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Transforming conservation by understanding the role of Indigenous Peoples and Local Communities and their economies

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Abstract

Protected Areas (PAs) are essential for biodiversity conservation and ecosystem services (ES), yet conventional approaches often overlook the role of Indigenous Peoples and Local Communities (IPLCs). This systematic review examines IPLCs' role in conservation through an economies-in-society-in-nature approach. A comprehensive search of Scopus and Web of Science databases (June-December 2024) identified studies examining IPLC economic activities, ES valuation, governance systems, and PA access. The review analysed 43 case studies across diverse geographic regions, highlighting monetary and non-monetary values of PAs from IPLCs' perspectives. Findings reveal significant valuation imbalances: provisioning and regulating services (food production, water regulation, carbon sequestration) are predominantly quantified using monetary methods, while cultural and spiritual services—critical to the identity and well-being of IPLCs—are assessed qualitatively and underrepresented in policy decisions. Exclusionary 'Fortress' conservation models that restrict IPLC access undermine traditional socio-ecological relationships and resource management knowledge and practices, exacerbating local dissent and cultural and traditional knowledge erosion. Such approaches deliver poor conservation outcomes. Conversely, IPLC-led or shared governance models demonstrate transformative potential, as demonstrated briefly from two case studies from northern Australia and India. Results advocate for a paradigm shift toward inclusive conservation policies that recognise both monetary and non-monetary PA values for IPLCs. Conservation strategies must align with community-based values and development to achieve the ambitious 30×30 global conservation target. This approach emphasises integrating traditional knowledge and governance systems into contemporary conservation frameworks for more effective and equitable outcomes.

Keywords: Indigenous Peoples, Local Communities, Protected Areas, Sustainable Economies, Conservation Policy, Governance

1 Introduction

Conserving nature is important for protecting unique flora and fauna and supporting human survival, particularly through sustaining ecosystem functions that fundamentally support

people's well-being. As Dasgupta (2021) says, "we are totally dependent on the natural world. It supplies us with every oxygen-laden breath we take and every mouthful of food we eat". Almost 50% of our global Gross Domestic Product directly depends on nature (Deutz et al., 2020; UNEP, 2023), and the remainder indirectly. Our fundamental needs, i.e. food, air, water, clothing, and shelter, are derived only from nature, with no replacement or alternative to support the living of eight billion people on the planet. Yet, there is hardly any realisation of this dependence among the mainstream community or policy decision makers. The recent reports by the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES, 2024), the United Nations Convention to Combat Drought (Reichhuber et al., 2023), The UN Special Report on Sustainable Development Goals (The United Nations, 2023), and by eminent scholars (Costanza et al., 2012; Costanza et al., 2014; Dasgupta, 2021) and several others highlight the cascade of biodiversity, climate change, drought, land degradation and food crises humanity faces at various local, regional and global scales, and suggest an urgent need for action to better manage, conserve and protect nature to restore its functions and processes that underpin our living.

Protected Areas (PAs) are considered the epitome of conservation and deliver fundamental ecosystem services (ES) such as clean air and water. According to the International Union for Conservation of Nature (IUCN, 2020), a PA is a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ES and cultural values. This definition incorporates people's connections with nature, but only one-way to 'achieve' ES and cultural values, not how people can help manage and deliver those services to sustain their own dependence and relationships with the area while maintaining ES for the broader population. As per the World Database on Protected Areas (WDPA, 2025), a total of 303,313 PAs across the globe cover 17.6% of terrestrial and inland waters (WDPA, 2024). Globally, the total PA coverage amounts to 54.29 mKm^2, with terrestrial and inland waters covering 22.06 mKm^2 (i.e., only about 15% of the total global land area) and marine areas covering 30.24 mKm^2 (WDPA, 2024). To tackle the global crises mentioned earlier, a target of protecting 30% of the terrestrial and inland water and marine and coastal systems by 2030 was set by the Global Biodiversity Framework (GBF) during the 15th Conference of the Parties (COP) (GBF, 2024), known as the '30X30' target. Achieving this target is critical for human survival, not just for the sake of protecting pristine areas.

Actively involving the wider population at every local, regional and global scale to raise awareness of the importance and need for protection of nature is required to achieve the 30x30 target. IPLCs are the key actors here, many of whom have lived in harmony with nature over millennia and can offer valuable insights for the wider population. Globally, IPLCs comprise over 2.5 billion people (Reytar & Veit, 2017) and Indigenous Peoples alone comprise about 476 million (The United Nations, 2020). Many of them live in rural and remote areas across the globe while continuing to follow their culture, traditional practices, languages, and connections to land. Many people of 'local communities', in fact, are Indigenous to their lands, but they are either not 'identified'/ 'self-identified' or formally recognised by their governments as 'Indigenous'. The current UN definition of 'Indigenous' focuses on self-identification, while many state (national) governments refuse to recognise their Indigenous peoples due to people's rights and associated responsibilities under legal frameworks such as the UN Declaration on the Rights of Indigenous Peoples (2007). For

example, a majority of the population in Asia, the Pacific and Africa is indigenous, but often not all are recognised by the state governments. Particularly, in countries like India, Bangladesh and Pakistan, where colonisers had to leave following independence (unlike in Latin America), a large majority of the population belongs to those places, and many rural people (Local Communities) have kept their value systems, including languages and culture, intact in one form or another. However, their recognition by the state governments is limited only to the tribal people living in the forests (Bijoy et al., 2010). Hence, we argue that an estimated 2.5 billion IPLCs, i.e. roughly one-third of the global population, broadly follow their traditional practices and hold close connections with the lands they live in. These people could be pivotal in informing, guiding, and transforming conservation to achieve the '30x30' target. Hence, this review, following a mixed approach of a global review analysis and transformative evidence-based case studies, aims to address the gaps in:

1. Understanding the IPLCs' economic values in relation to PAs, and their role in management by systematically reviewing case studies across the globe;
2. Offering evidence on transformative conservation for including IPLCs' perspectives and achieving outcomes both for people and the protection of biodiversity.

As per a WWF report (WWF et al., 2021), IPLCs own and/or manage at least 32% of the global land area, i.e. 43.5 mKm^2 out of 135 mKm^2, through legal and/or customary means (only including communal lands which include local communities; not lands managed by small-scale farmers under freehold or other entitlements). Out of that, 91% of the lands are in good or moderate condition, suggesting that achieving the GBF goals will not be possible without understanding and recognising the role of IPLCs in conservation. Many IPLCs have ongoing, imbued, multi-faceted, holistic, 2-way relationships with their landscapes that include meeting economic (livelihood) needs, the well-being of people and the rest of nature, fine-scale traditional knowledge and skills and capabilities, and people's rights and responsibilities towards their lands (Chan et al., 2012; Pascual et al., 2017; Sangha et al., 2015; Sangha & Russell-Smith, 2017). Such a close, reciprocal relationship enables communities to adapt and adjust their needs according to the resources available and to fulfil their social and cultural obligations towards their landscapes (Chan et al., 2012; Sangha et al., 2021).

In contrast, our modern (Western) conservation models, often called 'Fortress' or 'Protectionist' model, focus on protecting nature by excluding local people, implying top-down governance, along with other policy tools such as bans, fences, fines, etc. (Kegamba et al., 2023; Rai et al., 2021; Sangha et al., 2024; Wilshusen et al., 2002). Fortress models are based on the belief that the protection of nature is best achieved by creating PAs where ecosystems can function in isolation from human disturbance, such as prohibiting extractive resource use and other activities of local people, while ironically at the same time promoting state-regulated tourism, that many times involves a recorded spread of weeds, pests and wildfires (Sapignoli & Hitchcock, 2023). In the current Anthropocene era, with human footprints globally, understanding and managing human activities is critical if we seriously want to protect nature. In that context, understanding the economic values of IPLCs derived from their natural landscapes can offer valuable lessons to the rest of the world on transforming conservation practices.

A key element of IPLCs' close-knit relationship with nature is the integration of their activities, including resource use and values, with their landscapes; in contrast to modern society, which hugely depends on nature's resources but is oblivious to the same fact (Costanza et al., 2017; Sangha et al., 2024). The application of Fortress approaches for conservation has led to isolation, exclusion, and often evictions of local people from the landscapes they managed over millennia (The Indigenous World, 2024). Much of our work with IPLCs has revealed that isolation and lack of attention to their concerns by governments/decision makers have contributed in some circumstances to retaliation in different forms and shapes, such as poaching, and illegal harvesting of Non-Timber Forest Products (NTFPs) or fuelwood. From conservationists' perspectives, such behaviours are largely perceived as resource extraction or destruction, while Fortress conservation policies simultaneously isolate and deprive locals of their rights to their lands (The Indigenous World, 2024). We postulate that understanding and recognising IPLCs' connections with their lands, and finding a balance for them to meet their tangible and intangible needs at a sustainable scale, is the first step towards achieving effective conservation outcomes (Sangha et al., 2024). This paper highlights the tangible and intangible values IPLCs hold for their lands, which shape their economies and provide evidence that if people's values and economic needs are supported, better conservation outcomes could be achieved.

