

# Belt and Road Initiative in Central Asia: Anticipating socioecological challenges from large-scale infrastructure in a global biodiversity hotspot

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## Abstract

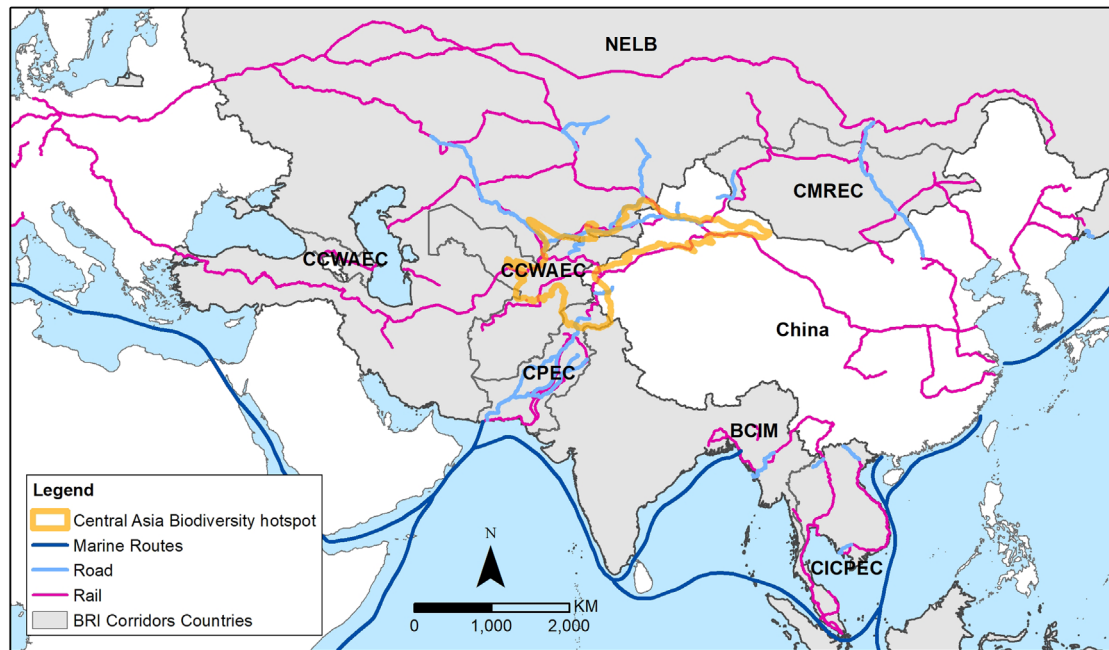
Until recently, China's Belt and Road Initiative (BRI) has overlooked many of the social and environmental dimensions of its projects and actions in favor of more immediate economic and sociopolitical considerations. The main focus of investments under BRI has largely been to improve transport, telecommunication, and energy infrastructures. However, in Central Asia, biodiversity is not only foundational for the livelihoods and socioeconomic wellbeing of communities, it also shapes people's culture and identities. Furthermore, ecosystem services derived from functioning landscapes bring enormous benefit for millions of people downstream through integrated and transboundary water systems. Already under pressure from climate-induced melting of glaciers, the fate of ecologically important areas is considered in light of the potential harm arising from large-scale linear infrastructure projects and related investments under China-led BRI. Following review of some of the anticipated impacts of BRI on mountain environments and societies in the region, we highlight several emerging opportunities and then offer recommendations for development programs—aiming fundamentally to enhance the sustainability of BRI investments. Leveraging new opportunities to strengthen partner countries' priority Sustainable Development Goals and enhancing their agency in the selection of collaborations and the standards to use in environmental impact and risk assessments are recommended.

## KEYWORDS

biodiversity hotspot, Central Asia, China, environmental conservation, impact and risk assessments, linear infrastructure, mountains, policy recommendations, strategic development planning, sustainable mountain development

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**FIGURE 1** Geographic overview of Road and Rail (BRI) infrastructure and maritime routes and Central Asia Biodiversity Hotspot. BRI corridor countries are: China–Mongolia–Russia Economic Corridor (CMREC); New Eurasian Land Bridge (NELB); China–Central Asia–West Asia Economic Corridor (CCWAEC); China–Indochina Peninsula Economic Corridor (CICPEEC); China–Pakistan Economic Corridor (CPEC) and Bangladesh–China–India–Myanmar Economic Corridor (BCIMEC). Road and Rail infrastructure spatial data from Reed and Trubetsky (2019)

## 1 | INTRODUCTION

China's ambitious and ever-expanding Belt and Road Initiative (BRI) is arguably the single most significant development program being undertaken this century. BRI is focused primarily on infrastructure projects, centered on transnational *connectivity*, especially transportation, energy, and communications, now spanning more than 80 countries across all continents except Antarctica (Hughes et al., 2020; Peel et al., 2019; SCMP, 2019). The BRI is anticipated to involve around one-third of the global economy and two-thirds of the world's population with proposed long-term investments estimated at over US\$4 trillion (The Economist, 2016) (Figure 1). Since its launch in 2013, at least US\$200 billion has been invested in over 200 development projects related to BRI (Chatzky & McBride, 2019); and elsewhere figures twice as high have been reported, around US\$400 billion (Ren & Zhong, 2019).

