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Reducing Environmental Risks from Belt and Road Initiative Investments in Transportation Infrastructure

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Abstract

The Belt and Road Initiative, due to its diverse and extensive infrastructure investments, poses a wide range of environmental risks. Some projects have easily identifiable and measurable impacts, such as energy projects' greenhouse gas emissions. Others, such as transportation infrastructure, due to their vast geographic reach, generate more complex and potentially more extensive environmental risks. The proposed Belt and Road Initiative rail and road investments have stimulated concerns because of the history of significant negative environmental impacts from large-scale transportation projects across the globe. This paper studies environmental risks—direct and indirect—from Belt and Road Initiative transportation projects and the mitigation strategies and policies to address them. The paper concludes with a recommendation on how to take advantage of the scale of the Belt and Road Initiative to address these concerns in a way not typically available to stand-alone projects. In short, this scale motivates and permits early integrated development and conservation planning.

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Reducing Environmental Risks from Belt and Road Initiative Investments in Transportation Infrastructure[1]

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INTRODUCTION

The location of Roman roads built almost two millennia ago still shapes modern landscapes and local economies (Dalgaard et al. 2018). That scholars can still detect the effect of this transportation footprint is testament to the transformational and enduring influence of transportation networks on people, the economy, and the environment. Environmentally speaking, networks of roads and railways often have been identified as one of the most significant anthropogenic interventions of the earth's ecosystems (W. Laurance 2017; W. F. Laurance et al. 2015; W. F. Laurance and Arrea 2017; Popp and Boyle 2017).

Historically, large-scale transport infrastructure projects have had significant negative environmental impacts across the globe. Given the enormity of the Belt and Road Initiative (BRI), what environmental risks do the proposed BRI transportation projects pose? In Part 1 of this working paper, we review many of the most significant risks facing BRI transportation projects. We consider both the direct effects from roads and rail – typically immediate and localized – and indirect effects from opening up new landscape frontiers, shifting human populations and markets, altering demands for transportation, and balancing energy efficiency with induced demands. Next, in Part 2, we review potential environmental mitigation strategies that could improve the environmental performance of BRI transportation projects. Finally, in Part 3 we will describe policies that can shape the implementation and enforcement of mitigation.

Though not addressed in this paper, BRI projects in other sectors also have environmental impacts. In particular, BRI energy projects such as fossil fuel and renewable energy projects can have a considerable effect on greenhouse gas emissions (GHG) and other pollutants. Serious concerns have been raised that the promotion of BRI fossil fuel investments (especially coal plants) could lock host countries into fossil fuel dependency for the coming decades and hamper them from reaching their nationally determined contribution carbon targets as established under the Paris Agreement on Climate Change (Gallagher and Qi 2018; Sausmikat et al. 2017; Zhou et al. 2018). While BRI transport projects – the focus of this paper – have less direct impact on GHG emissions, the vast geographic reach of road and rail networks results in a more complex set of environmental risks, which can include significant impacts upon GHG emissions.

Transportation investments also pose serious social risks, many closely paralleling environmental risks. Social risks can include economic and physical displacement from taking of land and assets; impacts on disadvantaged, vulnerable, or groups with special rights; impacts on quality of life; degradation of labor and working conditions; and community health, safety and security. These can be profound yet – like environmental risks – they vary by context such as settlement density, working conditions, labor force, worker protections, planning provisions, and other conditions. Social issues are not addressed here yet it should be noted that there is a complementarity between social and environmental risks and mitigation strategies. For instance, our recommendations are equally viable for addressing many of the social risks.

Throughout, we provide examples drawn from the BRI transportation projects within the BRI Corridors, illustrated in the appendices. Appendix 1 is an overview of environmental risks at the scale of the entire BRI. Appendices 2-9 focus on a number of aspects from one specific economic corridor, the China-Indochina Peninsula Economic Corridor (CICPEC) – specifically the three alternative transportation routes between Kunming, China and Bangkok, Thailand – to illustrate more general points made throughout the paper.

In sum, our working paper identifies serious environmental risks from the BRI transportation projects and the potential for mitigation via Corridor SEA planning done as early as possible. The CICPEC example will provide a model of how a BRI Corridor Strategic Environmental Assessment could meet these needs.

A. Data Basis

Our working paper and especially the CICPEC examples draw on the World Bank data set from Reed and Trubetskoy (2018) of BRI railway and road projects. These authors have geolocated almost 30,000 km of new or upgraded railways and roads that have been constructed or are in the process of being constructed since 2013 and almost 15,000 km more are currently in the planning stages (see Table 1; Reed and Trubetskoy 2018). The majority of these investments have been or will be in rails, not roads: more than 60% (by distance) of those recently constructed or under construction are rail projects and 90% of the planned BRI projects are railways (Reed and Trubetskoy 2018).[2] When possible, we will distinguish between transport categories (new versus upgraded infrastructure; train versus rail; high capacity versus conventional rail; divided highway versus undivided highway). Where research is lacking, we must speculate based on prior similarities and differences among these categories in other locations.

Table 1. BRI road and rail projects, completed, on-going, and planned

BRI Projects	**Km under construction or already built**		**Additional km planned, not built**		**Km total**	
	km	%	km	%	km	%
New Undivided Highways	5,547	19%	378	3%	5,926	14%
New Divided Highways	809	3%	-	0%	809	2%
Upgrade to Divided Highways	4,723	16%	841	6%	5,564	13%
Total Road Improvement	11,079		1,220		12,299	
New Conventional Railways	8,649	30%	4,030	27%	12,680	29%
New High Capacity Railways	2,835	10%	3,975	27%	6,809	16%
Upgrade to High Capacity Railways	6,228	22%	5,768	38%	11,997	27%
Total Rail Improvements	17,712		13,774		31,486	

[2] Because there is no official list of BRI projects published by the Government of China, analysts have assembled their own lists of transport. We utilize the BRI projects identified in Reed and Trubetskoy (2018). One of the criteria used for inclusion is that the endpoints of the road or rail investments in question are cities with at least 300,000 inhabitants, consistent with the BRI vision of trade corridors that would connect major hubs throughout Eurasia. Not surprisingly, then, the projects in the Reed and Trubetskoy (2018) data set are mostly large highways and high-speed rail corridors. Other analysts have chosen broader definitions concerning "BRI transportation projects" (see, for instance, analyses in Reconnecting Asia of the Center from Strategic and International Studies (Hillman 2018) or by Aiddata (BenYishay et al. 2016)). Those broader BRI classifications tend to capture more smaller projects.

Total	**28,791**	**100%**	**14,993**	**100%**	**43,785**	**100%**

Source: Reed, T. and S. Trubetskoy (2018) *The Belt and Road Initiative and the Value of Urban Land.* World Bank mimeo.

B. Road & Rail Typologies

We subdivide each type of transport infrastructure following Reed and Trubetskoy (2018) to consider: undivided roads, divided roads, conventional rail, and high-capacity rail. The four categories are described below with particular reference to proximities of both population centers and intact frontier landscapes – two factors that are especially important for understanding investments' environmental risks.

- *High Capacity Rail:* High-capacity rail is dual track and/or electrified rail that transport freight and/or passengers, including high-speed rail (HSR). HSR are defined as high capacity and frequency railway services achieving an average speed of over 200 km/hr (Givoni 2006). The HSR systems have restricted geographic access because passengers and/or freight are limited to entry/exit at very few stations. Further, those HSR stations are usually sited either in or adjacent to pre-existing urban centers, thus limiting new access to frontier landscapes.[3]
- *Conventional Rail:* Conventional rail travel is at speeds less than 200 km/hr and is typically fueled by diesel or other fossil fuels. Conventional rail stops at many more stations than the high-speed rail, thus creating many more entry points to access frontier landscapes. Smaller stations are sited in less populated areas, potentially increasing access to intact frontier landscapes.
- *Divided Highway:* These "high-quality" roads, classified as four-lane highways or larger, tend to be sited between large urban areas, though they may pass through less developed areas. They are restricted to high speed traffic. The divided highways often have limited or controlled access. The degree of access depends on the frequency of off-ramps. Access may also be restricted through tolls.
- *Undivided Highway:* These are "low-quality" roads, i.e., roads which have no more than two lanes but are serviceable for transporting freight. They connect population centers of varied sizes and are less likely to feature restrictions on access through ramps and/or tolls. BRI undivided highways may also be constructed to connect to other transport hubs (for example, to larger BRI projects) such as dryports, airports, or train stations. Because undivided highways typically have unrestricted access for entry and exit, new roads may expand gateways into undeveloped frontiers.

