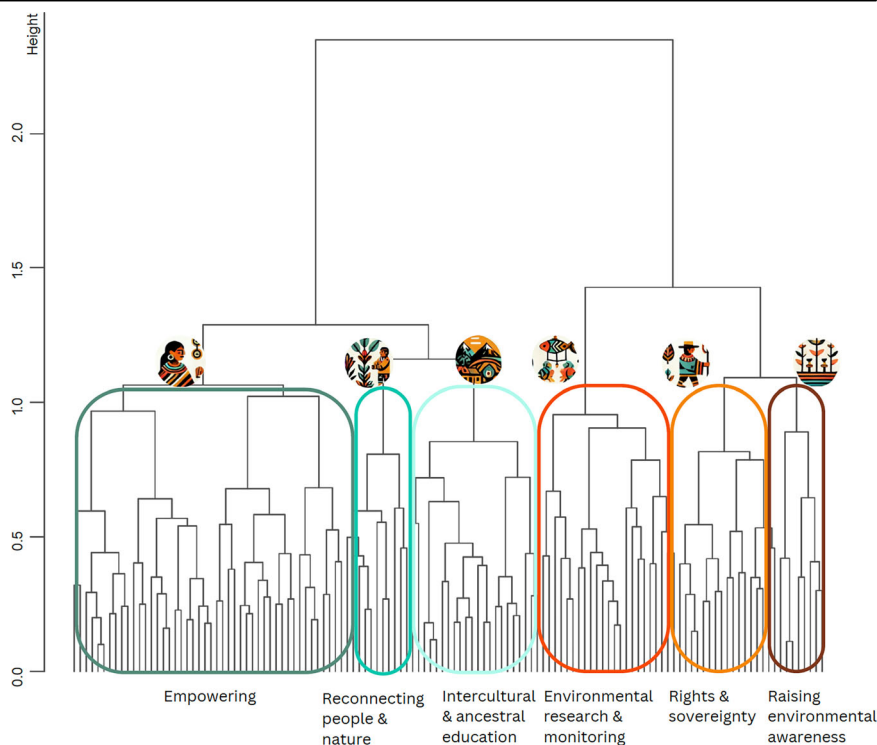
The cluster analysis of the initiatives revealed six groups, which were divided into a) biocultural initiatives initiated and led by IPLC and using co-design approaches to knowledge generation (i.e., *I-Seeds*), and b) other biocultural initiatives, namely, collaborations between IPLC and other social actors framed as consultations and co-production processes. *I-Seeds* consist of three clusters: *Intercultural and ancestral education, Reconnecting people and nature, Empowering*. Other biocultural initiatives also encompassed three clusters: *Rights and sovereignty, Environmental monitoring, and Raising environmental awareness* (Fig. 1). These clusters differed in the values, rules, and knowledge mobilized by the initiatives as well as in their potential to catalyze transformative change, measured through their outcomes and amplification strategies (Fig. 2, Table S2 in Appendix). In describing the clusters, we used the attributes from the V-test that were statistically significant, as well as those with the lowest or highest frequencies (even if non-significant). For the latter, we specified the frequency and that they are non-significant (ns) (see Fig. 2 for the detailed description of frequency and *p-values*).

I-Seeds: IPLC-led sustainability initiatives

We identified three clusters of initiatives that were initiated or led by IPLC (62% of the initiatives): *Empowering* (36%), *Reconnecting people and nature* (9%) and *Intercultural and ancestral education* (17%) (Fig. 1).

Empowering I-Seeds (*n* = 46) seek to improve IPLC livelihoods by addressing, for example, food insecurity, impoverishment, or exploitation of natural resources, or by addressing legislative challenges such as (land) rights violations or exploitation of IPLC labor. They are initiated and led by IPLC, combine both ILK and technological knowledge, and mainly focus on tackling the loss of cultural diversity. These initiatives apply processes of knowledge co-design that lead not only to economic-related outcomes, such as prioritizing local products and the generation of economic benefits, but also to community building, increasing levels of education, empowerment of women, and spreading of knowledge to people affiliated with the

Fig. 1 | Six clusters of initiatives were identified based on the values, rules, and knowledge mobilized within the initiatives and their potential for transformation. The potential for transformation is based on the initiatives’ outcomes and strategies to amplify their impact. We have included the 127 initiatives from Peru (*n* = 44), Ecuador (*n* = 44) and Colombia (*n* = 39). The first three groups (outlined in green) represent the *I-Seeds*, while the remaining biocultural initiatives appear at the end (outlined in orange). Icons generated with the assistance of Microsoft Copilot.



