Unveiling pervasive assumptions: moving beyond the poverty-biodiversity loss association in conservation

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This paper reflects on the continued persistence of the idea in conservation research and practice that poverty drives biodiversity loss (the poverty-biodiversity loss association [PBLA]). We draw on evidence to show how the PBLA has proven resistant to counter-evidence and is particularly visible at local-level implementation, and is often implicit in conservation strategies. We untangle three underlying reasons that help to explain why the PBLA has persisted under a verisimilitude (seeming truth) that can leave it hiding in plain sight. In doing so, we offer conservation science and practice the means to recognise and thereby remedy this thinking where it exists, and in so doing, advance conservation towards its aims of equitable and effective delivery. We outline how the Connected Conservation model may be better equipped to challenge the disproportionate role of wealth in biodiversity decline whilst empowering biodiversity stewards and their plural knowledge, values and governance systems.

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Introduction

Calls for decolonial, just, and rights-based approaches in ecology and conservation resound in previous work [1–5]. This perspective argues that the key to more equitable and effective conservation practice will be moving beyond the underlying emphasis on economic poverty as a main causal factor of biodiversity loss [6–10]. Whilst there has been some high-level movement away from the idea that economic and asset poverty drives biodiversity loss (the poverty-biodiversity loss association [PBLA]), it continues to persist in implementation at the site level. In this opinion, we establish the continued persistence of the PBLA in contemporary conservation practice. Once established, our main focus is on explaining why the implicit bias on poverty and the actions of the poor still underlies many conservation strategies. We untangle three key reasons: hegemonic values, disciplinary dominance and convenient

governance. Together, these help to explain why the PBLA has proven resistant to counter-evidence. In so doing, we aim to equip conservation scientists and practitioners to recognise the foundations of the PBLA, thereby enabling necessary transformations [11] to move away from it towards more legitimate and robust interventions to advance equitable and effective conservation. We briefly highlight how a Connected Conservation approach offers promise to break free of PBLA-informed thinking [18].

Hiding in plain sight: the poverty-biodiversity loss association in conservation practice

The PBLA refers to the assumption that poverty and economically and resource-poor people drive biodiversity loss, an assumption that we go on to show has proven persistent in the conservation endeavour. This framing is closely aligned with the equally persistent and problematic thinking that population growth is a key driver of biodiversity loss (e.g. [12,13]). The PBLA extends from inherently colonial ideas and was further consolidated in conservation and development by the 1987 Brundtland report, which stated that:

> "Those who are poor and hungry will often destroy their immediate environment in order to survive. They will cut down forests; their livestock will overgraze grasslands; they will overuse marginal lands; and in growing numbers they will crowd into congested cities. The cumulative effect of these changes is so far reaching as to make poverty itself a major global scourge" (p.28) [14].

Subsequent sections of this manuscript untangle in detail the reasons for the persistence of the PBLA, including exploring the legacy of influential theories (e.g. the environmental Kuznets curve [EKC], the forest transition model). This section highlights the evidence that the PBLA persists at the national and site levels. An effort we deem necessary because, at first glance, the PBLA can appear absent, particularly if we look at high-level policy discourse narratives. Indeed, high-level policy discourses have increasingly moved away from direct framings stating that poverty or population drive biodiversity loss. These international fora are recognising the growing evidence of the disproportionate role of wealth in biodiversity decline [15–19] and the significant contribution of Indigenous Peoples and local communities to biodiversity conservation [20–23,14,24]. For example, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Global Biodiversity Framework of the Convention on Biological Diversity (CBD) and The International Union for Conservation of Nature's Red List of Threatened Species all identify wealth and consumption (as opposed to poverty or population growth) as the leading drivers of biodiversity collapse [11,25,26].