Comprehensive development in recipient or partner countries, however, is contingent both on local geographies including natural and sociocultural resources and their conditions (Sternberg et al., 2017) and historic development pathways together with ongoing constraints or dependencies (Gajjar et al., 2019; Karpouzoglou et al., 2020). Development outcomes of China's investments also are subject to public policies and safeguarding mechanisms in the partnering countries and their levels of

engagement with BRI for aligning mutual interests and developing a common vision for the future across a range of sectors, including but not limited to the economy and construction.

To date, most projects and investments related to BRI have been considered mainly from economic dimensions, with most attention given to transport routes, energy generation and transmission, and telecommunications, primarily as a means to enhance interregional and indeed global connectivity. However, there is increasing recognition—in China and abroad—that sociocultural and environmental aspects of current, imminent and/or planned BRI developments should receive substantially more attention (Ascensão et al., 2018; Kirchherr et al., 2018; Lechner et al., 2018; Liu et al., 2019; Mogilevskii, 2019; Tang et al., 2017). The potential for significant cultural disruption in Central Asia's mountain regions is real in light of major interventions such as BRI. This must be weighed very carefully against desired local, regional, and national socioeconomic benefits, as development of access routes and market forces rarely leave societies unchanged; and this is especially pertinent for indigenous people who often are not properly engaged and may not have given free prior and informed consent.

Given that the BRI is still in relatively early stages of implementation in Central Asia, it should be noted that as of yet there are no comprehensive studies detailing the



**FIGURE 2** Mountain regions in greater Central Asia, with the globally renowned Mountains of Central Asia biodiversity hotspot (CEPF 2017) outlined in red

impacts of BRI on sustainable development. Central Asia includes the first countries to be affected by the BRI *en route* from China to Europe and is home to the globally renowned Mountains of Central Asia biodiversity hotspot (Körner, 2004; Spehn et al. 2006) (see Figure 2; CEPF 2017). Wildlife of special conservation interest in the region include migratory and transboundary species such as the snow leopard (*Panthera uncia*) and argali (*Ovis ammon*) (CEPF, 2017) as well as the region's native fruit trees and locally adapted crop varieties and livestock breeds (Beer et al., 2008; Giuliani et al., 2011; Kassam et al., 2011). The region provides many essential ecosystem services for the 64 million people who live within its 860,000 km<sup>2</sup>, and millions more downstream. Yet a significant portion of biodiversity may be transformed by BRI (Hughes, 2019), including critical ecosystem services such as the provision and regulation of water, stable and fertile soils, bio-cultural diversity and agrobiodiversity, and carbon sequestration (Ascensão et al., 2018; Teo et al., 2019). These mountain environments and their inhabitants are particularly vulnerable to rapid disruptions (Foggin, 2016; Price, 2015; Stone, 1992), including externally induced changes and resulting pressures on well-adapted mountain social-ecological systems.

In this article, we review the challenges for sustainable development in the mountain regions of Central Asia in the context of China's BRI. Specifically, we conduct a spatial assessment of the proximity of BRI infrastructure routes to priority biodiversity areas. We then review poten-

tial environmental challenges and emerging opportunities for sustainable development. Finally, we identify several high-level recommendations for BRI in Central Asia guided by the challenges and opportunities we identified in the previous section. The objective of this paper is to propose a *way forward*—to better advance *sustainability with equity* in Central Asia, with enhanced conservation of biodiversity through leveraging existing opportunities already recognized in China's commitment to biodiversity (see Li, 2019; Niu, 2021; Wang et al., 2020; but also see Foggin, 2020b; He & Cliquet, 2020; Sayer et al., 2021).

## 2 | REVIEW AND SPATIAL ANALYSIS OF ENVIRONMENTAL CHALLENGES

Conserving biodiversity is now widely recognized as a fundamental prerequisite to build, sustain, and strengthen local communities, societies, and nations (IPBES 2018; Millennium Ecosystem Assessment, 2005; Roe et al., 2018; United Nations, 2015). It is important to recognize the integrated nature of socioecological Central Asian mountain systems that have emerged—even codeveloped—over generations (Berkes et al., 2008; Folke, 2006; Kapsar et al., 2019), along with unique and often complex dynamics of telecoupled systems with development interactions and impacts occurring across long distances (Hull & Liu, 2018; Liu, 2017; Kapsar et al., 2019). Diverse and unique cultural heritage is often found in remote

### Environmental drivers

recognizing that mountain regions are integrated or coupled **socio-ecological systems**

