

Horizon Scan of the Belt and Road Initiative (BRI)

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Abstract

The Belt and Road Initiative (BRI) represents the largest infrastructure and development project in human history, and presents risks and opportunities for ecosystems, economies, and communities. Some risks, (habitat fragmentation, roadkill), are obvious, however many of the BRI's largest challenges for development and conservation are not obvious and require extensive consideration to identify. In this first BRI Horizon Scan, we identify eleven frontier issues that may have large environmental and social impacts but are not yet recognised. More generally, the BRI will increase China's participation in international environmental governance. Thus, new cooperative modes of governance are needed to balance geopolitical, societal, and environmental interests. Upgrading and standardising global environmental standards is essential to safeguard ecological systems and human societies.

Challenges of the Belt & Road initiative

The Belt and Road Initiative (BRI) is the largest and most ambitious global infrastructure initiative ever planned. Spanning 65 countries in its initial phase (with global expansion progressing) and with five components (policy coordination, transport connectivity, trade facilitation, currency convertibility, and people-to-people exchanges; **Box 1**), the BRI presents a suite of both well-known and novel challenges and opportunities to natural and social systems. To date, most research has focused on the potential impacts of the transport-connectivity component, which involves the building of roads, railways, and pipelines (the 'Belt'), seaports along maritime-shipping routes (the 'Road'), and special economic zones along these new transport links, and which can be subdivided into *direct* impacts (in the vicinity of construction, i.e. habitat loss and fragmentation, roadkill, and disruption of migratory routes [1]; [2]), *indirect*

impacts (e.g. supportive infrastructure, pollution), and *displaced* impacts (e.g. raw material extraction, climate change). However, a more holistic approach is needed to identify less obvious but potentially equally important impacts of a project of this scale and complexity; and few prior studies have included the interdisciplinary teams needed to assay the consequences of the intersection of social, economic, and environmental issues, and how associated risk may be appropriately managed (see Outstanding questions).

Some media reports have taken alarmist perspectives on the potential risks posed by the BRI ([3,4]), while other sources highlight its potential to act as a catalyst for green infrastructure development while enhancing human welfare and environmental health. Either way, careful and well-reasoned analysis and debate are needed to generate solutions to potential problems, to avoid or mitigate negative impacts, and to maximise emerging opportunities. Here, we look to the future to identify “frontier horizon issues” that may have large impacts within a few years but are not yet generally known to policymakers or academics, and provide suggestions of solutions and approaches to mitigate them.

Frontier Issues Identification

An interdisciplinary group of researchers was assembled to identify ‘frontier horizon’ environmental and social issues for the BRI using a modified Delphi method (Supplemental Methods). One hundred issues were initially submitted, then revised to 63 issues for voting. After voting, 33 issues (19 environmental and 14 social) were retained for in-depth discussion and on-site voting (Supplement 2). Of these, eleven issues were retained, being considered likely to have major impacts within the next few years but not yet well-known to policymakers or academics. These final-list issues are approximately half social and half environmental, though

most have implications for both. The top eleven issues were scored similarly by (self-identified) natural and social scientists, whereas lower ranked issues were more variable. Seven other issues were deemed high impact but insufficiently novel, with the natural scientists generally giving these six lower scores (Supplements 1). Two examples are (1) the prospect of ‘Cryptic PADDD’ (Protected-Area Downgrading, Downsizing, and Degazettement) driven by BRI routes fracturing existing reserves or displacing people into protected areas and (2) the loss of distinct native crop and livestock breeds/varieties, due to market pressures under globalising systems that homogenise food systems. The eleven final-list issues are presented below in descending order of their combined scores.

Frontier issues

1. Groundwater pumping threatening the viability of freshwater ecosystems

Rapid decline of natural river ecosystems was recognised as one of the most acute problems related to the BRI, as changing power and irrigation demands means damming of free-flowing rivers across many BRI regions. Yet surface-freshwater ecosystems (lakes, wetlands, rivers, and streams) are vulnerable not only to direct damming, but also to loss of ‘baseflow supply’ from groundwater reservoirs. Baseflow supply is essential to maintain continuity of water flow through dry periods and to supply the cool, clean, oxygenated water that is required for the survival of aquatic food webs during warm summer months [5]. Long before groundwater storage levels have been substantially depleted, pumping can reduce groundwater baseflows into surface waters by enough to threaten the viability of aquatic ecosystems [6]. High-resolution modelling now suggests that by 2050, under a business-as-usual groundwater-pumping scenario,

aquatic ecosystem viability will have been or will begin to be threatened in 42-79% of watersheds around the world [6]. Because many of these threatened aquatic ecosystems are in regions traversed by the BRI, such as Central Asia (Figure 1a), groundwater pumping rates will likely rise due to demand for infrastructure (e.g. concrete), mining, and agriculture. Severe groundwater depletion can also cause water flows to reverse from surface to underground, resulting in contamination by metals, nutrients, and pesticides into groundwater reserves, potentially restricting future groundwater use and harming little-known subterranean biodiversity [7]. Identifying areas most at risk (i.e. see Fig 1) and avoiding development already at risk of groundwater depletion is a simple step to minimise the probability groundwater depletion, whilst more holistic assessments of alternative sources of power provision may provide less environmentally harmful outcomes for ecosystems and societies along the route.