There are several additional categories of minor roads – roads smaller than undivided highways – that also have environmental risks but typically are not a focus of BRI projects. These can range from smaller two-lane highways to unpaved seasonal or logging roads. Minor roads could be included within the BRI as a form of access to primary BRI projects. Additionally, unplanned spur roads that diverge from larger roads (typically from undivided highways, due to their unrestricted access) may spontaneously result from planned BRI projects. Spur roads might penetrate into frontier landscapes, yielding, for instance, a grid of "fishbone development" as has been extensively documented in the Amazon (Barber et al. 2014).

[3] HSR is often flanked by roads for maintenance and emergencies that may provide some access between stations.

Part 1: Environmental Risks from BRI Investments in Transport

Transportation infrastructure can pose many risks to the environment. In this section we distinguish direct effects – abiotic, ecosystems, wildlife – from the indirect effects induced by changes in transport costs and land use. While the former tend to be localized and unambiguously linked to a road or rail project, the latter often have more complex connections but potentially more pervasive impacts. The magnitudes of various effects differ by context. As illustrated in Appendix 1 (*Forest Cover Change Across the Entire Belt and Road*), deforestation – a relatively straightforward proxy for environmental risks – has shown heterogenous responses to transportation investments, depending upon both the ecological and development settings in which investments occur. Cumulative risks of multiple factors are even more challenging to assess and predict, as these factors may evolve and also may interact.

Environmental risks are typically divided between those incurred in the design and construction phases of any infrastructure project and those experienced during the operations. This working paper will only review the latter because the former tend to be extremely site specific and can be confidently identified during a project feasibility study or environmental impact assessment process (World Bank 2012).

I. DIRECT EFFECTS

A. Abiotic Effects

i. Edaphic, Topographic, and Hydrologic Impacts

Once operational, roads modify their physical environment by alterations of hydrologic systems, sediment erosion dynamics, and debris deposition dynamics. The extent and intensity of these abiotic effects can vary as a result of the position of the road relative to slope, nearby waterways and drainage, surrounding land cover, and prevailing winds (Coffin 2007; Forman 1998; Sidle, Ghestem, and Stokes 2014). Most abiotic factors have localized effects immediately around the road and roadside. These impacts can be severe, as in the case of destructive landslides that damage nearby communities and ecosystems. Some abiotic effects, however, permeate across a wider landscape. For example, poorly constructed roads on mountainous terrain can generate increased sedimentation in rivers and streams, creating long-term effects on downstream aquatic communities and producing widespread flooding risks (Forman 1998; Renaud, Sudmeier-Rieux, and Estrella 2013; Sidle, Ghestem, and Stokes 2014). Because so many of the BRI Economic Corridors pass through steep terrain, BRI transportation projects are especially vulnerable to such risks. The consequences can be severe: Twenty-five million inhabitants living downslope from two proposed BRI road projects in Myanmar, for example, are potentially at risk due to vulnerability to increased sedimentation and flooding (Helsingen et al. 2018).

There is little environmental research (beyond engineering feasibility plans) on the effects of railways on hydrologic systems, sediment erosion, and debris deposition. However, it is expected that they will be similar to roads, with impacts depending on topography, hydrology, and climate. It is possible that risks related to uneven topography and steep slopes may be more severe for rail projects (especially HSRs), which for engineering purposes are constrained to relatively straight trajectories. Less able to adjust to the terrain, HSR may face greater complications than roads, and may require more tunnels and bridges.

ii. Pollution

In the context of the Belt and Road Initiative, new or upgraded highways or rail will be built primarily with the intention of increasing freight traffic, with the secondary effect of potentially increasing passenger traffic. In terms of roads, it is expected that increased high-speed freight truck traffic on new and upgraded BRI highways will generate significant noise and air pollution including greenhouse gases (GHGs). Water pollution will also be created from metal corrosion, tire wear, exhaust emission, trash and other pollutants that are washed into waterways, especially during heavy rainstorms or floods when drainage capabilities of ditches and soil are exceeded (Economic Commission for Europe 1975). Measuring pollution requires data on volume and composition of traffic as well as the weight, speed, and efficiency of the cars and trucks (Janic and Jovanović 2012). Assessing the increase in pollution from the new or improved BRI is more complicated, however, as it also requires identifying induced demand for highway travel and transport, displacement of traffic from other routes, and substitution between different modes of transportation. These issues will be discussed below in the Indirect Effects section.

With regards to pollution from BRI rail projects, conventional rail typically has higher emissions per passenger or per ton freight than high-speed rail because the latter is predominantly powered by electricity rather than diesel. HSR emissions are directly related to the sources used to generate electricity and their energy consumption. If significant coal is used as the source of the electricity, then HRS can contribute significantly to local air pollution around the coal plants through the production of SO_2. However, in general both conventional and HSR contribute significantly fewer GHGs per passenger or freight than other forms of transportation such as road, air transport, and waterways (Givoni 2006; X. Li, Fan, and Wu 2017; National Rail 2009; Viana and Cenamo 2008). Conventional freight rail has two to five times higher fuel efficiency than truck transport (Dorsey, Olsson, and Rew 2015), as well as uses 21% less energy per passenger mile (Federal Transit Administration 2009). In Europe along the Mega-TransEuropean transport corridor, the substitution from trucks to freight trains resulted in 64-70% savings in GHGs (Janic and Jovanović 2012). Train are even more efficient than airplanes. As compared to air transport, HSR have lower emissions of CO_2 and NO_x. Moreover, NO_x emissions at high altitude affect climate change much more than ground-level emissions, making air transport even more damaging (Givoni 2006). As with roads, the ultimate pollution impact from a BRI rail project will depend not only on the relative fuel efficiency and pollution controls, but also the induced traffic demand that could increase overall pollution, which will be addressed in the Indirect Effects section below.

Noise pollution from trains (freight and passenger) has also been recognized as harmful to the health of humans and wildlife populations. For freight trains, the longer, heavier, and faster trains generate higher level of noise but exposures are shorter due to higher speeds (Givoni 2006; Janic and Jovanović 2012).

B. Ecosystem Effects

i. Habitat Loss

The most basic environmental impact from a road or rail is the destruction of habitat to create a transportation corridor. The direct loss in habitat due to the footprint of roads and roadside is typically 1-2% of the land cover of most countries, with a greater proportion near urban centers and the lowest percentage in the less developed landscape frontier (Forman 1998). Habitat loss is closely correlated with many accompanying environmental risks that are related to loss of ecosystem services such as biodiversity habitats, carbon storage and sequestration, water provision and quality, soil stabilization and erosion protection (A. Dobson et al. 2006; Song, Huang, and Townshend 2014). (See Appendix 3: *Environmental Indicator: Ecosystem Effects as Measured by Forest Cover Change in CICPEC*.)

Roads are considered one of the leading proximate causes of habitat destruction, especially tropical deforestation.[4] For example, a meta-analysis by Geist and Lambin (2001) of the existing literature on the causal factors for tropical deforestation found that the extension of road infrastructure was a proximate cause of deforestation in 61% of the cases studied (93 of 152) while rail expansion was a proximate cause in 11% (17 or 152). Such evidence has led to the development of a relatively new discipline, "road ecology," which addresses solely the impacts of road construction and operations and their mitigation (Coffin 2007; Forman 1998; Forman et al. 2003; van der Ree, Smith, and Grilo 2015). More recently, "railway ecology" has also been proposed (Popp and Boyle 2017; Wingard et al. 2014), although the general assumption has been that the environmental impacts from rail, while similar in nature, are less severe in intensity to those from roads. Perhaps for this reason, the great majority of the research on environmental impacts has focused on roads rather than railways. For example, a survey of transport-related impacts on wildlife found that 94% of peer-reviewed articles were about impacts of roads, with only 6% on rail impacts (Popp and Boyle 2017).

ii. Edge Effects

The "road effect" (also known as the "edge effect") is the area over which the ecological effects of a road and traffic extend into the adjacent landscape due to habitat disturbance effects (van der Ree, Smith, and Grilo 2015). This is a more subtle but pervasive ecosystem effect of a road that extends well beyond the initial loss in habitat from the transportation corridor. The newly created edges along a roadside allow penetration of light, wind, and chemical pollution and modify microclimatic conditions. Such alterations affect the distribution and abundance of plant and animal species. Specialized "habitat-interior" species of plants and animals are often outcompeted by "edge-adapted" generalist or weedy species (Bruschi et al. 2015). The edge effect can also lead to cascading abiotic effects. For example, because the edges are desiccated from light and wind exposure, they are especially prone to forest fires. In the Amazon, edges are particularly vulnerable to fires initiated in adjacent burned pastures and/or selective logged forests with their built-up fuel load. Once the forest fire enters along the roadside, forest fires can burn deep into the interior of the forest (Cochrane and Laurance 2002).