In implementing Fortress conservation models, IPLC's economies (monetary and non-monetary) are typically ignored. At the same time, governments encourage economic development based on external tourism enterprises that deliver substantial monetary benefits, which largely accrue to the state, rather than local people (Balasubramanian & Sangha, 2023; Kegamba et al., 2024; Mahalwal & Kabra, 2023). Developing sustainable livelihood economies and well-being pathways for local people can help them to actively and effectively engage in managing resources and achieving conservation outcomes, as highlighted in this paper in two case studies, one from a high-income country, Australia, on Indigenous fire management, and another from a low-middle income country, India, on Indigenous-led economic activities in the Western Ghats which is a global biodiversity hotspot.

We call IPLC economies 'economies-in-society-in-nature' following Costanza et al. (2017) — representing an integrated systems perspective where economic activities are nested within social structures, which in turn are embedded within the ecological foundations of the planet. IPLCs' economic systems function as an integral component of complex social-ecological systems, alongside institutions and values, as proposed by Ostrom (2009). Conventional economic thinking has largely failed to acknowledge this nexus and its role in IPLCs' economies. In this paper, we underline the IPLCs' economies, for both monetary and non-monetary values, that operate mostly in the areas of conservation significance. This paper aims to contribute towards transforming conservation to achieve faster, authentic, and effective biodiversity outcomes in partnerships with local communities.

The paper is organised into the following sections: the next section describes methods, followed by results with a subsection on the review of selected studies and another subsection on selected case studies of transformative change for including IPLCs in conservation. The last section presents discussion and conclusions focusing on how

understanding the importance of IPLCs' efforts and economies can lead to developing sustainable pathways both for people and conservation outcomes.

2 Methods

We applied a mixed approach of review analysis of the selected articles, as described below in the first section (selection of studies), followed by two brief case studies that highlight the transformative change.

2.1 A review of global literature: selection of studies

This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure a systematic and transparent review process. A comprehensive search was conducted from June to December 2024 across two major databases: Scopus and Web of Science. The search strategy employed keywords related to Indigenous communities, PAs, ES, and local economies, in studies including a combined focus on the intersection of ES, IPLCs and PAs. The search yielded 4,667 records (106 from Scopus and 4,561 from Web of Science). After removing 21 duplicates using reference management software, 4,646 unique records remained for title and abstract screening. Using predefined inclusion and exclusion criteria (illustrated in Fig. 1), we excluded 4,579 records that did not meet our research objectives for lacking a combined ES, PAs and IPLCs focus, leaving 67 studies for full-text assessment.

Fig. 1. PRISMA flowchart illustrating the selection process of articles for the review.

Studies were included if they focused on IPLCs in terms of economic activities and livelihoods, identified and described ES, applied valuation methods (monetary or non-monetary), addressed land tenure arrangements or provision/access to ES, and were published in English in peer-reviewed journals. Studies were excluded if they were literature reviews without primary data, conference proceedings or abstracts, book chapters, or were unrelated to ES, PAs, and IPLCs. Following a full-text assessment against these criteria, an additional 24 studies were excluded, resulting in a final selection of 43 studies for a comprehensive review.

2.2 Analytical framework for study assessment

The selected studies were analysed systematically using a structured analytical framework designed to capture the complex relationships between IPLCs, PAs, and ES. This framework incorporated seven key dimensions, each evaluated according to specific criteria listed in Table 1. The framework was developed based on previous systematic reviews (Dawson et al., 2021; Jinhong et al., 2019; Martínez-Harms & Balvanera, 2012) and the ES classification frameworks established by the Millennium Ecosystem Assessment (2005), Díaz et al. (2015) and the Socio-Ecological System (SES) framework by Ostrom (2009) to address our specific research questions, which include types of ES provided by PAs, monetary and non-monetary values attributed to ES, including both market and non-market valuation techniques (Costanza et al., 2017); land tenure arrangements and governance systems affecting IPLCs; access to PAs for IPLCs; Payment for Ecosystem Services (PES) programs, if implemented in the study areas; natural resource management regimes and responsible authorities; and

policy recommendations proposed by the authors of the studies reviewed (Table 1). This analytical, multi-faceted approach enabled a comprehensive assessment of the complex relationships between IPLCs, PAs, and ES, with particular attention to economic implications and governance arrangements.

Table 1. Analytical Framework for assessing selected studies.

Each study was systematically coded according to this framework by two independent researchers. Discrepancies in coding were resolved through discussion among all the authors until a consensus was reached. We calculated category frequencies and their corresponding percentages to summarise quantitative coding results, identified patterns across the dataset, and employed thematic analysis for qualitative data to identify recurring themes and insights. This dual approach enabled a comprehensive assessment of relationships between IPLCs, PAs, and ES, including economic and governance perspectives.

Application of this analytical framework ensured consistent evaluation across all studies while allowing for the incorporation of context-specific nuances. It facilitated the identification of patterns, knowledge gaps, and promising approaches that inform our understanding of how ES from PAs contribute to IPLC economies under varying governance arrangements.

2.3 Selected case studies highlighting transformative changes

We selected two case studies that exemplify transformative approaches in protected area-related economies, governance and management. The case studies were selected based on specific criteria aligned with the principles of transformative change as described by Díaz et al. (2015) and Bennett et al. (2019). Selection criteria included: (1) demonstrating a shift in power dynamics toward IPLC leadership; (2) integration of traditional ecological knowledge with scientific approaches; (3) documented positive outcomes for both biodiversity conservation and community well-being; (4) innovative governance arrangements that transcend conventional protected area models; and (5) evidence of long-term sustainability (minimum five years of implementation).

To cover diverse socioeconomic contexts, we purposefully selected one case from a high-income country (Australia) and one from a low-middle-income country (India). This cross-income comparison enables the examination of transformative approaches in different resource availability contexts, institutional capacities, and historical backgrounds. The selected cases demonstrate that transformative change is possible and necessary across diverse global contexts to achieve equitable and effective conservation outcomes.

Each case study was analysed using a consistent framework that examined: (1) historical context and catalyst events leading to transformation; (2) governance innovations implemented; (3) mechanisms for knowledge co-production; (4) tangible outcomes for conservation and communities; and (5) challenges encountered and strategies to overcome them. The comparative analysis of these case studies provides insights into common factors contributing to successful transformative approaches and context-specific challenges requiring tailored solutions.

3 Results

We report results on a range of ES derived from PAs, related IPLCS values and economies and governance systems, followed by transformative case studies exemplifying how change is possible to achieve both economic and conservation outcomes. All quantitative summaries below report category frequencies (number of studies assigned to each category) and their percentage of the total sample (n = 43).

We reviewed 43 papers from studies across the globe examining links among IPLCs, PAs and their ES, and related local economies, details below.

3.1 An overview of selected review studies and bibliometric analysis

The bibliometric analysis of keywords from selected articles revealed several distinct thematic clusters centred around ES (Fig. 2). The central and most prominent cluster encompasses ecological, economic, and policy-related dimensions of ES. The economic valuation cluster emerges as the second most significant grouping, characterised by terms such as 'choice experiment', 'contingent valuation', 'willingness to pay', 'integrated value' and 'economic value'. The proximity and connection density between these terms illustrate the methodological approaches commonly employed to capture both monetary and non-monetary values of ES provided by PAs to IPLCs. The 'Indigenous land management' cluster, along with the 'participatory mapping' and 'community-based mangrove management' clusters, demonstrates inclusive governance arrangements that recognise the role of IPLCs as environmental stewards. The connections between this cluster and the central ES node highlight the growing recognition of IPLCs in resource management.

Fig. 2. Network diagram (generated using VOS viewer) of the 196 most frequent author keywords (2014–2024), showing conceptual linkages and thematic clusters in ES research.

3.2 Geographic distribution and temporal analysis of selected review studies

The geographic distribution of studies (Fig. 3) reveals significant regional disparities in research coverage. The highest number of studies was found in the Asia-Pacific region (14 studies, 32.6%), particularly in India, Indonesia, Australia, and the Philippines, followed by South America (8 studies, 18.6%), with notable research in Brazil and Argentina, and Eastern Europe/Central Asia (6 studies, 14.0%), primarily in Russia.

Africa was represented in 5 studies (11.6%), with research primarily conducted in Ethiopia and South Africa. North America and Western Europe contributed 4 studies (9.3%) and 3 studies (7.0%), respectively. The Middle East and North Africa were the regions with the least representation, with only 2 studies (4.7%) of our selected research coverage.

We acknowledge that our selection may have missed studies from some geographical regions. The geographic distribution of current studies reveals notable research gaps in regions with significant IPLC populations and PA coverage, particularly in Central Africa, South and Central America, and the Arctic.

Fig. 3. Geographic distribution of the selected case studies.

