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An overview of community livelihoods in Biosphere Reserves: based on the sustainable livelihoods framework for the 21st century

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Biosphere Reserves (BRs) are the protected areas proposed by the Man and the Biosphere Programme for harmonious coexistence between humanity and nature. Human activities represented by community livelihoods have always been one of the critical issues in the protection and development of BRs. However, the lack of comprehensive research on the status quo and problems of community livelihoods in BRs has caused difficulties in policy formulation and management. In the form of a literature review, this study attempts to summarize and sort out the overview of community livelihoods in BRs by screening the academic literature with the keywords of BRs and livelihoods and using the 21st Century Sustainable Livelihood Framework as the road map. As a result, community livelihoods in BRs highly depend on environmental resources, increasing vulnerability. Although establishing BRs has brought financial and business opportunities to the community, it also provides environmental resources, public services, and geographical areas in the climate-environmental context needed for livelihood maintenance. However, community livelihoods and climate-environmental context show a contradictory relationship of 'mismatch between supply and demand' in environmental resources and public services in BRs. In geographical areas, the conflicts brought by illegal activities, invasive alien species, and wildlife-human conflicts are also gradually increasing. At the same time, unbalanced physical and financial assets and relational power with mixed praise also challenge the sustainable development of community livelihoods in BRs. Therefore, this study believes that through multi-stakeholder joint efforts, BRs Friendly Community Livelihoods other than the initial livelihood with high environmental resource dependence can be sought for communities through livelihood diversification, community participatory management, and community spatial pattern refinement.

KEYWORDS

sustainable livelihoods framework, man and the biosphere programme, environmental resources, review, resource management

1 Introduction

Man and the Biosphere (MAB) Programme, initiated by United Nations Educational, Scientific and Cultural Organization (UNESCO), is its pioneering flagship venture in biodiversity, cultural diversity and the sustainable use of natural resources. This initiative aims to amalgamate the strengths of the natural sciences and social sciences, promoting

interdisciplinary research, training, monitoring and education. The overarching objective is to protect and use the world's biosphere resources judiciously and sustainably, promoting harmonious coexistence between humanity and nature (Wang et al., 2021). From the mid-1990s, the MAB Programme began to focus on the construction of the World Network of Biosphere Reserves (BRs), fulfilling objectives such as conserving biodiversity, propelling sustainable economic development in communities, buttressing scientific research, facilitating information sharing, experience exchange and bolstering international collaboration (Xian et al., 2022). According to UNESCO, BRs are areas of terrestrial, marine and coastal ecosystems that promote solutions meant to reconcile biodiversity conservation with sustainable use. They are “learning places for sustainable development”—special places for testing interdisciplinary approaches to understanding and managing changes and interactions between social and ecological systems, including preventing conflict and managing biodiversity (Canadian Commission for UNESCO and United Kingdom National Commission for UNESCO, 2022). As of 2021, globally, there were 721 BRs across 131 countries, spanning an aggregate area approaching 7 million square kilometers (Barraclough, 2021).

Within the framework of the MAB Programme, human activities, epitomised by community livelihoods, constitute one of the paramount themes in the conservation and development of BRs, reflected in their zonation norms. BRs are typically segmented into three zones: the strictly protected core area; the buffer zone where ecological practices are implemented; and the transition area, which is conducive to sustainable economic activities and human endeavors. Presently, more than 2.6 million residents inhabit BRs worldwide. The communities they form are instrumental entities in the practical conservation of biodiversity. These communities are at the forefront, discerning shifts in biodiversity and having the opportunity to be the earliest beneficiaries. Concurrently, these communities have amassed a wealth of indigenous knowledge because of prolonged livelihood sustenance. This knowledge, to an extent, harmonizes sustainable development with ecosystem conservation. Traditional production methodologies emerging from this balance have been corroborated in the literature to possess inherent climate resilience, offering defenses against adversities induced by extreme climatic events, such as floods, hurricanes, wildfires, and droughts (UNESCO, 2021). For instance, Yunnan Province, China, has consistently experienced droughts in summer since 2015. However, the indigenous knowledge accrued from the long-standing agricultural practices of the Hani ethnic community in the Ailao Mountains, including terrace construction techniques, water resource allocation strategies, and forest stewardship protocols, has proven instrumental in sustaining local water resources. Consequently, the United Nations and the MAB Programme have advanced a series of prescient conservation initiatives emphasizing community development in BRs, such as the *United Nations Declaration on the Rights of Indigenous Peoples United Nations* (United Nations, 2007) and *Lima Action Plan* (UNESCO Man and the Biosphere Programme, 2016). These conservation endeavors underscore the dialogues and collaborative knowledge-sharing between local communities and research sectors, emphasizing BRs communities' rights, needs, capacities and their ownership, access and sustainable rights to the environmental resources of BRs and their vicinities. The overarching goal is to identify, comprehend and manage challenges that span the economic, environmental, ethical, cultural,

and social dimensions while considering the context of global climate change (United Nations, 2007; UNESCO Man and the Biosphere Programme, 2016).

At present, community livelihoods have gradually become a hot topic in BRs research, focusing on the case level; that is, scholars take each BR as a case to carry out empirical research focusing on the assessment of livelihood conditions, the assessment of the impact of livelihood transformation on the BR environment, and the analysis of the driving factors of livelihood transformation. However, based on rich case studies, there is a lack of articles to sort out and analyze the overall situation of community livelihoods in BRs in the form of a review, which may result in the lack of adequate and systematic research support for policy makers and managers to control the overall development of community livelihoods in BRs. Thus, this paper endeavors to synthesize case studies in the literature and, grounded in the avant-garde theoretical frameworks of community livelihood research, systematically catalog developmental trends and principal challenges of BRs communities' livelihoods.

