Systemic bio-inequity links poverty to biodiversity and induces a conservation paradox

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Abstract

Biodiversity is declining globally, and poverty rates are not improving, so sustainable development initiatives aim to jointly reduce biodiversity loss and alleviate poverty. These initiatives expect biodiverse ecosystems to benefit people if nature were adequately valued in financial terms: thereby countries can use their natural wealth to reduce poverty. This logic predicts an eventual negative relationship between biodiversity and poverty, to be reached through conservation-minded economic development. We show that, paradoxically, the opposite pattern prevails, countries with highest poverty reside in the world's most biodiverse regions but the most financially prosperous countries reside in low biodiversity regions. We quantitatively resolve this paradox, by modelling biodiversity influences on poverty through historical pathways of colonialism that led to export economies with weak governance and increased poverty rates. This finding supports the proposed "systemic bio-inequity" hypothesis. In attempting to solve poverty through conservation, a second paradox emerges: conservation investments align neither with the economic capacity to protect nature nor with the global distribution of biodiversity. Overall, our findings better link systemic, historical and institutional drivers of modern poverty with biodiversity and, unfortunately, undermine the narrative that biodiversity, and its conservation, can underpin future economic prosperity of countries.

Introduction

The abundance and diversity of biological organisms are the foundation of human economic prosperity through ecosystem services. Yet, the global relationship between the distribution of biodiversity and economic prosperity has rarely been studied. Biodiversity is not equally distributed across the globe whereby biological richness tends to peak at low latitudes but prosperity tends to peak at high latitudes[1]. This implies a paradoxical geographical decoupling between society and ecology through inverse global patterns of nature's richness and people's prosperity. Historical accounts clearly demonstrate that low latitude countries are only recently economically poorer than northern countries, resulting from highly unequal economic growth between countries in the Global North and those in the Global South over the past five centuries [2,3]. As a result, large stretches of the Global South are now burdened with poverty, while the Global North has become rich [4,5]. The North's disproportionate ecological footprint[6] has caused nature in the Anthropocene, or Capitalocene[7], to be severely depleted with fewer species existing[8,9], lower biomass and abundance of animals and plants[10], fewer functioning ecosystems, and less diversity in species between locations[11]. These patterns are widely acknowledged in local scale case studies, for example, in examining interlinkages between biodiversity conservation, environmental degradation and poverty traps for households[12] (but see [13,14]). Yet, most papers addressing environment-poverty relationships arise from development economics focusing on aspects of ecosystem productivity (e.g., forest cover) rather than biodiversity per se (e.g., the variety of living organisms)[14]. As such, interlinkages between biodiversity, its depletion or conservation, economic development, and poverty alleviation between countries at a global scale still remain understudied[14]. This research gap at a global scale is surprising because decoupling between social and ecological systems, and lack of positive feedback between them, is generally understood to undermine conservation effectiveness[15,16]. Further the establishment of global consumption patterns and unequal exchange between economies due to historical processes such as colonialism are acknowledged as systemic drivers of global biodiversity loss and inequality[17], and while global perspectives both in (macro)ecology and (macro)economics could help address global challenges at this nexus of topics, there exist few quantitative synthesis that also address the history of this macro-scale socio-ecological structure [14,18,19].

Global development agencies and environmentalists have responded to the precipitous decline in biodiversity and persistent rise in poverty and inequality[2] by addressing the challenges of biodiversity loss and poverty together[20,21]. The Convention on Biological Diversity (CBD) marked a shift in 1992 from ecology-focused nature conservation to a development and poverty reduction approach[22]. Later global policy initiatives replicated this interlinkage [20,23–25]. A dominant narrative sustaining this approach is that biodiversity - and "nature" more generally - provides benefits that increase natural capital and thereby improve inclusive wealth[26,27]. Biodiversity is thought to contribute to an improved standard of living through effects on climate, flood protection, soil protection, water quality, nutritional diversity, disease control, emotional wellbeing, and providing a richer cultural sense of place and being[28], but relationships

can be complex[29,30]. In practice, economic forces often dominate this people-nature linkage which can involve pricing, commodification, and market formation[27]: biodiversity can be sold to tourists [31–33], sold as raw materials, sold as rights to land, to agricultural products and to biomedical and biochemical patents, or have its regulatory and cultural value monetised and bought from countries or local communities through Payment for Ecosystem Services schemes[18,34,35]. This monetary-nature linkage has been concretised in the past decade through initiatives to mainstream nature in global economic systems[36–38]. The concept of how nature contributes to people[35,39] reinforces the sustainable development narrative that predicts a positive relationship between biodiversity and general prosperity, but often specifically economic prosperity[40]. While this narrative has stimulated considerable critical debate[38,41–46], empirical studies that quantitatively link natural wealth to economic prosperity across the globe remain rare[19].

When considering how biodiversity might or might not sustainably address underdevelopment, a key factor is the strength of coupling between social and ecological systems, so called socio-ecological fit, required for allowing positive feedback between them where one supports the other[47,48]. Yet, it is rare in the ecological literature to acknowledge the long history of global power imbalance that systemically decouples social (herein economic prosperity) and ecological systems (herein biodiversity) through socio-ecological misfit[49]. These power imbalances now frame global economic and environmental decision making through inter-governmental organisations, which on the whole, lead to unequal benefit sharing and environmental degradation[50]. Many economists and historians have argued that 15th to 20th century European colonialism, imperialism and the associated genocidal enslavement of millions of people and other forms of unpaid labour exploitation were foundational to the emergence of this modern global capitalist economic system [3,51,52]. This system relies explicitly on the (often violent) extraction, undervaluation, and modification of natural resources - including the abundance and biodiversity of life - from formerly colonized countries and their transfer to, transformation, marketing and consumption in the colonizing countries and their allies by means of unequal exchange and trade[49,53–58]. The system hence thrives on the decoupling between social and ecological systems through geographically (and societally) moving the benefits of natural and associated labour resource exploitation away from the costs[59]. In such a system, a paradox emerges: natural resource wealth slows or stalls countries economic development, largely because of exploitative exchange conditions [60–62]. If we recognise this historical context, then environmental policies should have a strong evidence base to justify that poverty reduction through biodiversity conservation and nature valuation is effective[28]. This historical context also demands such policies to strive for just solutions to address the economic, socio-political and environmental challenges of our times [63,64].

The sustainable development discourse proposes that if positive feedback loops between biodiversity conservation and poverty reduction (e.g., ecology and society) can be formed, then conservation efforts can become central to economic development, and vice versa. The argument is that after the

commodification of nature through financial tools has been fully implemented and nature is "properly" valued by current economic systems, the proposed positive association between wealth of biodiversity and people's prosperity is an expected endpoint. We refer to this narrative as the "biodiversity underpins local wealth" hypothesis, and we assume that if economic benefits of biodiversity "trickle-up" this should increase a countries prosperity. We are aware we risk "setting up a strawman" - presenting an untrue hypothesis, position or argument to attack to make other arguments seem stronger. As such, we provide evidence for the widespread and strategic use of the narrative that links poverty eradication and biodiversity across three major COP meetings related to the Convention on Biological Diversity (i.e., Rio 1992, Aichi 2010 and Kunming-Montreal 2022, Table 1, Table S1). In addition, to avoid our own possible biases in summarising the sentiment of such relationships, we use large-language models to summarise these three documents with the resulting output stating: "*Protecting biodiversity is essential for poverty reduction, providing sustainable livelihoods, enhancing resilience, and ensuring access to vital ecosystem services. Integrating biodiversity into development strategies can mitigate poverty and foster long-term sustainability*" (see Methods). This statistical linguistic representation of the main sentiments of these policy documents aligns with what we propose as the "biodiversity underpins local wealth" hypothesis – that biodiversity is a major contributor to future economic prosperity of underdeveloped countries through improving local economies.