At the national and site levels, however, the PBLA is more obviously evident. For example, strictly protected areas (e.g. International Union for Conservation of Nature categories I - III) remain the cornerstone of many conservation efforts, and new declarations for establishing protected areas to meet the Global Biodiversity Framework targets are presently proliferating (e.g. see CBD Dashboard). This strategy can deliver conservation in some contexts but is problematically associated with the framing that poverty is a key constraint on conservation (i.e. through over-harvesting, 'poaching' or cultivating biodiverse land) [8]. Ongoing evictions of traditional groups for protected area establishment can be, and are being, founded on the declaration that their poverty is a central threat to biodiversity [27]. The Global Environmental Justice Atlas collates contemporary cases of conservation-related conflicts, many of which involve forced evictions and revoked resource use rights of local communities with high levels of cash poverty as part of the design of conservation interventions (ejatlas.org).

The PBLA is not only connected to protected area logics but is also implicit [8,28] in assumptions and theories of change orientated around other leading conservation interventions. These include strategies seeking poverty alleviation via payments for environmental services, replacing poverty with 'alternative' livelihoods [29] or removing rural poverty (e.g. through evictions), in order to relieve pressure on nature [8,28,30]. Further, simply through the tendency of emphasising the need to address the actions of small-scale, economically marginalised resource users, the conservation effort can propagate inevitable assumptions about their central role in biodiversity degradation, after all, as others have aptly stated — 'if communities are the solution, then what is the problem?' [6]. Meanwhile, the disproportionate role of distant capitalised actors is generally not a focus of conservation action, thereby largely exonerating the rich and their actions that drive biodiversity loss [6,18].

The continued presence of the PBLA at the site level was recently re-confirmed by Woodhouse et al. [10] and earlier by Walpole et al. [31] who assessed the narratives underpinning conservation interventions and although a decade apart, each found that the logic: poverty reduction will benefit conservation because the poor are a threat to biodiversity, was the leading narrative. Meanwhile, narratives emphasising the contribution of local people as biodiversity stewards are the least common [10]. Conservation action tends to exclude or consult local communities rather than pursue equal partnerships of locally-led or autonomous initiatives, yet the latter can perform best for conservation and equity [23,32]. Sustainable use reserves are the least populous category of protected areas, covering only 25% of the worlds protected land [33] and models of conservation that fundamentally recognise the contribution of diverse lifeways, values and forms of exchange that exist outside of cash-exchange and that recalibrate power dynamics between actors are still rare (e.g. biocultural heritage territories) [34].

As stated previously, a great number of conservation interventions operate on the basis of theories of change that target the 'extractive' rural poor: to compensate (in financial terms) for the opportunity cost of their *perceived transition to* practicing conservation; to incentivise delivery of ecosystem services; or to encourage 'alternative' livelihood activities to reduce the perceived pressures on biodiversity. While these measures could be seen, particularly through a Western gaze, as appropriate and even virtuous forms of compensation for the negative impacts of conservation action, they are also unjust. Unjust for the severed people-nature cultural fabrics they engender, for their failure to critically evaluate what constitutes poverty, introducing the perils of cash, and failing to recognise wellbeing, poverty and basic needs as important distinctions. They are also unjust because they seek to deliver consideration through these models targeted at the rural poor who bear the least responsibility for biodiversity loss, while leaving remote wealthy actors that continue to drive and benefit from nature's decline out of scope.

Why is the poverty-biodiversity loss association so persistent?

Having established the manifestations of the PBLA in conservation practice, we now untangle the three main reasons that help to explain its persistence.

Hegemonic values

The apparent 'win-win' combination of two seemingly unquestionable and virtuous goals — poverty reduction and conservation — can help explain the persistence of this association. This is likely bolstered by political convenience, as the focus on poverty avoids the need to critique the interests of economic and political elites or alter the mainstream development

paradigm. Under this rubric, income, production and consumption are considered the ultimate accolades of success delivering prosperity, whilst poverty is interpreted as the undesirable absence of these things. Therefore, implicitly or explicitly, focussing on poverty and the cash poor is far more convenient and achievable under the current system than the transformative, systemic change required to disrupt the influence of capital accumulation and consumption-based wealth on the environment and promote alternative ways of evaluating human wellbeing.