**Land use choices**, in both policy and practice

**Use/exploitation** of resources, including impacts of **pollution** (both local and distant sources)

**Invasive alien species**

**Conservation actions** including values, policies, activities, and partnerships with IPCLs

### Social drivers

integrated with **socioeconomic decisions** and consequent outcomes

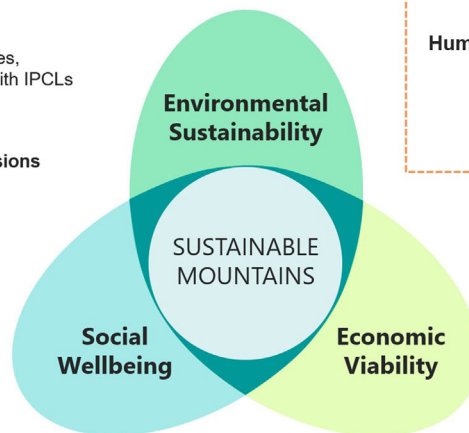
**Population**, including numbers and trends, also **migration** with associated flow of people, funds, ideas

**HDI and sense of wellbeing** including income, health, education

**Governance** (formal and informal) and **NRM practices** (traditional and modern) adopted or promoted

**Technologies**, opportunities, applications in development

## DRIVERS OF CHANGE IN MOUNTAIN SYSTEMS



Note: LULC – land use land cover; NRM – natural resource management; HDI – human development

### Mountain Characteristics affecting opportunities for change

**Biosphere** (biodiversity, carbon stock, land cover, ecosystem services)

**Geosphere** (geology, surface processes, natural hazards)

**Human Systems** (traditional and current LULC)

**Atmospheric and hydrological Systems** (climate change)

### Economic drivers

based in part on adopted **development philosophies** (or 'schools of thought') in economics

**Government policies**, including market integration, transport/access, subsidies

**Programmes/projects**, including funds and new ideas, tools and approaches

**Financial investments** to regions

**Urbanization**, new centres for trade (markets), exchange of ideas and innovation

**FIGURE 3** Conceptual model of sustainable development, with special consideration of key drivers of change in mountain social-ecological systems. Model developed by M. Foggín, adapted from original version published in Wang et al. (2019)

mountain regions with difficult access, where mountain peoples' traditional knowledge and livelihood practices also are regularly linked with a distinct sense of identity. Cultural heritage is integrally connected with mountain biodiversity and is foundational for the livelihoods and socioeconomic wellbeing of communities (Frainer et al., 2020; Gorenflo et al., 2012; Kassam, 2010; Loh & Harmon, 2005; Maffi, 2005; Wang et al., 2019). Extreme care is needed, therefore, to carefully balance the three pillars of sustainable development—environmental sustainability, economic viability, and social (and cultural) wellbeing, which must *all* be considered simultaneously, together with their highly interconnected drivers (Purvis et al., 2019) (Figure 3).

A preliminary spatial analysis of proposed and on-going Chinese funded linear infrastructure projects (roads and railways) in the Mountains of Central Asia is presented in Appendix I. Our analysis of the overall intersection between road and rail infrastructure with high priority biodiversity areas including key biodiversity areas, protected areas and snow leopard landscapes shows a significant number and total area of high biodiversity zones in close proximity to BRI interventions, many of which have little to no protective legislation in place or effective management contributing to the protection of their biodiversity. Nearly all BRI infrastructure projects will have associated direct impacts on the environment, such as through the clearance of vegetation, as well as sec-

ondary impacts including spill-over effects within proximity of infrastructure (Ascensão et al., 2018; Lechner et al., 2018; Teo et al., 2019). Increasing accessibility will further result in novel developments associated with agriculture, extractive industries, and urbanization, as well as waste and pollution such as greenhouse gas emissions and other air pollutants, water pollutants, and solid waste (Hughes, 2019; Teo et al., 2019). A major concern here is the *cumulative impact* derived from successive, incremental, and combined impacts of single or multiple activities (Franks et al., 2013). This is particularly relevant for an initiative of the scale of BRI and for hydrologically connected Central Asian mountain and downstream landscapes.

Four particular challenge areas arising from BRI investments and infrastructure are noted below:

#### 1. Design, assessment, and monitoring

Identifying, preventing, and mitigating potentially adverse environmental impacts including biodiversity loss will require that project design build in transparent monitoring systems for timely and comprehensive social and environmental impact assessments to be undertaken in all BRI development projects, from inception through to project implementation (Ascensão et al., 2018), and that appropriate risk monitoring continue for the entire lifespan of development programs and activities. Relevant risk and impact assessments are most significant for

vulnerable areas, such as ecologically important areas identified as having little/no protection yet are directly intersected by linear infrastructure projects under BRI (such as locations identified in Appendix I) and any overlapping territories and areas that are conserved by indigenous peoples and local communities. While this may pose short-term additional financial or technical burdens, it is widely recognized that in the long term the benefits of protecting biodiversity—and doing so in inclusive ways—will far outweigh the costs, as high levels of ecosystem services are provided by such areas, bringing lasting benefits to society at multiple scales across regions (Brooks & Montes, 2014; Costanza et al., 2014; Keith, 2015; Garnett et al., 2018; IPBES 2019).