2. Invisible invasives: incidental spread of fungi, bacteria, and viruses

Though the risk of invasive plant and animal species along new transport routes is well-acknowledged, the risk posed by smaller invaders is frequently overlooked [8]. Microorganisms are omnipresent and important for ecosystem services such as decomposition, and the vast majority are unknown, with <1% of expected species described for bacteria and fungi [9]. For example, a study in Thailand found that 96% of inventoried fungi were undescribed, with their invasive potentials unknown along the core BRI route [10]. Although few microbial species are directly pathogenic on humans, they are important [11], and plant-pathogenic microbes may endanger food security across highly-populated developing countries across the BRI [9]. Increased traffic of people and livestock along BRI routes also provide a risk of spread of diseases. Epidemics in amphibians [12], bats [13], and Saiga antelope [14] originated in Eurasia

and demonstrate the potential impact of disease on species and populations. Local microbial communities might also be exposed to competitive displacement, with unknown effects on soil functioning and the possibility of increased pathogenicity, since greater prevalence raises the probability of resistance development [15]. With enhanced connectivity among regions facilitated by BRI, biosecurity screenings and more stringent waste-disposal standards will become progressively more vital to prevent the potential of the spread of disease to naïve populations.

3. Cementing extinction

Sand-mining is a known biodiversity threat [16], but the impact cement production on limestone ecosystems is often overlooked. About 20% of terrestrial ecosystems are limestone-based karsts [17]; in Southeast Asia, this equates to ~800,000km². A single karst formation can host over twelve known site-endemic species, and it is estimated that 90% of karst-cave invertebrate species are still undescribed [18]. In Southeast Asia, these ecosystems lose about 6% of their area annually, largely for cement extraction. As a reference measure of cement demand, China itself accounts for around 63% of annual global cement consumption, at an equivalent of around 1.7 tonnes for each of its 1.34 billion people [19]. Many regions across the BRI preferentially use cement in road construction, given lower costs and higher durability, which will likely cause a significant increase in the mining of karsts for limestone [1]. Consequently, these irreplaceable karst ecosystems may be some of the most threatened by BRI, despite many being distant from BRI routes, and careful sourcing policies (or the use of alternatives to traditional cement such as polymers) will be needed to minimise the impacts of increased cement demand.

4. Polar/Arctic Silk Road

The thawing Arctic icecap is enabling marine traffic and increasing extraction pressures for natural gas, oil, fish, and minerals, creating the so-called ‘Polar/Arctic Silk Road’. In 2017, liquefied natural gas (LNG) icebreaking tankers with cargo capacities of 172,600 m³ started operation [20], and over 20 million tons of LNG have already been shipped from Russia’s Yamal LNG plant. The infrastructure for LNG plants has disrupted ecosystems [21] and impacted indigenous communities [22]. Increasing traffic in new shipping lanes risks marine-mammal collisions and the pollution of their habitats [23], and the reduction of Arctic sea-ice is already implicated in the transfer of phocine distemper virus from Atlantic to Pacific marine mammals [24]. Melting ice and permafrost also release diseases frozen for thousands of years, and measures need to be taken to ensure the preservation of new long frozen specimens, their screening for potential infections, and to monitor the release of mercury [25]. The precautionary approach has been widely endorsed [26] but cannot survive this acceleration into ‘new passageways and new trade opportunities’ [27]. Hence there is a need for an overarching legal treaty to provide environmental governance in the Arctic, both to maintain terrestrial and aquatic habitats and to provide adequate biosecurity measures.

5. Coastal ecosystems under threat

Coastal ecosystems tend to fall through the gap when considering terrestrial or marine systems, yet they are under huge threat as the interface between the maritime and terrestrial components, subject to increased shipping, new port development, and reclamation as well as pollution. The EAAF (East Asian–Australasian Flyway, a bird migratory route) spans much of East and Southeast Asia’s coastlines, but coastal reclamation and pollution, especially key breeding

grounds around the Yellow Sea, have already driven the loss of over 70% of some species populations for the estimated 50 million migratory birds that annually use this route [28]. The development of ports and reclamation of further coastlines for the maritime component of the BRI could prove disastrous for these species [29], especially given that around the Yellow Sea, 61% of priority bird sites are unprotected and tidal flats have decreased in area by 65% since the 1950s. Protected-area shrinkage has also been highest in coastal systems at 55% loss, relative to 3% average for China [30], reflecting the rapid loss and under-protection of coastal systems. Construction of industrial, agricultural, and aquaculture parks as well as new ports is impacting the coastline via sedimentation, destruction of biota, and pollution [31]. New guidelines for the sustainable management of these systems, and the identification and preservation of key sites are urgently needed to provide adequate protection for coast-dependent species.