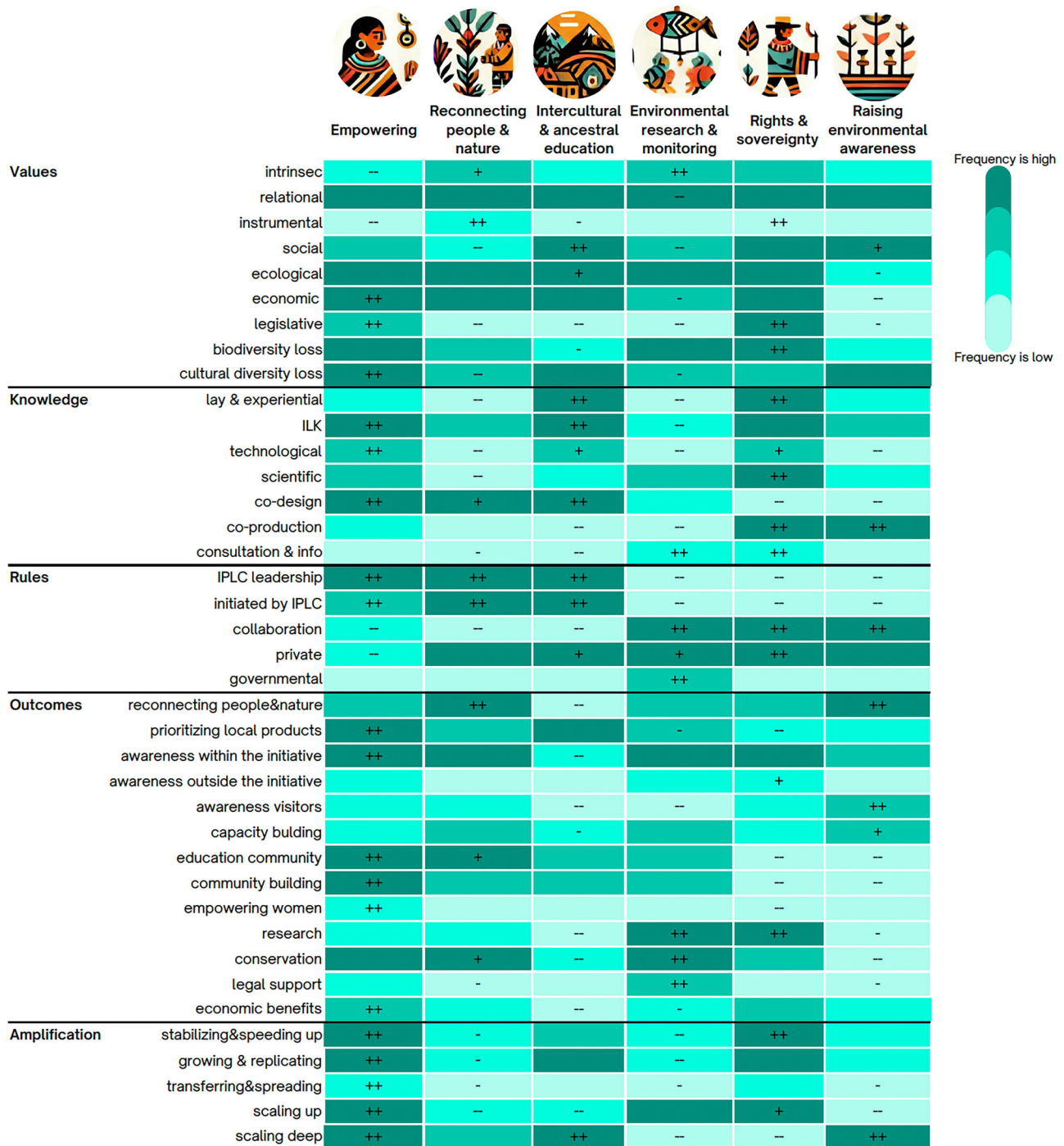


Fig. 2 | V-test to compare the clusters based on the values, rules, and knowledge that underpin the emergence and development of the initiatives and their potential for transformation measured through the outcomes and amplification strategies. The + and - symbols indicate which frequencies are significantly higher/lower for each attribute in the V-test (++/- indicates $p < 0,05$; +/- indicates $p < 0,1$). Colors represent a range of frequencies (initiatives coded as 1 for the attribute) as

percentages: 0-25% (the lowest); 25-50%; 50-75%; 75-100% (the highest). Frequencies can be very high for negatively significant attributes (when the frequency is close to 100% and there is a low variance, e.g., *relational*), and the other way around (e.g., *instrumental*). See Table S2 in the Appendix for the values of the frequency. ILK: Indigenous and Local Knowledge; IPLC: Indigenous Peoples and Local Communities. Icons generated with the assistance of Microsoft Copilot.

initiative. These *I-Seeds* apply a diverse range of amplification strategies, spanning from amplification within (stabilizing the initiative or speeding up the processes within the initiative), amplification out (growing, replicating, transferring, or spreading strategies or principles of the *I-Seed* elsewhere) to amplification beyond (scaling up to impact higher institutional levels and deep to change values and mindsets) (Fig. 2). One example of this group is the “Ikima Nukuri” (Women as Guardians of the Forest) initiative, which seeks to empower Achuar women in the Ecuadorian Amazonia by training

them as community health workers, reducing deaths in pregnancy and improving the health and wellbeing of mothers and newborns. This *I-Seed* embraces the deep interconnectedness between nature and human wellbeing, and recognizes that empowering Achuar women will result in reciprocal empowerment for the entire Achuar community. This *I-Seed* implements various amplification strategies to scale its impact, such as building the infrastructure by themselves to reduce costs (stabilizing), increasing the number of people involved and range of activities (growing),

and challenging existing norms at larger governance levels by becoming the first women-led initiative in the region (scaling up).