The penetration of the road-effect zone into the adjacent landscape is determined by the characteristics of the (i) road (divided versus undivided, paved versus unpaved, elevation relative to adjacent landscape); (ii) traffic (vehicle type, volume, speed); (iii) adjacent landscape (topography, hydrography, vegetation type, habitat quality); (iv) prevailing wind speed and direction; and (v) species traits and their sensitivity to the impact (R. van der Ree, Smith, and Grilo 2015). The road effect zone can be felt as far as 1500 m from a highway (Bruschi et al. 2015). It is estimated that 15-20% of the earth's landcover is influenced by this road effect (Forman 1998). Given that most BRI road projects are relatively large, we can estimate that the "road effect" will extend on average at least a kilometer into the adjacent roadside habitat (Benítez-López, Alkemade, and Verweij 2010; Ibisch et al. 2016). The China-Indochina Peninsula Economic Corridor in tropical Southeast Asia is especially vulnerable to edge effects because research has shown that this effect is especially pronounced in tropical ecosystems (Goosem 2015).

[4] It should be noted that much of the research focused on roads and deforestation in Latin America, especially the Amazon, and that more recent rigorous research in Asia also very strongly supports that the contexts are critical.

Often railways are lumped into the same category as roads and other linear infrastructure for their contribution to transforming landscapes (Bruschi et al. 2015). The magnitudes of edge effects from railway clearings are not well understood because the field of railway ecology is still nascent (Popp and Boyle 2017). However, there is strong reason to believe that the ecosystems effects for BRI rail projects would be, on average, less than those from BRI highway projects. The edge effect – that is, the area over which the ecological effects of rail extend into the adjacent landscape – is likely to be less severe for several reasons: First, the width of clearing is usually narrower for railways. The loss of habitat from the rail right-of-way corridor – typically 15 m on either side of the tracks – is on average smaller than the corridor destroyed for roads and roadsides (and substantially smaller than that of divided four-lane highways) (Dorsey, Olsson, and Rew 2015). More narrow corridors lead to less change in light exposure, wind patterns, and microclimates, and thus less opportunity for invasion by exotic and weedy species. Second, train traffic is less frequent than car and truck traffic, thus creating less frequent though louder behavioral disruptions of wildlife.

iii. Habitat Fragmentation

The edge effect is exacerbated by another attribute of the road network: fragmentation of the landscape. Roads often fragment large habitat expanses into smaller patches, leading to dramatic landscape transformation and loss of the ability to support healthy ecosystems, populations of plants and animals, and other ecosystem services (Bruschi et al. 2015; Ibisch et al. 2016; Potapov et al. 2017). A review of almost four decades of fragmentation experiments around the world found that habitat fragmentation reduces biodiversity by 13 to 75%, decreases biomass and carbon storage, and alters nutrient cycles. These impacts were most severe in the smallest and most isolated fragments and continued to grow in magnitude over time (Haddad et al. 2015).

The edge effect – described above – further exacerbates the impact of habitat fragmentation. The smallest and most irregularly-shaped patches have the largest ratio of perimeter to volume and consequently the greatest edge effects.

From a BRI perspective, it is important to distinguish the impact of fragmentation for different classes of roads, since approximately half the BRI road projects are large divided highways and most of the rest are relatively large, paved two-lane roads. Many of these road or rail projects represent upgrades rather than new transportation corridors, so may not be fragmenting additional habitat. By comparison, much of the fragmentation research reported in the literature has focused on smaller roads – often built for logging access – that abut intact frontier landscapes and areas with little prior development. Most but not all of this research has taken place in Latin America (Chomitz and Gray 1996; Pfaff 1999; Deininger and Minten 2002; Barber et al. 2014). The few studies of fragmentation that compare different size classes of roads have found that the smaller roads are responsible for most of the fragmentation. For example, a study of the impacts of the expansion of road network from 1970 to 2008 in Xishuangbanna in Yunnan Province, China found that increases in road density for the minor roads resulted in significantly greater levels of landscape fragmentation than for the larger roads and highways (S. Liu et al. 2011). While this would imply that the large BRI highways do not create as much concern about forest fragmentation, in the Indirect Effects section below we will discuss the conditions under which

BRI highway projects may lead to access to undeveloped landscapes and further generation of additional roads and thus fragmentation.

It is likely that rail lines result in less habitat fragmentation due to the fact that, for engineering purposes, rail lines are constrained to follow straighter pathways – especially for high-speed rail – and thus create fewer irregularly-shaped patches. Perhaps most significantly, railways allow greater control of access to the adjacent land by limiting the construction of new secondary roads, which drive fragmentation (Viana and Cenamo 2008), as will be discussed in the Indirect Effects section below.

iv. Intact Frontier Landscapes

A complementary concern is that, as more of the landscape is partitioned into smaller and smaller fragments by the road network, fewer large, undisturbed roadless tracts remain. As these large tracts diminish in number and size, the ecological importance of the remaining tracts increases because they create critical refugia for many plant and animal species that cannot survive in smaller fragments. They also provide significant ecosystem services such as carbon storage and sequestration, climate stabilization, water provision, indigenous culture, and the maintenance of human health (Ibisch et al. 2016; Selva et al. 2015; Watson et al. 2018). These large areas of undisturbed wilderness or frontier landscapes can be measured as "intact forest landscapes" (IFL), that is, connected mosaics of forest and naturally treeless ecosystems with no remotely detected signs of human activity and a minimum area of 500 km^2. As of 2013, ILFs represented less than 21% of once forested land cover globally. Tropical South America and the boreal regions contained the greatest percentage of the IFLs. (See Figure 1.) In Southeast Asia only 8% of IFLs still remain while the northern Eurasia/temperate and southern boreal region contains just 9% (Figure 1; Potapov et al. 2017). Because of the outsized role that IFLs serve in protecting biodiversity and generating ecosystem services, encroachment on IFL areas by transportation projects creates straightforward risks to these environmentally critical areas.

Almost none of the BRI projects identified by Reed and Trubetskoy (2018) cross or even approach intact frontier landscapes, except for a proposed road and a rail projects in the northern reaches of the China-

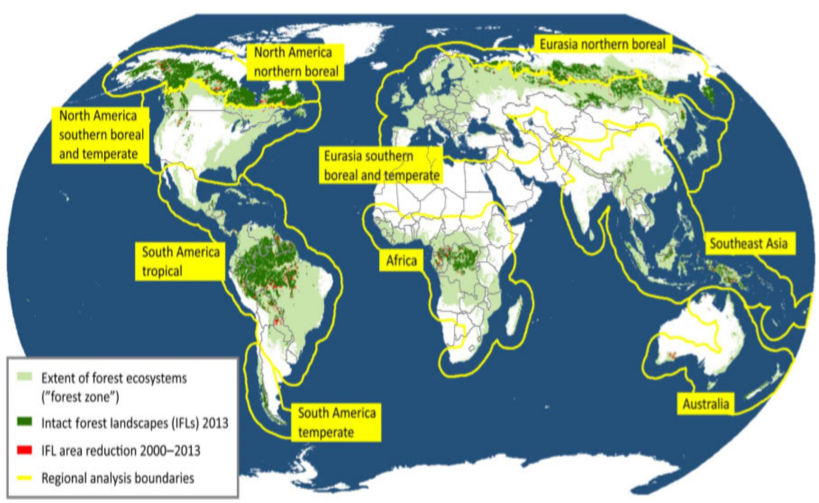

Figure 1. Intact Frontier Landscape extent for the year 2013, IFL area reduction from 2000 to 2013, and regional boundaries. From Potapov et al. (2017)

Mongolia Russia Economic Corridor (CMREC) and several segments of projects within CICPEC Southeast Asia pass. This may not be surprising, as BRI projects are designed to connect population centers. Given how few IFLs remain in the world, it is especially critical to safeguard the integrity of the few remaining IFLs in those two BRI Economic Corridors. (See Appendix 4: *Environmental Indicator: Ecosystem Effects as Measured by Intact Frontier Landscapes*.) It should be noted that the Ice Silk Road in the arctic region, however, traverses a region with a much greater proportion of large tracts within which IFLs are still relatively extensive in northern Eurasia and the Northern boreal region (45%) (Potapov et al. 2017).

C. Wildlife Effects

i. Habitat and Behavioral Disruption

Since the 1970s, researchers have focused on effects of roads on wildlife more than any other risks. Extensive research has been carried out concerning the risk of roads to mammals, birds, herpetofauna, pollinators, non-pollinating insects and other invertebrates (Ahmed et al. 2014; Coffin 2007; Popp and Boyle 2017; R. van der Ree, Smith, and Grilo 2015). For some animal species, road-related mortality ranks as one of the causes, if not the most significant cause, of species endangerment (Seiler and Helldin 2006).