2 Theoretical framework and literature search

2.1 Theoretical framework

The study of community livelihoods has a venerable history. Since the 1990s, the Sustainable Livelihoods Framework proposed by the Department for International Development has garnered extensive attention academically and pragmatically (DFID, 1999). Nevertheless, within theoretical and empirical research realms, scholars conventionally contend that community livelihoods are dynamic, adjusting in response to the evolving natural, economic, and social environment's trends, seasonality, and shocks. Against the backdrop of rapid global climate change and socioeconomic evolution, community livelihoods across varied regions and developmental paradigms manifest dynamic, transformative traits. Hence, academicians have introduced various analytical frameworks, adapting to the ever-shifting human–environment nexus.

In 2022, the Department for International Development researchers instituted a Sustainable Livelihoods Framework for the 21st Century, which is more open and adaptable than the sustainable livelihoods framework (Figure 1). This framework comprises seven interconnected, dynamically extensible components (Natarajan et al., 2022).

In contrast with most livelihood analysis frameworks, the advancements of the Sustainable Livelihoods Framework for the 21st Century can be delineated into four key distinctions: (i) the introduction of ‘livelihoods in flux’ underscores the dynamic, serendipitous nature of livelihoods, supplanting the previously conceived predictable, stable “livelihood strategies”. (ii) There is a diminished emphasis on the centrality of “livelihood assets”. Instead, the framework's core is characterised by a dynamically nested relationship among assets, relational power, and climate and environmental contexts or relations. The asset classifications have been reduced from five categories (human, social, natural, physical, and financial) to two (financial and physical). Material power relations, crucial for sustaining livelihoods, are now encapsulated

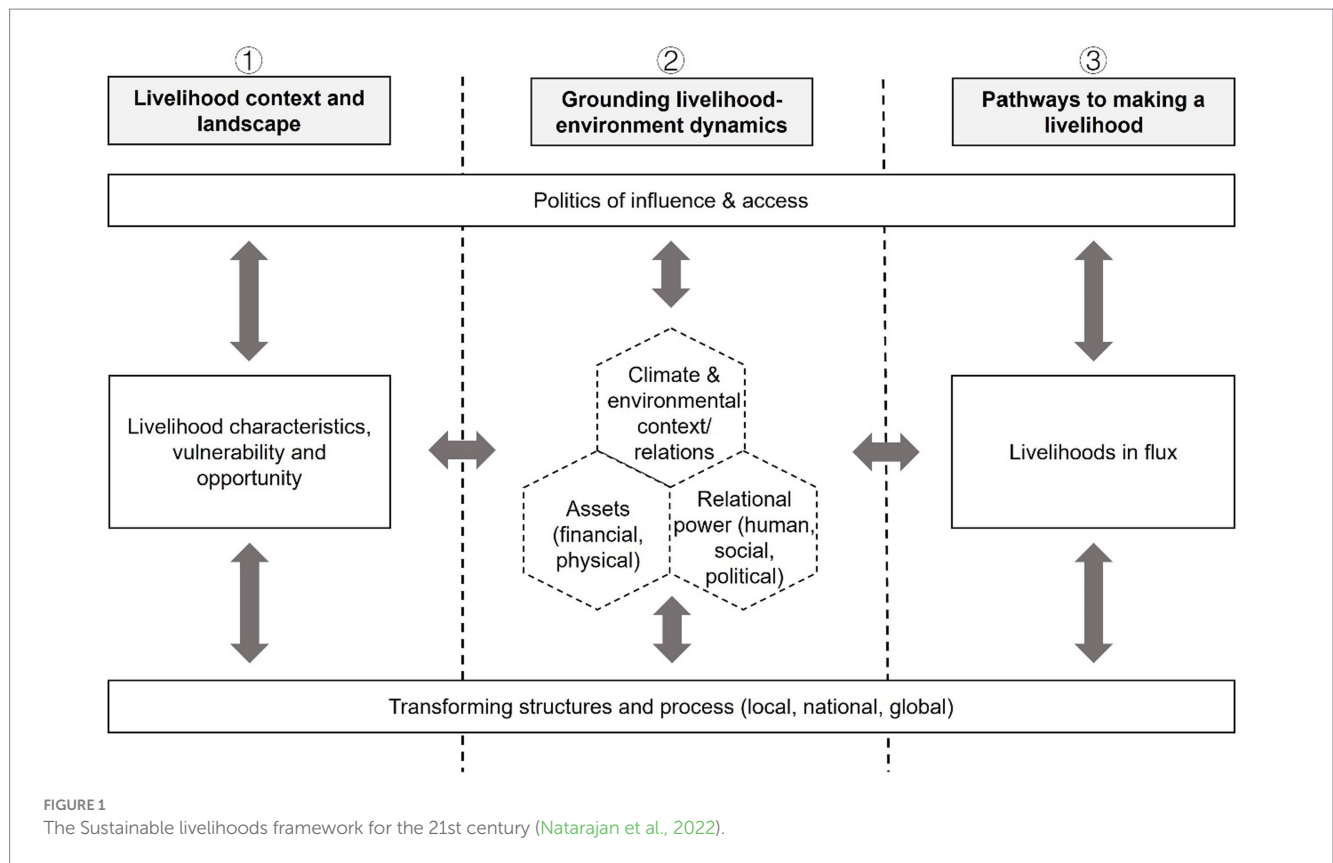


FIGURE 1 The Sustainable livelihoods framework for the 21st century (Natarajan et al., 2022).

under ‘relational power’, and the significance of local and broad environmental contexts on livelihoods is accentuated through ‘climate and environmental context or relations.’ (iii) The inclusion of ‘livelihood characteristics, vulnerability, and opportunity’ epitomises the potential for improving livelihoods, rectifying the original framework’s undue emphasis on the negative connotations of vulnerability. (iv) There is a heightened focus on macro factors such as policy shifts, market dynamics and societal transformations, as well as microelements such as cultural traditions and collective governance affecting livelihoods.