Reconnecting people and nature I-Seeds ($n = 11$) seek to revitalize the bond between people and nature while fostering conservation and education within the community. The main motivation for all these initiatives is fostering connections between people and nature (relational values; $n = 11$, ns), and some also aim to preserve nature because of its value as a means to achieve human well-being (instrumental values) and its right on its own (intrinsic values). These initiatives usually implement co-design processes to create knowledge, in which IPLC initiate and lead the work. These *I-Seeds* mainly amplify their impact by changing values or mind-sets (scaling deep; $n = 7$, ns) (Fig. 2). For example, the project “Tejedores de Vida” (Weavers of Life) was born as an initiative of the Curuinsi Huasi Indigenous association and seeks to generate ownership of turtle conservation by Colombian and Peruvian Indigenous communities in Santa Sofía. Some of their activities include empowerment and training of local conservation groups, conservation and environmental education activities, and support of conservation-based economic initiatives.

Intercultural and ancestral education I-Seeds ($n = 22$) mainly address the loss of cultural diversity ($n = 20$, ns). They are initiated and led by IPLC and informed by ILK, lay and experiential, and technological knowledge in co-designed processes of knowledge production. These initiatives implement scaling deep strategies since they intend to change or revitalize community values (Fig. 2). One example is the “Escuelita de Chaupín” (Peru), which promotes intercultural education of primary schoolers based on the ancestral Andean wisdom provided by (grand-)parents, *Apus* (deities), the river, the animals, the wind, the “chacra” (small farm), and other natural entities surrounding. Through the initiative, young IPLC connect with their culture and the Andean cosmovisions (scaling deep), ancestral knowledge is preserved, and the vision of living in harmony with nature is strengthened in the community.

Other biocultural initiatives

We found three clusters of biocultural initiatives that are not led by IPLC, but established as a collaboration with them (38%): *Environmental research and monitoring* (18%), *Rights and sovereignty* (13%), and *Raising environmental awareness* (6%) (Fig. 1). These clusters represent a gradient of IPLC engagement, from being consulted in biodiversity monitoring programs to active engagement in a co-production process.