Unequal power relations (both within and between countries) reproduce the interests of the dominant classes, which result in environmental degradation, perpetuate hegemonic values and place blame on the disempowered [35]. As a result, the politically and economically disempowered are an easier focal point. They are even perversely vilified for livelihood practices (e.g. sedentary pastoralism) that were forced upon them as a result of their powerlessness to defend customary lifeways (e.g. transhumance) [36]. The poverty association and power dynamics can be so strong in local political systems that people may be reticent or lack the opportunity to even express alternative perspectives [37]. Challenging the societal goal of consumption-based growth is rendered preposterous, and it is apparently more acceptable to consider the end of the world than an end to the capitalist paradigm [38]. Maintaining the unequal distribution in discursive power deflects from the truly transformative measures required to tackle the systemic drivers of poverty or biodiversity loss [7,11,39–42]. Within the constraints of the current system, it is far cheaper to centre on, and pay, the poor.

Historically, colonial authorities constructed narratives that served to reconcile the oppression of others; for example, the work ethic underpinning some colonial Christian faiths creates 'the myth of the lazy native' [43]. From this perspective, the poverty association can be understood as a form of 'imperial debris' [44] obfuscating local notions of wellbeing and replacing this nuance with a Western assumption that cash is the 'wanting' component. These vestiges of colonialism likely also contribute to a widespread form of unconscious bias that influences the types of framings and narratives of social–ecological relations. Some of these appear so reasonable that they are barely noticed, such as the need to introduce 'alternative' and cash-income-generating livelihoods [2]. In contrast, it is hard to imagine conservation organisations proposing alternative livelihood strategies for the wealthy and arriving in such a community to introduce them within the lifespan of a project. Yet introducing alternative livelihoods to deliver conservation is a widely accepted rationale, even though the most sustainable governance of biodiversity in many biodiverse (and culturally diverse) landscapes can be linked precisely to the market-peripheral lifeways, values and cultures of their Indigenous and traditional populations [20,21,23,45].

Conservations desire to replace, remove or deal with the problem of poverty represents unconscious bias linked to hegemonic conceptions of what values matter. It is wrapped up in economic, political and discursive power that rewards wealth and material value whilst obfuscating the rich tapestry of values that exists and can thrive in cash-poor yet often multispecies kin- and wellbeing-rich communities [46]. Wellbeing has been shown to be highest in cash-poor contexts where social relations, connectedness, autonomy, identity and biodiversity are also highest [20,21,46]. Despite their environmentally destructive global footprints, the super- rich are rarely considered as targets for interventions and are chronically understudied, undermining any possibility of designing solutions targeting their actions [47].

The emphasis on poverty alleviation is also convenient because it fits with the widespread understanding of 'wealth' as material assets. While there are many forms of value and economy, such as social, moral and gift economies, and diverse ways of valuing nature and measuring well-being, the current environmental emergency arises from the domination of material, instrumental and individualistic values (IPBES 2022). Plural values of nature are particularly strong in communities of local and Indigenous Peoples and contribute meaningfully to human wellbeing [48,49], as does customary and communal access to land and resources, which is also largely absent from definitions of poverty. The poverty association (perhaps unwittingly) promotes the notion that 'cash is best' in multiple ways (e.g. measuring impacts primarily in the material domain, introducing cash payments and rewards, conceiving of cash as adequate 'compensation'). Correspondingly, the diverse non-material values of nature — the intrinsic and relational values, which are central to wellbeing, cohesion and resilience, and can flourish even in the absence of cash (given recognised rights and welfare needs) are less often engaged, thereby marginalising those holding such values [46,48–52]. There is a deep irony in this, because cash itself is being romanticised, potentially contributing to the crowding-out of the biocultural diversity on which we all depend through its role in biodiversity conservation.

By being mindful that the broader development paradigm, political economy, power relations and colonial histories contribute to the verisimilitude (seeming truth) of the poverty association, conservation actors are better placed to call it out and seek redress. Whilst delivering system change (e.g. an alternative to capitalism) may appear beyond the scope of conservation action, greater equity and effectiveness in interventions can be achieved by recognising unconscious bias where it exists. Not being a bystander to the association is imperative, for instance, at conferences or in publications where biodiversity loss and poverty are presented together, it is crucial to open space to address the assumptions that could be propagated. Enabling, championing and promoting diverse worldviews and conceptions of well-being in conservation action could be achieved by embedding recognition of plural values and Indigenous or local knowledge in institutions as a conservation objective, not only in the CBD but also in instruments such as the Open Standards for the Practice of Conservation. Reallocating conservation investment so that it empowers the autonomy of communities to remain in their landscapes, enacting lives and livelihoods outside of the dominant development model, and tackling the disproportionate role of wealth-related drivers in biodiversity decline is essential if equitable and effective conservation is to be achieved [18].