## 2. Stakeholder participation

Promoting more inclusive development and recognizing formal and informal (customary) custodians of the land and biodiversity and their practices pose both challenges and opportunities for BRI (Foggin, 2018). Opaque decision-making processes and corruption often plague high value construction and development projects (Transparency International, 2016). Ensuring broader stakeholder participation, especially representation from local communities and indigenous peoples, as well as from a full range of sector interests, assists in identification of potential challenges and opportunities *before* plans are fully set in motion, and generally encourages greater local engagement and support through the lifespan of a project.

## 3. Uncertain futures

With uncertainty increasing in many different ways, from changing climate affecting glaciers and water resources, to the broad reorganization of political and socioeconomic spheres of influence—maintaining and ideally strengthening resilience and adaptability in integrated mountain socioecological systems is of paramount importance (Mitchell et al., 2016). Maintaining biodiversity requires not only the establishment of formal protected areas, but also the strengthening of indigenous and community conserved areas (Farvar et al., 2018) and advancing other effective area-based approaches to conservation (Berkes et al., 2008; Jonas et al., 2017; Swiderska, 2020). Further, a landscape-level vision is needed to address the many competing interests and complexities along with the multiplicity of sociocultural values and approaches (Hanspach et al., 2020; Swiderska et al., 2020; Verschuuren et al., 2021). Values and relational thinking are increasingly recognized as being necessary for sustainable development, leading toward an emerging paradigm shift in sustainability science (West et al., 2020).

## 4. Transboundary issues

Adopting regional and transboundary approaches that move beyond borders also is essential, due to the large scale of BRI projects and their multidimensional impacts. This is especially important where neighboring countries share water resources or keys habitats and wildlife (e.g., snow leopard and argali; CEPF, 2017). Several successful transboundary models are already emerging, such as programs of work advanced for example by the Central Asian Mammals Initiative (CAMI) under the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and International Centre for Integrated Mountain Development (ICIMOD), along with the “20 by 2020” Snow Leopard Landscapes (of which China and all countries in the *Mountains of Central Asia* hotspot are members; Global Snow Leopard & Ecosystem Protection Program [GSLEP], 2014). The geographic scope of all of the above initiatives presents significant spatial overlap with both current and proposed BRI infrastructure in the region.

### 2.1 | Emerging opportunities for partner countries

Drawing on the expanding scope of BRI- related development policy and environmental research emerging in the literature, several significant opportunities for sustainable development are noted for the region.

#### 2.1.1 | BRI can serve as accelerator for change

First and foremost, the BRI could beneficially be reframed and strengthened to serve as an “*accelerator*” for *achieving the Sustainable Development Goals (SDGs) prioritized in partner countries*. For this to succeed, however, there is a need both to clarify and to expand BRI’s stated approach (in China) so that it could more explicitly and also more proactively achieve desired results with sustainable transformations. In particular, BRI endorsed projects and investments should aim to reduce poverty, to increase environmental sustainability, and to advance goals of inclusive development. BRI should move beyond current perspectives of simply building or developing transport routes, and instead build wider and multidimensional regional economic corridors (Taisarinova et al., 2020). For this, greater emphasis on building human and natural capital is needed in tandem with the current focus on reaching ultimate “endpoints” of the long-distance multinational transport routes (Dossani, 2016). Sociocultural dimensions in development should equally be given attention, by addressing historic and geopolitical issues in mountain areas of

Central Asia (Kreutzmann, 2013) and leveraging ‘cultural diplomacy’ (Winter, 2016) alongside projects’ conservation and development goals.

### 2.1.2 | From transport routes to corridors and hinterlands

Secondly, as linear infrastructure construction and expansion currently represents the almost singular output of BRI in Central Asia, these existing projects should simultaneously be used as a springboard for *second-tier investment programs* in non-targeted “hinterlands” of the partnering countries. Such investment focus would help achieve regional development by enabling a wider and more equitable spread of the development benefits and opportunities, whilst maintaining high conservation standards. In all places impacted by BRI, biodiversity (and affiliated biocultural heritage) still must be preserved, lest the region’s hard capital, or assets, be lost—which would prove damaging in the long term for the area’s opportunities for development. However, such increased attention to natural assets must consider two scales, including not only direct and immediate project impacts but also the regional “hinterland” opportunities along with potential environmental challenges requiring mitigation.

### 2.1.3 | Investing in human and natural capital

Finally, long-term development success will only emerge as partner countries equally ensure suitable investment into the *comprehensive development of human and natural capital*—not simply injecting financial resources for development of transport routes or accessing natural resources. The knowledge and professional capacities in partner countries, including local and national hopes and aspirations, along with the countries’ tangible natural assets—many of which are subsumed within the regional biodiversity—are the basic and even essential foundations for their future.