Environmental research and monitoring ($n = 23$) aims to conduct research through IPLC consultation and information to foster conservation. IPLC do not initiate or lead these initiatives, and other types of knowledge besides scientific are frequently not considered. The motivations underpinning these initiatives are significantly intrinsic, framing the initiatives as means to collect scientific data about nature with the final goal of gaining knowledge for its protection. However, almost all initiatives combine intrinsic and relational values ($n = 21$, ns). Most of them implement scaling up strategies to expand the impact of their insights, e.g., influencing policies ($n = 16$, ns) (Fig. 2). One example is the “Fundación Ecosistemas Secos de Colombia” (Drylands Foundation), which seeks to deepen the knowledge and foster the conservation of dry ecosystems by supporting the planning and management of protected areas through a collaboration between scientists and rural communities. This foundation aims to guarantee the protection and sustainable management of biodiversity in drylands while contributing to the livelihood of the communities living in these ecosystems by, for example, providing periodic information on the state of these forests and their biodiversity. This initiative amplified its impact by influencing decision-making in generating new protected areas and their management (scaling up).

Rights and sovereignty initiatives ($n = 17$) seek to implement consultation, information, and co-production processes for addressing legislative challenges, such as land rights violations and exploitation of IPLC labor. These initiatives are established with private funding and in collaboration with IPLC. They use all types of knowledge, but significantly scientific, technological, and lay and experiential, and seek to amplify their

impact by stabilizing their initiatives, creating or changing rules at larger governance levels (scaling up), and growing and replicating in similar contexts ($n = 13$, ns) (Fig. 2). For example, the Biofuel Observatory of the “Sociedad Peruana de Ecodesarrollo” (SPDE) seeks to observe and mitigate the social, economic, and ecological effects of biofuel crops in the Peruvian Amazon, with a focus on deforestation and illegal logging. Funded by multiple international foundations and organizations, it also monitors the governmental activities concerning the administrative or normative reforms that can pave the way for more unsustainable crop growth. SPDE also initiates legal procedures concerning illegal logging and land rights violations (scaling up).

Raising biocultural awareness initiatives ($n = 8$) aim to reconnect people with nature mainly through the education of visitors and tourists and capacity-building strategies. Established through collaborations with IPLC, they are usually not initiated or led by IPLC. These initiatives intend to amplify their impact by shifting visitors’ and tourists’ mind-sets (Fig. 2). One example is the Museum of Handicrafts of Ecuador “Mindalae”, a cultural undertaking of the Sinchi Sacha Foundation, that is constituted as an alternative for the management of the handcrafted cultural heritage of Ecuador, promoting the production, exhibition and study of artisan, artistic and cultural goods.

Revealing the transformational potential of I-Seeds

Multiple initiatives are driven by IPLC around the world to ensure that their ways of living, languages, and traditions are secured—which are often in respectful relationship with nature based on reciprocity and care³⁸. Some authors have argued that IPLC paradigms challenge the business-as-usual development trends and the ways to relate with nature, which is key for mobilizing transformative change^{38–40}. Further, the Transformative Change Assessment of the Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES³⁴) highlights that IPLC’s knowledge -weaved together with other knowledge systems and approaches—is fundamental for enhancing transformative change strategies, offering “philosophies, ethics of care and reciprocity, values and practices to shape transformative change” (p.6). While IPLC’s knowledge is a key feature to shape transformative change, the application of the *vrk* framework adds some nuances to the different constellations of values, knowledge-building strategies, and organizational rules by which IPLC mobilize their transformative potential. Aligned with recent research^{38,39,41}, our analysis reveals the multiple options unfolded from IPLC to pursue sustainability based on their values, ILK, and their right of self-determination, which determines what and how sustainability initiatives are enacted in their territories. Yet, the transformative potential and the ultimate sustainability outcomes differ across the types.