In summary, colonial and capitalist systems impose Western materialist values, while erasing the lifeways of Indigenous Peoples and local communities that are often more sustainable and consilient with nature. This is visible in conservation efforts which (perhaps unconsciously) can reinforce these biases by promoting cash-based solutions and alternative livelihoods, rather than challenging hegemonic values and embracing diverse worldviews to achieve equitable and effective outcomes and biocultural forms of wealth.

Disciplinary dominance

Tackling the PBLA requires moving much further beyond the legacies and influence of controversial theories such as the Environmental Kuznets Curve (EKC) [53], the Forest Transition model [54,55] and the Tragedy of the Commons [56,57], all of which maintain influence in powerful institutions such as the World Bank [26]. They have formed narratives that remain powerful because they present a clear rationale that informs policy responses [58]. Fascinatingly, and equally frustratingly, these narratives have proven to be hard to uproot,

despite considerable scientific counter-evidence attesting to their fallacy [16,59,60]. Nearly 50 years on, inspired by Olson and Hardin [61,62], approaches to understanding and manipulating human incentives are still predominantly based on a unidimensional economic efficiency rationale of 'Homo economicus', which emphasises the actions of the individual bent on accumulation, rather than questioning structural conditions or the plurality of individual and communal values that explain decision- making [48,63,64].

Similarly, the EKC hypothesis proposes that environmental degradation initially increases with economic growth but reaches a turning point after which the relationship is reversed. Whilst the EKC hypothesis was attractive to proponents of continuous economic growth, evidence shows that there is no distinct turning point for biodiversity because economic growth continues to feed drivers of biodiversity loss, such as consumption, and consumption may be transferred to other locations through trade [16,53,65]. Yet the EKC is still largely ingrained in political and scientific imaginaries despite strong evidence against its validity for bending the curve on biodiversity loss [56]. Further, it invites the interpretation that spatial relations between poverty and biodiversity loss are causative rather than correlative [56], ignoring interactions between diverse proximate and indirect underlying factors [66]. Indeed, the association between biodiversity loss and poverty is reinforced precisely because the two overlap spatially [20,67]. Areas in lower and middle income countries in the Global South where substantial biodiversity remains and where population growth rates of poor people are relatively high and perceived to pose a biodiversity threat, but this perception of threat crucially ignores inequality and the enormous variation in patterns of consumption and environmental footprints that exist between the cash-poor, more capitalised citizens and the super-rich [64]. Further, the inverse interpretation appears less widespread — that global biodiversity remains and is sustained by the fabric of plural values, social ties, lifeways and connection to the land sustained by people who are at the periphery of the market, where nature and people have not been fully commodified into global production and consumption networks. Ironically given the emphasis of so much conservation on introducing alternative livelihoods, it is these very landscapes and the people–nature relationships therein that hold potential to inform conservation, bearing insight to living in ways more consonant with nature. Thus, the biocultural centres so often targeted by conservation hold key knowledge relevant to the transformations, redistributions and shifts towards simplicity that are so crucially needed in the centres of consumption that drive the biodiversity crisis [6,7,11,18].

In conservation and biodiversity research, we see a growing proliferation of tools such as modelling, remote- sensing and the use of geospatial datasets. While these forms of data and analysis are valuable, they have blind spots that can reinforce the PBLA. For example, global priority mapping in biodiversity conservation is an increasingly influential decision-making tool, yet one that highlights particular forms of knowledge and values (i.e. accessible tangible metrics) whilst hiding others (e.g. less accessible and quantifiable measures related to culture, governance, and social networks) [68]. Integrated assessment modelling increasingly includes social dimensions, but it does this by using global aggregates that ignore patterns in inequality within and between countries. In so doing, modelling approaches feed into the problematic narrative that global population growth (particularly of the poor) is a driver of biodiversity loss [63]. As we discussed in the previous section, this results not just in blaming poor people for biodiversity loss in regions with high reproduction rates but also in ignoring the greater role of consumption in regions with stable or even declining populations in driving biodiversity loss [64].