Yet even 30 years after the CBD, the benefits of biodiversity for poverty alleviation may not yet have been fully realized, and so instead of the predicted negative global relationships between poverty and biodiversity, weakly negative or flat relationships may still prevail. We refer to this scenario as the "weak" biodiversity underpins local wealth hypothesis. An alternative hypothesis, however, is that the current global economic hegemony characterized by the unequal exchange in international trade and global commodity chains, makes the benefits of biodiversity continue to systemically accumulate away from countries with attractive resources and is currently a main active driver of poverty [4,49,56,58,63,65]. This could also be framed as wealth transfer, and externalities of environmental costs, whereby consumption in the Global North nations of resources from Global South nations leads to a transfer of the benefits of biodiversity and natural productivity to the Global North and costs of ecosystem service loss to the Global South, increasing poverty[66,67]. To the extent that this hypothesis applies, we expect a positive association between poverty and biodiversity indirectly through colonialism and its systemic impacts on modern economies. We refer to the imbalanced economic benefits of biological diversity as the "systemic bio-inequity" hypothesis.

Here, we explore the current relationship between countries' biological diversity and their poverty rates to ask if extant global patterns align more with the (weak) "biodiversity underpins local wealth" hypothesis or the "systemic bio-inequity" hypothesis. Next, we develop a classification of countries based on jointly considering biodiversity, poverty and conservation investment through protected areas. This helps conceptualise responsibilities and inequalities amongst countries' contributions to global conservation

goals. To reflect the global and national policy development, we focus on country level properties, while acknowledging that linkages between poverty, biodiversity and conservation are scale- and context-dependent[15]. Poverty and biodiversity loss are two defining crises of our time which are exacerbated by climate change, land use change and social inequality and, together, these crises will determine the fate of human well-being and the state of the environment in the 21st century. In this paper, we aim to better contextualise the global sustainable development narrative and policy setting that aims to address these challenges together. This is urgent given the strong policy push towards commodification of nature for joint biodiversity conservation and poverty alleviation goals in the face of a potentially decoupled - if not inversely coupled - relationship between countries' biodiversity and their prosperity.

Table 1. Selected quotes and statistical linguistic summary of major COP policy documents related to biodiversity.

Document	**Direct quote**	**Linguistic representation of poverty-biodiversity relationships using LLMs**
COP 6 (1992) Strategic Plan for the Convention on Biological Diversity	Section A 3: "In addition to its intrinsic value, biodiversity provides goods and services that underpin sustainable development in many important ways, thus contributing to poverty alleviation"	The Convention on Biological Diversity emphasizes the critical link between biodiversity conservation and poverty eradication. It acknowledges that economic and social development, especially in developing countries, must be prioritized. The CBD highlights the need for financial resources, technology access, and local community support to promote sustainable development and biodiversity conservation.
COP (10/2, 2010) The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets	Annex Section I 3. "[Biological diversity]... contributes to local livelihoods, and economic development, and is essential for the achievement of the Millennium Development Goals, including poverty reduction."	The text emphasizes the interconnectedness of biodiversity and poverty, noting that biodiversity loss disproportionately impacts the poor, who rely on ecosystem services for survival. It highlights that protecting biodiversity contributes to poverty reduction through better health, food security, and livelihoods, urging integration of biodiversity into development strategies.
COP (15/4, 2022) Kunming-Montreal Global Biodiversity Framework	Target 14: "Ensure the full integration of biodiversity and its multiple values into… poverty eradiation strategies."	The text highlights implicit connections between biodiversity and poverty, emphasizing that biodiversity conservation can support sustainable livelihoods, ensure access to resources, and promote equitable development. It suggests that the Kunming-Montreal Global Biodiversity Framework can help alleviate poverty by fostering sustainable use of biodiversity, improving access for vulnerable communities, and promoting gender equality.

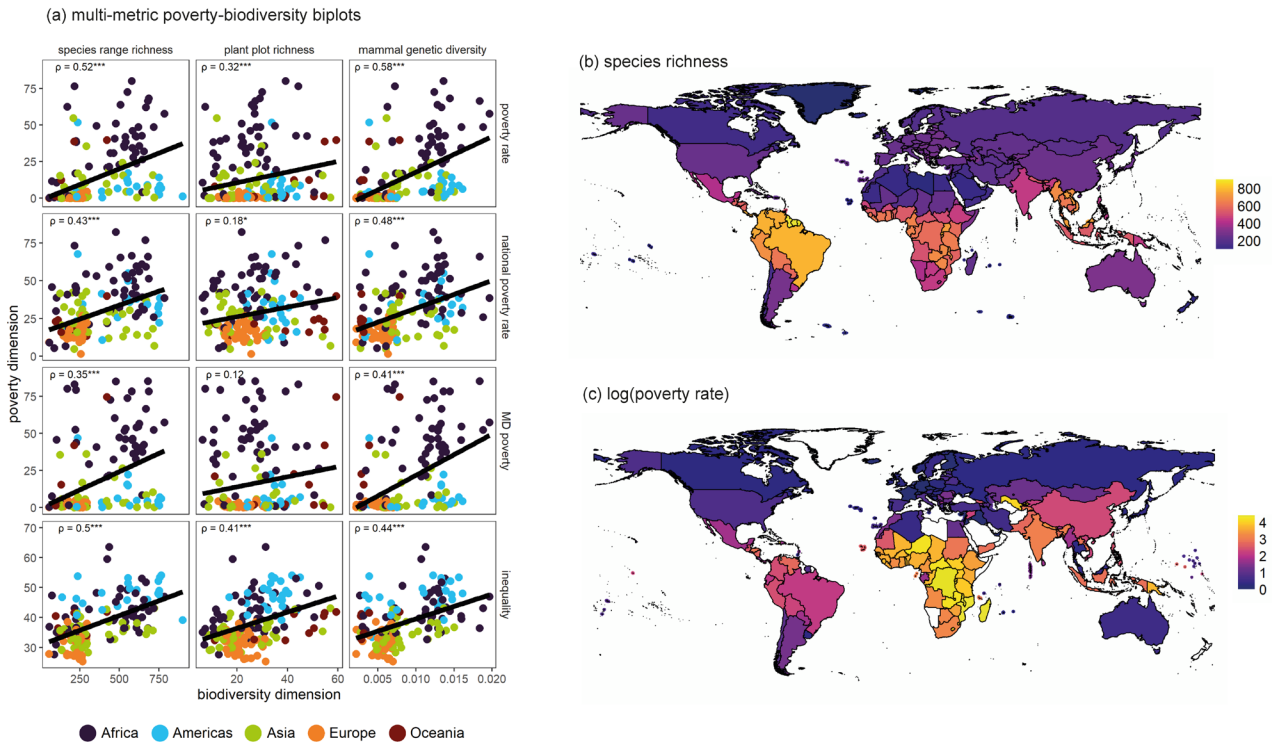

Figure 1. Inverted relationships - compared to the expected negative association - between biodiversity and poverty across multiple metrics (a-c). *(a) Shows biplots of biodiversity and poverty metrics with points indicating countries (n=168). Spearman's rank correlations are indicated in top left with significance of correlation indicated with asterisks (* = p < 0.05, ** = p < 0.01, *** = p < 0.001). (b) Shows terrestrial vertebrate richness using the IUCN range richness index, averaging species richness of overlapping IUCN range polygons across all grid cells per country. (c) Shows global map of country-level poverty using the international poverty line of $2.15 per day.*

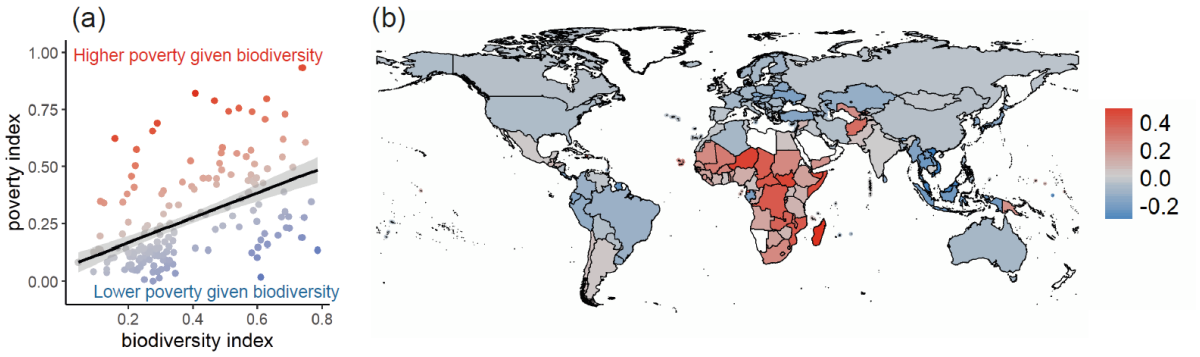

Figure 2. Hotspots of where poverty deviates from the (unexpected) positive relationship with biodiversity. *If assuming biodiversity contributes to well-being, then regions in red highlight areas affected by greatest bio-inequity. (a) Shows the relationship between aggregated biodiversity and poverty indicators from Figure 1. (b) Maps the residual value between aggregated metrics of poverty and biodiversity, as shown in (a). The indices were first standardised (0-1) across all countries and then averaged across poverty metrics and biodiversity metrics within each country. Areas and points in blue (poverty < biodiversity) to red (poverty > biodiversity) indicate the residuals of a linear model between these aggregated metrics for poverty as predicted by biodiversity. 95% confidence intervals of the regression coefficient are shown in grey shaded area of panel a.*