Overall, the Sustainable Livelihoods Framework for the 21st Century deconstructs livelihoods more comprehensively, objectively, and operably. Therefore, based on this framework, this study obtains information in the form of a literature review to achieve an overview of the characteristics, trends, and dynamics of community livelihoods in BRs.

2.2 Literature search

Based on the framework, this study sorted out the general situation and features of community livelihoods in BRs through a literature review. In fact, since the introduction of BRs, the global research on community livelihoods that used these reserves as case studies has proliferated. On a national scale of the MAB Programme, China has creatively pioneered the establishment of the National BRs—Chinese Biosphere Reserves Network, which by 2023 had 191 members. And the number of BRs is the first in Asia, with 34. The research on community livelihoods in BRs has gradually become a hot

topic in China’s BRs research. Almost two-thirds of BRs community livelihoods research papers come from China.

Thus, the literature search was limited to peer-reviewed articles written in English and academic papers (peer-reviewed articles and dissertations) in Chinese with English abstracts on the topics of “livelihoods” and “Biosphere Reserves” simultaneously. A systematic literature search of the articles on BRs and community livelihoods in Web of Science ($n=185$) and China National Knowledge Infrastructure ($n=157$), the most comprehensive database of Chinese publications, was performed. The search time is between 1994, the first year we can search standard-compliant articles in the database, and November 2023.

Finally, a total of 342 articles were gathered for review. After selecting uniform inclusion and exclusion criteria, including the fact that the research content and conclusions are irrelevant or relevant information cannot be extracted, 69 articles were included in the analysis. In general, global research on community livelihoods generally used these reserves as case studies from South America, Asia, and Europe (Table 1). Although mainstream topics such as livelihood assets and livelihood strategies have been the focus, there has been an emerging shift towards cutting-edge themes such as livelihood sustainability, livelihood resilience, and participatory management.

3 Results and discussion

According to the Sustainable Livelihoods Framework for the 21st Century, this study reviews the overall situation of community

TABLE 1 The list of BRs where community livelihoods research literature is located.

Country	Biosphere Reserves (year of publication)
Austria	SalCzburger Lungau and Kärntner ockberge (2018)
Bolivia	Pilón Lajas (2015)
Canada	Clayoquot Sound (2007), Redberry Lake (2007), Manicouagan-Uapishka (2016), Southwest Nova (2016/2017), Bras d'Or Lake (2016/2017), and Fundy (2016/2017)
Chile	La Campana-Peñuelas (2019/2021)
China	Wolong (2004/2013/2017/2018/2019/2020/2022), Maolan (2007), Xishuangbanna (2012/2018), Xilingol (2013/2014/2017/2018/2019/2021/2022), Wuyishan (2016/2017/2018/2019/2022), Fanjingshan (2017/2020), Shennongjia (2017/2021), Mount Huangshan (2018/2020), Qomolangma (2019), and Jingtangshan (2022/2023)
Croatia	Mura-Drava-Danube Transboundary BR (2022)
Ethiopia	Laka Tana (2020)
Guatemala	Maya (2016/2018/2021)
Hungary	Mura-Drava-Danube Transboundary BR (2022)
India	Manas (2010/2013) and Nilgiri (2021)
Indonesia	Giam Siak Kecil-Bukit Batu (2020)
Israel	Mount Carmel (2020)
Japan	Mount Hakusan (2021/2022)
Lebanon	Jabal Moussa (2021)
Mexico	Calakmul (2009/2014/2015), Ría Celestún (2009), La Sepultura (2012), Sian Ka'an (2014), Los Petenes (2016/2019), and El Vizcaino (2022)
Russia	Katunskiy (2021), Altayskiy (2022)
Serbia	Mura-Drava-Danube Transboundary BR (2022)
Spain	Urdaibai (2013), Alto Bernesga (2021), Área de Allariz (2021), Lanzarote (2021), Montseny (2021), and Sierra de las Nieves (2021)
UK	Galloway and Southern Ayrshire (2017)
Vietnam	Kien Giang (2018)

livelihoods in BRs from three aspects: community livelihood context, community livelihood-environment dynamics, and pathways to making a community livelihood (Figure 2).

3.1 Community livelihood context in BRs

In the Sustainable Livelihoods Framework for the 21st Century, the livelihood context defines the wide setting within which livelihoods take shape, including livelihood characteristics, vulnerability, and opportunity. It involves the risk of degrading and deteriorating and the scope and possibility of upward livelihood transformation (Natarajan et al., 2022).

3.1.1 Livelihood characteristics

Within BRs, the nascent community livelihoods generally exhibit pronounced dependence on environmental resources. This phenomenon signifies that communities predominantly use the

forests, pastures, firewood, wild flora and other environmental resources of the BRs and their adjoining areas for primary production, catering to fundamental food and livelihood requisites. In this manner, communities can accrue economic benefits through stewardship and commercialisation of these environmental resources or by transferring usage rights. For instance, in Wolong BR, China, firewood was the most relied-upon environmental resource, with local inhabitants gathering firewood for fuel and wild plants to supplement their daily diet (Song, 2013). In Jabal Moussa BR, Lebanon, residents historically relied on charcoal extraction to sustain their livelihoods (Karam et al., 2021). In the resource-rich Maya BR, Guatemala, the principal revenue source for local communities was from the collective franchise operations of the forest (Bocci et al., 2018).

The genesis of environmental resource dependence is typically attributed to the geographical positioning of BRs. Predominantly, BRs are located in regions marked by pronounced ecological significance but languid economic growth. Of the 34 BRs in China, 18 are within nationally prioritised ecological zones, encompassing reserves such as Baishuijiang, Dalai lake, and Fanjingshan BR; nine are in erstwhile concentrated and particularly impoverished areas. Specifically, BRs such as Foping, Gaoligong Mountain, Jingtangshan BRs have historically been the focal points of China's poverty alleviation efforts. In these territories, the juxtaposition of abundant environmental resources and deficient socioeconomic development dictates that inhabitants' fundamental dietary and livelihood necessities are predominantly satiated through the direct utilisation of proximate environmental resources.