6. BRI and Traditional Chinese Medicine supporting and stimulating a market in wildlife trade

Promotion of Traditional Chinese Medicine (TCM) is a central component of BRI “people-to-people exchange” goals. Formal agreements have been signed between China and BRI countries on cooperation related to traditional medicine [32], and TCM training centres are being established along BRI routes [33]. Active TCM promotion, coupled with its inclusion in the World Health Organization’s 2019 International Classification of Disease [34], will likely increase demand, use, and access to TCM products globally. Chinese overseas workers on BRI infrastructure projects might increase demand for threatened wildlife locally, and/or export wildlife products back to China. In addition, the BRI’s increased connectivity and access to previously unreachable wild places that could facilitate the sourcing from new areas of wildlife-

based TCM ingredients, along with species for pets, ornamentation, and food [35], all of which increase the risk of new arising zoonotic diseases and/or the transmission of those diseases along the BRI. Existing international and national legal mechanisms are insufficient to prevent illegal trade in endangered species between China and the countries involved in the BRI [36]. However, if measures are put in place to develop sustainable supply chains, new markets for some TCM products could also support sustainable development and rural livelihoods [37], potentially supported by China's newly announced supply-chain tracking system to ensure ingredient quality and safety (http://www.china.org.cn/china/2019-11/21/content_75431126.htm).

7. Harmonizing international and national environmental standards in BRI foreign investment projects

Mismatches frequently exist between international and domestic legal, environmental, and social standards (i.e. requirements of environmental or social impact assessments, and monitoring as conditions of financing). This creates challenges in the setting of locally appropriate standards and in the forms of investment that should be funded by BRI, even before considering enforcement. The lowering of trade barriers could mean that jurisdictions with laxer environmental regulations become attractive to polluting industries [38], or that competition for reducing costs forces down international standards. High-level policy on BRI (i.e. Greening the BRI [39]) as well as policies and regulations within China (i.e. 'Ecological Civilization') advocate for environmental and social protection, and green development. However, how these policies translate on the ground remains unclear, particularly beyond China's borders. Little alignment in standards and safeguards from the International Finance Corporations, development banks and Equator Principles institutions with Chinese financial institutions has occurred to date. However, China's multilateral investment bank, the Asian Infrastructure Investment Bank [40],

has adopted environmental and social safeguards resembling those of other development banks and committed to review them every three years [41]. There is also the argument that engaging with multiple stakeholders can help ‘scrutinise contracts, flag bad deals, and empower countries to push for better terms,’ as shown in the case of Myanmar, where a US task force facilitated renegotiation of the Kyaukphyu special economic zone development to protect human rights of people in the region (<https://ejatlas.org/conflict/kyaukpyu-special-economic-zone>). International actors are also pushing for the development of a project bank to improve screening and transparency mechanisms for investment projects [42], suggesting that with the right impetus, the BRI could propel a global rise in environmental and social standards.

8. Securing the inclusive governance and management of ‘Territories of Life’ and recognising the role of ‘culture’ in conservation of biodiversity by indigenous and local communities

Over a quarter of the world’s land across 87 countries falls under local collective governance, overlapping 40% of terrestrial protected areas and numerous key biodiversity areas (KBAs) [43] (Figure 1b). It is unlikely that any of the global goals of increasing protected area coverage and management effectiveness can be achieved without including these “Territories of Life” (territories/areas conserved by indigenous peoples and local communities) and their custodians [44]. BRI projects transect numerous such territories, but the potential social and environmental impacts are unquantified, and laws often provide insufficient protection (Figure 1b). Custodian communities should be included throughout all stages of planning and implementation to ensure cultural continuity and sharing of benefits, to enable wellbeing [45] and sustainable livelihoods, particularly in pastoral communities [46]. Multifaceted values of territories and biodiversity

require careful consideration, and the roles of culture and inclusive conservation within sustainable development need recognition and inclusion [47]. BRI projects need action plans that protect the rights of indigenous and local communities and ensure their full participation in environmental management and other development dialogues relevant to those projects. Common values regarding all socio-ecological systems affected by BRI need identification and inclusion [48] to enable more pluralistic societies to develop and prosper together.

9. The environmental consequences of geopolitical rivalry over infrastructure financing

In response to the BRI, other G20 countries have proposed global and regional development initiatives, such as the EU Strategy on Connecting Europe and Asia [49], the U.S. International Development Finance Corporation, and the Australian Infrastructure Financing Facility for the Pacific [50], which could accelerate investment in large physical infrastructure, potentially entailing less-thorough analysis of alternative, sustainable development options. Such geopolitical rivalry at the international level, combined with commercial competition for specific projects, could in turn decrease the appetite of sponsors and financiers for confronting corruption, scrutinising governance weaknesses, and addressing environmental and social risks in host countries [51]. Competition with BRI projects might exacerbate debt-fed, large-scale, top-down megaproject developments and perpetuate low-quality strategic development planning. For example, in 2019, the US, Australia, New Zealand, and Japan announced a commitment to connect 70% of Papua New Guinea's population to a nationwide electrical grid, which was reported as an explicit counterbalance to China-financed infrastructure projects in PNG [52]. Such competition could have consequences for the environment, as standards may be

compromised to compete, especially in time-limited projects. This project has been criticised for its failure to take advantage of greener and cheaper local-power-generation options. Another example of such rivalry is the funding of river damming projects by the World-Bank, which stopped in 1997 following the World-Commission on Dams report on the impact of large dam projects. But this decision was reversed twenty years later due to funding by China and Brazil, despite their well-recognised ecological consequences [53].

Alternatively, ‘counter-BRI’ initiatives could raise standards for more inclusive, environmentally sustainable, and locally-driven development (i.e. the World Bank’s Environmental and Social Framework, Japan and the ADB’s Partnership for Quality Infrastructure) [54], given that some of these new initiatives emphasise sustainability and high quality.