The temporal analysis of publications (Fig. 4) reveals increased research attention to the concerns related to IPLCs, ES and PAs over the past decade. The number of publications rose substantially from only one study in 2014 to a peak of seven studies in 2021 and 2022, with some moderation to five publications in 2023 (based on our 43 studies intersecting IPLCs, ES and PAs). The period from 2020 to 2022 accounts for 20 of the 43 reviewed studies (46.5%), reflecting the growing attention to IPLCs in conservation discourse.

Fig. 4. Publications on interlinked IPLC, PAs and ES matters by year.

3.3 Methodological approaches to ecosystem services valuation

Our categorical analysis of valuation methods employed across the 43 studies (Fig. 5) reveals a significant methodological imbalance. Broadly, monetary valuation methods were used in 32 studies (75% of all methodological applications), including market price analysis, contingent valuation, choice experiments, and cost-benefit analyses. This predominance reflects the persistence of conventional economic valuation methods in assessing the relationship between PAs and local communities.

Socio-cultural valuation methods were employed in 9 studies (21% of the methodological approaches), including participatory mapping, cultural significance assessments, and narrative analysis. The comparatively limited application of these methods indicates a persistent gap in capturing a full spectrum of values that IPLCs derive from PAs. Biophysical methods and other qualitative approaches were notably underrepresented, appearing in only 1 study each (2% respectively), suggesting limited integration of ecological metrics and context-specific qualitative insights in current research.

This methodological distribution demonstrates the continuing challenge of developing truly integrated valuation frameworks that can adequately capture the multi-dimensional nature of ES from PAs for IPLCs.

Fig. 5. Valuation methods applied in selected studies to assess ES for IPLC economies.

3.4 Analysis of ecosystem services: Types, economic contributions, and governance influences

3.4.1 Provisioning services

Provisioning services form the foundation of IPLC livelihoods across various ecosystems (Table 2). Among the reviewed studies, forests were most frequently identified as sources of timber, non-timber forest products (NTFPs) such as honey, fuelwood, medicinal plants, and freshwater, while wetlands and mangroves primarily deliver fishery products, timber, and irrigation water. Mountain ecosystems offer unique services like seasonal grazing and specialised medicinal plants, and peatlands contribute to crop production, fuel, and fisheries. Among all, timber and fishery products, crop production, fuelwood, and NTFPs were the most commonly valued resources across these ecosystems.

These services directly support IPLCs' subsistence economies and generate income opportunities. In the Amazon, bushmeat provides critical protein valued at US$2.66 million annually (Nunes et al., 2019), while Bangladesh's mangroves generate US$976 per hectare yearly from fisheries alone (Rahman et al., 2018). Indigenous communities in Australia's

Warddeken Indigenous PA derive substantial economic value, estimated at $2.7 million per annum from local employment (estimated in 2020) (Coyne et al., 2022) (Table 2). Beyond monetary benefits, the ecosystems support construction materials, toolmaking, traditional foods and medicines, and crafts for local markets and provide direct sustenance. Fuelwood remains essential for IPLCs for cooking and heating, reducing their external energy dependence; cooking stoves/fire areas also support cultural space for conversations.

Governance structures significantly influence how provisioning services are recognised and managed. As seen in Australia and Indonesia, Indigenous governance systems tend to incorporate traditional harvest practices and recognise a broader range of provisioning services (Coyne et al., 2022; Mathys et al., 2023; Rumahorbo et al., 2020; Sangha et al., 2021). Areas under shared governance typically show a balanced valuation of multiple provisioning services (Al-Assaf et al., 2016; Aryal et al., 2021; Das et al., 2022; Elia & Yulianti, 2022; Endalew & Wondimagegnhu, 2019; Gagarin et al., 2022; Islam et al., 2020; Lee, 2021; Mishra & Rai, 2014; Nunes et al., 2019; Okumu & Muchapondwa, 2022; Quoc Vo et al., 2015; Totino et al., 2023), while government-governed PAs often emphasise more marketable resources like fisheries, NTFPs or timber (Bhatta et al., 2020; Din et al., 2020; Gandarillas et al., 2016; Loc et al., 2018; Minayeva et al., 2021; Rahman et al., 2018; Rodríguez-Piñeros et al., 2022). Access restrictions in government-managed areas may limit IPLC benefits from these resources, creating tension between conservation goals and traditional livelihoods.

3.4.2 Regulating services

Regulating services provide essential ecological functions that enhance environmental resilience and long-term sustainability across ecosystems (Table 2). Mangroves excel in storm protection, erosion control, and carbon sequestration, while forests are often valued for carbon storage, water regulation, and soil erosion prevention. Mountain ecosystems provide crucial water regulation, soil stabilisation, and hazard mitigation, and wetlands deliver flood control and water purification services. In our analysis, carbon sequestration emerges as the most frequently identified regulating service, followed by water, storm protection, and temperature regulation.

Though less directly monetised than provisioning services, regulating services represent significant economic value to the wider public. Carbon sequestration in Australian savannas offers an opportunity value of US$18 million yearly (Sangha et al., 2021), while the willingness to pay by 210 households for coastal protection from mangroves in the Philippines is valued at US$1,659 annually by local communities (Gagarin et al., 2022) (Table 2). Bangladesh's mangroves deliver storm protection valued at US$13 per hectare yearly (Rahman et al., 2018). In the Sikkim Himalayas, soil and water conservation practices increase crop yields—providing additional income (Mishra & Rai, 2014). Water regulation ensures steady availability for agriculture and fishing, while protection from extreme weather reduces disaster recovery costs for vulnerable communities.

Governance frameworks significantly influence how these services are valued and managed. Indigenous governance systems in Australia and Colombia often recognise the long-term value of regulating services and integrating them into land management (Coyne et al., 2022; Sangha et al., 2021; Toledo et al., 2018). Shared governance arrangements may incorporate customary water management practices alongside scientific approaches (Aryal et al., 2021;

Endalew & Wondimagegnhu, 2019; Okumu & Muchapondwa, 2022), while government-controlled areas might prioritise large-scale carbon offset projects with less local benefit (Din et al., 2020; Rodríguez-Piñeros et al., 2022). Protected area designations further affect this dynamic, with IUCN Category VI areas (sustainable use) frequently highlighting carbon sequestration and water regulation as valuable services (Aryal et al., 2021; Elia & Yulianti, 2022; Lee, 2021; Okumu & Muchapondwa, 2022; Quoc Vo et al., 2015; Rumahorbo et al., 2020; Sangha et al., 2021; Senadheera et al., 2019; Sinsin et al., 2023; Toledo et al., 2018). At the same time, Category II National Parks emphasise watershed protection and climate regulation as conservation priorities (Loc et al., 2018; Minayeva et al., 2021).

3.4.3 Cultural services

Cultural ES provide some tangible, but many intangible benefits supporting IPLCs' identity and well-being (Table 2). Forests provide spiritual, educational, social, and recreational values, while wetlands offer tourism opportunities and religious and existence values. Mountain ecosystems support cultural practices and educational experiences, and mangroves contribute to tourism, aesthetic appreciation, and cultural heritage. Tourism, aesthetic values, and spiritual or religious significance emerge as the most commonly recognised cultural services in the literature reviewed. However, many studies did not measure cultural services, indicating a significant methodological gap.

These services contribute substantially to IPLC economies, well-being and social cohesion. Tourism and recreation in Nepal's wetlands rank third in importance after wood products and edible food, generating direct income through ecotourism and cultural experiences (Aryal et al., 2021). Indigenous well-being benefits from Australian savanna management are valued at US$198 million yearly as non-marketable benefits for 200 communities (varying in size from 500 to 5000 people) living in remote areas (Sangha et al., 2021). Religious and cultural values of wetlands in Nepal and bamboo forests in Vietnam hold significant perceived importance for local communities, contributing to social resilience and traditional knowledge transmission even when not directly monetised (Aryal et al., 2021; Lee, 2021) (Table 2).

The recognition of cultural services varies dramatically, based on governance structures. As demonstrated in Argentina and Benin, Indigenous governance systems strongly recognise spiritual, cultural heritage, and existence values (Arzamendia et al., 2021; Sinsin et al., 2023). IUCN Category III Protected Areas (Natural Monuments) specifically emphasise cultural values, exemplified by Ethiopia's church forests (Endalew & Wondimagegnhu, 2019). Areas with shared governance typically recognise a broader spectrum of cultural services than government-managed areas, which may prioritise tourism revenue over local cultural values (Din et al., 2020; Loc et al., 2018; Minayeva et al., 2021; Rodríguez-Piñeros et al., 2022). Indigenous PAs in Australia integrate cultural services into core land management approaches, simultaneously preserving ecological and cultural heritage (Coyne et al., 2022).

3.4.4 Supporting services

Supporting services such as soil formation and nutrient cycling underpin ecosystem functions and provide the ecological foundation for IPLC livelihoods (Table 2). Mangroves are consistently valued for habitat and nursing functions, while forests provide pollination, biodiversity conservation, and wildlife habitat. Wetlands support nutrient cycling and

biodiversity, and mountain ecosystems maintain critical habitats for wildlife. The data identifies habitat and nursery functions, biodiversity conservation, and pollination as the most frequently recognised supporting services.