3.1.2 Livelihood vulnerability

Vulnerability is the susceptibility of individuals or collectives when managing external perturbations, encompassing calamities, climatic oscillations, and economic fluctuations (Tong et al., 2020). The environmental poverty trap theory posits a pernicious cyclicality: an exacerbated reliance on environmental resources intensifies impoverishment, catalysing the augmented consumption of these resources. Consequently, communities within BRs, characterised by high environmental resource dependence, inevitably exhibit heightened fragility. However, the provisioning services directly offered to communities by diverse protected areas, epitomised by BRs but inclusive of National Parks and Nature Reserves, have recently experienced multifaceted challenges, exacerbating community vulnerability (Liu and Huang, 2019). This phenomenon's underlying causatives can be bifurcated as below.

3.1.2.1 Negative impacts of climate change

Global climate metamorphoses and the increasing prevalence of extreme weather events detrimentally affect environmental resource provision. BRs inherently function as climatic bellwethers within their respective regions, rendering them more palpably reactive to climatic transitions than non-protected zones are, which accentuates the instability of environmental resource provision within these confines. For instance, Qomolangma BR, Qinghai-Tibet Plateau, has, since 1980, registered an average annual temperature increase of 0.04°C and an incremental annual precipitation of 0.67 mm (Hopping et al., 2018). This trend towards a thermally augmented and humidified vegetative season has destabilized plant species compositions, net primary productivity and the hospitable habitats for various fauna and flora (Liu et al., 2018; Yuan et al., 2022).

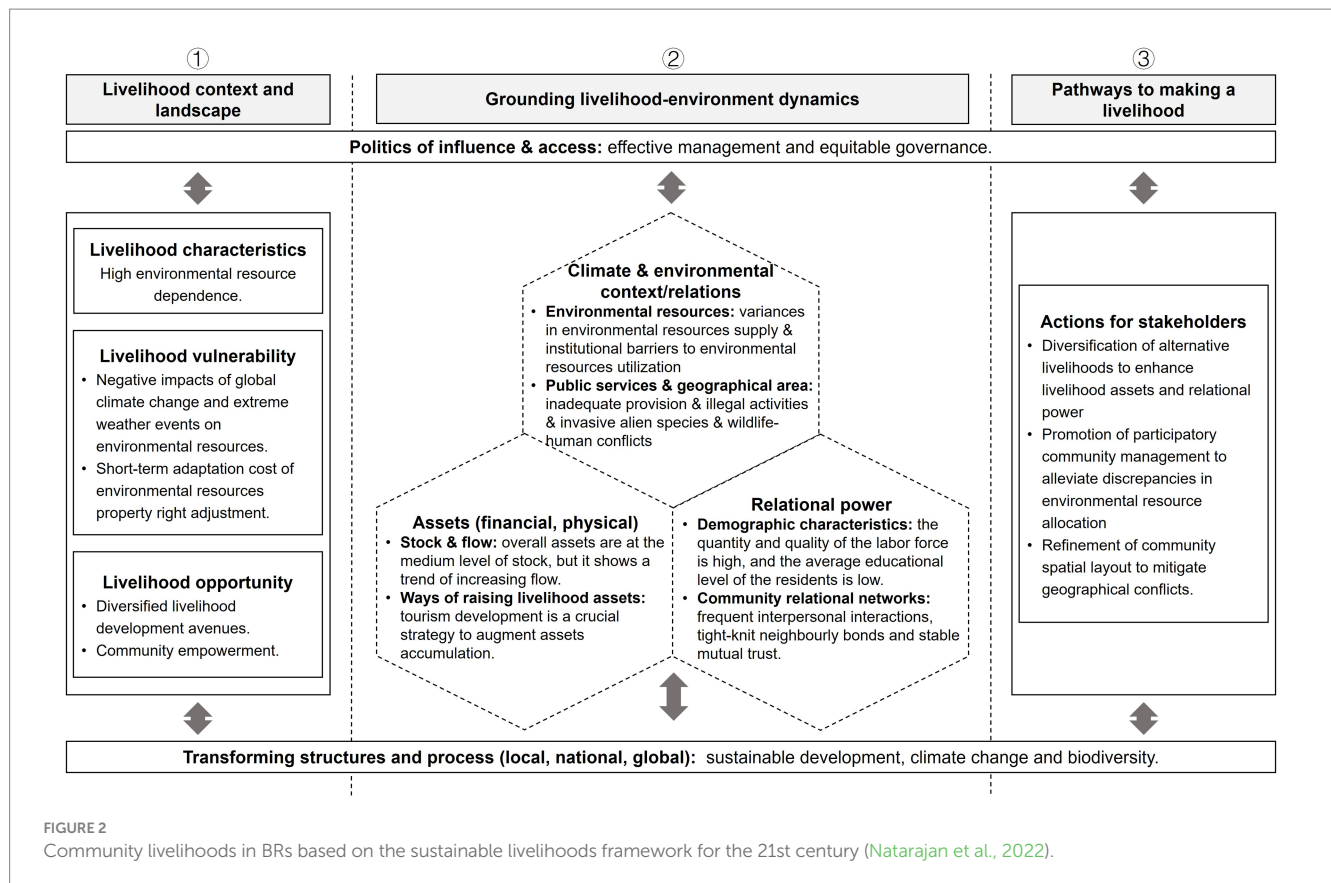


FIGURE 2
Community livelihoods in BRs based on the sustainable livelihoods framework for the 21st century (Natarajan et al., 2022).