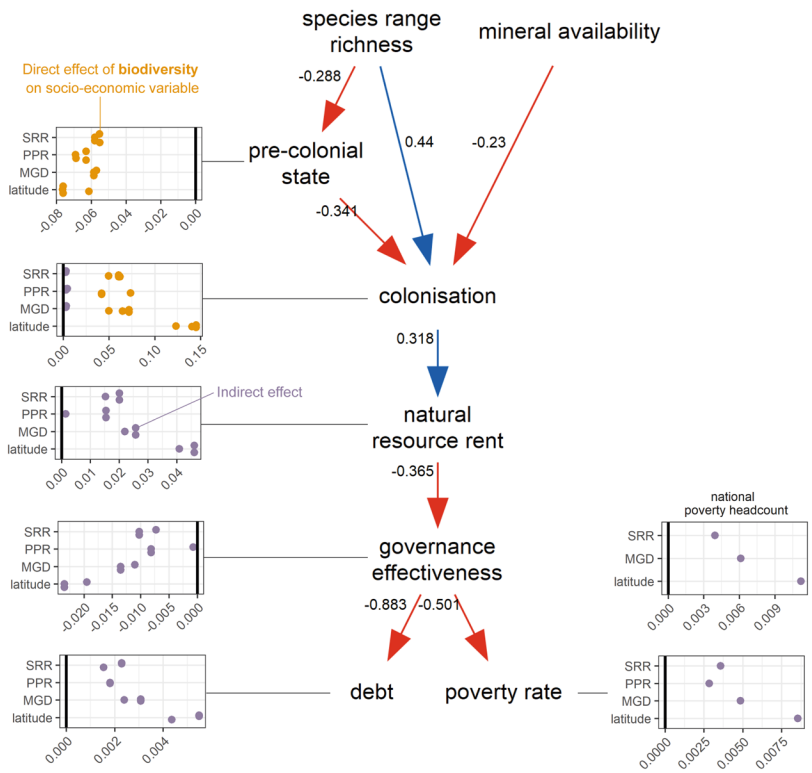

Figure 3. Biodiversity and poverty relationships act within in a global socio-economic structure giving rise to systemic bio-inequity, revealed through structural equation modelling. *Relationships are presented from our backwards selection of a minimal model based on the full model (Figure S2). Insets show effects of biodiversity variables (n=3), and sign-inverted latitude as a proxy of biodiversity's compounded effect, on socio-economic metrics. Direct (orange) and indirect (purple) path coefficients were estimated with 1,000 bootstrap samples. Only significant path coefficients are shown, such that missing variable by response combinations are not show in insets. Numbers on edges indicate standardized effect sizes. All path coefficients and indirect effects are significant at $p < 0.05$. R^2 values were as follows: pre-colonial state = 0.13, colonisation = 0.42, natural resource rent = 0.10, governance strength = 0.39, debt = 0.75 and poverty rate = 0.4. Biodiversity variables are indicated as SRR = species range richness, PPR = plant plot richness, MGD = mammal genetic diversity. This model structure is statistically supported based on Fisher's C of 45.49, p=0.18, d.f. = 38.*

Biodiversity-poverty relationships at a global scale

We synthesized three very different and biologically independent metrics of biodiversity to represent variation at multiple scales of biological organisation, from population distributions across geographic ranges, species richness of communities in local sites, to within-species genetic diversity. Similarly, we used four metrics of poverty that are at least partly economically independent (see materials and methods) ranging from economic poverty (poverty headcount, national poverty headcount), within-country economic inequality (Gini index) and multidimensional poverty index that integrates social and economic factors. Studying the relationships between these, we find no support for the negative relationship between biological diversity and poverty that would be expected under the "biodiversity underpins local wealth" hypothesis (Figure 1). Overall, we find consistently positive relationships: higher poverty and greater inequality in countries with richer biodiversity (median Spearman's rank correlation = 0.42 (0.15 to 0.58); median R^2 = 0.19 (0.02 to 0.30)), more consistent with the "systemic bio-inequity" hypothesis. Broadly, European countries, despite having consistently low to very low biodiversity (Figure 1b, have consistently low to very low poverty rates (Figure 1c), while African countries tend to have high to very high poverty despite having often high to very high biodiversity. Further, countries' deviation from the unexpected positive relationship between biodiversity and poverty indices show that much of Africa and some countries in West and SE Asia have even higher rates of poverty than predicted based on the global trend, whereas national poverty is less dramatic than predicted in most of southeast Asia and south America (Figure 2).

The strength and consistency of the association that is opposite to the "biodiversity underpins local wealth" hypothesis, make us worry that the mechanisms which underpin variation in biodiversity and variation in poverty are deeply interconnected but in an ultimately unsustainable way. Indeed, our structural equation models revealed a positive indirect effect of biodiversity leading to higher poverty. Biodiversity indirectly increased metrics in economic poverty (poverty headcount and national poverty headcount) mainly through colonisation and governance strength (Figure 3, Figure S2, S3). Most notably, a direct link between biodiversity and any poverty metric, either positive or negative, was never supported across all 12 combinations of poverty and biodiversity metrics. However, a complex set of paths between biodiversity and poverty was generally supported whereby biodiversity rich countries had higher chances of being colonised. Biodiverse rich countries also had lower chances of a pre-colonisation state formation which indirectly increased colonisation rates. Colonisation increased economies dependence on the export of raw materials (higher natural resource rent) which weakened governance effectiveness. Lower governance effectiveness affected higher debt and higher poverty rates. Notably, mineral richness did not explain a significant portion of variation in poverty rates, which might have been expected if colonising countries were mainly exploiting mineral wealth. This overall structure in our model, and the paths, linking biodiversity to poverty was statistically supported for most metrics of biodiversity with poverty headcount and national poverty headcount (Figures S3, Table S2), but the multi-dimensional poverty index or Gini

index did not show significant support in path diagram. Further, replacing biodiversity metrics with latitude, one of the variables most strongly associated with species richness for a number of reasons[1], showed the same overall structure. Structural equation modelling of our data, hence, identifies a plausible pathway to explain the paradoxical positive relationship between biodiversity and poverty that we uncovered.

An unexpected inversion of biodiversity-poverty relationships

While acknowledging the lack of a truly causal analysis, our findings are more consistent with the "systemic bio-inequity" hypothesis, compared with the "biodiversity underpins local wealth" hypothesis. Our path analysis indicates that benefits of biodiversity have been, and still are, systemically accumulated in privileged sectors of global society, with historical pathways helping establish this accumulation which may be self-reinforcing to the benefit of biodiversity-poor countries of the Global North.

Latitudinal biodiversity gradients conform to the most ubiquitous rule(s) in macroecology and are broadly understood to be driven by an interplay between greater energy availability and productivity, greater habitat area, larger niche space, and long periods of environmental stability which drive higher diversification and accumulation of species in low latitudes[1]. Low latitudes are therefore expected to hold wild populations of a much larger number of plant and animal species that were at some point in the past, are currently, or will in the future, become of great value to people[68]. Not surprisingly, therefore, most major agricultural crops trace their origins to low latitudes, including cotton, coffee, sugarcane, tobacco, tea, rice, maize, potato and cocoa and many of these were domesticated from more than one wild species that were crossbred. The global poverty gradient, with poverty peaking at low latitudes and prosperity peaking in the temperate North, is only a recent phenomenon, chiefly a result of European conquest and colonialism beginning 500 years ago, officially ending ~60 years ago for most territories, and the subsequent enforcement by the former colonial powers of neoliberal free-market economic policies and unequal terms of trade on governments in the Global South. These economic policies facilitated debt creation alongside repayment structures that entrench structural poverty, political dependency and North-South inequality, giving the economically powerful Global North undue control over pricing of biodiversity and natural resources from the Global South [60,69–72].