## 2.2 | Recommendations for sustainability

If considered and engaged appropriately, BRI has the potential to contribute not only to China’s own development goals and commitments but also to globally agreed conservation targets as currently being developed under the post-2020 global biodiversity framework. It equally could contribute much toward sustainable development in recipient/partner countries, including achieving the global SDG Goal 15, *Protect, restore, and promote sustainable use of*

*terrestrial ecosystems and halt biodiversity loss*. Biodiversity conservation is integral for development and now broadly recognized as being a *development issue* (Roe et al., 2018); and therefore, should be mainstreamed across all sectors in government, in the donor and banking communities, and elsewhere. In more concrete terms, we recommend the following areas of intervention and actions in relation to BRI (also see rapid-fire summary, Appendix II):

### 2.2.1 | Recommendation 1: Evaluating benefits to partner countries and communities

It is particularly important to clearly evaluate benefits to partner countries and how they can effectively influence emerging partnership agreements (and avoid dependencies); and to determine whether internal policy or institutional reforms are needed, or are advisable, in light of the new arrangements and spheres of influence emerging around the world (World Bank, 2018). Three elements should be recognized and integrated into the BRI vision: (1) only projects that align with partnering countries’ national Sustainable Development Goals should be agreed and implemented, (2) biodiversity conservation should be explicitly recognized as a core value, and (3) greater attention should be given to the broad suite of stakeholders and rights holders—including local *mountain voices*—and thus advance more *inclusive development* in the bioculturally diverse mountain regions of Central Asia.

### 2.2.2 | Recommendation 2: Strengthening and diversifying connectivity

Under the broad framework of regional connectivity regularly highlighted by China’s President Xi, BRI projects should strive to build human capital—especially with a wide range of exchanges at different levels, including academic and other people-to-people interactions, and engaging not only academia but also managers and policymakers in order to promote a sharing of knowledge and cocreation of context-specific solutions of mutual benefit. Overall, strengthening such *human connections* is recognized as essential for greater “deepening [of] political trust and promoting mutual understanding, peace, and friendship among people of all countries” (Sadovskaya & Utyasheva, 2018). More recent BRI-relevant development plans are beginning to highlight projects that also promote social integration, the creation of digital information superhighways, and capacity development (Dossani, 2016; Xinhua News, 2017, 2018).

Exchanges should consider multiple and diverse values, understandings, and uses for nature and biodiversity,

including locally developed governance regimes surrounding the management of natural resources and use of biodiversity. Furthermore, under the broad umbrella of *inclusive development* (Foggin, 2020a), where local communities or indigenous peoples are concerned, obtaining free, prior and informed consent (FPIC)—not only offering prior “consultation” or subsequently “informing” of plans—is of paramount importance (FAO, 2016). In all instances, fair and effective communication amongst partners is contingent on developing and maintaining trusting relationships. Such relationships are encouraged with mechanisms such as the creation of stakeholder networks aiming to promote personal and professional exchanges and knowledge sharing, for example for strengthening conservation and development through a network of mountain protected areas along the Silk Route (van Oosten, 2018). Such people-to-people networks can help to promote critical dialogues across borders and advance initiatives focused on biodiversity and its conservation, complementing or enhancing other established transboundary agreements already focusing on transportation and economic development.

### 2.2.3 | Recommendation 3: Ensuring sustainability best practices

Best practices for infrastructure projects and related developments must be identified, or if needed redeveloped, in order to establish a practical suite of core standards to be followed and monitored across all relevant projects. Such core principles and standards must include environmental elements such as the mitigation of climate related risks of natural hazard in mountain areas, together with a range of social elements such as promoting more inclusive conservation and development and protecting land tenure and access rights. With respect to biodiversity, whatever the methods used (especially with offsetting methods), it is especially important that there be no net loss to biodiversity (Kiesecker et al. 2010; Maron et al., 2015). The BRI could even contribute positively to conservation purposes, beyond mitigating impacts, if sufficient political will were present (Lechner et al., 2018).

Furthermore, it is encouraged that recipient countries require that Environmental Impact Assessment (EIA) processes and mitigation standards be applied to all BRI related projects as well as Strategic Environmental Assessments (SEA) for programs and policies, aiming to ensure that the cumulative impacts of BRI interventions also are considered (Lechner et al., 2018; Hughes et al., 2020); with such processes linked as basic requirements for all international financing and loans (Narain et al., 2020). This will of course require centralized transparent reporting structures, but gains are potentially enormous. For example,

over three-quarters of all the economic benefits derived from building new roads in the Amazon arise from a smaller subset of all road projects with only 10% of the social and environmental damage (Vilela et al., 2020). In the same study, 45% of road projects actually generated economic losses, often resulting in landscape-level changes with substantial negative impacts on the livelihoods of indigenous peoples and infringing on fundamental rights to a healthy environment (Knox, 2018). Rigorous impact assessments are therefore essential. Relevant environmental regulations and governance structures are expected to vary between countries, together with their effectiveness—in large part commensurate with the extent to which the rule of law and the ability to monitor and enforce compliance are in place. Thus, reviews and appropriate legislative and regulatory framework reforms must be considered.

At a fundamental level, risks and impacts of infrastructure projects must also consider uncertainties—including in relation to climate change and globalization (cf. external market forces; Foggin & Cabrera, 2020; Hodges et al., 2014) alongside the financial dimensions of project implementation and subsequent operations, as well as unintended sociocultural and environmental costs and consequences. In many instances the livelihoods of indigenous people will change, which in turn may have consequences for biodiversity as a property of the integrated socioecological Central Asian mountain systems that have developed over many generations but cannot fail to change in the face of growing interconnectivity. Thus, appropriate risk assessment measures should be followed, in order to help not only project investors and developers but also (and especially) recipient countries and local communities to minimize potential impacts of uncertain futures.