3.1.2.2 Adaptation cost of property right adjustment

The demarcation and establishment of protected areas instigate property rights recalibrations on environmental resource ownership and usufruct, engendering elevated adaptational costs for local denizens in the interim. In Jabal Moussa BR, Lebanon, regulatory enactments supplanted pastoralists' land user status with administrative entities, concomitant with a constrained emergence of new employment opportunities, imperiling short-term community livelihood sustenance (Karam et al., 2021). Within Xilingol BR, China, concomitant with escalating industrialization and urbanization, an increasing number of pastoralists have migrated from pastoral regions, catalyzing pervasive grassland transitions. This realignment of grassland resource entitlements engenders stark disparities in unit livestock production costs and economic remunerations between leasehold and non-transitioning households—a disparity accentuated during precipitation-deficient years (Mu et al., 2021).

3.1.3 Livelihood opportunity

Although the establishment of BRs might transiently exacerbate the vulnerability of community livelihoods, the overarching ambition of BRs is to orchestrate a harmonized resolution emphasizing both biodiversity conservation and sustainable utilization. It will lead to several positive opportunities for livelihood development in the community.

3.1.3.1 Diversified livelihood development avenues

Through collaborative synergies with nongovernmental organizations (NGOs), research institutions, universities and corporate entities, BRs proffer diversified livelihood development

avenues for residents, spanning financial backing, ecological product development and market expansion. In China, the valorisation mechanisms of ecological goods inherent to BRs are garnering increasing attention. The portfolio of these ecological products encapsulates green agricultural produce and recreational services, serving dual roles as a sustenance source for wildlife and the bedrock of regional ecological security and habitat integrity. The monetisation of these ecological goods—by morphing them into signature agricultural products and health tourism attractions—proffers economic dividends and employment opportunities for communities (Wang and Xie, 2023). Commodities, such as Wuyishan black tea and Xilingol beef, from BRs in China, have metamorphosed into high-market-value products, often commanding prices 3 to 5 times higher than analogous offerings. Concurrently, the accreditation of BRs attracts environmentally conscious demographics, gravitating to them for nature education and ecotourism. This influx fuels the community's economic engine, leading to roles such as interpreters and tour guides and opportunities in the hospitality sector, amplifying financial gains. For instance, Chebaling BR, China, over the past two years, orchestrated ten nature education events, drawing nearly 200 elementary and middle school students from metropolises such as Beijing, Guangzhou, and Shenzhen. With an average frequency of three visits, each approximately three days, residents, by offering services in gastronomy, accommodation, and transport, earned an average daily revenue of RMB 200. Internationally, beyond ecological product valorisation, BR management entities are fervently searching for how to equip community residents with specialised education and training. For instance, in Katunskiy BR, Russia, in conjunction with NGOs, a comprehensive community development support

architecture was established, encompassing the formulation of over 300 commercial strategies, delivering direct financial aid and employment prospects to nearly 200 households. Moreover, by partnering with local universities to curate rural tourism management and guide training modules, 20–30 local inhabitants are trained annually. Cumulatively, 150 individuals have been credentialed and pursued tour guiding and nature education vocations (Mammadova et al., 2021).

3.1.3.2 Community empowerment

BRs consistently champion the empowerment of local communities, promoting a robust cooperative nexus among communities, administrative bodies, and NGOs. In these communities, such synergistic ties facilitate collaboration with external markets, reduce transactional costs and enhance managerial efficacy. In BRs in Russia, residents are directly involved in the BR's management. Specifically, within Altaisky BR's core area, community committees and publicly governed autonomous entities have been established, collaborating with the BR's management body. Together, they address issues such as waste collection and processing, ecological monitoring, and community participation in tourism. In the buffer zone, a non-profit board is instituted to provide a platform for dialogue and cooperation among management bodies, communities, research and monitoring entities and NGOs (Mammadova et al., 2022). Within China, interconnectivity among BRs is achieved through the Chinese Biosphere Reserves Network's communication mechanism, facilitating regular information dissemination. This network holds a minimum of one national member exchange event and several regional member exchange sessions each year. Participants encompass front-line conservation management personnel, community representatives, researchers, and NGO delegates. The discourse predominantly focuses on cutting-edge scientific research and best practices in conservation management. Within the internal structure of BRs, administrative divisions have instituted specialised roles dedicated to community development. These roles ensure periodic dialogue, problem resolution and feedback concerning community progression. Additionally, recruiting residents as conservators invigorates enthusiasm for active participation in management. For instance, in Chebaling BR's core area and its five administrative villages within the buffer zone, at least one villager from each village is commissioned by the management to serve as a conservator. These individuals partake directly in monitoring forest biodiversity and act as the pivotal conduit for communication between the management and the community.

3.2 Community livelihood-environment dynamics in BRs

Within the Sustainable Livelihoods Framework for the 21st Century, livelihood-environment dynamics are depicted as an evolving nexus where residents, anchored by their foundational livelihood assets and relational power, engage with the spatial-temporally varied climate-environmental context, forming the crux of livelihood analysis. Livelihood assets are perceived as the foundation of individuals' means of subsistence, typically encompassing tangible and fiscal assets. Conversely, relational power characterizes the human, social and political affiliations requisite for sustaining

livelihoods. Relational power supports the foundation of livelihood assets and signifies the pivotal conduit bridging community livelihoods and the climate-environmental context (DFID, 1999; Natarajan et al., 2022).

3.2.1 Climate and environmental context/relations

From an ecosystem perspective, because of their high biodiversity, ecosystem heterogeneity and landscape diversity, BRs are major purveyors and custodians of ecosystem services (UNESCO *Man and the Biosphere Programme*, 2016). These reserves not only supply pristine water sources and various products from agricultural, forestry, livestock and fisheries sectors but also execute functions such as carbon sequestration, soil nutrient modulation, erosion control, biodiversity conservation, water source conservation and climatic regulation. Additionally, leveraging their pristine natural and cultural landscapes, they offer tourism, recreational and aesthetic opportunities (Castillo-Eguskitza et al., 2018; Orna et al., 2021).