10. Regreening the never green: “Anti-desertification” and “restoration” in natural ecosystems

Across Central-Asia along the route of the BRI, there are efforts to counter desertification through large-scale planting of drought-resistant and deep-rooted species. However, some of these efforts aim to convert native deserts and savannas into more economically productive systems. For example the conversion of a third of the Kubuqi desert (Inner Mongolia) to productive landscapes, with plans for expansion across Central Asia. The Chinese company ELION claims that biodiversity has increased in their projects (<http://www.elion.com.cn/en/>), but third-party supporting evidence or standardised inventory data do not seem to exist, which raises potential risks of reduced ecosystem functioning and invasion by alien animal and plant species. For instance, tree-planting campaigns have been used to combat erosion and climate change in other native ecosystems (e.g. savannas [55]), but when composed of non-native species, they

have reduced native biodiversity [56] and lowered the water-table [57] and actively damaged native biodiversity. Yet, these schemes are still championed to “combat climate change” despite often being less effective than native functional ecosystems and at huge potential cost to biodiversity, as has been demonstrated with the AFR100 scheme, which aims to afforest native grassy-biomes across Africa ([58]). These “regreening initiatives” are being actively explored by arid countries along the route of the BRI (Kubuqi Forum 2019: <http://en.kubuqiforum.org/>). A BRI-facilitated drive for afforestation as climate-change mitigation and anti-desertification measure based on monocultures and/or on non-native and water-thirsty species could reduce native biodiversity, by changing the dynamics of natural systems, especially if conducted with no inventory of native diversity. To minimise ecological risk better methods for inventorying native diversity are needed, in addition to policies that target systems which requiring restoration or rewilding, rather than modifying viable native ecosystems for commercial gain.

11. Willingness to build infrastructure in existing conflict zones

At the international level, policy frameworks and codes of conduct for undertaking large-scale infrastructure projects in conflict zones do not exist, and the standard response to conflict has been to restrict investment. Such ‘frozen conflicts’ can break connectivity and drive up inefficiencies, cause large diversion routes to bypass conflict zones, as exemplified by the closure of borders to Armenia by Azerbaijan and Turkey, which in turn has resulted in billions of dollars of compensatory road building to facilitate trade between Azerbaijan and Europe [59]. In the West, infrastructure building in conflict zones has been thought only to provide a barometer of the likelihood of transition out of conflict [60]. In contrast, since the conflict in Darfur, Sudan in 2007, China has advocated economic development as a driver of peace and a primary means

of post-conflict reconstruction [61]. However, on the China-Pakistan Economic Corridor (including Pakistan-occupied Kashmir), the construction of roads and rails to link Xinjiang in China with the Indian Ocean has required a large security force to ensure the safety of BRI projects [62]. The Kyaukpyu-Kunming railway and three new Special Economic Zones in Myanmar intersect with conflict zones that are currently occupied by independent army groups (Figure 1c). The diversion of resources for security reduces the scope for carrying out environmental and social impact assessments and addressing other critical issues such as water conservation, wildlife trafficking, and the modification of infrastructure to avoid environmentally and socially sensitive areas. Infrastructure projects in such regions could also exacerbate existing social tensions and environmental challenges. Navigating such challenges is difficult, and may require the development of additional funding programs in areas where the cost of security reduce the budget available for carrying out standardised environmental assessment.

Discussion

Many of the 100 issues in our initial list were considered high impact but not novel and thus were not included in the final list of 11 frontier issues (Supplements 2). However, to our knowledge, no holistic interdisciplinary evaluation of even the non-novel impacts exists for any given geographic region. Though ecological analyses have been conducted [1,51] analysing environmental impacts is challenging due to the lack of biodiversity data for many BRI regions, and have largely ignored more complex topics or the interactions between environmental and social issues.

The role of China in shaping global environmental governance.

China's BRI presents both risks and opportunities for economies, ecosystems, and human societies. In the current geopolitical climate, we are witnessing a build-up of competition that threatens to undermine international cooperation. As the centre of global power shifts, conflicting strategic and economic concerns between China and other parts of the world will only become more pronounced. New modalities of global governance thus must seek to reconcile diverging national interests while mitigating friction between different groups of stakeholders, in the pursuit of improved environmental and social standards. Above all, to ensure long-term sustainability, social and environmental impact assessments need to be fully integrated into BRI-mandated projects. In many of these issues, there is a clear trade-off between development and sustainability, and though some issues may be effectively managed through financial policies, which require EIA with oversight, and may only require bilateral or even just donor based policy consideration, others such as provisions to protect against fallout from geopolitical rivalry, may require more global agreements, such as international conventions. Issues such as access to water are likely to become more pronounced; thus equitable modes of Governance need to be developed to ensure with water access is not impacted by demand from other countries. In addition some issues highlight the importance of the inclusion of diverse voices, and the development of processes that ensure their role from planning to development. There is also the need to develop safeguards to protect cultural diversity and local varieties in formerly isolated areas.