### 2.2.4 | Recommendation 4: Focusing on sustainable financing

Finally, in regard to the financial basis of development in Central Asia, new possibilities also exist for securing natural resources (i.e., conserving biodiversity), some of which are ideally suited to emerging, growing markets—and these are becoming increasingly accessible with improvements in regional connectivity through communications and transport infrastructure. In particular, further developments in both agricultural and nonagricultural *value chains* can readily be advanced with increased access to China and its markets, maximizing the benefits from emerging market opportunities. With appropriate novel branding and marketing, niche mountain products may bring high returns, as can ecotourism when developed in community-friendly ways and connecting globally with trusted partners. Conversely, however,

long-term risks or other implications arising from national debts owed for China-backed developments—with debts increasing almost 189 times in Kyrgyzstan in less than a decade (Seneviratne, 2019)—further highlight the continued need for careful, strategic prioritization of the types and the sources of development investments and for simultaneously addressing social and environmental concerns.

### 3 | CONCLUSION

The enormous geographic scale of China's BRI brings with it both challenges and great opportunities for conservation and sustainable use of biodiversity. However, Central Asian (or any local or regional) perspectives must always be considered clearly and explicitly, and strengthened, so that local benefits may arise alongside more China-centric goals (Lechner et al., 2018; Vakulchuk et al., 2018). Building a new *Green Silk Road* with support from China's development investment portfolio under BRI could help to promote and to develop mountain regions, bringing improvements in people's quality of life while maintaining biodiversity and ecological services (Kirchherr et al., 2018; Yang, & Yang, 2019)—but only if the BRI were to extend its remit from current economics, energy, and transport orientations and begin to invest appropriately in a range of other complementary sectors as well. With the lead to be taken by the partner countries, more SDG-friendly approaches that promote more inclusive social development together with long range and comprehensive environmental perspectives could be leveraged from China's multifaceted interests in Central Asia. Yet, as always, there will remain instances where biodiversity loss or social infringements are too severe, where it is critical to hold fast to precautionary principles and imperatives of autonomy and the rights of indigenous peoples and local communities (i.e., localization should take priority over globalization), and not automatically allow (for example) a proposed road infrastructure development to proceed. With any genuine partnership, there must be acceptance that not all proposals will necessarily be supported and proceed, and that stakeholder engagement is critical from the start of planning processes. Fortunately, China's own noninterference policies already point toward such eventuality, broadly endorsing that national views and perspectives be upheld. It is thus now up to the partnering countries themselves to develop and promulgate appropriate measures that can herald a viable *Green Silk Road*, both socially and environmentally sound—clearly working in partnership, yet duly upholding more local perspectives and priorities.

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### AUTHOR CONTRIBUTIONS

JMF conceived the manuscript. JMF, AML, ACH, and TS led sessions at the aforementioned workshops, which underpinned concept development and discussions. JMF drafted the initial manuscript and managed inputs from all the authors, with most substantial inputs from AML and ACH. MES conducted the spatial analysis, AML and MES produced the figures, and RD contributed substantially to the policy analysis. All authors contributed to the detailed development of the major concepts, findings, and key recommendations, and all the authors reviewed and contributed to the manuscript's final revision.

### ETHICS STATEMENT

The manuscript does not contain field data and complies with ethical scientific standards.

### DATA ACCESSIBILITY STATEMENT

All data analyzed for preparation of this manuscript were sourced from publicly available sites, as referenced in the text.