Diversity of flora and fauna is often considered a supporting service underpinning many ecosystem functions. Biodiversity in Bolivia's wetlands is valued at US$200 per hectare annually (Gandarillas et al., 2016), while the habitat functions of Bangladesh's mangroves are valued at US$9 per hectare yearly (Rahman et al., 2018). Wildlife habitats in Nepal's wetlands support ecosystem health that underpins fisheries and other provisioning services (Aryal et al., 2021) (Table 2). Biodiversity ensures the continued availability of fishery resources, medicinal plants, and raw materials that sustain traditional livelihoods, while pollination directly enhances agricultural productivity and food security in many communities.

Governance approaches significantly shape how supporting services are recognised and valued. Some Indigenous governance systems emphasise supporting services like habitat provision and biodiversity conservation, integrating them into customary management practices (Rumahorbo et al., 2020; Sinsin et al., 2023; Toledo et al., 2018). IUCN Category VI PAs recognise supporting services while balancing sustainable resource use (Aryal et al., 2021; Boeraeve et al., 2020; Das et al., 2022; Gagarin et al., 2022; Lee, 2021; Okumu & Muchapondwa, 2022; Quoc Vo et al., 2015; Rahman et al., 2018; Rumahorbo et al., 2020; Sangha et al., 2021; Sinsin et al., 2023; Toledo et al., 2018; Totino et al., 2023), whereas Category II National Parks highlight biodiversity and habitat functions as core conservation values (Gandarillas et al., 2016; Loc et al., 2018; Minayeva et al., 2021). In government-managed reserves, the focus often shifts to species protection rather than holistic ecosystem functions, potentially undermining traditional management practices that have maintained these services for generations (Gandarillas et al., 2016; Loc et al., 2018; Minayeva et al., 2021; Rahman et al., 2018; Rodríguez-Piñeros et al., 2022).

3.5 Governance impact on ecosystem service values

Analysis of governance structures and protected area designations across the 43 studies revealed distinct patterns in how ES are recognised and quantified. Different IUCN Protected Area Categories show distinctive patterns in ES valuation. Category VI (PAs with sustainable use) represents the majority of cases in our data and shows balanced recognition across all service types, making it more aligned with IPLC economic needs. In Australia, Indigenous Protected Areas (under Category VI) specifically recognise and support IPLC livelihoods through integrated approaches to resource management (Arzamendia et al., 2021; Coyne et al., 2022; Sangha et al., 2021). As seen in Colombia, Category Ia – Strict Nature Reserves focus strongly on water regulation and watershed protection (Rodríguez-Piñeros et al., 2022), Category II National Parks emphasise regulating and supporting services but may restrict access to provisioning resources, and Category III Natural Monuments highlight cultural services (Flood et al., 2021).

Types of governance, i.e. indigenous, shared, government or private, exhibit clear patterns in how they value different ES. Indigenous-led governance demonstrates broader recognition of traditional and cultural services, higher consideration of supporting services, more holistic integration across service types, and often higher total economic values.

Shared governance arrangements balance multiple service types, recognise market and non-market values, employ collaborative valuation approaches, and integrate scientific and Indigenous perspectives. Government/State governance typically focuses more on regulating services, uses standardised economic valuation methods, sometimes undervalues cultural services, and emphasises policy-relevant services. Private governance often prioritises market-based approaches like carbon trading or commercial tourism, potentially marginalising local community interests.

Different ecosystem types show distinctive service value profiles that interact with governance approaches. Mangroves demonstrate the highest per-hectare values (reaching US$3,000/ha/year in Vietnam) (Quoc Vo et al., 2015), wetlands exhibit balanced values across service categories (Aryal et al., 2021; Gandarillas et al., 2016), and forests show the highest total economic values in many regions (Okumu & Muchapondwa, 2022; Rodríguez-Piñeros et al., 2022; Senadheera et al., 2019) (Table 2). Mountain ecosystems provide unique combinations of services with high cultural values (Arzamendia et al., 2021; Bhatta et al., 2020; Din et al., 2020; Downing et al., 2023; Mishra & Rai, 2014), while peatlands offer specialised services, including carbon sequestration and crop production. These patterns highlight the need for tailored governance approaches that recognise the specific service profiles of different ecosystems while respecting IPLC needs and values.

Table 2. Ecosystem services across ecosystems, governance and valuation methods

3.6 Transformative case studies

To demonstrate how Indigenous-led approaches enhance ES-based Indigenous economies and improve the ecosystems to deliver conservation benefits, we briefly describe two case studies. The intention was not to provide an exhaustive global representation but to showcase practical, evidence-based examples that demonstrate what works in real-world contexts.

These cases were chosen for several reasons. First, they represent diverse socioeconomic and governance settings—one from a high-income country (Australia) and the other from a low-middle-income country (India). This contrast highlights that transformative approaches can succeed under vastly different resource conditions, institutional capacities, and historical contexts. Second, both cases have demonstrated long-term sustainability, operating successfully for more than a decade and delivering enduring benefits for biodiversity and community well-being. Third, they exemplify governance innovation, moving away from exclusionary models toward participatory or Indigenous-led systems that integrate traditional ecological knowledge with modern science. Finally, these cases offer replicable lessons for other regions, providing practical insights into how culturally appropriate, community-driven strategies can help achieve global conservation targets.

Indigenous fire management in northern Australia

Introduction: Northern Australia's tropical savannas (≈1.2 million km²) were historically prone to extensive late-dry-season wildfires that elevated greenhouse gas (GHG) emissions (Fig. 6). Under the Carbon Farming Act (2011), the Savanna Fire Management (SFM) program formally recognised Indigenous burning as an emissions reduction method. Since 2012, SFM has abated ~1.2 million tonnes of GHGs across >24 million hectares, with documented biodiversity gains and substantial socio-economic benefits for remote Indigenous communities, including significant non-market well-being values and reduced public expenditure (Edwards et al., 2021; Sangha et al., 2021). Carbon credit sales now generate ~AU$100 million per year (Table 3), alongside hundreds of culturally appropriate ranger jobs that strengthen on-Country learning and cultural practice (Sangha et al., 2021).

Governance & knowledge co-production: Indigenous-led entities such as Arnhem Land Fire Abatement (ALFA) Ltd. coordinate clan-based governance over large estates, integrating traditional burning knowledge with remote sensing, modelling and verification systems to assure integrity and investor confidence (Russell-Smith et al., 2013; Sangha et al., 2021).

Impact: Beyond carbon, SFM delivers biodiversity benefits, reduces destructive wildfires, and strengthens cultural practices. This model demonstrates that integrating traditional knowledge with modern policy can create sustainable economies and conservation outcomes.

Why it matters: The SFM model shows that empowering IPLCs and blending Indigenous knowledge with science and policy can deliver durable conservation and livelihood outcomes (Russell-Smith et al., 2013; Sangha et al., 2021).

Fig. 1. Australian savanna landscape with dominant vegetation types (following the Australian National Vegetation Information System dataset). Savanna Burning ('carbon') projects (outlined in black) above the 600mm rainfall isohyet (blue line) using data from the carbon project register by the Emissions Reduction Fund (ERF), Australian Government. Source: (Sangha et al., 2021).

Table 1. Carbon credits for all the main land uses (actual values in US$ 2020, we used a conversion rate of 1 US$ = 1.54 AU$ as on 27 May 2025) from managing fire in the savanna landscape above the 600mm rainfall isohyet region (Sangha et al., 2021)

Indigenous-led Local Economies — Periyar Tiger Reserve (India)

Introduction: The Periyar Tiger Reserve (PTR) in the Western Ghats shifted from decades of conflict—poaching, illicit felling, and exclusion of forest-dependent communities—to a model of inclusive, community-led governance (Fig. 7). The turning point was the India Ecodevelopment Project (IEP) in 1996, which created Ecodevelopment Committees (EDCs) to devolve decision-making, co-design microplans, and develop culturally aligned livelihoods (The World Bank, 1996). This represents a transition beyond fortress conservation toward participatory approaches that recognise IPLC rights, knowledge, and roles in stewardship.

Governance & knowledge co-production: EDCs were supported by a Microplanning Implementation Support Team (MIST), an Ecodevelopment Officer, local NGOs and universities, and later the Periyar Foundation to ensure continuity. This architecture integrated local ecological knowledge with technical planning and tourism expertise, aligning with broader evidence that IPLC-centred approaches can deliver effective, equitable conservation.

Impact: Communities diversified livelihoods—ecotourism, organic agriculture, handicrafts, and women's self-help enterprises—reducing pressure on forests while strengthening social cohesion and 'social fencing' against illegal activities. Conservation outcomes include improved management effectiveness and stability of key habitats and species, consistent with findings from the Western Ghats on the importance of valuing IPLC perspectives and ecosystem services.