From a livelihood standpoint, BRs and the plethora of ecosystem services they proffer construct the requisite environmental context for community livelihoods. These resources can be compartmentalized into four categories: environmental resources with private goods characteristics (such as farmland), for which allocation and utilization exhibit exclusivity and competitiveness; environmental resources with common-pool resource attributes (such as climate and biodiversity), for which resources are non-rivalrous among users; public services integral to the production and daily living (such as transport infrastructure, socioeconomic conditions and demographic structures); the geographical domain encompassing the BRs and their communities, demarcated into core, buffer and transition zones, each with distinct conservation protocols and explicit boundaries.

3.2.1.1 Environmental resources

Regarding provisioning environmental resources, BRs may not inherently possess a pronounced comparative advantage over non-protected areas. There exists a paradoxical relationship between community livelihoods in BRs and the environmental context, characterised by a 'mismatch of supply and demand'.

3.2.1.1.1 Variances in environmental resources supply

Initially, the geographical positioning of BRs encompasses diverse ecosystems (such as mountainous terrains, coastal areas, tropical rainforests, drylands, and savannas). This phenomenon leads to notable variances in the direct resources they can proffer. For instance, Wuyishan BR, revered as the cradle of black tea, endows the community with abundant resources such as tea leaves and bamboo. However, Qomolangma BR, also mountainous but characterized by its fragile alpine ecosystem, may offer significantly fewer direct production resources to residents than its external regions do.

3.2.1.1.2 Institutional barriers to environmental resources utilization

Community acquisition, consumption and management of environmental resources are connected to conservation regulations, resulting in resource stockpiles that may not directly satiate the community's fundamental livelihood needs. The scale, intensity and modus operandi of utilizing accessible environmental resources are also primordially aligned with

conservation objectives. For example, although land ownership in most BRs in China resides with the community collective, BR management typically secures land leasing and operational rights through protracted contracts, often exceeding 50 years, with the community. Such elongated contract durations might lead to a generational disparity between the contract signatories and executors, with potentially vast differences in environmental resource needs. Existing restrictive stipulations on environmental resources, coupled with land lease costs, may have difficulty catering to contemporary community livelihood development requisites.

3.2.1.2 Public services and geographical area

Geographically, a majority of BRs, owing to their remote locations, often have subpar provisions of public transport and foundational educational services. Meanwhile, the frequent occurrence of illegal activities, invasive alien species and wildlife–human conflicts is progressively casting detrimental effects on community livelihoods. Illegal activities and invasive alien species either directly or indirectly constrict the geographical ambit of BRs communities, diminishing the stock of available environmental resources. Wildlife–human conflicts are manifested when livestock nurtured by community members within and around BRs fall prey to predators or when herbivores ravage grain crops, posing a direct threat to community livelihoods.

3.2.1.2.1 Inadequate provision of public services

Many mountainous BRs in southern China, for example, Chebaling BR, have deficient road conditions. Residents find maintaining regular external communications via public transport challenging, necessitating the acquisition of personal vehicles or motorcycles. Concurrently, with educational institutions primarily located in distant towns and villages, many residents, hindered by the costs of private transport, may forgo educational opportunities. This results in an average educational attainment of less than nine years among the inhabitants, substantially below the mean duration for residents in southern China.

3.2.1.2.2 Illegal activities

Based on the literature of 166 BRs across 66 countries, prevalent illegal activities within geographical confines chiefly comprise poaching, wood forest product collection, non-wood forest product collection, drug cultivation, infrastructure expansion, settlement proliferation, disregard for BR regulations, wildfire incidents, land conversion, trash deposition and inadequate agricultural practices. Among these illegal activities, poaching and non-wood forest product collection are the most recurrent, and fires primarily jeopardise forestry-centric BRs and are closely associated with activities such as wood forest product collection, land conversion and settlement, which potentially augment forest flammability (Mehring and Stoll-Kleeman, 2008).

3.2.1.2.3 Invasive alien species

Within 44 National Parks and/or BRs across eight Central European countries, an average protected area contained 11.2 \pm 6.9 invasive alien species; prominent among these, which also remain under stringent management focus, are *Fallopia japonica*, *Heracleum mantegazzianum* and *Impatiens glandulifera* (Braun et al., 2016). These species significantly contribute to the attrition of local species and the

degradation of environmental resources. For example, in Mura-Drava-Danube BR, which spans five European countries, 198 invasive alien species have been reported. Among them, 11 of these species caused local extinctions of a native species, 35 led to a population decrease, 51 to a reduction in performance in at least one native species (Lapin et al., 2021). In Kachchh BR, India, the spread of *Prosopis juliflora*, an invasive alien species, expanded by 42.9% between 1977 and 2011, supplanting grasslands predominantly composed of local species (Vazeed Pasha et al., 2014).

3.2.1.2.4 Wildlife–human conflicts

Regions harbouring multiple protected areas in Asia and Africa continually experience grave losses in material assets, human resources, and finances. For instance, annually, in Africa and Asia, 80,000–138,000 people die from snake bites. In Nepal, the average per-household loss attributed to wild elephants is USD 73, and crop losses due to wildlife–human conflicts average USD 20 (Gross et al., 2021). Consequently, within the geographical domain, the mounting adverse ramifications of illegal activities, invasive alien species and wildlife–human conflicts have rendered the relationship between community livelihoods and the environmental context increasingly discordant, marked by “escalating conflicts”.

3.2.2 Livelihood assets

The assessment of livelihood assets is a pivotal criterion for gauging the progression of community livelihoods. A heightened level of livelihood assets typically signifies an advanced stage of community livelihood development, and a reduced level indicates the contrary. Moreover, minimal disparity among various types of livelihood assets suggests a balanced, sustainable development of community livelihoods.