The uncoupling between poverty and biodiversity that we observe appears as a historical anomaly, with ecological and social systems being geographically more closely coupled through most of human history. Largely overlooked in, but consistent with, the hypothesis that "biodiversity underpins local wealth" is that economies were larger and human well-being higher in major sectors of the Global South than in the Global North from prehistoric times and throughout the pre-imperial and pre-colonial eras ([3,73]; Figure 4a). Many of the largest economies in ancient, classical and mediaeval times emerged in Africa, South and Central America and West, South and SE Asia between 20° South and 40° North (Figure 4b; [73,74]), and those in Europe emerged in Europe's SE and South (Minoan, Greek, Roman). Just prior to European

colonialism, 20-30% of global GDP is estimated to have been generated in the Indian sub-continent, a region that now generates <5% of global GDP[73], and the motivation for early West European exploration of Africa was the mythical wealth of polities south of the Sahara [3,73,75]. Indeed, while data is scarce and global research patterns extremely biased, findings indicate the last 1000 years has seen a reversal, and transfer, in global proportions of wealth from Africa and India to Europe and the USA (Figure 4c). This suggests that more closely coupled socio-ecological systems have become geographically uncoupled only in the past 500 years, in the wake of European colonization and the lasting hegemony that resulted from it, thereby inverting the direction of the relationship between biodiversity and prosperity of regions.

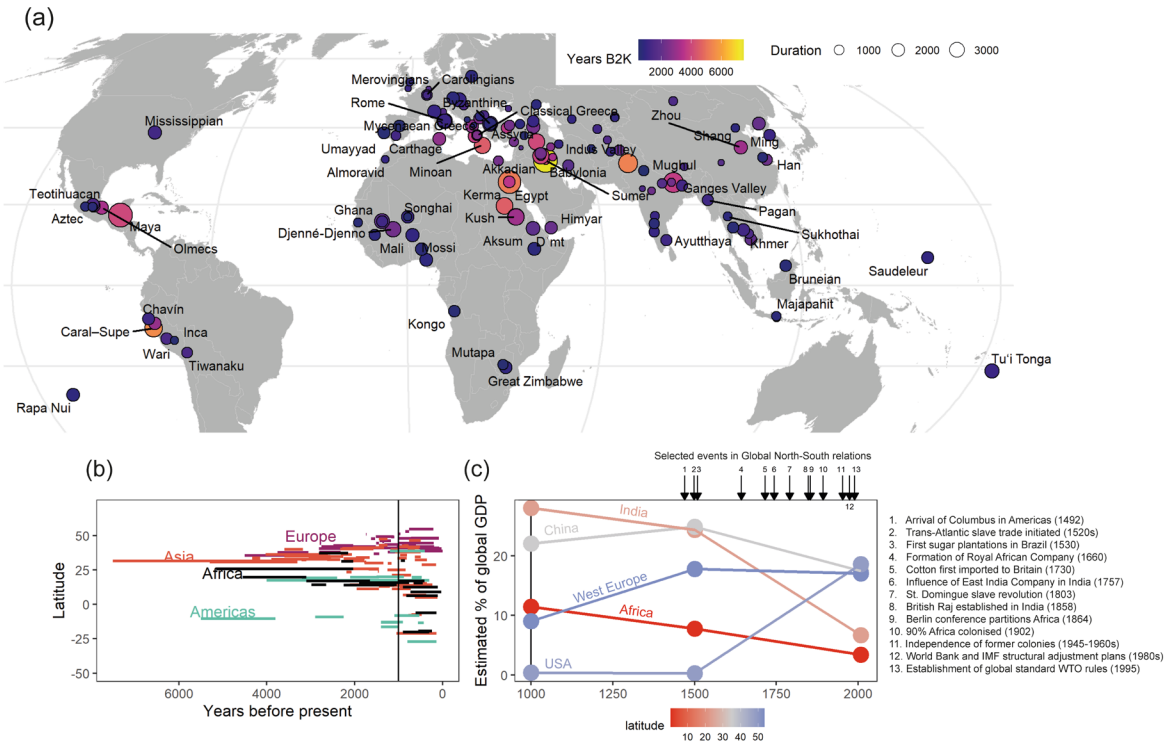

Figure 4. The distribution, emergence and wealth of early complex polities show a global distribution of wealth and earlier emergence of complex polities in regions which now have low proportions of global GDP, these regions were the origins of complex civilisation and had far greater historic GDP. *(a) shows the spatial distribution of civilisations exhibiting large infrastructure, cities and complex political systems. The colour of points indicates the years before present when the polities is estimated to have formed in years before 2000 CE and the size indicates the duration of the polity. (b) The emergence latitude and time of the polities with colours indicating the geographic regions. The horizontal line is at year 1000, where data on GDP across 5 countries and regions is available for comparison in panel (c). Panel (c) indicates the change in proportional global GDP from year 1000 CE to*

2008 CE based on [73]. We also indicate major historical events that coupled North-South ecological and economic relationships. Colour in (c) indicates the mean latitude of the region or country.

The flow of benefits from biodiversity resources and dividends from biodiversity rich countries, as proposed in the "systemic bio-inequity" hypothesis, seems the most plausible mechanism explaining the now prevailing positive poverty-biodiversity relationship. This network of historical to present day impacts received quantitative support in our path analysis, but also aligns with much previous quantitative and qualitative research. For example, our explanation aligns with historical records and current patterns in unequal trade [4,59]. In this scenario, colonialism and imperialism that came with genocide, enslavement and other forms of violent labour exploitation, allowed the economic benefits of biodiversity - that in principle would help reduce poverty in regions of its origin - to accrue predominantly in European nations, and fuelled Europe's rapid economic development during the past few centuries. Such a process is strengthened if institutions that generate economic wealth in a neoliberal economy were environmentally extractive, rather than investing wealth back into countries' institutions [60] a phenomenon shown to have enduring impacts on poverty and inequality today [4,49,76]. These mechanisms would have reduced poverty in biodiversity poor European countries but impoverished and underdeveloped biodiversity-rich countries in the Global South.

To illustrate our hypothesis, and to stimulate further deeper causal examination in the global conservation field more generally, we briefly summarize the history of cotton. Wild cotton (*Gossypium* spp) is a species-rich genus of Rosid plants. The natural distribution of its 50-plus wild species is confined to the tropics and subtropics. Most wild cotton species are diploid, but a group of five species from Mesoamerica, the Caribbean and Pacific islands are tetraploid. They arose as a result of a natural hybridization event between preexisting species around 1.5 to 2 million years ago, a case of diversity begetting more diversity, characteristic of tropical biomes [77]. Indigenous agriculturalists had worked with the tetraploid species and bred cultivars in Mesoamerica long before Europeans arrived. Soon after European conquest of Mesoamerica the colonizers began to enslave local people for mass-production of cotton for export to Europe. The genocidal enslavement of native Americans was swiftly followed by importation of enslaved workers from Africa and expansion of the plantation system into south-eastern North America. Upon arrival in British-colonized North America, this industry sparked the development of chattel slavery which in turn fuelled the industrial revolution in England, France, Germany, Switzerland and so forth [3,51,78]. Tetraploid cotton has been the most used natural fibre ever since the 1700s, amounting at times to 80% of world natural fibre production [79]. This example serves to illustrate how the technical and economic rise of western Europe (and its settler colonies) was fuelled by the appropriation of biodiversity resources from the Global South[58]. The people of the South were deprived of the dividends for the resource (social-ecological systems decoupling). On top of this, the people in several continents in the South paid with genocide which caused the indigenous economies in those regions to spiral down. Beyond the stolen dividends, endured genocides and destroyed economies, production of cotton in vast

plantations from then-to-now impacts biodiversity negatively through large scale transformation of land to monocultures all across the tropics while unequal trade rules simultaneously entrench the Global North's control over the global price for cotton [79]. Agriculturalists continue to develop new varieties of cotton by selective breeding within species and cross-breeding wild species from Global South countries to combine desirable traits of several wild species into the commercial species, such as resistance to insects and fungi, and drought tolerance[77]. Amazingly similar stories linking tropical evolutionary diversification, colonial exploitation and contributions to global socio-ecological decoupling and poverty in the South could be told about many other major crop plants such as sugar cane[80], contributing to Europe's rise to dominance and the simultaneous devastation of economies and environments across the South[3,57]. Many crop plants of global importance derive from highly species rich tropical clades[68] and their domestication very often involved genetic contributions (through crossbreeding) of multiple of the species. This all points to the importance of species rich biomes, where colonialism focussed its efforts, as the source of domestic plants even when the domesticated products eventually can be grown beyond the tropics, such as tobacco and potato.