Why it matters: PTR demonstrates that empowering IPLCs through co-governance and livelihood transitions can resolve conflict and deliver win–win outcomes for people and biodiversity.

Fig. 2. Map of Periyar Tiger Reserve highlighting tribal settlements within the Reserve, ecodevelopment zones, location of EDCs (Eco-Development Committees), along with the inset maps showing location of the Reserve within the state.

4 Discussion

4.1 Significance of ecosystem services for IPLCs

This paper highlights the importance of ES from PAs for IPLCs, indicating their economic needs, values and associations with protected landscapes and their potential role in conservation. We reviewed 43 case studies from across the globe, analysing various monetary and non-monetary values of provisioning, regulating and cultural ES. The provisioning (mainly food, NTFPs, water for irrigation, fuel wood, etc.)—largely reflecting in-situ IPLCs' values, and regulating services (climate regulation, carbon sequestration, etc.)—largely reflecting values of external parties such as government/NGOs—were typically evaluated in monetary units. Whereas, cultural and spiritual services (camping, bird watching, tourism) (12 case studies out of 43) largely remained unaccounted for due to a lack of monetary units. When cultural and spiritual services were evaluated, that was mostly in terms of their qualitative benefits. We acknowledge that among the cultural services, recreational services were often better studied applying mainstream approaches (10

studies) than the spiritual, ritual and customary values which are vital for IPLCs' identity, customs and overall well-being of people.

4.2 Protected areas as socio-ecological systems

Based on our review and case studies, we postulate that PAs are essentially the socio-ecological systems, as proposed by Ostrom (2009), in which IPLCs operate either directly or indirectly, depending upon their access to the area (reported in only 15 out of 43 studies). A lack of/restricted access to PAs has contributed to IPLCs' isolation from the landscapes they managed over centuries, impacting their relationships, identity and cultural traditions, which at times has also erupted in dissent (per. communications with IPLCs from India, Australia, Tanzania). A kind of regulated access to PAs using GIS/Remote Sensing and applying the eight rules (Ostrom, 1990, 2009) formulated for communal natural resources can assist in the sustainable use of resources and management of protected landscapes. Notably, the current conservation strategies and approaches largely undermine IPLCs' role in managing those landscapes (Rai et al., 2021; Sangha et al., 2024), something which needs to be changed unhesitatingly if we want to achieve the '30x30' target.

4.3 Beyond livelihoods: well-being and identity

Currently, the relationship between IPLCs and PAs is largely considered in terms of livelihoods or economic dependence, with little consideration of how the well-being of IPLCs is connected to PAs that they would have managed for centuries before those areas were designated as PAs by governments (Sangha et al., 2024; Veit & Ding, 2016). The focus of the reviewed studies for this article has largely been on provisional services, not to the same extent on the cultural and spiritual values. Well-being is beyond livelihoods, and embraces identity, spiritual, traditional, ritual and relationship values, which directly and indirectly contribute towards people feeling well, connected, and able to lead the lives that they want to live (following Sangha et al. 2023, 2015 and Sen 1999). For example, conservation policies in many States focus on providing alternative livelihood options for IPLCs to reduce their use of resources and dependence on PAs (e.g. the Forest Act 2006 in India). Hence, restricting access, without considering that people's identity, cultural traditions and ceremonies, languages, relationships and capabilities are developed around the use and value of natural resources from PAs, directly affects well-being.

4.4 IPLCs' capabilities and related opportunities

We emphasise here the role of IPLCs' capabilities, i.e. skills and knowledge—important well-being components—acquired by IPLCs through their in-situ, ongoing, site-specific connections and relationships with the landscapes they live in. People's capabilities play an essential role in leading the lives they want to lead, following the Capability Approach proposed by the economics Nobel Laureate, Prof Amartya Sen (1993, 1999). Put simply, Sen (1999) suggests that if people's capabilities (i.e. their '*set of valuable functionings*') are realised by offering them the right opportunities, it will lead to their 'functionings' (their '*doing and being*') or achievements. Consequently, such achievements will enhance people's well-being/satisfaction or '*utility'* (in Sen's words) (Fig. 8). We apply this approach to suggest that if IPLCs' capabilities, i.e. their knowledge and skills to manage PAs, are appropriately respected and supported, this will enable them to realise work opportunities related to managing PAs as demonstrated in the Australian fire management case study (Sangha et al., 2021; Sangha & Russell-Smith, 2017). Such an approach of realising IPLCs' capabilities and

offering suitable opportunities will further enhance people's utility/well-being, so enabling them to lead their lives the way they want to lead (Fig. 8).

Importantly, IPLCs have two-way relationships with the lands they live in or have access to (Sangha & Russell-Smith, 2017). Hence, the status and functioning of those lands directly impact their well-being, in contrast to the mainstream population, where, despite high levels of dependence on nature (approximately 50% of global GDP is directly, and the rest indirectly derived from nature; IPBES 2024), there is little realisation of nature's role in people's lives (Costanza et al., 2017; Costanza et al., 2014). A global review of IPLCs' involvement in the conservation of PAs suggested that IPLCs play a central and inseparable role, especially when those areas are controlled and owned by locals (Dawson et al., 2021). The Periyar case study demonstrates this point clearly. To date, only a few regional or global-scale studies recognise IPLCs' knowledge and skills to sustainably use and/or manage PAs (for example, Dawson et al. 2021; IPBES 2022 & 2024; Reytar & Veit 2017 ; Sangha et al. 2021; UNEP 2023).

Fig. 8. A framework linking IPLCs' capabilities, functionings, and utilities/well-being with the management of PAs for developing culturally appropriate and equitable economic opportunities (adapted from Balasubramanian & Sangha, 2023).

4.5 Key insights from global evidence

This study reveals four main points:

1. IPLC economies are essentially 'economies-in-society-in-nature' following Costanza et al. (2012), where most of these economies are customary, derived from nature and embedded in local society, and hidden from mainstream market mechanisms. Social relationships, cohesion, and harmony are an integral part of these economies. Such non-monetary economies are pivotal for people's well-being but largely invisible to policymakers and governments. Hence, there is a need to highlight their importance.
2. Isolating IPLCs from the landscapes that they previously managed results in the loss of people's well-being, including identity, cultural norms, ceremonies, and relationships, and most importantly, their capabilities that are pivotal for managing those areas.
3. IPLC's capabilities, i.e. fine-scale knowledge and skills, are vital to be utilised and enhanced to manage PAs, which will help deliver localised, fine-scale, fast solutions to problems such as weed and pest invasions, which are common in many PAs. This will also deliver ES not just for IPLCs but also for the regional and global populations.
4. Involving IPLCs in the conservation and management of PAs offers a cost-effective approach both for socio-economic gains and conservation outcomes. Explicitly defining sustainable use and scale in partnership with locals, following strict traditional governance and rules, in combination with modern monitoring and evaluation tools, can help achieve better management outcomes.

We acknowledge that many studies on PAs, ES and economies, particularly highlighting livelihoods, cultural and spiritual values, are available as grey literature or in local languages, especially in Asia and Latin America, which otherwise could have further enriched the content of this article.

4.6 Pathways for transformative change

To realise the above points, there is a need to develop transformative economic opportunities through a culturally appropriate collaborative approach, genuinely working with IPLCs, understanding and accommodating their needs and aspirations (IPBES, 2024; Sangha et al., 2023; Sangha et al., 2024). Such an approach can lead to innovative Nature-based Solutions (NbS)/Nature-based Economies (NbE), which are being seen as approaches for addressing cascading, ongoing biodiversity and climate crises, as mentioned in the Transformative Assessment by IPBES (2025). Our case studies are a testament to this idea; if IPLCs are enabled through culturally appropriate processes and procedures, there could be substantial conservation gains.

To date, most Governments emphasise finding alternative income sources such as cultivating crops, selling NTFPs, labour, etc., for IPLCs (Balasubramanian & Sangha, 2023), with little appreciation and understanding that IPLCs' management of the landscape also contributes to delivering several ES for the public, such as clean air, water, etc. A narrow livelihood-focused conservation approach can lead to a loss of the very values and practices that have historically contributed to sustainable land management in those landscapes. Economies can be shaped around ES, cultural artefacts, traditional learning, food and medicine, and eco-cultural tourism that align with local value systems. Following Veit and Ding (Veit & Ding, 2016), we argue that a collective, just, and collaborative approach to conservation, including IPLCs' perspectives supporting people's well-being, in-situ traditional practices and management of the landscape, can be cost-effective and deliver efficient conservation outcomes for PAs (Sangha et al., 2024).