We found that the types of knowledge-building strategies and organizational rules were specifically distinct for the three clusters with greater transformative potential or *I-Seeds* (Fig. 2). We found that *Empowering*, *Reconnecting people and nature*, and *Intercultural and ancestral education* applied processes of knowledge co-design in which ILK was at the core of the decision-making and promoted that IPLC become leaders in the development of the initiative (Fig. 2). Recent studies suggest that those initiatives that set processes for knowledge co-design, in which IPLC actively engage, can significantly increase their impact (e.g.^{25,29}). Likewise, our results suggest that the potential for transformative change might be higher for these *I-Seeds* clusters. *Empowering* and *Reconnecting people and nature* show multiple and relevant sustainability outcomes (such as conservation or education of the communities), and *Intercultural and ancestral education* addresses the loss of cultural diversity by prioritizing local traditions and the promotion of IPLC languages and culture within and outside of the communities. All these *I-Seeds* implement strategies to change deep values and mindsets, with the former implementing multiple amplification strategies. Some authors have argued that a greater variety of amplification strategies might presumably lead to a greater transformative potential¹⁰. Further, scaling deep strategies are a recognized powerful leverage point to foster transformative change⁴². However, although scaling deep strategies might have a more powerful transformative potential than other scaling strategies,

transformation scholars have found that when the emphasis is placed on raising awareness about sustainability (like in the case of the *Raising environmental awareness cluster*), these strategies might fail to promote deep changes in paradigms or worldviews^{12,37}. Although beyond the scope of this study, future research should explore whether some *I-Seeds* scaling deep strategies grounded in ILK and Indigenous worldviews might pose a higher potential to bring about profound shifts in paradigms or worldviews – especially in comparison to more conventional sustainability education strategies.

Furthermore, the *I-Seeds* clusters reflect that the higher transformative potential of the initiatives that involved IPLC (considering their reported outcomes and amplification strategies) might be related to decision contexts that mostly rely on the IPLC's rules and knowledge and not on the values underpinning the initiatives – since all clusters mainly rely on relational values (Fig. 2). This is also the case for the clusters under other biocultural initiatives, like the *Rights and sovereignty* cluster, which shows an example of a collaboration between IPLC and other actors that builds on the waving of different types of knowledge in a co-production process, thus producing relevant sustainability outcomes and implementing a variety of amplification strategies, including impacting higher institutional levels. In contrast, *Environmental research and monitoring* initiatives are set as a collaboration that relies on scientific knowledge and consultation-information processes (similar to the results found in Colombia by Burgos-Ayala et al.⁴³). Some authors highlighted that, in some cases, this type of initiatives might lead to positive social outcomes for the communities, such as increasing their empowerment and external recognition⁴⁴, or as in our specific example above, fostering positive administrative changes in environmental planning and management. However, in the last years, multiple initiatives have flourished to safeguard ILK and to promote the engagement of IPLC in local to global citizen actions^{38,45}. While this brings out many opportunities for collaboration between IPLC and other relevant actors (e.g., NGOs or governments), such partnerships can only succeed if relying on mutually agreed-upon goals and equitable benefit sharing²⁴.

Concerning the values of the initiatives, the fact that all clusters of initiatives took decisions based mainly (but not only) on relational values (Fig. 2) aligns with the vast literature on IPLC, highlighting that Indigenous Peoples understand nature as an interconnected web of life, where humans and non-humans are intertwined in complex reciprocal relations (e.g.^{46–48}). Thus, we argue that the IPLC's notion of 'Living in Harmony with Nature' might provide different alternatives for sustainable and just futures, drawing on ethics based on reciprocal relations between humans and nature, occupation of spaces for self-determination and sovereignty, and temporary custody for future generations^{24,28,48–50}.

Finally, our results show the added value of applying the *vrk* framework to explore the key features of *seeds* that underpin their transformative potential, providing empirical evidence of the relevance of the organizational rules that promote IPLC leadership and of the processes of knowledge co-design. Similarly, by applying the *vrk* framework in two European Biosphere Reserves, Dabard et al.⁵¹ found that sustainability innovations motivated by plural values, processes of knowledge co-production, and collaborative networks of actors are more likely to enable transformative change. Therefore, we argue that there is a greater understanding gained when combining the frameworks of "Seeds of Good Anthropocene"⁸ and the *vrk*^{35,36} when researching sustainability transformations.