Wildlife impacts are mediated through a range of mechanisms, the first of which was covered above, i.e., risks due to habitat loss, fragmentation, and the edge effects. A meta-analysis of fragmentation investigations shows that reduced fragment area and increased fragment isolation has significantly reduced the abundance of mammals, birds, and insects (Haddad et al. 2015). Understory birds in Amazonia are particularly vulnerable to edge effects, road-induced fragmentation, fire, selective logging, hunting, and traffic disturbance (Ahmed et al. 2014). While populations of many habitat-interior species may be diminished in the roadside buffer, other animal species are attracted to the open canopy and thick understory. These tend to be edge-adapted species – secondary forest species with life history traits to maximize growth rates, often referred to as “weedy species.” Many of these weedy species are not native to the area (Bruschi et al. 2015). Because edge-adapted animal species are generalists and have very large ranges and high reproductive rates, they contribute little to the biological diversity levels of the broader region. Meanwhile, the loss of species adapted for the intact habitats diminishes the species diversity and ecosystem resilience. (See Appendix 5: *Environmental Indicator: Wildlife Effects as Measured by Biodiversity hotspots and Umbrella Species in CICPEC*.)

Wildlife are vulnerable to a range of additional road-related conditions beyond ecosystem effects. Wildlife-vehicle collision (WVC) is perhaps the most visible and well-studied. Vehicles are inherently dangerous to wildlife. High-volume and high-speed traffic – which typifies BRI road projects – contribute to the highest rates of WVC (Gunson, Mountrakis, and Quackenbush 2011; Litvaitis and Tash 2008). The situation is exacerbated for wildlife that are attracted to open flyways and paths, further increasing their risk of WVC (Bruschi et al. 2015; Coffin 2007; Morelli et al. 2014; Myczko et al. 2017). This phenomenon has been documented especially for predators and large herbivores and explains the high level of collision mortality among Florida panthers (*Felis concolor*), Iberian lynx (*Felis pardina*), wolf (*Canis lupus*), and brown bear (*Ursus arctos*) (Seiler and Helldin 2006). The decreased wildlife abundance due to vehicle collisions has been shown in some studies to pose a greater risk than the negative effects of habitat fragmentation (Jackson and Fahrig 2011).

Within railway ecology, environmental research has also focused primarily on wildlife effects. Wildlife-train collisions (WTC) may be similar to that from roads, but their magnitude of the impact is uncertain (Dorsey, Olsson, and Rew 2015; Forman et al. 2003; Popp and Boyle 2017; Seiler and Helldin 2006; Wingard et al. 2014). Where railways pass through high-quality wildlife habitat, collisions with ungulates and carnivores are common. Some characteristics of rail as compared to roads make them more prone to collisions, such as dense vegetation (habitat) near tracks that obscures visibility. Railway corridors – lacking the hard asphalt pavement of roads – are also more likely to serve as corridors for animals to travel on. For species attracted by the rail "corridor effect," WTC can be especially dangerous. In area of Alaska, for example, moose populations declined by 70% due to WTC (Dorsey, Olsson, and Rew 2015).

For most BRI road and rail projects – which tend to be large – the more serious risk is not the attraction of open corridors but rather the barriers created by the linear infrastructure project. Large divided highways may serve as barriers to all species except those that are habituated to open-air flight. These large roads are not only wide but most have additional barriers such as medians in the middle and fencing on either side of the road (Bruschi et al. 2015). In addition to physical obstacles, frequent and loud traffic can create behavioral modifications that lead some wildlife species such as elk during the hunting season to avoid areas with roads (Paton et al. 2017). At the other extreme, narrow roads with low traffic volume and some regrowth create far less of a barrier, though even in these cases the road can inhibit sensitive species that tend to avoid both edge-affected habitat and the road clearing itself (W. F. Laurance et al. 2014). Like roads, rail lines can create a barrier for some species. Rail lines, especially HSR, often are lined by fences that create added barriers to both resident and migratory wildlife species (Bruschi et al. 2015).

The barriers created by roads and rail endanger animal populations by disrupting migration, splitting populations, and thus reducing genetic variability (Sawyer et al. 2013; Wingard et al. 2014). Roads are responsible for decreased movement and genetic variability among populations of understory birds in the Amazon (S. G. W. Laurance, Stouffer, and Laurance 2004). For migratory and nomadic mammal species, these barriers can create an even more serious obstacle. The Qinghai-Tibet Railway, for example, created a barrier to the migration of the endangered Przewalski's Gazelle which has reduced the genetic viability of that species (Yu et al. 2017).

Railway creates some unique hazards to wildlife not found in roads. For example, train embankments, when high, can present a significant barrier (Wingard et al. 2014). Similarly, wildlife can be electrocuted by the third rail of HSR. Small animals, especially turtles, can become trapped between the two rails (Dorsey, Olsson, and Rew 2015; Seiler and Helldin 2006).

ii. Wildlife Poaching and Illegal Trade

Roads and railways not only create conduits for wildlife travel, but they also often increase access for hunters. Roads, and in particular minor roads that penetrating frontier landscapes, can increase both legal and illegal hunting of wildlife (Clements et al. 2014; Gray et al. 2018; W. F. Laurance 2015; Wingard et al. 2014). This is likely a greater threat from roads than railways, due to the limited human access points along rail lines. Train stations are built in human settlements, so rarely offer new access for poaching in frontier landscapes. That said, as noted earlier some HRS lines have access roads flanking the rail line for maintenance and emergencies which could be used by poachers.

Transportation infrastructure – both roads and rail – poses a second and perhaps more serious threat to wildlife trade: Improved transportation networks can facilitate the movement of illegal wildlife traffic. This is an especially serious concern for the CICPEC in Southeast Asia, one of the world's most active centers for illegal wildlife trafficking (BenYishay et al. 2016; Broussard 2017; Felbab-Brown 2013a, 2013b). Ultimately, it is this improved transportation efficiency – ironically, a key goal of the BRI Economic Corridors –that presents the greatest threat for some of wildlife species highly prized in East Asian markets. (See Appendix 5: *Illegal logging and wildlife trade in CICPEC*.)

II. INDIRECT EFFECTS

Once road and rail projects begin operating, they set into motion additional, unintended changes that can affect the environment even more profoundly than direct effects. Two particularly notable indirect effects are the changes in forest cover and GHG emissions that often result from new frontier access and changes within markets. In this section, we will review the conditions under which the land use and GHG change are most prevalent and the implications for BRI road and rail projects.

A. Land-Use Change & Deforestation

Deforestation caused by land-use changes following changes in transport costs can dramatically exacerbate environmental risks. Road building opens up frontiers to settlement, while increasing market access for farmers and ranchers to forests. Studies of deforestation in Brazil (A. Pfaff et al. 2007), Mexico (G. C. Nelson and Hellerstein 1997), Belize (Chomitz and Gray 1996), and Democratic Republic of Congo (Man Li et al. 2014) indicate some close relationships between road building and deforestation. More generally, in fact, road building has been correlated with deforestation rates − noting that the research has been heavily focused on the impacts within many settings in Latin America in the 1980s and 1990s (Chomitz and Gray 1996; Cropper, Griffiths, and Mani 1999; Deininger and Minten 2002; Ferretti-Gallon and Busch 2014; Geist and Lambin 2002; G. C. Nelson and Hellerstein 1997; A. S. P. Pfaff 1999). Nearly 95% of all deforestation in the Amazon, occurs within 5.5 km of roads or 1 km of rivers (Barber et al. 2014). This can generate a spiraling loss of forest and increasing damage to biodiversity and ecosystems from forest loss, habitat fragmentation, and edge effects discussed in the Direct Effects section above.