Establishing a ground-up, incentivising the NbS/NbE scheme and providing resources and access to people to manage PAs could significantly benefit State Governments and the global public (IPBES, 2024, 2025). These benefits include managing weeds and pests; sustaining wildlife through managing their habitat; preventing natural hazards (wildfires, landslides, flooding, etc.); supporting people's subsistence living; and providing knowledge and skills to future generations to continue practising sustainable living in PAs. Such a collaborative and transformative approach could help achieve conservation as well as Sustainable Development Goals (SDGs), as also typified by fire management in northern Australia (Russell-Smith et al., 2018; Sangha et al., 2021; Sangha et al., 2023). Most importantly, such a joint approach is in line with the so-called 'Malawi principles' of the CBD, emphasising that management should be decentralised to the lowest appropriate level (The United Nations, 2023), and with the International Labour Organization's Convention 169, which states that Indigenous people should be involved when decisions are made related to their livelihoods (International Labour Organisation, 2019).

To transform current conservation approaches, recognition of traditional knowledge, genuine engagement with, and empowerment of, local communities, and provision of equitable, efficient, locally appropriate, supportive local governance structures and pathways are essential (Bennett et al., 2019; IPBES, 2024; Sangha et al., 2023). Once the capabilities of IPLCs and their relationships with their landscapes are recognised and actively employed through NbS/NbE, the benefits will far exceed just the cost of conservation for addressing ecological crises and poverty, hunger and other socioeconomic issues prevalent

in many IPLCs worldwide. In line with Veit and Ding (2016), we suggest that supporting IPLCs in their efforts to manage lands makes good economic sense.

Globally, IPBES, UNEP, the UN-led Finance Initiative and several other organisations have emphasised the need to invest in NbS/NbE to protect biodiversity (IPBES, 2022; WWF et al., 2021). NbS will create ongoing, culturally appropriate, economic opportunities for IPLC to manage and conserve PAs while delivering ES vital for our economies and overall survival (Sangha et al., 2020). Developing such solutions and genuine collaboration with IPLCs will also help realise 10 out of the 17 UN SDGs (i.e. Goals 1-6, 8, 10, 13, 15) along with the protection of biodiversity and delivery of many ES for the global public whilst enabling IPLCs to lead their lives in their own ways.

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Figures

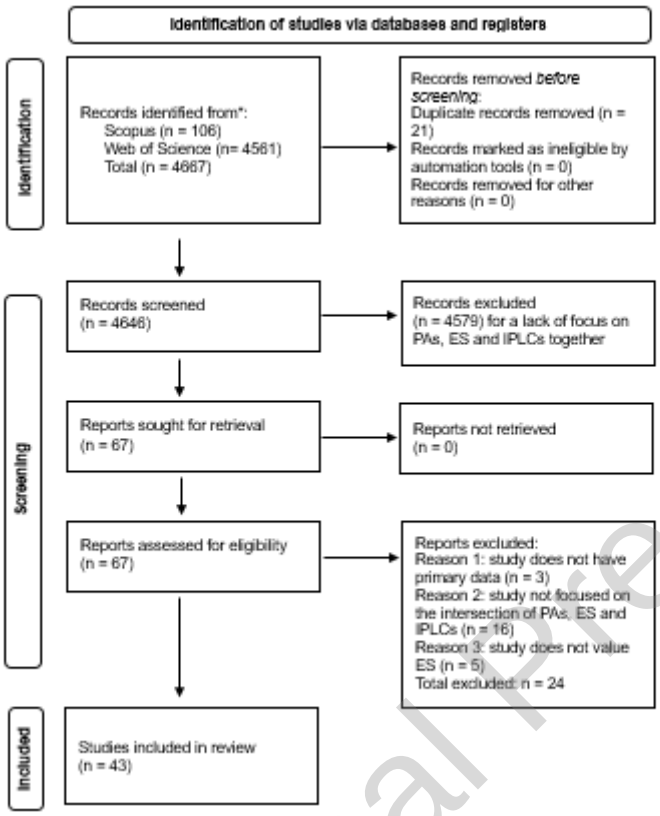

Fig. 1. PRISMA flowchart illustrating the selection process of articles for the review.

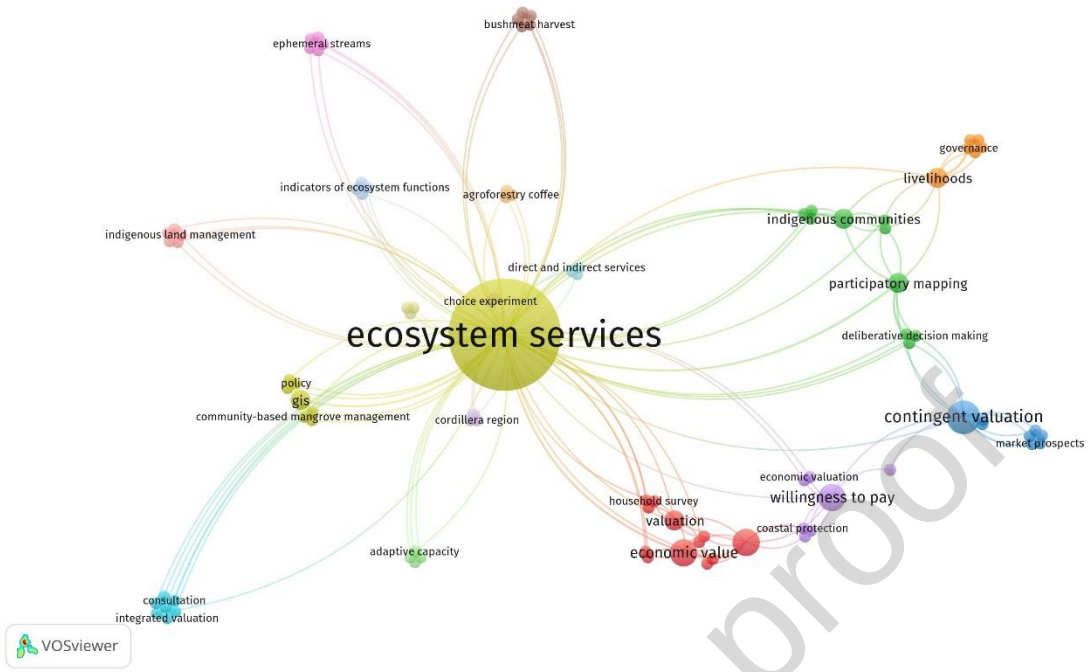

Fig. 2. Network diagram (generated using VOS viewer) of the 196 most frequent author keywords (2014–2024), showing conceptual linkages and thematic clusters in ES research (representing main foci – ES at the centre with different ES types (to the left), valuation methods (to the bottom right), and social-cultural approaches (top right)).

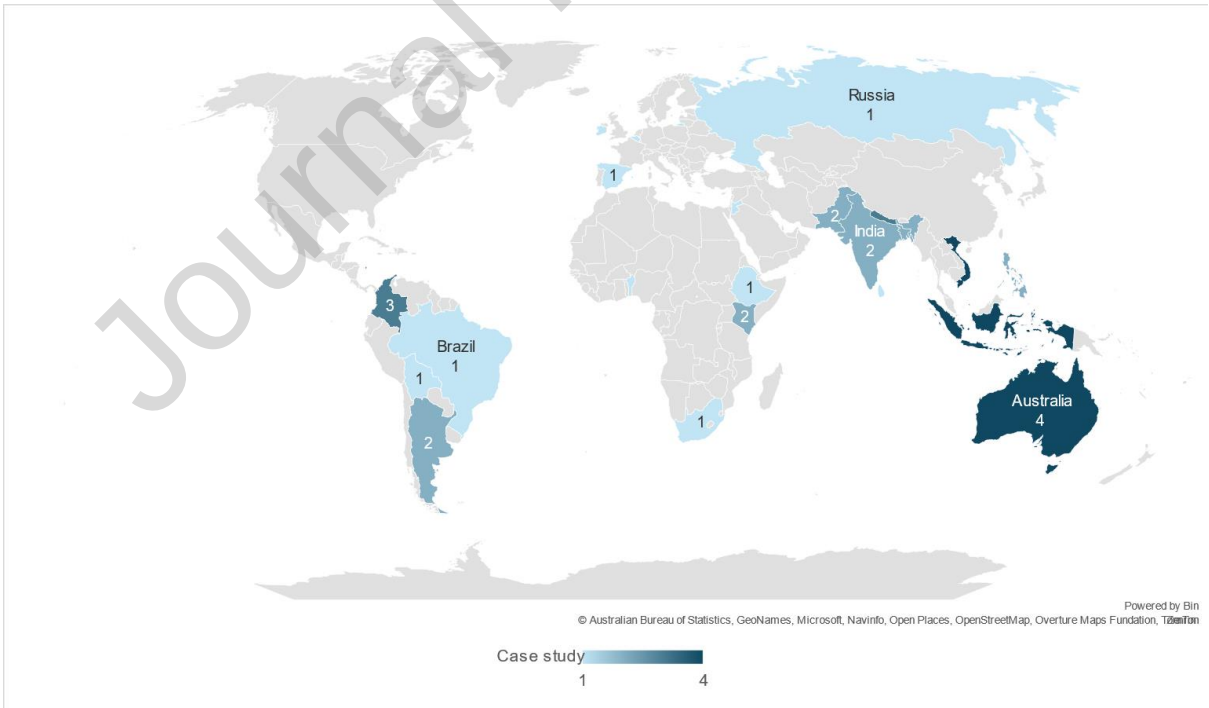

Fig. 3. Geographic distribution of the selected case studies.