Positive relationship between poverty and biodiversity in a protected world

In this context of positive biodiversity-poverty relationships at least partly conforming to the "systemic bio-inequity" hypothesis, we next explored the intersection of these relationships with conservation investment (through terrestrial protected area coverage). If global conservation efforts are both efficient and just, we expect higher protected area coverage in regions with higher biodiversity and lower poverty (Figure 5a), with other scenarios indicating inefficiencies and injustice. These predictions make the assumptions that protected areas have associated costs which are harder to bear in smaller economies, and that biodiversity conservation is more efficient when protected areas align with biodiverse regions. Assessing the relationships with protected area coverage, we found no support that more biodiverse or less poverty-stricken regions have higher protected area coverage, despite the intersections of poverty and biodiversity we report above (Figure 5b; biodiversity: slope = 1.24, $t = 1.08$, $p>0.05$; poverty: slope = -0.35, $t = -0.24$, $p > 0.05$). This illustrates a decoupling of biodiversity-poverty gradients on the one hand and conservation investment on the other. For example, 36% of African countries invested in protected areas with coverage greater than 17% national land, which is within the global range across all other continents (17% - 69%). Yet, 84% of African countries had above average poverty rates, far higher than any other continent (0-29%), and Africa has the most countries with above average biodiversity (35%) compared to other continents (0-29%). In contrast, all European countries had below average poverty and biodiversity but 69% of European countries had already committed more than 17% of land to protected areas. We find strong geographical signals in the global patterns of biodiversity, poverty and conservation investment combined: countries fall into 4 quantitative groups (Figure 5c and 5d). However, none of these groupings were strongly related to protected area coverage (maximum standardised basis vector = |0.15|) indicating mis-aligned conservation effort compared with gradients in biodiversity and poverty. The main

factors contributing to these four groupings were variation in poverty rates (standardised basis vector = -0.94) and species range richness (-0.3). A second axis of variation determined grouping according to multidimensional poverty (0.54) and divergent gradients in species range richness (0.49) and mammal genetic diversity (-0.49).

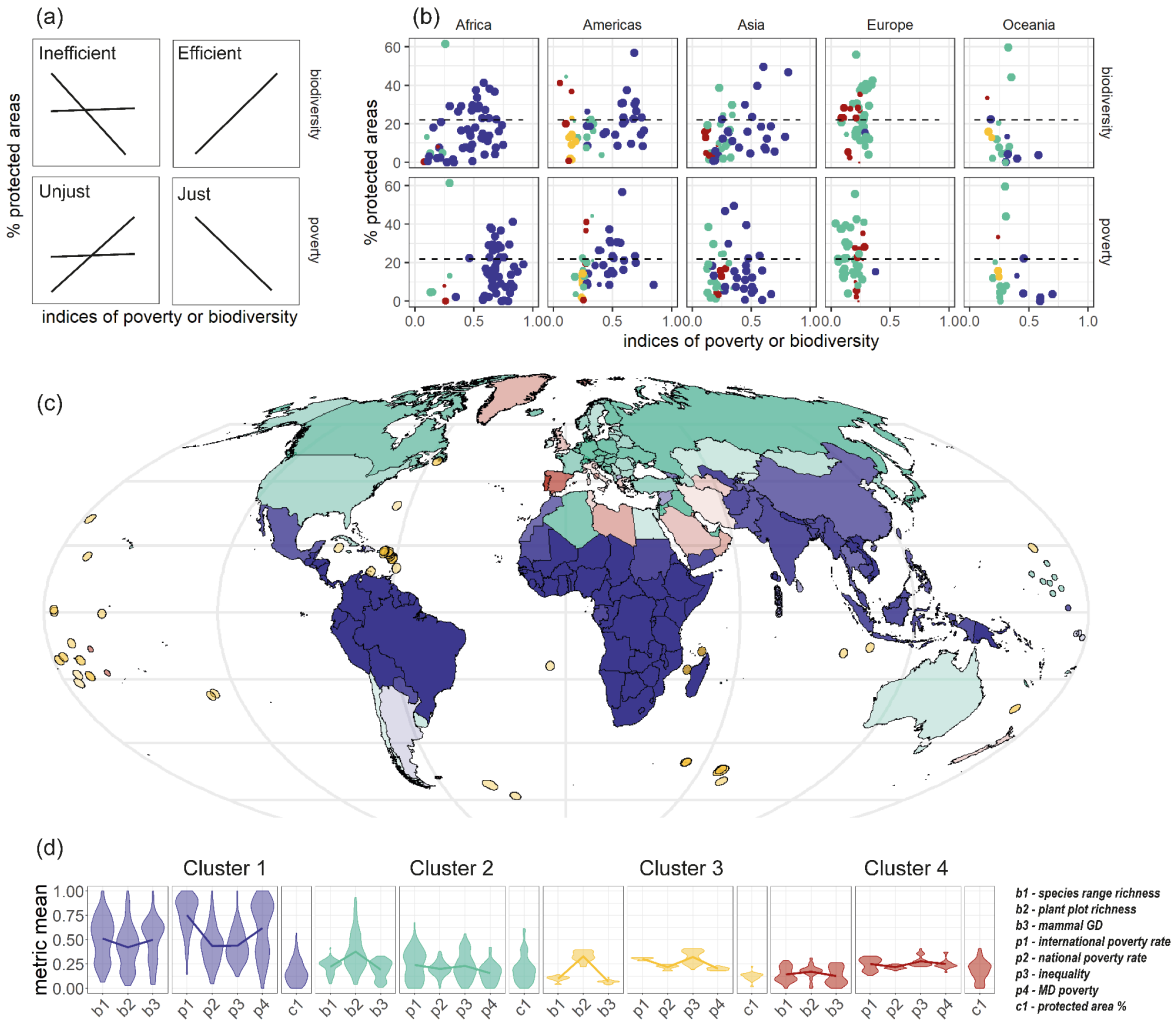

Figure 5. Relationship between biodiversity and poverty with conservation investment in protected area coverage across five continental regions. *(a) The expected marginal relationships between biodiversity, poverty and protected areas and indication of whether the global conservation system is efficient and just based on these relationships. (b) Empirical relationships between biodiversity and poverty indices with % protected area coverage for each country, indicated by points. Generalized linear models found no support for significant relationships in any of these regions, with an intercept only model the best supported (dashed lines). Colours indicate the cluster identity of countries based on the unsupervised learning using gaussian mixture models across all metrics of biodiversity, poverty and conservation. (c) Shows a global map of each cluster identity. Note that group 3 is exclusively island*

countries, characterized by very low species and genetic richness of vertebrate animals and are buffered by 100km for easier visualisation. (d) Indicates the mean values and density distributions of the 8 metrics of biodiversity, poverty and conservation which were used as quantitative inputs to the GMM for the 4 country clusters.

A conservation paradox that urges realignment of conservation investment, poverty, and biodiversity gradients

Bringing together supposedly disparate forms of information on biodiversity, poverty and conservation in this study has revealed a dual conservation and sustainable development paradox: global conservation investments are poorly aligned both with economic capacity for conservation and with the distribution of biodiversity. We demonstrate that this paradox exists in the context of a global pattern of systemic bio-inequity, likely initiated historically by processes of colonialism that determine and are now maintained by modern socio-economic structures, with the consequence that poverty and biodiversity are now positively correlated. Sadly, the "biodiversity underpins local wealth" hypothesis proposed by global CBD policies is unsupported based on our macro-scale assessment and sustainability policies largely overlook this paradox. We view poverty as a constraint on conservation, as the latter comes with substantial economic and social costs, e.g., setting aside land for nature displaces and often disempowers local people [81,82]. Thus, our results indicate that the share of this conservation burden is not currently well-balanced against differences in poverty and biodiversity among countries and peoples.