Looking to the future

Many of the issues that we identified in our Horizon Scan, especially issues 6 (TCM supply-chain tracking), 7 (harmonization of environmental standards), 9 (geopolitical rivalry) and 11 (building in conflict zones) suggest that China will need to increase its participation in the

structures of global environmental governance. Domestically, China has recently instituted a high-level policy of achieving an ‘Ecological Civilization’, which includes as one of its measures the definition and protection of ‘ecological redlines,’ which are the minimal areas needed to guarantee ecological functioning and biological diversity [63]. This is arguably the largest ecosystem-service-protection policy in the world, and its implementation, assessment, and enforcement are posing large challenges to China’s scientists and policymakers [64]. Important questions to ask are whether China will apply the ecological redline concept to the BRI, and if so, how the governance of such an approach can be instituted in a more complex international environment (see Outstanding Questions).

Alternatively, the build-up of economic competition within the international system may fuel a race to the bottom. Thus, new cooperative modes of governance are needed to balance a wide range of geopolitical, societal, and environmental interests. Upgrading global environmental standards is a prerequisite for ensuring a more sustainable and equitable BRI that can play a role in safeguarding the future of ecological systems and human societies.

Box 1. What is the Belt and Road Initiative?

The Belt and Road Initiative (BRI; One Belt One Road (一带一路), Silk Road Economic Belt and the 21st-Century Maritime Silk Road) was officially launched in 2013 by China’s President Xi Jinping as the modern version of the historical Silk Road, which had for centuries facilitated trade and cultural exchange across Eurasia. The BRI is primarily intended to increase trade and connectivity amongst China, Central and South Asia, the Middle East, Europe, and Africa [65], though global expansion is underway. This will be achieved by advancing BRI’s five main

components: policy coordination, transport connectivity, trade facilitation (i.e. more efficient border crossings), currency convertibility, and people-to-people exchanges.

The BRI's initial geographic coverage encompassed 65 countries (including China) across mainland Eurasia, Africa, and the Middle East, although the BRI 'brand' has since been applied to many other China-financed projects globally. Consequently, it is difficult to delimit the amount of China-sourced finance that will be spent on the BRI, but one estimate is >US\$100 billion/yr 2017-2027 [66]. To put this in perspective, the European Bank for Reconstruction and Development estimates the 2018-2022 infrastructure spending needs of the 36 countries in its remit (largely overlapping with the BRI) as >US\$320 billion/yr, with two-thirds needed for transport connectivity [59]. While there is talk of integration between the BRI and other regional infrastructural plans, concrete actions are incipient (ASEAN-China Joint Statement on Synergising the Master Plan on ASEAN Connectivity (MPAC) 2025).

To fulfil the strategic visions of the BRI, numerous projects aim to generate new high-resolution data and improve the capacity to plan and understand the impacts of the route. For example, the "Digital Silk Road" (DBAR) has been developed with an initial budget equivalent to US\$32 million [67]. DBAR aims to provide high-quality remotely sensed data to overcome present data deficits (the "digital divide") to apply remotely sensed data as a tool for global targets and challenges such as the SDGs and to better inform sustainable development across BRI partner countries [68]. DBAR also aims enable scientific cooperation across BRI regions, thus an Alliance of International Science Organisations of the BRI region has been established, including over 120 nations, in addition to regional alliances [69].

411 The cultural component of BRI should not be overlooked and has already included over 10,000
412 scholarships, >240% increase in tourist visits, and 374 training facilities for cultural activities
413 (such as TCM) in BRI countries
414 (<https://news.cgtn.com/news/3d3d674d7841544d34457a6333566d54/index.html>).

415 Understanding the BRI and associated impacts and opportunities requires consideration of all
416 components of the BRI vision, including not only hard infrastructure, but also social,
417 environmental, economic, and technological change. Most studies have focused on the impact of
418 hard-infrastructure to the ecosystems traversed by the BRI [1], which though significant are only
419 a part of the environmental and ecological implications of the initiative. As highlighted above
420 BRI has the scope to have global impacts that are less obvious but simultaneously provide
421 opportunities for new forms of governance.

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424 **References**

425 1 Hughes, A.C. (2019) Understanding and minimizing environmental impacts of the Belt and Road
426 Initiative. *Conserv. Biol.* 33, 883–894

427 2 Nandintsetseg, D. et al. (2019) Challenges in the conservation of wide-ranging nomadic species.
428 *J. Appl. Ecol.* 3, 1

429 3 Laurance, W. F. (2018) China's Belt & Road is "Environmentally Riskiest Venture Ever" Alert
430 Conservation May 23, 2018 [http://alert-conservation.org/issues-research-highlights/2018/5/23/chinas-](http://alert-conservation.org/issues-research-highlights/2018/5/23/chinas-belt-road-is-environmentally-riskiest-venture-ever)
431 [belt-road-is-environmentally-riskiest-venture-ever](http://alert-conservation.org/issues-research-highlights/2018/5/23/chinas-belt-road-is-environmentally-riskiest-venture-ever)

432 4 Laurance, W. F., & Arrea, I. B. (2017) Roads to riches or ruin? *Science* 358, 442-444.