Positionality

We are a group of non-Indigenous scholars who are native to Colombia, Germany, and Spain, and based in Chile, Colombia, Germany, and Sweden. As sustainability scholars, we have worked with IPLC and with other Indigenous and decolonial scholars, with whom we (had) collaborate(d) on diverse research projects in the Global North and South. The learning outcomes from these collaborations make us aware of our position as Western-science scholars, the risks of perpetuating colonial extractivism from IPLC, and the relevance of IPLC's ways of doing and knowledge^{52,53}. While we acknowledge that the current research was not co-designed with

the initiatives or validated by IPLC scholars/elders, and that the concepts of "sustainability" or "transformations" might not speak to (many) IPLC, we do not aim to set a universal and irrevocable vision of IPLC-led initiatives; rather we aim to explore their potential for transformation and, as a result, this study is merely exploratory. Thus, we are aware that should this same information be assessed with IPLC worldviews, different groupings and interpretations of the groupings could be expected. Rather, we use our Western-based knowledge, language, and frameworks (i.e. frameworks of *values, rules, and knowledge (vrk)*^{35,36} and amplification strategies^{12,37} to characterize some of the variety of IPLC initiatives and explore their potential to bring about the much-required transformational change towards just and sustainable futures.

Conclusions

Indigenous Peoples and Local Communities (IPLC) can guide diverse pathways towards sustainable and just futures as illustrated by the whole spectrum of initiatives represented by the six clusters. Indeed, IPLC can potentially support and catalyze transformative change if opportunities are created for new ancestral systems to (re)emerge^{3–5}. This requires, among other things, engaging IPLC and including their ILK in the design and development of sustainability initiatives. In a manner analogous to 'Mother Trees' -i.e., the oldest trees in the forest that are highly connected with other trees through an underground network that is used to support and nurture young seedlings⁵⁴-, *I-Seeds* and other biocultural initiatives can contribute to revitalizing human-nature connections by bridging the ancestral knowledge and skills with the present and future initiatives. Recognizing that sustainable and just transformations will require present innovations—an acknowledgment explicitly made by research on sustainability transformations—as much as they will require retro-innovations, suggests a significant shift in the way we conduct sustainability transformations research.

Methods

Data collection

IPLC are essential to sustain the biocultural diversity that has evolved over thousands of years in their territories⁵⁵. Biocultural diversity refers to the "diversity of life in all its manifestations -biological, cultural and linguistic-[and how it] interrelate[s] within a complex socio-ecological [...] system" (⁵⁶ p. 602). In this study, we identified initiatives that integrated IPLC values, knowledge, or practices connected with biodiversity stewardship-related practices in Ecuador, Peru, and Colombia - countries renowned for their exceptional biological and cultural diversity^{31–33}. For this purpose, we applied two otherwise identical search strings in Spanish and English in Google including keywords related to seven categories: (1) biodiversity (e.g., ecosystem, species or biodiverse), (2) cultural diversity (e.g., Indigenous, cultural heritage or tradition), (3) country, (4) bioregion, (5) seed type (e.g., project, initiative), (6) activity of the seed (e.g., ecotourism, education), and (7) goals (e.g., sustainability, conservation). The number of keywords in the seven categories varied between one and thirteen and some search strings were specifically adapted for the different countries (e.g., to include the keywords "resguardo" in Colombia to refer to the official name of the Indigenous territories). We included keywords that were most widely used in the literature and refined them in an iterative data collection process. Section 2 in the Appendix provides the complete search strings for each country.

We filtered the initiatives provided by Google by using three criteria. First, initiatives should engage with biocultural diversity approaches- by explicitly mentioning this perspective and/or referring to the initiative's approach towards nature conservation and preservation of Indigenous or local culture. Second, they should be situated in the three countries (Ecuador, Peru, and Colombia). For Ecuador and Peru, we focused on the bioregions of Andes and Amazonia, where most of the Indigenous communities are located. For Colombia, we identify initiatives in its six bioregions (i.e., Andes, Amazonia, Caribbean, Plain, Oriniquia, and Pacific), as Indigenous communities are broadly spread in the country (see map in Section 3 in the Appendix). And third, the initiatives are initiated by IPLC or set as a