### CONFLICT OF INTEREST

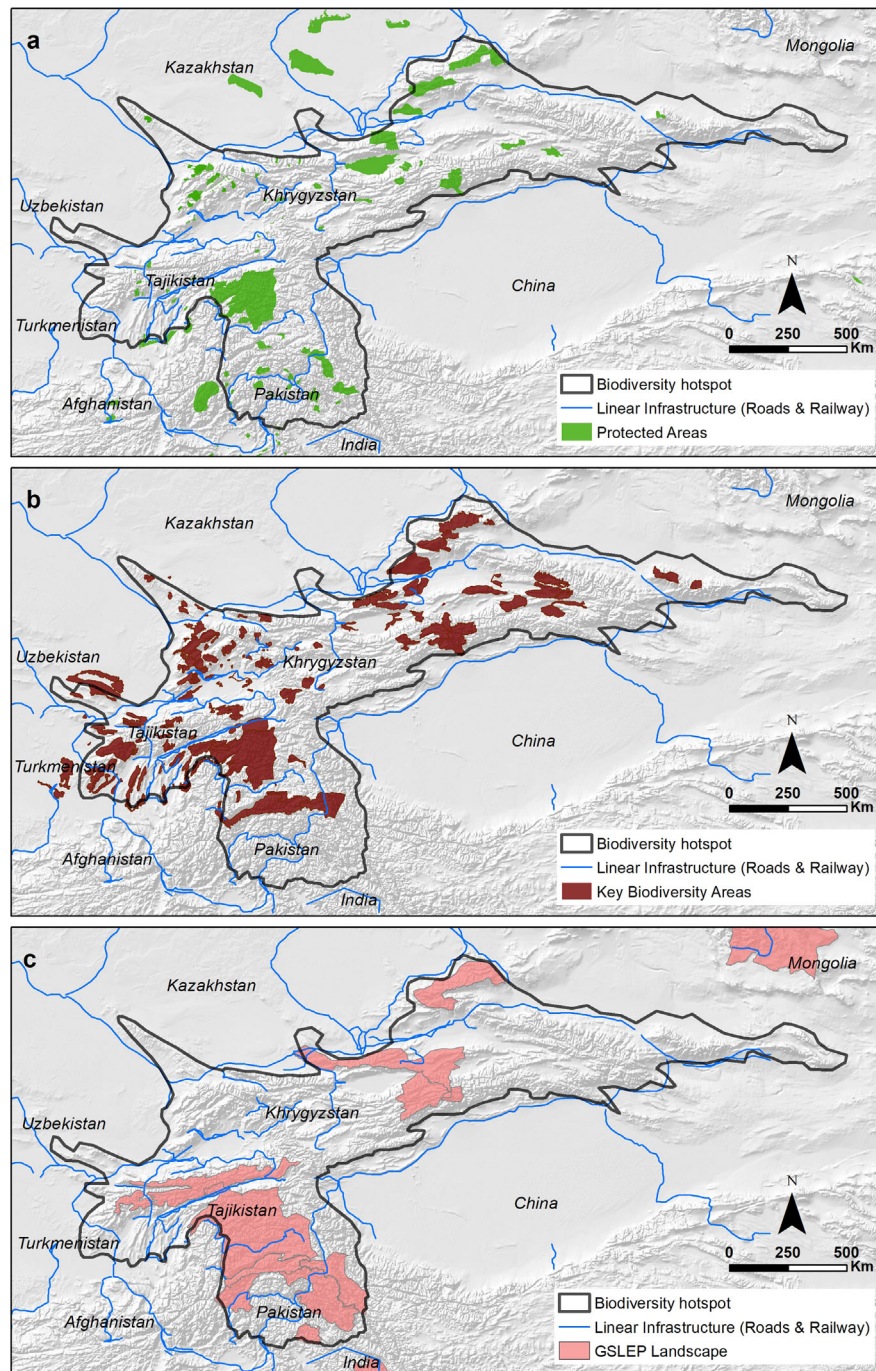
The authors declare no conflict of interest.

### Appendix I

#### **Spatial overlap of BRI linear infrastructure with ecologically important areas in Central Asia**

A preliminary spatial analysis of proposed and ongoing Chinese funded linear infrastructure projects (specifically





**FIGURE A1** Intersection between China's BRI and areas recognized for their biodiversity and ecological values. Blue lines represent current and proposed roads and railways developed or enlarged under the BRI; as sourced from the Reconnecting Asia Database. The black boundary line highlights the Mountains of Central Asia biodiversity hotspot. Three types of priority conservation areas are noted: (a) Protected Areas, PAs; (b) Key Biodiversity Areas, KBAs; and (c) GSLEP Snow Leopard Landscapes, SLLs

roads and railways) in the globally renowned *Mountains of Central Asia* biodiversity hotspot (cf. Myers et al., 2000; CEPF, 2017) has been carried out to determine the overall degree of intersection of such projects with priority areas for conservation. Based on the literature as well as current programming, three complementary approaches were adopted for identifying areas of high conservation

value: (1) key biodiversity areas, or KBAs (CEPF, 2017; IUCN, 2016; Jacobs et al., 2021); (2) protected areas, or PAs (UNEP-WCMC 2019); and (3) "snow leopard landscapes," or SLLs, identified under the high level "20 by 2020" initiative undertaken by the Global Snow Leopard and Ecosystem Protection (GSLEP) Program in conjunction with national governments of the 12 countries that

**TABLE A1** Matrix of level of protection of KBAs within three buffer distances from current and planned BRI linear infrastructure in the Mountains of Central Asia biodiversity hotspot

Level of protection	Intersection of BRI and other infrastructure and areas of biological or ecological significance (KBAs) (number of intersections)		
	Buffer = 1 km	Buffer = 5 km	Buffer = 25 km
Little/none	17	29	60
Some	8	9	21
Most	5	6	13
Whole	3	8	28
Unknown/partial	4	8	10
Total	37 (in 32 KBAs)	53 (in 45 KBAs)	125 (in 88 KBAs)

**TABLE B1** List of KBAs in the Mountains of Central Asia biodiversity hotspot that currently have little or no formal protection status, identified as those KBAs with areas either transected by or falling within 1 km of current or planned BRI linear infrastructure