433 5 Gleeson, T. and Richter, B. (2018) How much groundwater can we pump and protect
434 environmental flows through time? Presumptive standards for conjunctive management of aquifers and
435 rivers. *River Res. Appl.* 34, 83–92

436 6 de Graaf, I.E.M. et al. (2019) Environmental flow limits to global groundwater pumping. *Nature*
437 574, 90–94

438 7 Aeschbach-Hertig, W. and Gleeson, T. (2012) Regional strategies for the accelerating global
439 problem of groundwater depletion. *Nat. Geosci.* 5, 853

440 8 Hulme, P.E. (2009) Trade, transport and trouble: managing invasive species pathways in an era of
441 globalization. *J. Appl. Ecol.* 46, 10–18

442 9 Hawksworth, D.L. and Lücking, R. (2017) Fungal Diversity Revisited: 2.2 to 3.8 Million Species.
443 *Microbiol Spectr* 5,

444 10 Hyde, K.D. et al. (2018) Thailand’s amazing diversity: up to 96% of fungi in northern Thailand
445 may be novel. *Fungal Divers.* 93, 215–239

446 11 McFall-Ngai, M. (2007) Adaptive immunity: care for the community. *Nature* 445, 153

447 12 O’Hanlon, S.J. et al. (2018) Recent Asian origin of chytrid fungi causing global amphibian
448 declines. *Science* 360, 621–627

449 13 Hayman, D.T.S. et al. (2016) Environment, host, and fungal traits predict continental-scale white-
450 nose syndrome in bats. *Sci Adv* 2, e1500831

451 14 Fereidouni, S. et al. (2019) Mass Die-Off of Saiga Antelopes, Kazakhstan, 2015. *Emerg. Infect.*
452 *Dis.* 25, 1169–1176

453 15 Sanglard, D. (2016) Emerging Threats in Antifungal-Resistant Fungal Pathogens. *Front. Med.* 3,
454 11

455 16 Saviour, N.M. (2012) Environmental impact of soil and sand mining. *Intl. J. Sci. Env. Tech.* 3,
456 221–216

457 17 Clements, R. et al. (2006) Limestone Karsts of Southeast Asia: Imperiled Arks of Biodiversity.
458 *Bioscience* 56, 733–742

459 18 Whitten, T. (2009) Applying ecology for cave management in China and neighbouring countries.
 460 J. Appl. Ecol. 46, 520–523

461 19 Hughes, A.C. (2017) Understanding the drivers of Southeast Asian biodiversity loss. Ecosphere
 462 8, e01624

463 20 Staalesen, A. (2019) New Arctic partnership announces construction of 17 icebreaking LNG
 464 tankers. , The Barents Observer, The Independent Barents Observer AS. 05-Sep-2019

465 21 Ametistova, L.E. and Knizhnikov, A.Y. (2016) , Environmental Aspects of Arctic LNG Projects
 466 Development. https://new.wwf.ru/upload/iblock/3bc/broshura_gas_eng_web.pdf

467 22 Schwalbe, D.M. (2017) The Yamal LNG Project and the Nenets Reindeer Nomads: Impacts,
 468 Survival and Indigenous Opposition to Gas Exploitation in Russia’s Arctic, GegenStrömung.

469 23 Pirotta, V. et al. (2019) Consequences of global shipping traffic for marine giants. Front. Ecol.
 470 Environ. 17, 39–47

471 24 VanWormer, E. et al. (2019) Viral emergence in marine mammals in the North Pacific may be
 472 linked to Arctic sea ice reduction. Sci. Rep. 9, 15569

473 25 Alex, B. (2019) Arctic Meltdown: We’re Already Feeling the Consequences of Thawing
 474 Permafrost. Discover Magazine 03-Jan-2019.

475 26 State Council Information Office of the People’s Republic of China 26-Jan-(2018) , China’s
 476 Arctic Policy.
 477 http://english.www.gov.cn/archive/white_paper/2018/01/26/content_281476026660336.htm

478 27 Pompeo, M.R. (2019) Looking North: Sharpening America’s Arctic Focus - United States
 479 Department of State. United States Department of State 06-May-2019 [https://www.state.gov/looking-](https://www.state.gov/looking-north-sharpening-americas-arctic-focus)
 480 [north-sharpening-americas-arctic-focus](https://www.state.gov/looking-north-sharpening-americas-arctic-focus)

481 28 Li, J. et al. (2019) Mapping wader biodiversity along the East Asian-Australasian flyway. PLoS
 482 One 14, e0210552

483 29 Xia, S. et al. (2017) Identifying priority sites and gaps for the conservation of migratory
 484 waterbirds in China’s coastal wetlands. Biol. Conserv. 210, 72–82

485 30 Ma, Z., Chen, Y., Melville, D. S., Fan, J., Liu, J., Dong, J., ... & Li, B. (2019). Changes in area
486 and number of nature reserves in China. *Conservation Biology* 33, 1066-1075.