Our conservation paradox requires further attention given that the effectiveness of nature protection to jointly improve nature and people's well-being is highly heterogeneous in terms of benefits and costs. Concerningly, there exists little consensus on effectiveness across social, economic and ecological outcomes of conservation [15,82,83] whilst there is broad agreement that social-ecological systems decoupling is a common cause of failure in nature protection. Yet, well designed conservation actions do benefit biological diversity in the short term in the available studies[84,85], especially in terrestrial and marine and not generally in freshwater systems[86] (but note far fewer studies exist in economically poorer countries). If nature protection is advanced without reducing local poverty then conflicts are exacerbated, people dispossessed of land, and power structures favouring local elites reinforced [15,38,82,87]. As such, the widespread acceptance of the "biodiversity underpins local wealth" hypothesis - i.e., conservation-driven improvements to biodiversity and ecosystem-services will reduce poverty - may have harmful consequences particularly in the countries within regions having lower-than-average biodiversity and higher-than-average poverty (41% and 14% of countries in Africa and Asia respectively) and for underprivileged sectors of society within all high poverty and probably also other countries. Global-scale conservation science and conservation planning that fail to address questions of power, politics, inclusion, or vested interests in local realities can lead to wrong and potentially harmful assessments of the

interrelationship between people and nature[88,89] by risking scientifically wrong conclusions[90] that perpetuate unjust practices and entrench the decoupling of social and ecological systems [91].

The separation of people from nature, most distinctly through protected areas, is a predominant mode of western conservation which decouples socio-ecological systems and appears to be applied across the globe irrespective of local biological or economic context. That we find the extent of protected areas is largely unrelated to poverty or biodiversity is likely symptomatic of a system that overlooks local and Indigenous people's participation, rights, and sovereignty and instead imposes discursive and material separation of people and their surroundings into the categories nature, culture, environment, and society based on Eurocentric values and worldviews [81,82,91]. Recent shifts in the encoding of local values in conservation algorithms highlight how justice-based approaches can jointly benefit biodiversity and people[92]. These may eventually guide us away from global-scale conservation prioritisation schemes that lack local context [93,94], but in the meantime many communities in and around protected areas in the Global South continue to face dispossession and violence.

To further evidence these broad summaries, we prove here specific examples of how decoupling of socio-ecological systems through protected areas can lead to social and ecological harm. For instance, in Tanzania's Eastern Arc Forests local communities bear significant protected area costs while international stakeholders reap financial gains[95]. In Namibia, extreme racialised inequalities in land ownership were inherited from the colonial regime, which still negatively impact protected area effectiveness designated since the 1990s in community conservancies[16]. In Southeast Asia too, protected areas often overlap with territories where Indigenous and other minority groups have weak or informal tenure. States are frequently reluctant to formalize these rights, and Indigenous populations are often concerned that conservation is a means of resource appropriation by elites, as seen in Myanmar[96,97], Cambodia[38] and Kenya[82]. In Ethiopia, Western ideals of protected areas, assumed ecological degradation, and overpopulation in an “African Eden”, favoured the displacement of local pastoralists and the establishment of a protected UNESCO world heritage site as a solution to these perceived problems [98]. In Vietnam, over the last three decades, conservation and natural restoration efforts have prioritised large scale, economically profitable, and quick solutions, with the unintended consequence of exacerbating biodiversity loss by converting natural forests to exotic fast-growing species that do not support long-term ecological or social integrity [99–101]. These examples highlight a persistent decoupling of supposed biodiversity conservation outcomes through area-based conservation from the local social, political and economic realities. This disconnect is currently a key systemic driver of local conservation failures and biodiversity loss [17,102], and our analysis suggests that this disconnect is also systemic at the global scale.

The findings we report are unsettling and demand solutions to addressing the conservation and sustainable development paradox that we identified. First and foremost, acknowledging and recognising that sustainability in the long run may be undermined by the current narrative, which advocates for

sustainable development through conservation but ignores the colonial history of, and hegemonial thinking underlying current benefit sharing from conservation. Better recognition and understanding these historical and current political interlinkages may help shift towards decolonizing conservation science[90] and to shift applied conservation to forms that are globally aware but locally rooted, pluralistic and socially just (Owuor et al submitted). Conservation practise should prioritise the restoration of the coupling between social and ecological systems from local-to-global scales[103]. The recognition that inverted poverty-biodiversity relationships causally emerge from colonial, neocolonial and neoliberal economic structures urges knowledge brokers in civil society, especially those who inform government and international policy, to actively support equitable and locally-driven solutions, and recognise the limitations and historical injustice of top-down, neocolonial or Eurocentric conservation strategies. One specific example where scientific and conservation discourses act unjustly and ignore structural inequality is debt-for-nature swaps, whereby tweaking financial systems towards nature conveniently overlooks the injustice of Global South debt in the first instance and instead opts for paternalistic biodiversity conservation from afar [104,105]. Indeed, the world views that lead to such pseudo-solutions are dominant due to existing power imbalances which promote Eurocentric ontologies and epistemologies, embedded in mainstream conservation approaches, which divide people and nature through protected areas, market-based instruments[41,103] and Eurocentric value-laden concepts [81]. Instead, context-specific conservation strategies adapted to governance modes, economic dynamics, cultural practices, and historical legacies will better facilitate work towards transformative solutions. To enable such solutions, global system-wide restoration of mechanisms of local social-ecological feedbacks is urgent, and this likely requires such measures as international debt-cancelling, fair commodification of biodiversity resources and establishment of fair trade.

Conclusion

Our results indicate a critical framing of global conservation narratives is in order, one that acknowledges the prevalence of relations between biodiversity and poverty that are opposite to those predicted by the dominant and popular “biodiversity underpins local wealth” narrative. Further introspection is urgently needed on how historical inequities that emerged in European conquest and colonialism, and became entrenched in the modern global economic system, can be placed at the centre of any globalised perspective on curtailing biodiversity loss and poverty through sustainable development and conservation. Our assessment aligns strongly with the interpretation that “biodiversity underpins local wealth” likely predominated through much of human history, as indicated by historic distribution of wealth and polities, but that several centuries of exploitation of nature and people have now led to the breakdown of social-ecological system coupling in many Global South countries and to accumulation of wealth and institutional power in the Global North. Countries in the Global North now leverage power to argue that conservation, often through protected areas, in the Global South would bring poverty alleviation. This occurs despite unequal global trade rules continuing to favour the rich North. A major

effort is required to create a fair global trade system with the goal of restoring local-to-global social-ecological system coupling at its heart. In the absence of the latter, the continued export of the idea that biodiversity underpins local wealth risks undermining of conservation motivation in the Global South and implementation of unjust conservation practices, embedded in global inequalities, which is deeply unsustainable.

Methods and materials

Large language sentiment assessment of United Nations Conference of Parties Convention of Biological Diversity policy documents

We aimed to understand the main linguistic statistical representation of the relationship between poverty and biodiversity from major policy documents in biodiversity science. We obtained PDF versions of the Rio 1992, Aichi 2010 and Kunming-Montreal 2022 documents and used *pdftools* (version 3.5.0 [106]) in R to extract all text from these documents. For each document separately, we used the open-source mistral-nemo (24.07) large language model (LMM) with a temperature parameter 0.1, 0.2, and 0.3 and token size of 1,000 and 10,000. We assigned the LMM the "role" of "*You answer the following question only based on the provided text, what is the relationship between biodiversity and poverty?".* For each temperature and token size combination, we provided the text of each policy document as a message and saved the returned output summary. We tested whether the LMM used its role to provide the returned message by inputting two dummy text objects, the poem "*Because I could not stop for Death*" by Emily Dickenson and a series of 20 random sentences of 100 words usings *OpenRepGrid* package (version 0.1.17 [107]) both of which returned statements qualifying these dummy documents were not related to biodiversity or poverty. We saved all output summaries of the provided documents across all parameters and provide a selected set of these in Table S1. For each policy document, we combined all of text summaries from mistral-nemo across all parameter settings and obtained a meta-summary of the document summaries using chatGPT-4.0 turbo, for convenience, requesting the following "*Summarise the following text in 50 words, emphasising the relationship between poverty and biodiversity:*". We also input all mistral-nemo summaries as a single text string into chatGPT-4.0 for a single summary provided in the text of the main manuscript.