However, spatially-explicit studies with attention to diverse contexts reveal significant heterogeneity in the deforestation generated by roads − by the locations of roads (and perhaps also the types, although evidence is limited). The degree to which roads lead to deforestation vary with the topography (Freitas, Hawbaker, and Metzger 2010; Hoyos, Cabido, and Cingolani 2018) and agricultural suitability (Ruan, Qiu, and Dyck 2016), local wealth levels (Deininger and Minten 2002; M. Li, Wu, and Deng 2013), protection enforcement (BenYishay et al. 2016; Bhattarai, Conway, and Yousef 2009; Hargrave and Kis-Katos 2013), and tenure arrangements (Geist and Lambin 2001; Mena, Bilsborrow, and McClain 2006). Crucially for forest dynamics, it has been found that prior land clearing and prior development affect roads' impacts (Andersen 1996; Cropper, Puri, and Griffiths 2001; A. Pfaff et al. 2018). In sum, for a number of reasons the deforestation that a policy maker should expect due to a new road varies greatly by the setting.

i. Evidence on Road Impacts Given Prior Development and Deforestation

Chomitz (2007) delineates three main types of forest settings: forest-agriculture mosaicland where population densities are relatively high, markets are near, and deforestation rate is high for the sparse remaining natural forests; frontier and disputed areas where pressures for deforestation and degradation are high or increasing, and control is often insecure and in conflict; and areas beyond the agricultural frontier where substantial forest remains with few and largely indigenous inhabitants, and some pressure on timber resources. These categories accord with those used by Pfaff et al. (2018) in looking at heterogeneous impacts of new roads, distinguishing between settings with high, medium, and low levels of prior roads and deforestation. For those settings with medium prior deforestation, new roads are expected to lead to significant deforestation, as those areas tend to be where the frontier of development is located and expanding. By comparison, more developed forest-agriculture mosaiclands may have already experienced more deforestation given that they already had relatively low transport costs and higher economic activity. Such forest-agriculture mosaicland areas may even experience net reforestation as a result of new road construction if the further improvements in transport cost lead to outmigration or a transition away from agriculture as the primary economic activity. Finally, for regions beyond the agricultural frontier with low prior deforestation it is important to distinguish between the short-run and long-run impacts. In the short run, inputs for rapid expansion of production, such as labor and capital, are limited. Thus, deforestation responses can be minimal. However, if new roads generate profit opportunities, inputs and labor will enter the area, increasing production—and deforestation—in the long run. That can lead, in turn, to spatially path-dependent dynamics in which early arrivals create the conditions for others, including by lobbying for other infrastructure, so that the frontier expands.

The implications of this relationship between prior development and deforestation for environmental impacts are manifold. New road access to forest with medium prior development as compared to new access to areas with high prior development, on average, leads to greater absolute deforestation and its consequent habitat loss, fragmentation, edge effects, and biodiversity loss. New road access to intact frontier landscapes (areas with low prior development) could do either little or a great deal to forests, depending on the time period being considered as well as any complementary mitigation policies such as protected areas that could flank investments (see Part 2). If such access sets in motion a significant economic development dynamic, the impact on forests can be highest of all. This impact is further compounded by the fact that habitat loss and degradation to intact frontier landscapes is relatively more harmful than to secondary or disturbed habitats because of the ecosystem functions of large intact areas of forest, including higher levels of biodiversity, high levels of ecosystem services such as carbon sequestration, and role as a refugia, as described above in the Direct Effects section on IFLs.

ii. Theory about Shifts in Such Risks as Economic Development Proceeds

Two well-known theoretical frameworks – not mutually exclusive − provide "macro-scale" rationales for expecting heterogeneities across sites in the impacts of investments in transportation infrastructure. In considering average impacts of new roads, given other factors, and marginal impact for each condition, both Environmental Kuznets Curve (EKC) and Forest Transition (FT) frameworks consider evolutions of whole economies. They are potentially relevant if BRI investments unleash significant economic shifts.

The literature considering EKCs focuses on changes in per capita income and their implications for the change in environmental quality. As incomes rise for any given population, consumption tends to rise over time with it, while environmental quality tends to fall due to the effects of both production and consumption. As a consequence, eventually the marginal utility of consumption tends to diminish while, in contrast, rising scarcity of environmental quality raises the marginal utility of preserving ecosystem services and environmental public goods. This could motivate changes in individual behaviors and could lead to support for public environmental regulation that would increase environmental quality even if at the expense of consumption. Empirical evidence for an EKC in terms of deforestation remains mixed (Cropper and Griffiths 1994; Foster and Rosenzweig 2003; Koop and Tole 1999). Nevertheless, the point holds that a wealthier society might find it worthwhile to use more costly routes to lower environmental damage or put protected areas alongside roads to lower impacts. (See Part 2 on mitigation strategies.)

More recent studies suggest that EKC patterns could be more N-shaped, with a return to high levels of deforestation as wealth increases demand for land-intensive products (Joshi and Beck 2017). DeFries and colleagues (2010) provide evidence that concords with the proposed N-shape: in a time series from 2000-2005 they find that urbanization and trade are associated with increased demand for agricultural products, which leads to increased deforestation. It seems therefore that any posited EKC is likely to be a context-dependent depiction of the relationship between demand for different commodities and their corresponding land uses. At low levels of income, the most important factors may be local demand for local agricultural goods vs. local demand for forest products. At higher levels of income, a country's forested regions are likely to be more integrated into the urban economy and global trade networks, so the relevant variables will include demand for exportable agricultural commodities versus the demand for sustainably harvested timber and other commodities or amenities provided by forest cover.

This competition between land uses appears to be significantly related to trade openness and comparative advantage. Leblois and colleagues (2017) find that trade in agricultural commodities and trade competitiveness are associated with deforestation. However, this effect is less pronounced where agricultural land is already extensive (Leblois, Damette, and Wolfersberger 2017). It appears that regions where agriculture is still expanding into forest areas will experience more deforestation pressure as development progresses, while regions whose comparative advantage lies in sustainable timber or agroforestry production systems may see net reforestation. This pattern is borne out by the experience of the American South, where land use has transitioned from agriculture toward forestry in the 20th century (Carter, Kellison, and Wallinger 2015). Similarly, Kenya has seen significant secondary forest regeneration as a result of post-colonial demand for tree products on small-holding farms (Holmgren, Masakha, and Sjöholm 1994), while in Indonesia comparative advantage in annual agriculture versus in tree plantations is significantly linked to deforestation outcomes (Baylis, Fullerton, and Shah 2016).

Forest Transition (FT) theory, which has focused upon forests in particular, posits that at least some countries may undergo a large-scale transition from net deforestation to net reforestation. FT theory depicts a progression over time that starts from widespread intact forest landscape, moves through a period of high deforestation, toward a state of stabilized forest cover and forest-agriculture mosaics, and eventually generates net reforestation (noting that historically this has included rising plantations). Shifts from net forest losses to net forest gains have been observed in Europe and the Eastern United States (Rudel, Schneider, and Uriarte 2010), as well as in some developing nations such as Vietnam (Meyfroidt and Lambin 2009), Costa Rica, Puerto Rico, and regions of Indonesia and India. However, there are multiple possible mechanisms for such "forest transitions" and not all of them clearly involve net forest gains when looking more broadly across space, for example, at the global level. Trade clearly can allow for one country to rise in forest by simply displacing deforestation elsewhere via inputs of timber and agricultural products (Meyfroidt, Rudel, and Lambin 2010; A. Pfaff and Walker 2010).

Another mechanism that could support a forest transition via movements within one country might be labor reallocation from agricultural to urban areas − where forest impact per person may be lower. If labor is scarce in an area, and the non-agricultural economy expands, then agricultural land use could decrease and forests could increase. This accords with patterns of structural transformation and could be caused by improved transportation infrastructure (Asher and Novosad 2015; D. J. Kaczan 2016). This can happen when the manufacturing sector expands and may continue as the services sectors expand.

Thinking at the regional level, employing a general equilibrium perspective, transport improvements might themselves increase the pace of urbanization, facilitating migration to urban areas. This can also be part of increasing the relative productivity of manufacturing and services in urban areas versus agriculture, so land and population exit agricultural production in rural areas (Deng et al. 2011).

Moving to general equilibrium effects for the economy as a whole, more transportation infrastructure could increase the rate of economic growth. Country-wide growth could lead to increased demand for agricultural commodities or timber, raising deforestation. Alternatively, growth could contribute to an EKC pattern, and a possible net reforestation, since the marginal impact of increased income is not the same at all points of economic development but instead appears to vary with food and natural scarcity.

Which of these mechanisms dominates in a particular setting and time period is an empirical question. With more information about a setting, we can speculate about the likely impacts of various forms of investments in transport infrastructure, including new transportation corridors and various upgrades.

iii. Empirical Examples

The empirical literature on roads and forest cover on the whole, then, provides the opportunity to match cases to theoretical predictions. The following summaries review empirical studies by region, then raise the question (not sufficiently explored in the empirical literature) of the type of investment.

Brazil: The Brazilian Amazon contains a significant share of the world's primary forest and has attracted a high degree of attention from conservationists, including due to its extensive intact frontier landscape (Potapov et al. 2017). The literature about roads and deforestation in Latin America indicates that road building tends to raise deforestation in such settings and higher road density if anything raises land clearing, particularly for cattle production. As studies have suggested that deforestation impacts differ by pre-existing clearing patterns (Pfaff et al. 2018), and road-linked deforestation in some areas was lower than some expected (Chomitz and Thomas 2003), avoiding deforestation from investments seems likely to require both targeting of particular settings and complementary mitigation policies.

India: Relative to Brazil, much of India is already characterized by forest-agriculture mosaicland, with virtually no remaining intact forest landscape (Potapov et al. 2017). Studies of the Prime Minister's Rural Road project have concluded that in this type of setting increasing the road network in rural India has resulted, on average, in roughly zero net deforestation (Asher, Garg, and Novosad 2017; D. J. Kaczan 2016). Heterogeneity analysis suggests net reforestation for densely populated agricultural areas (D. J. Kaczan 2016) with net deforestation for more distant and heavily forested regions. One mechanism that seems to at least in part explain the result for densely populated areas is labor reallocation, since road building is found to be linked to an increase in non-agricultural employment (Asher and Novosad 2015).