Conservation science has progressively developed a greater understanding of the human dimensions [69–71], yet inputs for such understanding have largely come from the fields of economics and psychology [72,73] and have manifested in natural capital, ecosystem services and behavioural change approaches [74–76]. The underlying theoretical premises of these approaches — specifically neoclassical economics, methodological individualism and rational choice — have profound limitations in appropriately understanding social context and relations between discourse, institutions and practices. While we do not deny the relevance of these fields and theories, their dominance perpetuates blind spots, as well as biases and risks of developing strategies that only work in a limited number of contexts. For example, such simplification has led to the adoption of stylised approaches to understanding and manipulating human incentives, for example, via nudging, rationality and cash rewards [48]. These approaches downplay the considerable role of plural values in decision making, as well as the role of vested interests and financial capital accumulation in accelerating activities that aggravate not just biodiversity loss but also global inequality, while continuing to reproduce the false narrative of trade-offs between biodiversity conservation and wellbeing [77–80].

Effective and just conservation practice will benefit from a more pluralist knowledge system, with enhanced and equitable engagement from the critical social sciences and humanities and non-academic forms of knowledge [24,68]. Approaches such as biocultural diversity mapping, Indigenous and feminist methodologies, political economy, science and technology studies, as well as de- and anticolonial scholarship [81] can enable a more in-depth understanding of non-material values, power relations, justice and pluralism, and offer [81] promise to challenge, supplant and reframe dominant problematic narratives. Such transformation will enable conservation to move beyond the binds of disciplinary dominance and power dynamics that appear to 'lock-in' [36,64], rather than counter, the PBLA.

Despite being both decades old and equally current, such calls for transformations towards complexity and transdisciplinarity in research have not yet resulted in major shifts in practice and have met with resistance from vested interests in powerful actors in science [82]. What this suggests is that the hegemonic values we discussed earlier — that reproduce underlying biodiversity loss-association thinking — are themselves being continuously reproduced by persistent inequities and hegemonic paradigms and priorities in research to such a degree that the PBLA can hide in bare sight.

Convenient incremental governance Governance and institutions (e.g. laws, rules, programmes and customs) dictate, legitimise and regularise decisions. Institutions can be changed, but the process is challenging because they tend to suffer strong inertias or 'lock-ins'. Yet institutions have often evolved in line with current regimes and interests, meaning that institutional reform is a necessary disruption for transformative change [11,36,83,84]. The PBLA is embedded in various institutions and governance arrangements. Donor institutions exert significant influence on the conservation endeavour. For example, international donors often demand that conservation and development finance be linked [85,86], thereby requiring practitioners to write proposals that deliver conservation whilst alleviating poverty [78]. The governance of grants increasingly requires impact evaluation, making it more difficult for conservation action to target the diffuse, distant and systemic wealth-related drivers, which are inherently harder to measure, verify and report. Funding for the type of telecoupled conservation and research required to address distant drivers is scarce, as donor funding addressing biodiversity loss must typically be spent in the 'target' location (even when systems approaches are the aim)

and is linked to overseas development aid budgets. This presents an unfortunate conundrum for conservation actors who must conform to the system to secure funding.

Private sector–funded conservation can also contribute to reinforcing the poverty association. For example, powerful billionaires and companies with vested interests in the status-quo continue to grow their wealth through resource extraction and mass consumption, yet greenwash their image by using a small fraction of their wealth to promote and invest in conservation and sustainability, introduce green value chain initiatives and include interventions that claim to resolve poverty and valiantly wield 'alternative' (i.e. apparently less resource-depleting) livelihoods for local people [87,88]. Meanwhile, conservation interventions working outside of monetary mechanisms, for example, via unconditional provision of basic services that can empower and enable communities to remain in their territories albeit peripheral to the market, are comparatively rare, although some examples do exist (e.g. Planet Indonesia operates through unconditional health provisions to local communities) [18].