Data synthesis

We compiled multiple global scale biodiversity datasets representing intraspecific genetic to community scales of biological diversity covering multiple taxonomic groups. We extracted country mean values of i) terrestrial species richness for amphibians, birds, mammals and reptiles by summing overlapping range polygons to a global harmonised raster layer (IUCN Red List Data 2022-2), ii) terrestrial mammal genetic diversity of co1 and cytb mitochondrial genes comparing the mean number of nucleotide differences per site within a species for >2,000 species and >54,000 sequences [108], and iii) plant local scale species

richness based on >400,000 vegetation plots in a small-scale delimited area ([109]; w3_tile_joint_sr1000.tif). Note that the latter two global layers are generated by modelling environmental correlates of diversity and projecting these spatially to provide a globally continuous layer (see original publications for details). Our approach aimed to broadly indicate global-scale spatial patterns in biodiversity with measures of biodiversity that are comparable between countries. We acknowledge that substantial biodiversity knowledge shortfalls exist in many countries but assume that global scale gradients are well represented herein [110]. We intentionally did not aim to investigate within-country biodiversity variation where locally collected data are more suitable. We also note that the high dimensionality of biodiversity prevents any attempt at being comprehensive, with biological variation being measured across biological groups and organisational scales (genes, species, communities, ecosystems) as well as spatial resolutions (1m, 1km, 100km) and spatial scales (alpha, beta, gamma diversity).

We compiled four metrics of poverty and inequality from the World Bank Group's data portal: poverty headcount based on an international poverty line; poverty headcount based on national poverty lines; multidimensional poverty index; and, income inequality using the Gini index. Poverty headcounts indicate the % of the country living below the international poverty line of $2.15/day based on 2017 Purchasing Power Parity. Poverty headcount using national poverty lines use country-specific national poverty lines provided by household surveys by each country's government sources or World Bank staff which reflect cost of living differences between countries. Some economists argue that international poverty lines inflate estimates of poverty improvements in recent decades compared with national poverty lines, so we provided here both for consideration[2,111,112]. Poverty measured in monetary terms does not represent non-monetary forms of poverty [113] so we used the multidimensional poverty index that equally weighs monetary poverty, school enrolment rates, primary education completion, access to clean drinking water, access to sanitation and household electricity supply. Using our combined poverty index, individuals are considered poor if in the lowest ⅓ of the combined weighted index, and the country metric is expressed as the % of individuals indicated as poor. Finally, economic inequality is measured using the Gini index to calculate the wealth share amongst individuals in the country where 0 is perfect equality in wealth between individuals and 100 is complete inequality. For each metric and country, we averaged all available poverty metrics from the year 2000 to the most recent available date. Poverty headcounts and Gini inequality were available from the World Bank Poverty and Inequality Platform using the R package *pipr* ([114]; version 1.0.0) and we obtained the multidimensional poverty index from the Multidimensional Poverty Measure database (8th edition, circa 2021) available at https://www.worldbank.org/en/topic/poverty/brief/multidimensional-poverty-measure which are based on the World Bank's Global Monitoring Database.

We focused on protected areas as an indicator of conservation investment defined by the International Union for Conservation of Nature as "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with

associated ecosystem services and cultural values". A key policy in the Post-2020 Global Biodiversity Framework is furthering protected area coverage to 30%[25], and protected areas are a key focus of multiple NGO's and intergovernmental organisations (IUCN and United Nations Environmental Program World Conservation Monitoring Centre attempt to compile global data to monitor protected area coverage and internationally standardised quality globally). For convenience, we used the World Bank's DataBank to obtain country level calculations from the Protected Planet website (https://www.protectedplanet.net/) of % of total land area protected where protected areas are of at least 1,000 hectares (for full methods see https://databank.worldbank.org/metadataglossary/world-development-indicators/series/ER.LND.PTLD.ZS). For some countries there were multiple years available for protected area %, and we took the value of the most recent year available.

We compiled the above data into a country scale dataset with a total of 168 countries with no missing data for biodiversity metrics and poverty metrics. To test for the direction of relationship between country-level poverty and biodiversity we perform a Spearman's rank correlation between each pairwise comparison of metrics, giving 12 comparisons (3 biodiversity metrics x 4 poverty metrics) and report the correlation statistic (ρ) and p-value. Spearman's rank correlation is robust to data being on different scales, having non-linear relationships, and having non-normal distributions. We also calculated a linear model of poverty metrics as a response variable and biodiversity metrics as an explanatory variable, from which we calculate the coefficient and r^2 statistic. We next calculated an index for each of the metrics groups for poverty and biodiversity by combining all metrics within a group. To do so, we rescaled all metrics between 0-1 and calculated the mean of the rescaled metrics within poverty and biodiversity metric groupings. Next, we calculated the residuals of a linear model between the poverty index and biodiversity index to represent whether a country's poverty index is higher or lower than expected given its biodiversity index and the global relationship.

Structural equation model of poverty-biodiversity relationships accounting for socio-economic history

We tested how biodiversity is related to poverty using a structural equation model that comprised of multiple modern and historical socio-economic and environmental factors. We used data from [115] which provides an overview of quantitative links between historical factors and the emergence and timing of colonisation. From this publication we obtained country level data on colonisation, pre-historical state formation, latitude, maritime and land travel distance, and landlocked status. Ertan consider a country as colonised if > 20% land area was controlled by Belgium, England, France, Germany, Italy, Netherlands, Portugal or Spain between 1462 and 1945 (see Appendix of Ertan et al. for full descriptions and justifications). Differing from [115] we considered settler colonies as not colonised, as our aim is to explain modern day poverty whereas settler colonies institutionally benefited from colonisation in terms of economic wealth[60]. We follow Ertan et al in considering Armenia, Azerbaijan, Georgia, Kazakhstan,

Kyrgyzstan, Turkmenistan, Uzbekistan, Lebanon, Syria, Isreal, Jordan and Iraq as non-colonised as these were colonized very late, in addition to Ethiopia which was colonized late and for a brief period. Pre-historical state formation is described as the presence of supra-tribal government between 1CE - 1500CE. We downloaded modern socio-economic data from the World Bank data portal for total debt as a % of GDP, agricultural land %, control of corruption, rule of law, government effectiveness, political stability and absence of violence, regulatory quality, and voice and accountability. Note that the latter 6 metrics all indicate governance quality and were highly correlated, so we used only government effectiveness as a covariate as it had the highest correlation with the others. As a primary motivator of European exploration was control of mineral wealth in the form of gold, silver and diamonds, we counted the number of known mineral resource deposits for these three minerals per country from the Mineral Resources Data System at hosted at the USGS.

We formulated the following expected paths between variables based on multiple hypotheses and supported findings in the published literature. From this conceptual model, we generated a structural equation model representing statistical relationships between countries socio-nature-economic properties from historical-to-modern day time periods. Importantly for our work, we allowed a direct link between poverty and biodiversity metrics, testing the “biodiversity underpins local wealth” hypothesis. We also allowed biodiversity metrics to effect colonisation probability and state-formation probability, and biodiversity to indirectly impact poverty trough the model structure, testing the “systemic bio-inequity” hypothesis. The model structure is presented in Figure 1.