China: China also has a significant rural population living in what might be characterized as forest-agriculture mosaicland and little intact forest landscape (Potapov et al. 2017). Deng et al. (2011) find that road connections in rural China, controlling for economic variables at the watershed level, are associated with net reforestation. The mechanism posited is labor migration, as roads in China tend to allow migration into swiftly growing industrial centers of production. Another element here is the high degree of economic growth. In addition to causing rural-urban migration, a growing economy creates more demand for commodities which may be produced at the expense of forests. General equilibrium effects like these are more difficult to empirically verify but may have significant impact in reality.

Cross-country Comparisons: Dasgupta and Wheeler (2016) and Danyo, Dasgupta and Wheeler (2018) provide spatially explicit estimates of forest loss associated with road upgrading in Cameroon, Bolivia, Myanmar and the Lao People's Democratic Republic. Their estimates indicate a footprint between 5 and 10 km where forest loss is likely following road improvements. But within their estimates significant heterogeneity supports the framework presented in this report. For Lao PDR, the most significant forest loss is expected in the northern region where low pre-existing clearing coincides with relatively high expected returns from agriculture. Similarly, the less-developed northern highlands of Cameroon experience significant forest loss associated with road improvements. Myanmar's central and east-central forests and Bolivia's Yungas region are also seriously threatened. Protected areas appear to have a positive effect on forest cover in all countries covered by these studies, pointing toward a need for protection in areas with both low prior clearing and high potential for agricultural profitability. This can complement roads and rails.

iv. Application to BRI

BRI road projects are proposed for a wide range of settings, so it is not helpful to offer a single view concerning the indirect deforestation effects from new construction and upgrading of BRI roads. Yet several factors lead us to believe that for large fractions of potentially affected areas, the patterns identified in India and China to date may on average be more applicable than those documented for the Brazilian Amazon − although we hasten to emphasize that even within regions of India and China it appears that the heterogeneity of impacts can include falling versus rising forest area. (Appendix 7: *Environmental Indicator: Indirect Effects as Measured by Forest Cover Change in CICPEC* explores in more detail indirect effect trends in Southeast Asia and their relevance to three BRI transportation routes.)

The single clearest reason for the applicability of some more than other past results for roads' impacts is that most BRI road projects – including even the new construction projects – are built or intended to be built either on or very near to the existing footprints of smaller roads. Thus, they are not providing any entirely new access to landscape frontiers even if they are improving access (perhaps to critical levels). Most such planned investments are also connecting population centers and, as such, not creating access to frontiers at their endpoints − though potentially creating access to intact frontier forests in the areas between the population centers (it is within those latter types of areas that the type of infrastructure and complementary mitigation policies are likely to matter a lot for forest outcomes). For BRI divided highway projects with four lanes or more, access to intact forest may be restricted by exit ramps or tolls. In such cases, a limited-access highway that replaces a smaller, unrestricted road could actually reduce access to frontier forests, at least in principle. Within the already more densely developed areas, effects from increased commerce and expansion of new manufacturing or services, urbanization, changes in land prices, and other equilibrium effects are likely to dominate. Finally, while most BRI transportation projects have not been sited or planned near to Intact Frontier Landscapes – remote and undeveloped wilderness areas would be disturbed by any deforestation from new road construction – a few planned projects already have been. (See map of IFLs in Figure 1 and the example of a Thai project in Appendix 4: *Environmental Indicator: Ecosystem Effects as Measured by Intact Frontier Landscapes*.)

v. Roads versus Rails

Most BRI projects are rail not road projects, yet the literature on indirect effects from rails on land use is far less extensive. Donaldson (2010) finds that rail connections in India decrease trade costs and price gaps between regions, integrating markets and transmitting prices across the sub-continent. In the US context, Vessali (1996) finds that rapid transit infrastructure tends to increase urban density near stations, if urban zoning regulation is aligned with this outcome. Thus, it appears that rail investments exhibit similar economic impacts as do roads, creating opportunities for the expansion of agricultural commodities while also potentially increasing urbanization and outmigration (de Soyres et al. 2018).

Yet one might nonetheless conceptualize a continuum in terms of the degree of local access to transport networks and consequent local environmental risks. Rail provides access to freight and passengers only at stations. High-speed rail lines service fewer stations than conventional railways. As such, rail allows access at fewer points and thus they may open less access to frontiers. This has led some to advocate for rail links as an alternative to roads in sensitive areas like the Amazon (Viana and Cenamo 2008). Risks could still be high if stations are near forest frontiers or serve as new nodes for transportation network growth which generates expansion into forest frontier areas. Moreover, many high-speed rail lines are often accompanied by minor access roads near the tracks to facilitate maintenance and emergency repairs. Thus, BRI rail investments are likely to allow some access to frontier forests, even if perhaps in general that is less than is created by roads. Limited-access highways similarly provide access only at designated exits, while the conventional road infrastructure might allow access at any point along its length. Thus, it might be expected that both railroads and limited-access highways cause less indirect environmental risk on average than do highways which provide greater access. Moreover, one could envision the possibility that such investments in rail systems or limited-access divided highways could potentially reduce pressure on habitats if they draw traffic from smaller roads that offer greater access.

B. Carbon and Other GHG Emissions

The potential for indirect effects of land-use change and deforestation from BRI road and rail construction, as described above, could not only profoundly affect forest cover and ecosystem health but also generate a significant impact on the global climate. Deforestation, especially in the tropics, represents a significant source of carbon emission, to the point of contributing close to one-fifth of all anthropogenically-produced emissions (Harris et al. 2012). Deforestation within tropical IFLs could be especially harmful for their impact on carbon emissions from dense forests (Potapov et al. 2017).

BRI projects can have indirect effects on GHG emissions through the secondary impact via shifts in trade and resultant changes in vehicle traffic and land use (Maliszewska and van der Mensbrugghe *in prep*.). An assumption has been that fuel-efficient modes of transportation should reduce energy consumption and GHG emissions, as above. High-speed rail has higher energy efficiency and lower GHG emissions on a per passenger or per ton freight basis than conventional rail, which has higher efficiency than freight trucks and cars, which in turn have higher efficiency than air transport. However, whether the upgrade to a more efficient mode translates into an absolute decrease in GHGs or air pollution emitted depends on several factors including substitution (how many passengers or freight shift from air transport, cars, or conventional rail) and traffic generation (how much new demand for transport is generated by the construction). Emissions saved also depends on how freed capacity (on the road and runway) is used. If newly available runway capacity is used for more energy-intensive long-haul flights, for instance, then mode substitution could raise environmental impact (Givoni 2006). The results vary depending on the setting and the competing modes of transportation as well as uncertainty in future transport demand, patterns of urbanization, technology, and sources of energy production (e.g. Chai et al. 2016; National Rail 2009; Westin and Kågeson 2012). For example, when comparing HSR and air transport using a duopoly model, D'Alfonso and colleagues (2016) found HSR are more energy efficient per passenger/km but because of the induced demand, the new railway system tends to increase energy consumption and GHGs when competing with air transport. Similarly, modeling by Westin and Kågeson (2012) found that substitution would have to be very large, and mostly from air transport, to balance GHG emissions from new HRS construction and increased traffic. A general equilibrium study by Chen and colleagues (2016) of high-speed rail in China used data from the last 15 years of HRS construction. The authors found that HSR construction has resulted in increased demand for transport services, thereby resulting in more GHG emissions than were displaced. Studies like these indicate that induced demand is an important element of transportation infrastructure's impact that may affect land use and deforestation as well.

Part 2: Mitigation of Environmental Risks from BRI Investments in Transportation Infrastructure

While environmental risks generated by BRI road and rail projects can be significant and extensive, a range of choices exist that could lower both the chances and the magnitudes of such potential harms. Within Part 2, we present these activities in terms of the "mitigation hierarchy," a sensible framework to organize the consideration of ways to limit varied environmental risks from BRI road and rail projects to biodiversity and ecosystem services. Such a hierarchy is commonly comprised of four types of actions – avoid risks, reduce risks, restore, and offset damages – that often are used in combination (Figure 1).