The contemporary conservation toolkit appears underequipped for conservation in a telecoupled world or achieving the transparency and inclusivity that will be fundamental to realising nature positive and just conservation futures. The phenomenon of telecoupling — the transfer of goods and services connecting distant landscapes — is increasingly acknowledged [15,16,89], yet despite some progress (i.e. conservation interventions that target chains of supply and demand), distant drivers mostly fall beyond the scope of traditional site-based conservation models [28]. There is a degree of irony in this since targets for conservation may be designed globally, yet are not able to target global market flows and exchanges [18]. There is more that must be done to develop conservation action along the relevant loci in threat chains, including towards the disruptive transformations in governance that will be required to steer towards nature-positive futures [42,76]. Governance systems so far remain inadequate, for instance, through poor enforcement mechanisms, for tracking and dealing with transboundary issues associated with 'distant' wealth, and a lack of protection in defence of the voices and values of the rural poor [18]. These issues perpetuate the recalcitrant nature of the PBLA because reproducing it via the strategies outlined above affords a convinient path of least resistance. Whilst growing investments in biodiversity conservation and other forms of natural capital may present opportunities to local and Indigenous Peoples if rights, autonomy, agency and co-design are adequately approached, they also present considerable risks (e.g. over-emphasis of material values, exclusion, attenuated biocultural diversity) to local communities and much depends on the approach that is taken [32]. It is important therefore that conservation funding is linked to secure customary tenure rights to land and sea territories and resources [90] and that 'unconventional' and challenging efforts are made to embed Indigenous Peoples and local communities in governance through autonomy, representation and dialogue at all levels [32,34].

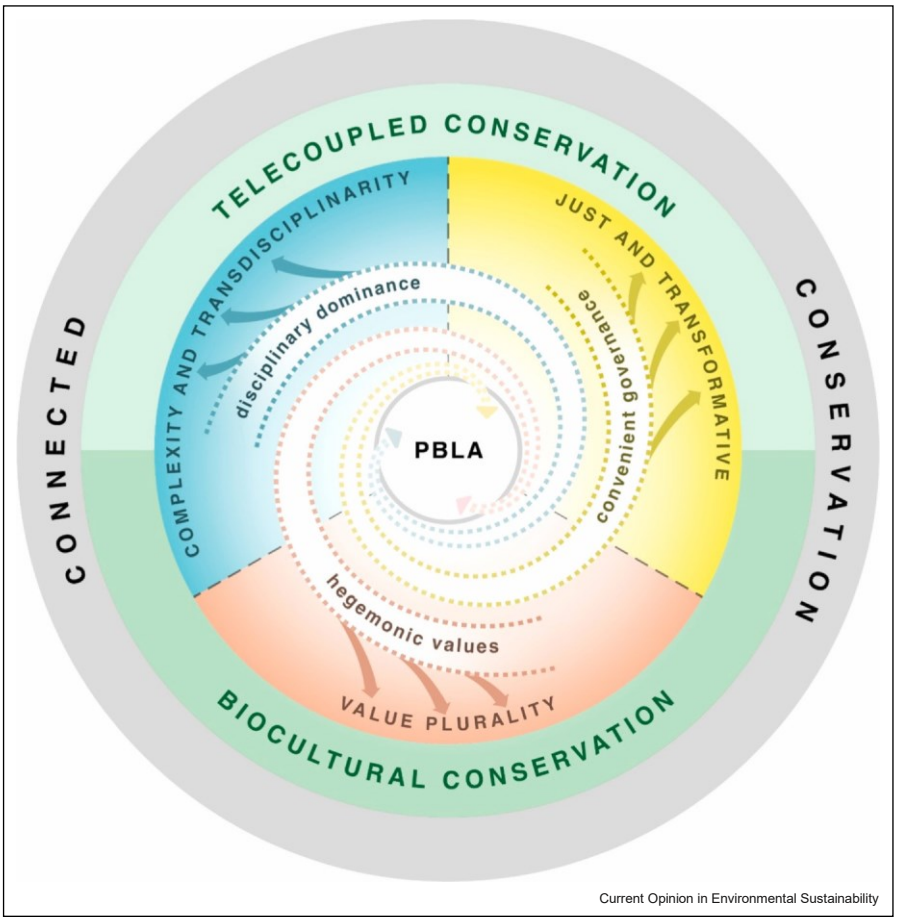
Transforming conservation to empower biodiversity stewards whilst addressing distant wealth-related drivers: Connected Conservation