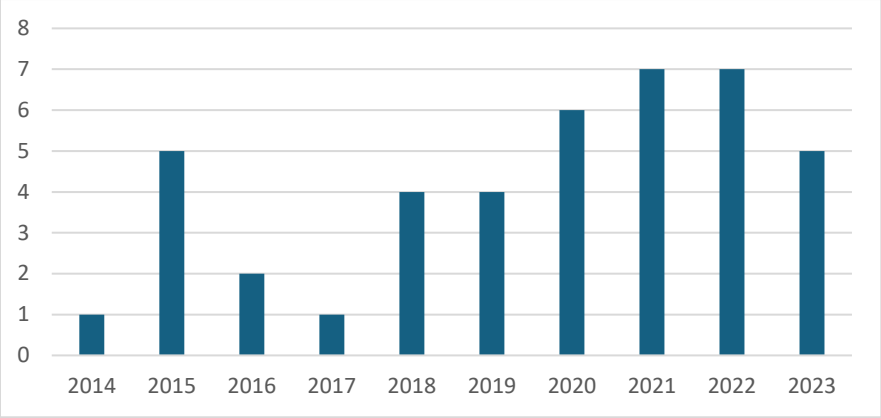

Fig. 4. Publications on interlinked IPLCs, PAs and ES matters by year.

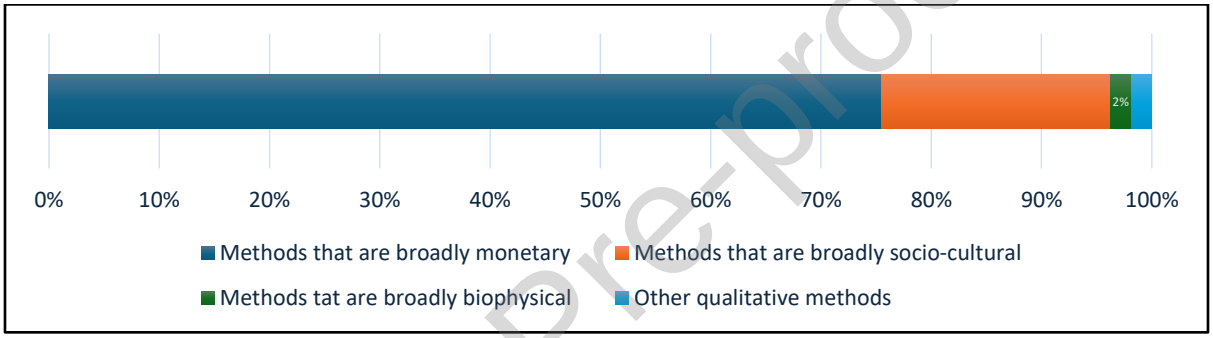

Fig. 5. Valuation methods applied in selected studies to assess ES for IPLC economies.

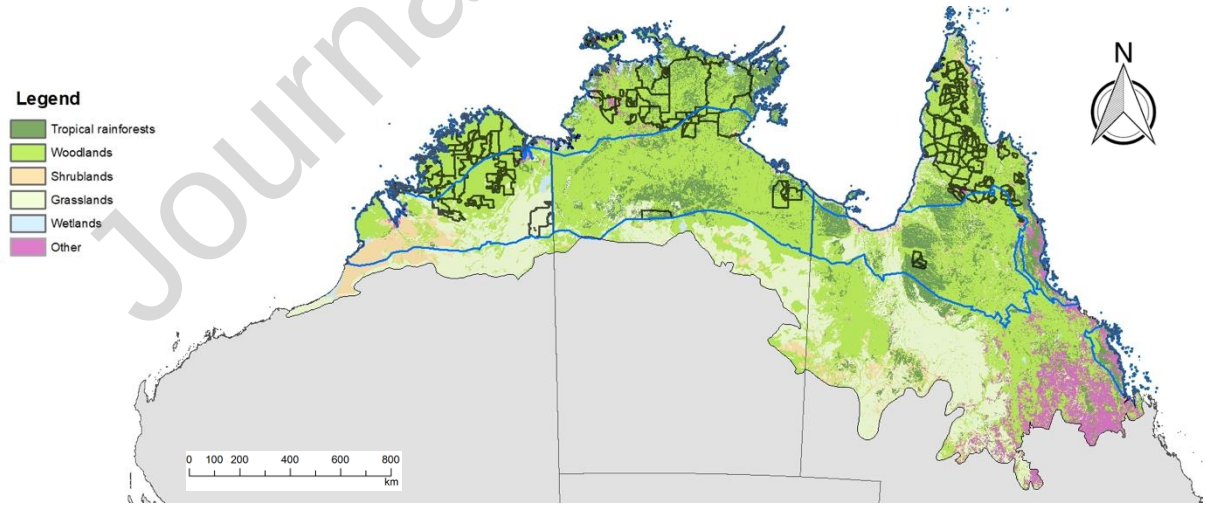

Fig. 6. Australian savanna landscape with dominant vegetation types (following the Australian National Vegetation Information System dataset). Savanna Burning ('carbon') projects (outlined in black) above the 600mm rainfall isohyet (blue line) using data from the carbon project register by the Emissions Reduction Fund (ERF), Australian Government (Source: Sangha et al. 2021)

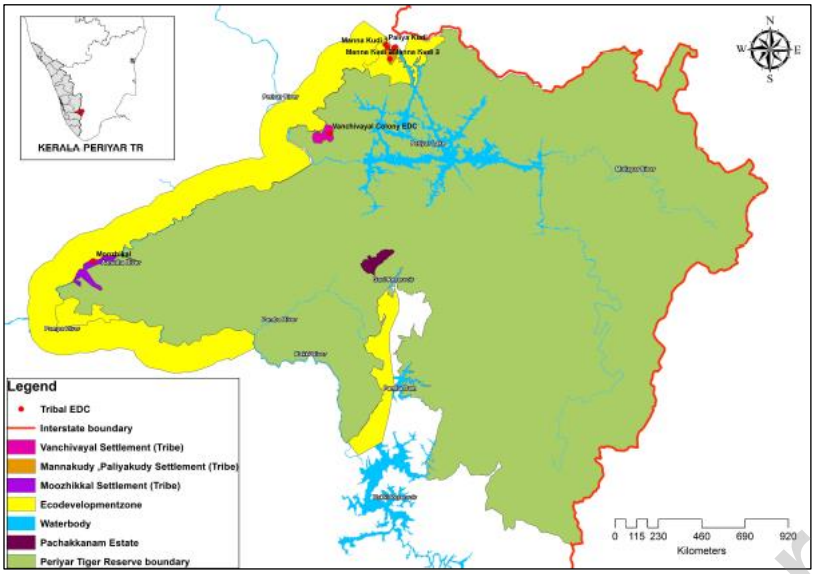

Fig. 7. Map of Periyar Tiger Reserve highlighting tribal settlements within the Reserve, ecodevelopment zones, location of EDCs, along with the inset maps showing the location of the Reserve within the state of Kerala, India.

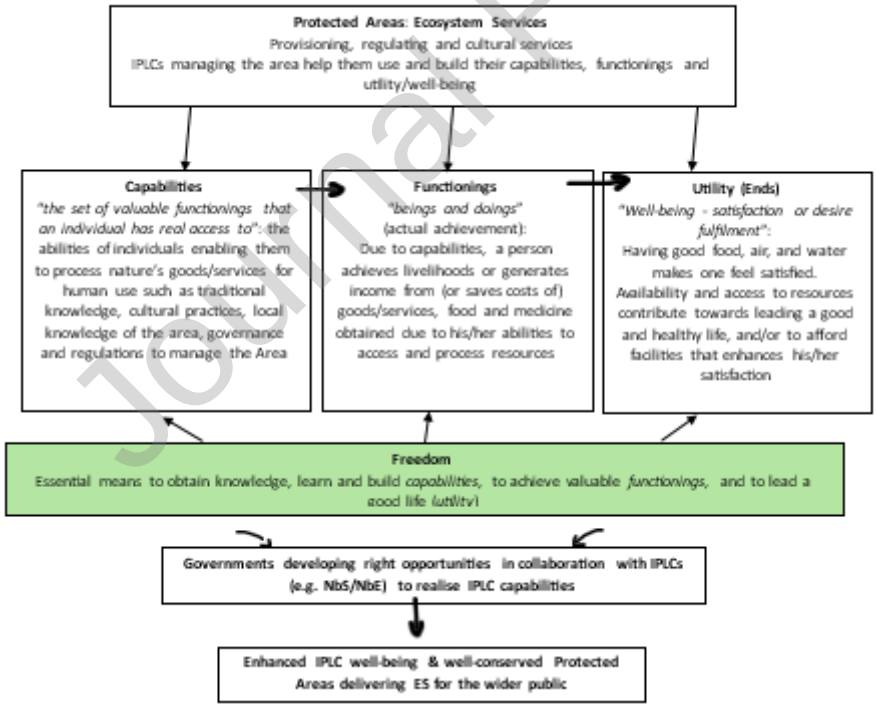

Fig. 8. A framework linking IPLCs' capabilities, functionings, and utilities/well-being with the management of PAs for developing culturally appropriate and equitable economic opportunities (adapted from Balasubramanian & Sangha, 2023).