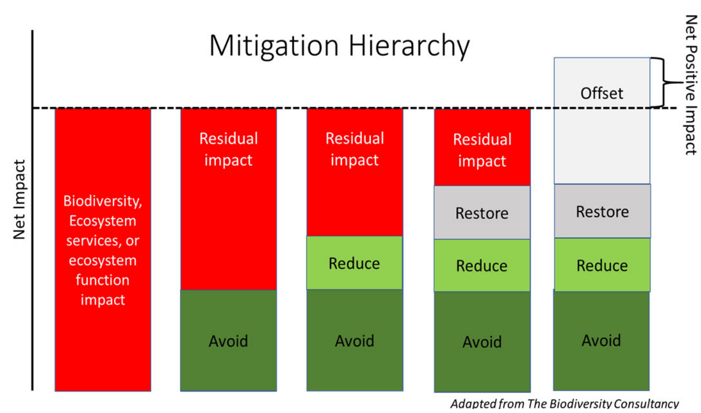

Figure 2. The Mitigation Hierarchy.
www.thebiodiversityconsultancy.com/approaches/mitigation-hierarchy/

For the BRI, such activities could balance economic gains from transport investment with gains from sustaining natural capital. Both support human well-being locally and around the globe. Mitigation activities can help to reduce the direct and the indirect effects from BRI projects (described in Part 1). Such activities can help meet standards or guidelines established by multilateral development banks, Chinese banks, industry associations, and various other financial stakeholders. They can also help to meet environmental policies and regulations set by host country governments and by Chinese government agencies overseeing BRI and other overseas investments. Environmental policies including laws, regulations, standards, and guidelines will be discussed directly in Part 3. Taken together, mitigation activities can reduce the risks, costs, and delays of BRI projects and improve stakeholder support in host countries, in China, and internationally (Ekstrom, Bennun, and Mitchell 2015).

Appropriate mitigation actions for any BRI project may be identified through environmental assessment processes if they are applied at sufficiently early planning stages and at sufficiently broad spatial scales. For the most important mitigation step – avoidance – strategic environmental assessment (SEA) from the very start of planning can be a critically useful tool. SEA are typically a distinct regional or sectoral assessment conducted by government agencies at the stage of prioritization within plans, programs, or policies prior to the development of any individual project (UN Environment 2018a). Environmental assessments that are conducted at early stages in the planning process and with a broad spatial scope – for example, across an entire "BRI Economic Corridor" – can help to avoid substantial environmental risk and, further, allow the coordination of mitigation choices to broaden project benefits. This allows all decision makers the most possible flexibility in placing new roads and rails where they are likely to cause the least environmental and social harm, while maintaining desired economic and connectivity benefits. For other steps within the mitigation hierarchy, well-established environmental impact assessment (EIA) processes can usually guide individual project planning and implementation, especially for the localized direct effects generated during construction phases. Such mitigation strategies might include reducing impact through altering project design, restoring impacted areas, or developing offsets to compensate for unavoidable impacts and damages. Both SEAs and EIAs will be discussed in greater detail in Part 3.

Table 2. Potential mitigation actions for BRI transportation Infrastructure investments using mitigation hierarchy

Avoid	Integrated planning of route choice to avoid vulnerable environments and maximize net gains:[1] • Identify alternative route options that can simply avoid the environmentally and socially most sensitive areas, i.e., where there are clearly high environmental or social damages; • Conduct an integrated cost-benefit analysis (considering economic, environmental, and social impacts) to guide selection between alternative routes, given that all of the benefits and costs are heterogeneous across routes and some routes may be better on many counts. • This should be done at the micro level, for BRI corridors, and the BRI as a whole, to account for the interdependency of locations, investment impacts, and affected environments.
Reduce	Mitigate impacts through environmentally-conscious engineering and complementary policy: • ***Choices of techniques***: Wildlife crossings (bridges and underpasses, with mechanisms to 'funnel' wildlife to crossing), sound barriers, lights downwards to reduce light pollution, retention of trees, timing construction to avoid important times for animal migration or mating; tunnel-bridge-tunnel engineering in order to reduce landslide and erosion risks. • ***Choices of complementary policies***: Regulations, their enforcement, and incentives to reduce deforestation, poaching, and vulnerable species trade. This may include the creation of protected areas (PAs) nearby to transport investments, addressing weaknesses in enforcement capacity, and/or incentive/compensatory payments to landlords or local governments in return for maintaining forests and ecosystems. PAs should be coordinated along the BRI, to ensure these reduce, rather than displace, harmful activity. • Apply integrated cost-benefit analyses in selecting across transport options (road categories, rail versus roads, electric versus standard rail) as well as regulation on vehicle emissions and maintenance, etc. These considerations raise the case for (particularly high-speed electric) rail over roads – due to lower pollution, and reduced encroachment on frontier landscapes due to fewer access points and their concentration in already dense cities.

[1] Such as Intact Frontier Landscapes (IFLs), biodiversity endemism hotspots, protected areas, forests liable to deforestation, landscapes with topographical or earthquake hazards, and other vulnerable landscapes.

Restore	Take remedial action to repair damage inflicted by the construction process: Stabilize damaged slopes; replant vegetation; and repair waterways or wetlands disrupted by new investments.
Offset	Compensate for environmental damage that cannot be avoided, reduced, or restored by investing in off-site locations to achieve overall net neutral or net positive environmental outcomes: • carbon offsetting, or, following harm to biodiverse areas, the enhancement of alternative comparable sites elsewhere (e.g. with similar endemic species or ecosystem functions). • mechanisms for achieving such impacts elsewhere could include protected areas (that target pressure), "Payment for Ecosystem Services" (PES), biodiversity compensation funds into which projects pay, biodiversity banks selling off-setting credits, and more *ad hoc* project-by-project solutions, all supported by national or local off-setting laws. Off-setting is proposed, however, only as a 'last resort', because at least in light of past evidence it appears to suffer both efficiency (impact) and equity (distribution) challenges.

For the rest of Part 2 we describe in detail the four categories of the mitigation hierarchy in relation to BRI transportation infrastructure. Table 2 describes examples of mitigation actions and Appendices 7 and 8 describe how the mitigation hierarchy framework can be used to develop a suite of mitigation actions for the CICPEC in Southeast Asia.

I. AVOID: Selection of Projects and Routes

Avoidance is generally considered the most effective way of reducing potential negative impacts from transportation investments (ICMM and IUCN 2013; McKenney and Wilkinson 2015; Pilgrim and Ekstrom 2014). Avoiding the risks to the environment from BRI transportation projects could entail relocating or rethinking a project or prioritizing other projects when resources are limited. Such spatial planning and prioritization across all possible BRI transportation projects (not just single projects) would ideally be part of an early-stage SEA-type regional assessment that would consider entire or large sections of BRI Economic Corridors. It is important to conduct such planning during the early stages of the planning process when cost-effective avoidance options are still available and feasible. As a proposed project moves toward approval it is more likely to just proceed as initially conceptualized, regardless of the gains from alternative options (Ekstrom, Bennun, and Mitchell 2015; UN Environment 2018b). It is important to conduct such early planning over a wide region, with all potential projects and locations considered, so that individual projects are not simply displaced to other locations with similar risks.

Project planning for infrastructure investments often identifies environmentally sensitive areas that should be avoided. At the level of an individual project, a feasibility study is conducted early in the process to identify disqualifying risks such as high vulnerability to landslides, flooding, hydrologic disruptions, or other risks that cannot be reasonably minimized and managed. Sensitive areas for biodiversity and ecosystem services should also be addressed in project feasibility studies, though that is not always the case (W. F. Laurance 2015). Protected areas (PAs) and large expanses of undeveloped wilderness are often used to designate the environmentally sensitive areas that should be avoided.

As described in the Part 1 and in Appendix 4, PAs and intact frontier landscapes (IFLs) typically function as important refugia for biodiversity and safeguard many ecosystem services. To be effective, though, these protected areas should be established as "off limits" or avoidance areas for environmental objectives early within a planning process (Bruschi et al 2015; Mahmoud et al. 2017).[5] Appendix 8 (*Mitigation Strategies: Protected Areas*) illustrates the opportunities that might be available within CICPEC for locating new protected areas or increasing the enforcement of existing PAs within relatively undisturbed forested areas that are targeted for planned BRI highway projects. Ensuring adequate enforcement is an important component of this conservation strategy, as is illustrated by the encroachment in Snuol Wildlife Reserve, Cambodia, where enforcement was lacking (Appendix 8).

It is relatively easy to use PAs and IFLs for planning purposes – again leaving implementation as critical for achieving actual impacts – because they are relatively easy to designate spatially. However, some of the areas at risk that contain some of the richest, most unique and threatened biodiversity or ecosystem services are outside protected areas. These are particularly important to avoid when siting roads and railways because of their lack of protected status. Appendix 5 (*Environmental Indicator: Wildlife Effects as Measured by Biodiversity Hotspots and Umbrella Species*) provides an example of hotspots for biodiversity which considers species richness, endemism, and vulnerability within CICPEC. Identifying and mapping such hotspots for biodiversity, water provision, carbon storage and sequestration, and other ecosystem services is more challenging than mapping PAs and IFLs but attention to these natural assets early in the planning process can preclude costly actions at a later stage of project development.