3.2.2.1 Stock and flow

The extensive evaluations conducted in Wolong, Mount Huangshan, and Xilingol BRs, have demonstrated that although BRs communities exhibit a median level of overall livelihood assets, there is no equilibrium among asset categories. Physical and human assets are often abundant, but financial assets are notably scarce. This phenomenon implies that BRs communities generally possess sufficient infrastructure and an abundance of production resources adequate to fulfil the fundamental livelihood and productivity demands. However, financial resources pivotal to sustaining livelihood objectives, such as liquid cash, bank savings and livestock, are frequently insufficient. As conservation efforts intensify, a growth trend in BR community livelihood assets is observed (Zhang, 2017). Additionally, there is a pronounced spatial differentiation in livelihood assets. Communities located in areas emphasising research, education, and recreation manifest superior levels of livelihood assets than their counterparts located farther from such hubs in BR (Yu et al., 2020).

3.2.2.2 Ways of raising livelihood assets

Tourism development, as a primary alternative to agricultural production, has been validated as a crucial strategy to augment residents' accumulation of livelihood assets and elevate the overall standard of BR community livelihood assets. At the individual level, residents more engaged in tourism development typically possess physical and financial assets superior to those predominantly involved in agricultural production. At the

community level, the augmentative effect of tourism on livelihood assets diminishes with increasing distance from tourism hotspots (Yu et al., 2020). Livelihood assets also play a crucial role in influencing the quality of residents' living environment, life satisfaction, inclination towards ecological migration, policy participation enthusiasm, diversification of livelihood and degree of non-agriculturalization. For instance, for Mount Huangshan BR, increases in livelihood asset levels correlate with increases in environment quality and life satisfaction (Fang, 2018). For Xilingol BR, the level of livelihood assets indirectly affects ecological migration strategies by directly affecting the *per capita* income from business operations and transfers (Zhang, 2018). For Wolong BR, financial assets have a significantly positive impact on residents' propensity to participate in grain-to-green programmes (Xu et al., 2017).

3.2.3 Relational power

A robust relational power framework facilitates the formation of efficient, sustainable livelihood assets, mitigating the tensions between community livelihoods and the climate–environmental context. In many studies on community livelihoods, demographic characteristics, community relational networks and collaborative network structures collectively constitute relational power.

3.2.3.1 Demographic characteristics

Regarding demographic characteristics, the labour capabilities, health status, skills, and knowledge of residents in BRs communities collectively endow them with the aptitude to sustain their livelihoods and achieve developmental objectives. Empirical studies conducted in Mount Huangshan and Xilingol BRs have indicated that the labour force, in quantity and quality, is generally higher than that in the surrounding areas within these communities. However, households typically shoulder a substantial dependency burden, and the average educational attainment of family members is comparatively lower than that in communities outside a BR's perimeter. Concurrently, these demographic attributes considerably influence residents' inclination to persist in agricultural and pastoral productions. Notably, residents with higher educational backgrounds tend to abandon production methodologies heavily reliant on environmental resources (Wu et al., 2017).

3.2.3.2 Community relational network

The majority of communities in most BRs in China have evolved from settlements that share kinship ties or possess a common migratory history. For instance, residents of Chebaling BR are predominantly of Yao ethnicity and migrated during the same period, and residents of Qomolangma BR are primarily from a singular Tibetan lineage, establishing intricate kinship relations among them. Such profound relational bonds have resulted in pronounced uniformity in their production methods, life decisions and cultural beliefs. Hence, the relational fabric of these BRs communities is characterised by frequent interpersonal interactions, tight-knit neighbourly bonds and stable mutual trust. Such traits inherently promote trust and cooperation within the community and expand their outreach to external entities, such as local government agencies, administrative bodies, and environmental conservation NGOs (Fang, 2022).

3.3 Pathways to making a community livelihood in BRs

Under global cooperative frameworks and initiatives such as the Sustainable Development Goals, the Paris Agreement and the Kunming–Montreal Global Biodiversity Framework, extensive collaborations have burgeoned between regions and nations, focusing on sustainable development, climate change and biodiversity. Against this backdrop, the effective management and equitable governance of existing protected areas have coalesced into a new consensus (Chen et al., 2023). Particularly for countries represented by China, which are in the developmental phase in the protected areas sector, institutionalised management and governance have increasingly become focal discussion points. In 2019, the Chinese government officially proposed establishing a protected areas system, primarily characterised by National Parks, but debates regarding the protective prerequisites, methodologies and developmental strategies for these protected areas are ongoing. Because BRs communities exhibit high reliance on environmental resources and demonstrate significant initial livelihood vulnerability, undergoing a transformation—seeking alternative livelihoods for BRs communities—is essential. This transition aims to achieve sustainable utilisation of environmental resources under the premise of fulfilling community developmental objectives, mitigating adverse environmental impacts.

Based on the community livelihood context and livelihood–environment dynamics in BRs, we proposed alternative livelihoods, which should concurrently fulfil the following three criteria: (i) alternative livelihoods can alleviate the contradictory relationship between the BRs communities' environmental resource demands and the climate–environmental context's supply mismatch. (ii) alternative livelihoods can mitigate the frequent geographical conflicts between the BR community and the climate–environmental context. (iii) alternative livelihoods can efficaciously elevate residents' livelihood assets and relational power during their developmental trajectory.

According to the literature on National Parks and Nature Reserves, major stakeholders in BRs community livelihood development comprise the community's residents, management bodies, NGOs, and authorities, including local, regional, and central governments. Hence, beyond amplifying infrastructure investment transport and educational facilities, these stakeholders can undertake the following measures to facilitate community livelihood transformation:

3.3.1 Diversification of alternative livelihoods to enhance livelihood assets and relational power

Empirical research from underdeveloped regions suggests that diversified livelihoods, integrating both agricultural and non-agricultural production, can efficaciously elevate livelihood asset levels better than a singular reliance on environmental resources (Yang et al., 2018). Non-agricultural ventures typically include local or external business activities, labour services and local tourism developments. Nonetheless, promoting non-localised alternative livelihoods in BRs communities might lead to the gradual dissolution of the community, contradicting the BRs' ethos of “harmonious coexistence between humans and nature”. Therefore, promoting a localised blend of agricultural and non-agricultural production becomes a viable pathway for BR community livelihood transformation. In the agricultural sphere, eco-friendly production methodologies such as those endorsed by Rainforest Alliance, Bird