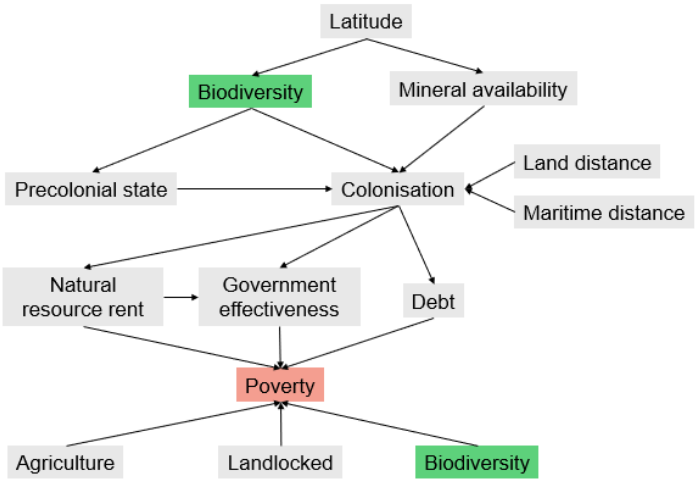

Figure 1. Overview of hypothesised links tested in our structural equation modelling. *The direct link between biodiversity and poverty indicates the “biodiversity underpins local wealth” whereas the indirect links between biodiversity and poverty test the “systemic bio-inequity” hypothesis.*

We fitted this full model as shown in Figure 1. From this full model, we observed that the non-mechanistic link between latitude with each of precolonial state, colonialism and resource rent variables were not d-separated, indicating that including these links would result in a better supported model structure. Given the already oversaturated state of our model and the constrained sample sizes (ranging from 85 to 108 countries depending on the poverty metric), we decided to also fit models where we replace our metrics of biodiversity and mineral availability with latitude. Latitude was strongly related to the suite of factors in our SEM, with one of these being biodiversity. Yet, in this model factors are not mechanistically related to poverty and its proposed determinants (hereafter "non-mechanistic models"). As such, we also fitted a "mechanistic-only" model, which we present in the main manuscript, including biodiversity metrics and mineral resources directly and removed latitude as a predictor from all models. The logic here is that latitude is not a direct driver of any property in this model, except for biodiversity. Fitting this full model without latitude, we then performed backwards stepwise model selection iteratively removing variables until only variables with significant coefficients were retained. We calculated Fisher's C statistic and chi-squared statistics, but caution we have a low sample size for SEMs based on the available data across all countries and instead prefer to interpret coefficient effects rather than compare amongst competing overall model structures. We calculated the direct and indirect effects of biodiversity metrics, and latitude, on poverty in our final models. We fitted non-mechanistic and mechanistic models for each combination of poverty metrics (n=4) and biodiversity metrics (n=3). The direct links between poverty and biodiversity metrics test the "biodiversity contributes to local wealth" hypothesis, the indirect links between biodiversity metrics and poverty through colonialism, governance and debt tests the "systemic bio-inequity hypothesis".

We fitted structural equation models using *piecewiseSEM* package (version 2.3.0; [116]) and calculated direct and indirect effects through bootstrapping for 1,000 repetitions using the *semEff* package (version 0.7.2; [117]).

Comparing biodiversity, poverty and conservation

We next aimed to qualitatively categorise and quantitatively cluster a globally consistent dataset of poverty and biodiversity metrics for all 275 countries available in the world bank dataset. We used the dataset with 168 countries and their poverty and biodiversity metrics to impute the values for the missing metrics of all 275 countries. We used imputation using random forests using the missForest package in R[118] (verson 1.5) with an increasing amount of missing entries during computation and setting *maxiter* as 10,000, *ntree* as 1000 and *mtry* as the square root of the number of variables. These imputations provided excellent imputation quality with a median out-of-bag normalised root mean squared imputation error of just 1.4%, ranging from 0-1.5%, supporting previous demonstrations that missForest is a powerful imputation approach. We first classified countries into "high" or "low" categories for poverty and biodiversity by having the combined indices (described above) greater, or less, than 0.5. We classified

conservation as “high” or “low” using a threshold of 17%, a value based on the Aichi biodiversity targets. We therefore identified countries as falling into one of 8 predefined categories being high or low for biodiversity, poverty and conservation. This subjective, but simple definition was then compared to a quantitative and data-driven analysis of clustering across all metrics of our poverty, biodiversity and conservation data. We used model-based clustering based on parameterized finite Gaussian mixture models using four groups, having first assessed the optimal model parameterization and number of groups using Bayesian Information Criteria [119]. We also ran dimension reduction for model-based clustering to obtain the linear combinations of the original biodiversity, poverty and conservation metrics quantified by the associated eigenvalues. For each country, we therefore obtain the qualitative classification based on our subjective thresholds and the quantitative classification based on the GMMs. We then ran a chi-squares test on the country groupings between the two methods, which in all preliminary assessments, and in our final analysis was highly significant (see Results). We present this work using the World Bank’s classification of countries into 5 regions: Africa, America’s, Asia, Europe and Oceania, but acknowledge cultural and political diversity is overlooked when defining heterogeneous countries into regions. Data on the geographic location of well-established historical civilisations, empires and polities were compiled from Wikipedia, focusing on those those established prior to 1500s, apart from the Mughul empire (1526 BCE). Geolocation points were represented from the coordinates of reported metropolitan centres but note that many civilisations or empires spanned larger areas than represented by point coordinates. Our aim is not to be comprehensive but instead to provide spatial overview of well-known large polities. We compiled GDP (PPP) per capita from 1000CE to 2000CE data for West Europe, United States, India, China and Africa from Maddison (2007) “Contours of the World Economy, 1-2030 AD”[73].

All analyses were performed in R (version 4.3.3) for full session info and package usage see “Code Availability”.

Data Availability

The datasets generated during and/or analysed during the current study are available in the figshare repository available after submission of the article.

Code Availability

The code to reproduce the figures and analyses in this manuscript are available at https://github.com/cwaldock1/biodiversity-poverty which will be made a release version on acceptance.

Author contributions statement

Author contributions following the Contributor Roles Taxonomy (CRediT):

C.W. – Conceptualisation, Data curation, Formal analysis, Investigation, Methodology, Project Administration, Software, Visualisation, Writing - Original Draft, Writing - Review and Editing

M.A.O. – Conceptualisation, Writing - Original Draft, Writing - Review and Editing

V.T.H.N. – Conceptualisation, Writing - Original Draft, Writing - Review and Editing

A.S. – Writing - Review and Editing

O.S. – Conceptualisation, Investigation, Project Administration, Writing - Original Draft, Writing - Review and Editing

Positionality, inclusion and ethics statement

In writing a global study, we must reflect on who we are as authors and who we imagine we write for [120]. CW undertook his education and post-doctoral work in the Global North and, in writing on a global topic, unavoidably applied a foreign pose (from where one writes). He writes for others with a foreign gaze (for who we write) to better recognize that research on global biodiversity and poverty, and the resulting conservation "solutions", exist in a world of power imbalances and asymmetries that shape interpretations which continue from the colonial project. OS undertook most of his education in the Global North but lived and studied in the Global South for some years in his early formation. He has continued to work with partners and students in and from the Global South throughout his career, and his family is rooted in the Global South. He writes for readers in the Global South and in the Global North, struggling with identity conflicts through much of his academic career. MAO is from Kenya, "Global South", lived, undertook her education and developed a career in Kenya working in academia and initiating conservation projects with local communities in Kenya. MAO undertook her studies at MSc and PhD in the "Global North" through scholarships. Her exposure and experience allows her the privilege to compare the understanding she has of the inequality and power imbalances in the issues we are addressing in this manuscript between the "Global North" and "Global South". MAO is writing from experience and lived realities for the global community of scientists, researchers, development organizations and governments both North and South with the hope that goodwill and interest prevails to address conservation and economic disparities in an integrative and inclusive way as we aim to realize "biodiversity underpins local wealth". VTHN's education and professional experience span diverse contexts, including mainland Southeast Asia, the USA, and Europe. This global trajectory provides a unique perspective for the paper on the ways global environmental problems like biodiversity loss manifest locally—capturing both their differences and their shared commonalities ("different but also same same"). VTHN's work focuses on critically examining issues of power imbalances, social justice, human vulnerability, and resilience in the face of change. As an interdisciplinary social scientist, through this paper, she aims to bridge the perspectives of biological scientists with the social and political dimensions of biodiversity challenges to underscores the

importance of integrating ecological-social systems for transformative change. Writing from these lived and professional experiences, VTHN seeks to contribute to the global conversation on biodiversity, poverty and conservation, emphasizing the need for inclusive, equitable solutions that address both local realities and global disparities.AS was born and raised in the Global South. She studied political science in the Global North. She has lived in the Global North for 30 years, which has shaped her critical thinking on North-South relations. During her academic career, she learned about the decision-making processes of international instruments and organisations whose legal mechanisms and implementations are characterised by a power imbalance that manifests itself in various political/economic/social issues, such as the unequal distribution of resources, the perpetuation of poverty, and the marginalisation of certain communities. Some of these issues, including the implementation of the SDGs, are highlighted in this article from an interdisciplinary perspective. AS writes mainly for the Global South and is committed to bringing these specific global injustices to the attention of those most affected by this systemic inequality.

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