487 31 Moores, N. et al. (2019) National Actions and International Frameworks for the Conservation and
488 Wise Use of Tidal Flats and Other Coastal Wetlands in the Yellow Sea. In *Wetlands: Ecosystem Services,
489 Restoration and Wise Use* (An, S. and Verhoeven, J. T. A., eds), pp. 159–184, Springer International
490 Publishing

491 32 Nepal Foreign Affairs (2019) Nepal and China sign 20 agreements and MoUs. , Nepal Foreign
492 Affairs. 13-Oct-2019. <http://nepalforeignaffairs.com/nepal-and-china-sign-20-agreements-and-mous/>

493 33 Jia, C. (2018) Chinese medicine popular along BRI routes. , Belt and Road Portal. 12-Oct-2018
494 <https://eng.yidaiyilu.gov.cn/qwyw/rdxw/68450.htm>

495 34 Lam, W.C. et al. (2019) ICD-11: Impact on Traditional Chinese Medicine and World Healthcare
496 Systems. *Pharmaceut. Med.* 33, 373–377

497 35 Farhadinia, M.S. et al. (2019) Belt and Road Initiative may create new supplies for illegal wildlife
498 trade in large carnivores. *Nat Ecol Evol* 3, 1267–1268

499 36 Wong, R.W.Y. (2017) The Role of Reputation in the Illegal Purchase of Protected Wildlife in
500 China. *Deviant Behav.* 38, 1290–1302

501 37 Hinsley, A. et al. Building sustainability into the Belt and Road Initiative Traditional Chinese
502 Medicine trade. *Nature Sustainability*

503 38 Teo, H.C. et al. (2019) Environmental Impacts of Infrastructure Development under the Belt and
504 Road Initiative. *Environments* 6, 72.

505 39 Boer, B. (2019) Greening China's Belt and Road: Challenges for Environmental Law. Sydney
506 Law School Research Paper 16-Jul-2019

507 40 AIIB (2019) Environmental and Social Framework, Asian Infrastructure Investment Bank.

508 41 He, A. (2019) The Belt and Road Initiative: Motivations, Financing, Expansion and Challenges of
509 Xi's Ever-expanding Strategy,

510 42 Tritto, A. and Park, A. (2020) The Belt and Road in Southeast Asia: the case of Myanmar.
511 HKUST IEMS and UOB report

512 43 Garnett, S.T. et al. (2018) A spatial overview of the global importance of indigenous lands for
513 conservation. *Nature Sustainability* 1, 369–374

514 44 Farvar, M.T. et al. (2018) Whose “Inclusive Conservation”? Policy Brief of the ICCA
515 Consortium No. 5, The ICCA Consortium and Cenesta.

516 45 Chandler, M.J. and Lalonde, C.E. (2008) Cultural Continuity as a Protective Factor against
517 Suicide in First Nations Youth. *Horizons --A Special Issue on Aboriginal Youth, Hope or Heartbreak:*
518 *Aboriginal Youth and Canada’s Future* 10, 68–72

519 46 Hodges, J. et al. (2014) Globalisation and the sustainability of farmers, livestock-keepers,
520 pastoralists and fragile habitats. *Biodiversity* 15, 109–118

521 47 Foggin, J.M. (2018) Environmental Conservation in the Tibetan Plateau Region: Lessons for
522 China’s Belt and Road Initiative in the Mountains of Central Asia. *Land* 7, 52

523 48 Brombal, D. et al., (2019) The Cansiglio Declaration. Advancing a common “Charter of Values”
524 for the mutual benefit and well-being of living communities along the New Silk Roads. Sep-2019,
525 [https://www.researchgate.net/publication/337063011_The_Cansiglio_Declaration_Advancing_a_commo](https://www.researchgate.net/publication/337063011_The_Cansiglio_Declaration_Advancing_a_common_'Charter_of_Values'_for_the_mutual_benefit_and_well-being_of_living_communities_along_the_New_Silk_Roads/)
526 [n_'Charter_of_Values'_for_the_mutual_benefit_and_well-](https://www.researchgate.net/publication/337063011_The_Cansiglio_Declaration_Advancing_a_common_'Charter_of_Values'_for_the_mutual_benefit_and_well-being_of_living_communities_along_the_New_Silk_Roads/)
527 [being_of_living_communities_along_the_New_Silk_Roads/](https://www.researchgate.net/publication/337063011_The_Cansiglio_Declaration_Advancing_a_common_'Charter_of_Values'_for_the_mutual_benefit_and_well-being_of_living_communities_along_the_New_Silk_Roads/), The Marco Polo International Research
528 Center (MaP)

529 49 European Commission High Representative of the Union for Foreign Affairs and Security Policy
530 (2018) Joint Communication: Connecting Europe and Asia - Building blocks for an EU Strategy. 19-Sep-
531 2018. [https://eeas.europa.eu/sites/eeas/files/joint_communication_-_connecting_europe_and_asia_-](https://eeas.europa.eu/sites/eeas/files/joint_communication_-_connecting_europe_and_asia_-_building_blocks_for_an_eu_strategy_2018-09-19.pdf)
532 [_building_blocks_for_an_eu_strategy_2018-09-19.pdf](https://eeas.europa.eu/sites/eeas/files/joint_communication_-_connecting_europe_and_asia_-_building_blocks_for_an_eu_strategy_2018-09-19.pdf)

533 50 Fletcher, L. and Yeophantong, P., (2019) Enter the Dragon: Australia, China, and the New Pacific
534 Development Agenda. 29-Mar-2019.
535 https://www.jubileeaustralia.org/_literature_164854/Enter_the_Dragon_2019.