Tables

Table 1. Analytical Framework for assessing selected studies.

Dimension	Evaluation Criteria	Assessment Method
Ecosystem Service Types	Provisioning services Regulating services Cultural services Supporting services	Studies were analysed to identify which ES were explicitly mentioned. Each service was coded as present (1) or absent (0).
Valuation Methods	Monetary valuation approaches Non-monetary valuation approaches Mixed valuation approaches	Studies were categorised based on the valuation methods used. Monetary approaches included market price, replacement cost, contingent valuation, etc. Non-monetary approaches included cultural significance, ranking and/or mention of specific ecosystem services, etc.
Governance Type	Governance mainly by: Government Shared Private IPLCs	The predominant governance system was identified for each study. Multiple categories could be assigned where hybrid systems existed.
PA Access for IPLCs	Full access Regulated/restricted access Seasonal access No access Access in transition	Access was evaluated based on explicit mention of IPLC rights to enter, withdraw resources from, or manage areas within the PA.
PES Programs	Present (formal) Present (informal) Absent In development	Studies were assessed for the presence of Payment for Ecosystem Services schemes, including their formality, structure, and implementation stage.
Natural Resource Management	State-led Community-led Co-management Private management Traditional management	Natural Resource Management approaches were categorised based on explicit descriptions of decision-making authority, implementation responsibility, and monitoring roles.
Policy Recommendations	Governance reforms Benefit-sharing mechanisms Rights recognition Capacity building Market integration Other	Recommendations were extracted verbatim and coded according to their primary focus and intended outcomes.

Table 2. Ecosystem Services Across Ecosystems, governance and valuation methods.

Ecosystem Type	Provisioning Services	Regulating Services	Cultural Services	Supporting Services	Governance Type	ES Value Assessment Method	Reference
Bamboo	Food Raw materials Bioenergy Timber Medicine Freshwater	Natural hazard regulation Soil erosion Water purification Fresh air regulation Carbon sequestration	Landscape beauty Cultural/religious values	Habitat for species Biodiversity	Shared governance	Priority survey	Lee, 2021
Cultivated	Food production	Water pollution protection Pest control Flood protection Erosion protection	Landscape aesthetics Social cohesion Recreation Education Inspiration Heritage	Biodiversity	Private governance	Scoring method	Boeraeve et al., 2020
Desert	Water for irrigation Crops	Not measured	Not measured	Not measured	Private governance	Willingness to Pay	Aslam et al., 2018

Ecosystem Type	Provisioning Services	Regulating Services	Cultural Services	Supporting Services	Governance Type	ES Value Assessment Method	Reference
Forest - Rainforest	Raw materials Non-timber Forest Products (NTFPs) Forage Fruits Coal Firewood Hunting Farming Medicinal plants Water supply	Water regulation Climate regulation Carbon sequestration Soil fertility Erosion prevention Flood control Erosion control Seed dispersals Wind protection Rain regulation	Camping Bird protection, Scientific research Bird watching Recreation Environmental education Nature appreciation Aesthetic values Spiritual values Worship	Habitat Biodiversity Seed banks Ecosystem integrity Native Forest regeneration	Shared governance Governance by government Private governance Governance by IPLCs	Contingent valuation Replacement cost Choice modelling Growth prediction modelling Ranking matrix GIS Mapping ES Socio Ecosystem Mandala	Al-Assaf et al., 2016; Das et al., 2022; Endalew & Wondimagegnhu, 2019; Mathys et al., 2023; Nunes et al., 2019; Okumu & Muchapondwa, 2022; Rodríguez-Piñeros et al., 2022; Senadheera et al., 2019; Totino et al., 2023
Grassland	Water Timber Grazing NTFP	Soil conservation Air purification	Recreation Tourism	Nutrients cycling Habitat	Governance by government	Deliberative mapping	Loc et al., 2018

Ecosystem Type	Provisioning Services	Regulating Services	Cultural Services	Supporting Services	Governance Type	ES Value Assessment Method	Reference
Mangrove	Fishery products Timber products NTFPs Firewood products Hunting Handicraft Fodder Medicinal resources Genetic resources	Carbon sequestration Air purification Water purification Temperature regulation Waste treatment Shoreline protection	Recreation Tourism Cultural heritage Spiritual and Aesthetic values	Nutrient cycling Habitat and nursing functions Primary productivity Biodiversity Soil formation	Shared governance Governance by government Governance by IPLCs	Market price Travel cost Contingent valuation Opportunity cost Damage-avoid cost Benefit Transfer Production function Meta regression CICES framework	Gagarin et al., 2022; Islam et al., 2020; Quoc Vo et al., 2015; Rahman et al., 2018; Rumahorbo et al., 2020; Sinsin et al., 2023; Toledo et al., 2018
Mountain	Crops Fruits Fodder Medicinal plants Fuelwood Timber products Physical material (stone, sand, or soil) Drinking water Electricity	Carbon sequestration Soil and water conservation Soil/erosion control	Tourism Sports (trophy) hunting Andean cosmology Cultural practices Education Spiritual value Recreation and aesthetics Tourism	Not measured	Shared governance Governance by government Governance by Indigenous peoples and local communities	Market price Net revenue Benefit transfer CBA Ranking method Indicators proposed by IPBES (2019) IPBES's generalised categories of NCP	Arzamendia et al., 2021; Bhatta et al., 2020; Din et al., 2020; Downing et al., 2023; Mishra et al., 2021
Peatland	Crop production Food Fishery products	Carbon sequestration Temperature regulation	Aesthetic values	Not measured	Shared governance	Net Present Value Income	Elia & Yulianti, 2022

Ecosystem Type	Provisioning Services	Regulating Services	Cultural Services	Supporting Services	Governance Type	ES Value Assessment Method	Reference
Savanna	Pastoral and conservation land uses	Carbon sequestration	Indigenous well-being	Soil formation	Governance by Indigenous peoples	Substitute value of government expenditure on Indigenous welfare The market price of Carbon Basic Value Transfer (BVT)	Sangha et al., 2021
Wetland	Timber products Fuelwood Fodder NTFPs Water for irrigation Water supply Livestock grazing	Water regulation Carbon sequestration Flood control Water quality	Education and research Cultural and religious values Tourism and recreation Existence and bequest value	Nutrient cycle Pollination Biodiversity conservation Wildlife habitat	Shared governance Governance by government	Priority ranking method Market price method Net revenue method Transfer method Contingent valuation Benefit transfer Replacement cost method	Aryal et al., 2021; Gandarillas et al., 2016
Woodland	Bundle	Bundle	Bundle	Bundle	Governance by IPLCs	Basic Value Transfer Method	Coyne et al., 2022

Table 3. Carbon credits for all the main land uses (values in US$ 2020) from managing fire in the savanna landscape above the 600mm rainfall isohyet region (Source: Sangha et al., 2021).

	Northern Territory	**Queensland**	**Western Australia**
Carbon benefits per year (values in AU$, applying C price from Emission Reduction Fund (ERF) auction at AU$16/tonne of GHG abatement as in 2020)			
Carbon credits in the form of Australian Carbon Credit Units (ACCUs) from fire management on Indigenous lands (2015-2020 using the Clean Energy Regulator data). 1 ACCU = 1 tonne of GHG emissions abatement	3,445,652	893,554	833,725
Average value (AU$)/year (@AU$16/ACCU)	9,208,734	2,388,081	2,228,185
Jobs# (number of people employed)	>400	>100	>100

[#] these are conservative estimates as the number of rangers working on fire management projects can vary significantly due to the seasonal availability of work, and cultural, social, or ceremonial responsibilities.

Conflict of interest statement

We state that there is no actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations.

Highlights

1. This paper highlights the role of Indigenous Peoples and Local Communities (IPLCs) in managing and sustaining Protected Areas.
2. It examines the role of IPLCs economies, emphasising their consideration and integration into conservation management.
3. It advocates for a novel 'economies-in-society-in-nature' approach for including IPLCs' economies and management perspectives into consideration for conservation.
4. The study highlights that typically, provisioning and regulating services are quantified (& assessed in monetary terms) whereas, cultural services—vital for IPLCs' well-being—are often either ignored or underestimated.
5. Presents two transformative case studies on inclusive, culturally appropriate conservation approaches (i.e. Indigenous fire management in Australia and community-driven ecotourism initiatives in the Periyar Tiger Reserve), yielding significant socio-economic benefits and enhancing conservation.