By unveiling the persistence of the PBLA and untangling the reasons that help explain its endurance, we are questioning the contribution (both in terms of effectivness and equity) of

site-level conservation efforts that are anchored in PBLA thinking. We are calling for a far higher degree of recognition of, and action on, the disproportionate role of wealth in biodiversity decline. Such efforts must be coupled with greater emphasis on the positive possibilities that exist in working to support and enhance the rights, values and governance structures of Indigenous Peoples and local communities [32]. We recognise that there are undoubtedly instances in which local cash poverty can result in increased and immediate pressure on biodiversity, and requires local, site-level intervention. However, conservation must accelerate its move away from the focus on simplified ideas of what constitutes poverty and the associated misrecognition of poverty's role in biodiversity collapse. Addressing these issues is facilitated by understanding the reasons for the persistence of the PBLA and a subsequent rethink and reallocation of conservation effort [18,42]. This rethinking can form part of a conservation model that has a stronger evidence base for a more effective and just approach (Figure 1).

The biodiversity crisis will only be resolved with increased attention to the disproportionate role of distant wealth-related drivers on biodiversity decline [42]. This countering of the poverty association can be enacted through the recent contribution of 'Connected Conservation' [18]. A compelling conservation model that offers tools equipped for achieving conservation in a telecoupled world — working to 'disrupt and diminish' the wealth-related drivers of biodiversity loss while 'enhancing and amplifying' the plural values, diverse knowledges and governance structures that underpin biodiversity conservation at the site level and beyond [18,91]. Connected Conservation can help to counter the tightening of hegemonic values, disciplinary dominance and convenient governance that perpetuate the PBLA and move towards convergence. It counters this tightening direction by pulling back towards the plurality of values, complex disciplinary links and transformative governance that will form the space where biocultural diversity can thrive (Figure 1). Others have documented

Figure 1



Conceptual model of the key reasons for the pervasiveness of the poverty-biodiversity loss association (PBLA): hegemonic values, disciplinary dominance, and convenient governance. These three factors of PBLA-informed conservation work to 'tighten the crank' of conservation action towards the centre where there is convergence (indicated by colour strength fading to white). Countering this tightening tendency requires efforts to engage value plurality, just and transformative governance and embracing the complexity of social-ecological systems and transdisciplinary methods. These counter actions can re-orientate efforts towards the outer ring where biological and cultural diversity can thrive. A Connevcted Conservation model which includes sets of biocultural conservation actions at the site-level, and telecoupled conservation actions to tackle wealth-related drivers can help conservation abandon the pervasive PBLA.

how biodiversity conservation may only be possible within scenarios that consider economic systems where growth is not the priority and where, instead, wellbeing and biodiversity flourish [42,92] and do best when Indigenous Peoples and Local Communities are autonomous leaders or equal partners in conservation initiatives [32]. Connected

conservation outlines what steps such a transformation of the conservation sector may involve, it balances site-level actions with far greater emphasis on interventions that target the consumption patterns and the values of the wealthy. In this way, it abandons the PBLA and serves to correct the injustices legitimised under that narrative. Bending the curve on biodiversity loss will require bending the narrative about the role of poverty, and placing a greater emphasis on the imperative of structural and systemic change in the conservation agenda.

Author contributions

RC, CH, BV and JB conceived of the work. RC wrote the original draft and visualization, and all authors contributed to multiple drafts through review and edits.

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Data Availability

No data were used for the research described in the article.

Declaration of Competing Interest

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

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.cosust.2025.101537.

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