536 51 Tracy, E.F. et al. (2017) China's new Eurasian ambitions: the environmental risks of the Silk
537 Road Economic Belt. *Eurasian Geography and Economics* 58, 56–88

538 52 McLeod, S. (2019) Plugging in PNG: electricity, partners and politics. *The Interpreter* 10-Apr-
539 2019 <https://www.lowyinstitute.org/the-interpreter/plugging-png-electricity-partners-and-politics>

540 53 Bosshard P. (2013) The World Bank is bringing back big, bad dams. *The Guardian*.
541 Tue 16 Jul 2013 <https://www.theguardian.com/environment/blog/2013/jul/16/world-bank-dams-africa>"

542 54 Runde, D.F. and Ramanujam, S.R. Sep-(2018) , Financing and Implementing the Quality
543 Infrastructure Agenda [https://csis-prod.s3.amazonaws.com/s3fs-](https://csis-prod.s3.amazonaws.com/s3fs-public/publication/180829_Financing_Quality_Infrastructure.pdf)
544 [public/publication/180829_Financing_Quality_Infrastructure.pdf](https://csis-prod.s3.amazonaws.com/s3fs-public/publication/180829_Financing_Quality_Infrastructure.pdf)

545 55 Veldman, J.W. et al. (2015) Where Tree Planting and Forest Expansion are Bad for Biodiversity
546 and Ecosystem Services. *Bioscience* 65, 1011–1018

547 56 Wang, X. et al. (2019) The biodiversity benefit of native forests and mixed-species plantations
548 over monoculture plantations. *Div. Distrib.* DOI: 10.1111/ddi.12972

549 57 Wilske, B. et al. (2009) Poplar plantation has the potential to alter the water balance in semiarid
550 Inner Mongolia. *J. Environ. Manage.* 90, 2762–2770

551 58 Bond et al (2019) The Trouble with Trees: Afforestation Plans for Africa. *TREE* 34. 963-965.

552 59 Griffiths, R.T. (2019) *The New Silk Road: Challenge and Response*, HIPE Publications.

553 60 Mashatt, M. et al., (2008) Conflict-Sensitive Approach to Infrastructure Development. Jan-2008,
554 United States Institute of Peace <https://www.usip.org/sites/default/files/resources/sr197.pdf>

555 61 Large, D. (2008) China's role in the mediation and resolution of conflict in Africa. , OsloForum
556 28-Jun-2008 [https://www.hdcentre.org/publications/chinas-role-in-the-mediation-and-resolution-of-](https://www.hdcentre.org/publications/chinas-role-in-the-mediation-and-resolution-of-conflict-in-africa/)
557 [conflict-in-africa/](https://www.hdcentre.org/publications/chinas-role-in-the-mediation-and-resolution-of-conflict-in-africa/)

558 62 Arduino, A. (2017) China's belt and road initiative security needs: The evolution of Chinese
559 private security companies. , S. Rajaratnam School of International Studies 26-Aug-2017

560 63 Jiang, B. et al. (2019) China's ecological civilization program—Implementing ecological redline
561 policy. *Land use policy* 81, 111–114

562 64 Bai, Y. et al. (2018) Developing China's Ecological Redline Policy using ecosystem services
 563 assessments for land use planning. Nat. Commun. DOI: 10.1038/s41467-018-05306-1
 564 65 Wan, M. (2016) The Asian Infrastructure Investment Bank: The Construction of Power and the
 565 Struggle for the East Asian International Order, Palgrave Macmillan US.
 566 66 European Bank for Reconstruction and Development, (2017) European Bank for Reconstruction
 567 and Development Transition Report 2017-2018. 13 Nov 2017. 978-1-898802-46-5.
 568 <https://www.ebrd.com/transition-report-2017-18>
 569 67 Guo, H., Qiu, Y., Massimo, M., Chen, F., Zhang, L., Ishwaran, N., ... & Liang, D. (2017). DBAR:
 570 International Science Program for sustainable development of the belt and road region using Big Earth
 571 Data. Bulletin of Chinese Academy of Sciences, 32(Z1), 2-9.
 572 68 Guo, H, et al.(2018) The Digital Belt and Road program in support of regional sustainability,
 573 International Journal of Digital Earth, 11:7, 657-669, DOI: 10.1080/17538947.2018.1471790
 574 69 Masood, En & Roussi, A (2019). China's science silk road. Nature 569: 20-176
 575 70 Sutherland, W.J. et al. (2018) A Horizon Scan of Emerging Issues for Global Conservation in
 576 2019. Trends Ecol. Evol. 34, 83–94
 577 Weblinks were checked on 16-Nov-2019
 578 **Figures 1a-c.** Spatial overlaps between BRI-associated roads (light purple) and railways (light
 579 blue) in Eurasia and Africa with **(a)** groundwater supply projection for 2020 based on the RCP of
 580 2.5, SSP2 at the CMIP5 phase (as projections were most complete for 2020), **(b)** indigenous
 581 territories (scale is progress towards providing legal security for indigenous groups) and state-
 582 protected areas, and **(c)** conflict areas and level of conflict. Some of these routes already exist but
 583 may be rebuilt, upgraded, resurfaced, enlarged or have new routes built to replace them. Routes
 584 continuous to those built as part of the BRI are expected to receive additional traffic from BRI-

585 facilitated trade (e.g. some of those in China, India, and the EU). Sources of data and figure
586 construction are detailed in supplemental methods.

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