collaboration between IPLC and other actors. We use the term IPLC as defined by the IPBES²⁴, namely “individuals and communities who are [...] self-identified as Indigenous and [...] members of local communities that maintain inter-generational connection to place and nature through livelihood, cultural identity and worldviews, institutions and ecological knowledge [to be] as inclusive as possible when evaluating data” (p.27). Our sample includes mostly Quechua/Kichwa ($n = 26$) and Aymara ($n = 10$) communities in Peru, Quechua/Kichwa ($n = 28$) and Achuar ($n = 6$) in Ecuador, and Raizal and Afro-Colombian Communities ($n = 11$) and peasant Indigenous communities in Colombia ($n = 10$) (see Section 4 in the Appendix).

We reviewed the first five links provided by Google to select the initial set of initiatives. From all identified website entries (approximately between 200 and 300 per country), we checked for initiatives following the above-described three criteria and websites with enough information in all variables considered (Table S3 in the Appendix). “Snowball” sampling was conducted when relevant initiatives (i.e., following the above criteria) were identified in the initial set of reviewed websites and reports. The final set of initiatives with available information to characterize the processes underpinning their transformative potential comprised 127 initiatives: Ecuador ($n = 44$), Peru ($n = 44$), and Colombia ($n = 39$). While we recognize that these sources of information might have limitations regarding the quality and detail of the information provided and a potential bias on the initiatives that can access communication channels, online sources can be relevant sources to improve our understanding of transformative change as it has been shown in former literature (e.g.^{10,37}). Moreover, the use of worldwide data from online searches carried out through Google’s search engine has been proposed as a suitable approach to explore and understand the interest and engagement with sustainability topics⁵⁸. Finally, it is important to note that this approach is specifically suitable for the time when the data was collected in 2020, during the COVID-19 pandemic (see Section 5 in the Appendix).

Data analysis

To identify types of initiatives, we selected variables referring to the *values, rules, and knowledge* (*vrk* framework^{35,36}) that underpin the emergence and development of an initiative and their potential for transformation based on the self-reported outcomes and the strategy used to amplify the initiative impact^{12,37} (Table S4 in the Appendix). Therefore, we used two different frameworks to code these variables—i.e., *values, rules, and knowledge* (*vrk*)^{35,36} and amplification strategies^{12,37}—to appraise the circumstances that influence how sustainability objectives are set by the initiatives, the aspects of the initiative’s decision-making that might enable or constrain transformative change, and their transformational potential.

The *vrk* framework has its origins in climate change adaptation research^{59–61}, and has been more recently applied to understand decision-making in ecosystems management⁶², assessing nature-based solutions and innovations for transformative change^{51,57}. While other frameworks could be used to examine the contributions of place-based initiatives to sustainability (e.g.²⁹), we argue that the *vrk* framework is uniquely suited to explore the characteristics of our initiatives since the emphasis on values, rules, and knowledge is particularly pertinent when studying biocultural initiatives that draw upon ILK and Indigenous cosmovisions. To code values, we explored the values underlying the initiative’s mission and vision by coding them according to the classification of specific values suggested by IPBES: intrinsic (value of nature as an end in itself and regardless of people’s interests), instrumental (value of nature as a means to a desired human end), and relational (the value of meaningful relationships between people and nature and among people mediated by nature)^{50,63}. Moreover, we coded the initiative’s purpose into social, ecological, economic, or legislative, and whether the initiative was specifically motivated by the loss of biodiversity or cultural diversity (Table S4). In the *vrk* framework, rules refer to the formal and informal institutions, as well as the governance arrangements that underlie the organization of the initiatives⁶⁰, including the IPLC involvement in the initiative’s decision-making²⁵. Accordingly, we coded rules

based on five attributes (Table S4): (1) whether the initiative is led by IPLC; (2) whether the initiative was initiated by IPLC, or (3) established as a collaboration with other actors; and the source of funding being (4) private or (5) governmental. Finally, the *vrk* framework refers to knowledge as different types of information, such as technical, scientific, experiential, or ILK³⁵. To code knowledge, we considered seven attributes (Table S4) in relation to the type of knowledge used in the initiative (i.e., lay and experiential, ILK, technological and/or scientific⁶⁴) and the processes for knowledge building (i.e., co-design, co-production, and consultation & information⁶⁵).