Key Biodiversity Area (KBA) name	Country	KBA type*
Alai Valley and Mountains	Kyrgyzstan	B1
Alichur Valley	Tajikistan	B1
Darvaz	Tajikistan	B1
Kattakurgan Reservoir	Uzbekistan	D1
Kayrakkum	Tajikistan	B1
Kelif-Sherabad Mountain Range	Uzbekistan	B1
Khaudaktau	Uzbekistan	B1
Paap foothills	Uzbekistan	B1
Rushan	Tajikistan	B1
Syr Darya Upstream	Uzbekistan	B1
Tarkapchigay River Basin	Uzbekistan	B1
Toraigyr	Kazakhstan	B1
Turkestan Mountains Southern Slope	Tajikistan	B1
Upper Chadak and Chorkesar River Basin	Uzbekistan	B1

Note: KBAs may be identified as being of significant conservation value for several reasons. Two main categories are highlighted in the Mountains of Central Asia hotspot, those with significance arising primarily from the presence of geographically restricted species (B1) and those for which critical biological processes are deemed to be threatened and requiring protection (D1).

encompass the species' distribution (GSLEP, 2013, 2014). The resulting three indicative maps are presented as Figure A1.

Spatial data on current and proposed linear infrastructure being developed under China's BRI was sourced from the Reconnecting Asia database (Center for Strategic & International Studies, 2019) and digitized with QGIS spatial analysis software. Outlines of KBAs were obtained on request from the KBA Secretariat; the protected area locations were downloaded from the UNEP-WCMC World Database on Protected Areas (see <https://protectedplanet.net>); and locations of "snow leopard landscapes" were obtained and used with permission from GSLEP's Secretariat.

Additional information about KBAs intersected by BRI infrastructure projects is provided through two tables,

focused on protection status. Intersection analysis was carried out, using QGIS, for the high conservation value KBAs in the target area, both on the basis of direct overlap with linear infrastructure and overlap within buffer distances of 1, 5, and 25 km from such infrastructure. The two shorter buffer distances (1 and 5 km) were selected on basis of prior work undertaken by Benitez-Lopez et al. (2010) and Torres et al. (2016) and the 25 km buffer included to account for secondary and tertiary effects of linear infrastructure (Laurance et al., 2015; Laurance & Arrea, 2017). Table A1, below, highlights the level of protection of KBAs within three buffer distances from current and planned BRI-related linear infrastructure within the biodiversity hotspot, whereas Table B1 provides a list of the KBAs that currently receive little or no formal protection in the Mountains of Central Asia biodiversity hotspot.

## Appendix II

### Rapid-fire summary of key ways in which biodiversity could or should be mainstreamed more widely in development dialogues and investment planning

*Mainstreaming biodiversity and its conservation* across key development sectors in national, regional, and international programming is one of the most important measures necessary to advance and ensure sustainable mountain development (Bass et al., 2010; UCA et al. 2012; Huntley & Redford, 2014; Wehrli, 2014; IPBES 2018; OECD, 2018). Specific mechanisms should include *inter alia* a shift from local site-specific assessments (often too narrowly confined to particular project locations, ignoring wider impacts) to *landscape-level assessments and development planning approaches* (Sayer et al., 2013). Other important mechanisms that also should receive greater attention include adoption of *biodiversity aware* and *climate smart approaches* within development programming (MacKinnon et al., 2008; Pecl et al., 2017), including the strengthening of *regional networks of protected and conserved areas* (Dudley et al., 2010; Gross et al., 2016). Notably, indigenous and community conserved areas, or ICCAs - territories of life, comprise over a quarter of the world's land surface (Garnett et al., 2018), overlap with many though are far from limited to formal protected areas (Farvar et al., 2018; Jonas, & Jonas, 2018; Stevens et al., 2016), and collectively encompass around 80% of the world's biodiversity (Sobrevila, 2008). Finally, a greater recognition of the overall value of *key biodiversity areas* in future development investments also is recommended (EU Commission, 2018; Kirchherr et al., 2018; IUCN, 2016; Neugarten et al., 2018).

Expressed more concisely, the above concerns cover the key realms of *spatial scale*, *thematic priorities*, and *geographic focus* in context of biodiversity conservation—all of which would benefit from more explicit and dedicated attention in the future.

In addition, “safeguarding” measures such as China’s “*ecological redline*” policy to strictly protect key ecological zones (recognized for their provision of critical ecological services to society; Bai et al., 2016, 2018; Wang et al., 2021) and more widely recognized assessment processes such as *social and environmental impact and risk assessments* (applicable to infrastructure and non infrastructure projects alike; Ascensão et al., 2018) may also contribute substantially to ensuring more effective, sustainable, and equitable mountain development. Impact assessments in particular are vital, with the aim to ensure that due consideration is given to all potential risks and that appropriate mitigation and adaptation measures are identified and integrated into development plans and activities from the outset. Furthermore, environmental conditions must be monitored both during and following projects’ implementation.

*Sustainable financing mechanisms* to ensure functional integration of biodiversity conservation with other development sectors are equally necessary for long-term sustainability, and these can be readily justified when the cost-effectiveness of *internalizing the major social and environmental concerns* is considered—as the comprehensive costs to national economies that are accrued by ignoring such impacts are immensely more prohibitive (Dossani, 2016; Narain et al., 2020; OECD, 2018; Roe et al., 2018).

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