Friendly and Wildlife Friendly Enterprise Network have, under the aegis of natural conservation, yielded substantial economic benefits for several protected area communities (Pereira et al., 2021). In the non-agricultural domain, many BRs and protected areas have introduced ecological tourism initiatives, primarily focused on nature education, in three categories: (i) Homestay-style ecotourism initiatives organised by residents: These projects are generally small-scaled but exhibit flexibility, making them relatively prevalent. (ii) Franchise operations are organised by management or governmental bodies: An example is the snow leopard observation franchise in China's Three-river-source National Park. The park's management body selects and trains local herders to act as hosts, offering accommodations, drivers, and guide services to visitors. The revenue structure ensures that 45% of the earnings are allocated to the host families, 45% to the village collective and the remaining 10% to a wildlife conservation fund. (iii) Community-Collective-Led Initiatives: These remain in the nascent stages of development. For example, in 2018, in Hani Terrace, Azheke Village, China, a tourism company managed by village residents was established. The tourism proceeds are distributed among villagers based on their individual contributions. Notably, due to the moderate involvement of management bodies, governments, and community collectives, the latter two types can assist individual residents in circumventing certain operational risks.

3.3.2 Promotion of participatory community management to alleviate discrepancies in environmental resource allocation

The crux of the tension between BRs communities and the broader climatic–environmental context concerning environmental resource supply and demand lies in the community's limited opportunities to engage in equitable dialogues with the management authority. Many BRs' environmental resource policies are unilaterally formulated by management authorities, devoid of community consultation. However, as nature conservation becomes an increasingly unanimous imperative, communities are progressively acknowledging the significance of safeguarding BRs and environmental resources. Such top-down resource management approaches inadvertently overshadow the community's legitimate developmental aspirations, such as the judicious use of environmental resources, and make sustainable practices—akin to eco-friendly production in protected areas—elusive, perpetuating supply–demand imbalances. Exemplary practices in the BRs of Russia, Guatemala and Indonesia underscore that participatory community management can substantially mollify tensions between the communities and managing authorities, amplifying managerial efficacy (Rasyid and Saghita, 2020; Butler and Current, 2021; Mammadova et al., 2022). Specific strategies for participatory management include establishing regular consultative mechanisms between BRs' management, communities, and NGOs; creating employment opportunities within BRs for community residents; and endowing communities with management responsibilities.

3.3.3 Refinement of community spatial layout to mitigate geographical conflicts

The escalating geographical conflicts between BRs communities and the climatic–environmental context principally stem from the misalignment between the community's original spatial design and the ever-expanding territories of wildlife habitats. For instance, certain

BRs communities might be perilously close to wildlife habitats, or their initial spatial structures might be dispersed, interspersed within these habitats. Nevertheless, BRs communities not only must promote community livelihoods but also become principal arenas for nature education, ecological tourism, and cultural exposition. Territorial conflicts between these communities and conservation territories gravely imperil the sustainable trajectory of BRs. In the majority of National Parks in the United States and Europe, gateway communities have been instituted, relocating communities at the entrances of protected areas, which promotes external community interactions and substantially assuages territorial tensions. Additionally, China's Baishanzu Nature Reserve has formally launched wildlife-induced damage insurance, offering coverage up to RMB 370,000 for agricultural fields, livestock, property, and humans adversely affected by wildlife. Drawing from these extant models, BRs communities can optimise their spatial designs through relocations or refined functional zoning. Concurrently, management authorities, NGOs and governmental bodies can collaboratively institute insurance or funds to provide compensation for wildlife-induced damages stemming from geographical conflicts.

4 Conclusion

Generally, the Sustainable Livelihoods Framework for the 21st Century is highly practicable for sorting out the overall situation of community livelihoods in BRs. Based on this framework, this review elucidates the developmental trajectory and primary challenges inherent in the livelihoods of BRs communities.

4.1 Livelihood context and landscape

The livelihoods of BRs communities display a pronounced dependency on environmental resources, manifesting heightened vulnerability under the influence of climate change and the intricate ownership dynamics of environmental resources. Nevertheless, the BR designation results in various novel livelihood opportunities for the communities, encompassing fiscal support, ecological product innovation and marketing and tourism ventures.

4.2 Grounding livelihood–environment dynamics

The climate–environmental context requisite for community livelihoods comprises environmental resources characterised by private goods and common-pool resource attributes. This also encompasses essential public services integral to production and daily life, as well as the geographical expanse where BRs and their communities reside. However, a discernible mismatch emerges between the supply and demand of environmental resources and public services within the ambit of BRs communities' livelihoods and the climate–environmental context. In the geographical domain, conflicts instigated by illegal activities, invasive exogenous species, and wildlife–human confrontations are intensifying. Regarding livelihood assets, BRs communities' assets hover at approximately a moderate level with conspicuous spatial heterogeneity. While physical assets are

generally abundant, financial assets remain notably deficient. As conservation efforts gain momentum, the overall livelihood assets of BRs communities are increasing. Concerning relational power, BRs communities typically have robust community relational networks, albeit with populations exhibiting lower educational attainments. The ongoing empowerment drive championed by BRs stimulates the formation of consistent cooperative ties between communities and external markets, curtailing transactional costs and enhancing managerial efficiency.

4.3 Pathways to making a livelihood

Based on this review, besides infrastructural investments, stakeholders, such as management bodies, NGOs, and local to central governmental entities, should champion diversified alternative livelihood strategies, encourage participatory community management, and refine community spatial configurations. Such endeavours will facilitate a sustainable transformation to BRs Friendly Community Livelihoods from initial livelihoods, especially for communities characterised by a high dependency on environmental resources and pronounced vulnerabilities.

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Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

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

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