To explore the transformative potential of the initiatives and according to the typology of amplification strategies³⁷, we considered five strategies: (1) have a longer or faster impact (i.e. amplification within), (2) grow and replicate themselves (i.e. amplification out 1), (3) transfer or spread their principles to other initiatives (i.e. amplifying out 2), (4) scale up by changing the rules at larger governance levels and (5) scale deep by changing values in society (the last two, amplification beyond)³⁷ (Table S4). Finally, we included a set of 13 attributes to assess the achieved outcomes self-reported by the initiatives. We iteratively reviewed qualitative data on what the initiatives reported to have realized or generated in Peru (which was the first set of initiatives analyzed), and inductively identified these attributes (see Table S4). Then the 13 attributes were used for the coding of the initiatives in Ecuador and Colombia. These outcomes, in combination with the information on the amplification strategies that might enhance the initiatives’ impact, were used as a proxy for their transformative potential. While we acknowledge that these variables cannot directly predict or assess transformative change, we argue that the positive sustainability outcomes achieved by the initiatives combined with the implementation of strategies that can contribute to achieving greater impact can serve as an adequate indication of transformative potential (see²⁹ for a similar approach).

To code the variables, we conducted a qualitative content analysis of the initiatives’ websites and reports⁶⁶. The framework was first tested on 28 initiatives in Peru (where the first data was collected) and modified into the final variables and attributes in an iterative review process. An intercoder agreement was undertaken between three of the researchers to reduce bias and improve the quality of the coding process⁶⁷ when conducting the content analysis of the first 28 seeds in Peru. Once the intercoder agreement was settled, it was applied to the rest of the initiatives. Attributes were treated as dichotomous variables, indicating whether they were mentioned (1) or not (0) in the initiative’s dataset. To reflect the complexity and diversity of initiatives, more than one attribute could be mentioned per variable. The total 39 dichotomous attributes grouped into 10 variables are described in Table S4 in the Appendix.

To identify the types, we conducted a hierarchical cluster analysis (HCA) with all 127 initiatives. We used *hclust* with ward.D2 method in R 2023.12.1 + 402⁶⁸ and applied binary distances to measure the similarity between the initiatives with the *dist* function⁶⁹. This method considers the 39 attributes and starts by clustering single elements (i.e., initiatives) into aggregates of two elements based on the minimization of the within-group variance. Next, it groups the previous aggregates until one cluster remains, aiming to minimize within-group variance and maximize dissimilarities between clusters. The method ward.D2 in R uses a modified distance metric than the Ward method, in which the dissimilarities are *squared* before the cluster merging. This prioritizes variance minimization, resulting in tightly grouped clusters that are distinct from each other. We selected this choice because it provides the most stable and informative clustering, yielding a high agglomerative coefficient (0.80) and a relatively even distribution of cluster sizes (see, e.g.⁷⁰). We used a silhouette analysis (*cluster package* in R) to define the optimal number of clusters based on the highest average silhouette widths (see Section 5 in the Appendix). We found that six clusters provided the best balance of internal cohesion and external dissimilarity of the

data. However, although all six cluster scores are above zero, they are low, with an average silhouette width of 0.08, which indicates that the boundaries among initiative types are fuzzy. For this reason, we performed a core-periphery analysis to identify the most representative members of each cluster (see Section 5 in the Appendix). To describe the different clusters according to the binary variables, we used the function *catdes* in R (*FactoMineR* package in R). This function uses a V-test (based on the Chi-squared test) to evaluate the association between categorical or quantitative variables and the categories of one factor⁶⁹.

Data availability

This study utilized publicly available data accessible via the Internet. The dataset and all code generated and/or analyzed during the current study are deposited in the public repository Zenodo and can be accessed at: <https://doi.org/10.5281/zenodo.14261824>. Any additional information required to access the data or code is available from the corresponding author upon reasonable request. There are no restrictions on data access.

Code availability

The coding scheme developed and used for data analysis in this study is included in the Zenodo repository linked above.

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