Many examples exist in which geospatial modeling and data analysis have been used to assist with the mapping of avoidance areas for linear infrastructure. Most focus on road networks, such as studies of alternative routes in Myanmar, Nigeria, and Tanzania (Caro et al. 2014; Dobson et al. 2010; Fyumagwa et al. 2013; Helsingen et al. 2018; Mahmoud et al. 2017; but see Fyumagwa et al. 2013), showing how route choice can avoid damage to protected areas, ecosystem services, and wildlife migration patterns while still generating high socioeconomic benefits by connecting agricultural centers with markets. Dasgupta and Wheeler (2016) and Danyo, Dasgupta and Wheeler (2018) spatially explicitly estimate the losses that could be avoided within upgrading of roads in Cameroon, Bolivia, Myanmar and Lao PDR.

Similar balancing of objectives could be done for rail projects to optimize environmental, engineering, economic, and other factors. For example, Dong and colleagues (2018) developed an integrated risk evaluation model using ecological, social, and economic data from the high-speed railway proposed for the China-Mongolia-Russia Economic Corridor. Using data on biodiversity, forest cover, protected areas, proneness to fire and earthquake disasters, the authors identified regions within Heilongjiang, Republic of Buryatia, Irkutsk Oblast, Zabaykalsky Krai, and the Lake Baikal area that face high ecological risk from HSR. To avoid these ecologically sensitive areas yet allow social and economic benefits, they proposed alternate routes and policies to mitigate construction risks. In Kenya, public attention to environmental risks from the Standard Gauge Railway led to the modeling and mapping of risks and alternative routes between Nairobi and both Mombasa and Malaba. The goals of mapping and modeling included avoiding wildlife-train collisions, pollution, barriers to wildebeest migration and more (Ambani 2017). Appendix 9 (*Mitigation Strategies: Using Umbrella Species for Mitigation Planning in CICPC*) provides some examples of mapping and planning in the China-Indochina Peninsula Corridor to identify key areas for mitigation.

China has experiences with environmental safeguards within the development of its rail network − over 30 years − working in close coordination with international institutions such as the World Bank (World Bank Technical Assistance Program 2009). China routinely does national and project-level railway EIAs,

[5] Establishing PAs or IFLs as off limits to road and rail development can be politically challenging because, in some cases, the very fact that they have no preexisting development could make them attractive for linear infrastructure since a government would not have to purchase or expropriate private land and/or resettle landowners.

which include analyses of alternative routes to avoid environmentally sensitive sites. For example, in its planning of the recently completed HSR Guiyang-Guangzhou Railway Project, the Chinese government identified 47 environmentally sensitive sites that included protected areas, forest parks, scenic areas, watersheds, and cultural relics sites. In the project feasibility study, planners created many alternative routes and the route selected avoided 40 of those sensitive areas (Wang, Yang, and Quintero 2012).

II. REDUCE: After Projects/Routes Selected

If avoiding risks is impossible, then reducing[6] environmental risks should be considered, as suggested by Ekstrom and colleagues (2015): "Measures taken to reduce the duration, intensity, significance and / or extent of impacts (including direct, indirect and cumulative impacts, as appropriate) that cannot be completely avoided, as far as is practically feasible." Reductions in the environmental risks of a project below thresholds of harm may be possible. If not, actions may reduce the scale and the expense of the remediative measures, such as restoration or offsets, that may be required later for unmitigated loss.

Risk reduction via project and route selection has been introduced above, within the Avoidance section. For some infrastructure projects, such as the HSR Guiyang-Guangzhou Railway Project, China, described above, there can be an overlap between decisions to fully avoid impacts versus partially avoid impacts, i.e., reduce impacts. In that example, railway planning completely avoided 40 sensitive sites yet broadly it would also be right to claim risk reduction by 85% (40 of the 47 sensitive sites). For this case, actions could be considered "avoidance" or "reduction" but we will not repeat the avoidance discussion here.

Instead, for the rest of this section on reducing risks, we will consider several other reduction decisions for BRI transportation projects. First is the selection of techniques during infrastructure construction and operations. Second is the use of complementary policies that could change the impacts of investments.

Just as for avoidance, reductions should be proposed during early project feasibility studies (additional options will likely be identified through EIAs). There are many strategies to reduce direct environmental impact during construction and, to a lesser extent, operations of roads and railways. Many concentrate on adjusting the design of the infrastructure, but others focus on location and timing. Here we list just a few examples that address reducing the impacts from a range of different environmental direct effects. An exhaustive review of strategies to reduce impacts is found in van der Ree et al. (2015). Prescriptive good engineering design strategies are also detailed in voluntary sustainable infrastructure standards developed by organizations such as SuRe®, CEEQUAL, Envision®, and Greenroads® (see Part 3 and Appendix 15).

A. Local Strategies for Reducing Direct Effects: Good Engineering Design

Strategies to reduce local direct effects such as abiotic and wildlife impacts from investments in transport often have been focused upon changes to the design and the construction of infrastructure. Good engineering design solutions at both the project and landscape level are among the most frequent strategies to address hydrologic, sedimentation, and erosion dynamics. For example, tunnel-bridge-tunnel engineering schemes can be instituted to avoid dangerous landslides or erosion along steep

[6] The term "minimize" also is often used alongside or instead of "reduce," for the second element of this mitigation hierarchy. As it is hard to minimize more than one objective, and as truly minimizing means avoiding, we use reduce as our default.

terrain (Wang et al. 2012). Similarly, engineers can install wildlife crossing structures such as bridges and underpasses to reduce wildlife collisions and barriers to migration while increasing habitat connectivity (Iuell et al. 2003; Litvaitis and Tash 2008). Underpasses include tunnels, culverts, and viaducts beneath raised roadways while overpasses can range from small canopy rope crossings for arboreal primates to large vegetated landscape bridges up to 50m wide (Iuell et al. 2003; van der Ree, Smith, and Grilo 2015). Such structures must be coordinated with the funneling of animals to the appropriate crossing points. The most common funneling technique is a fence (Iuell et al. 2003; R. van der Ree, Gagnoy, and Smith 2015; D. J. Smith, van der Ree, and Rosell 2015) preventing wildlife from entering a road or rail line anywhere other than at safe crossing points. This is especially important for reducing wildlife access to “roadkill hot spots” along roads or rails – where some physical, biological, or topographical factor increases the likelihood of wildlife collisions (Litvaitis and Tash 2008).

A range of design options using behavioral modifications exist to reduce negative impacts of transport corridors. Focusing artificial lighting downward reduces bird attraction (Blackwell, DeVault, and Seamens 2015) and constructing sound barriers reduces stress or interference with animal communication (Parris 2015). Retention of trees retains habitat features (Soanes and van der Ree 2015; Weller 2015), while specialized noise and light spectra can be used to deter certain targeted wildlife species from a road or railway to avoid collisions (D’Angelo and van der Ree 2015). Recordings of natural animal warning calls triggered by oncoming trains have been shown to elicit faster reaction times and increased escape by certain wildlife species (Babińska-Werka et al. 2015). In contrast, commonly used roadside reflectors have had limited success in deterring wildlife from entering roads (Angelo et al. 2006; Iuell et al. 2003).

Timing of construction can also help reduce impacts. For instance, Construction could be scheduled to avoid times of the year when certain species are especially mobile. Amphibians are especially vulnerable when they move across the landscape during their breeding season and birds when they migrate for wintering and nesting (Andrews, Langen, and Struijk 2015; Hamer, Langton, and Lesbarreres 2015). Wildlife-vehicle collision rates have been shown to be higher during migrations (Litvaitis and Tash 2008). Timing construction or traffic to avoid times of high wildlife migration can reduce collision incidence.

Some direct impacts result from human behavior and are best reduced through environmental policies, regulations, and enforcement. For example, roads and rail provide access for illegal logging and wildlife poaching and provide transportation for illegal trafficking of this contraband. Environmental policies and enforcement to address these activities can be implemented in tandem with the BRI investment. Environmental policies may be more effective influencing impacts from some transportation modes versus others. For instance, airborne particulate pollution and GHG emissions from increased freight traffic are relatively easy to reduce in rail projects – via high efficiency engines, efficient scheduling, and appropriate maintenance which limits emissions – while emissions from road projects are less easily regulated because of the dispersed nature of related pollution sources. EIAs typically call for national measures regarding, for instance, regulations on fuel type and purification of exhaust gases, vehicle emission regulations and standards, and the local enforcement of laws concerning vehicle condition.

B. Broader Strategies for Reducing Indirect Effects: Complementary Policy

Reducing indirect impacts from transportation projects – such as induced land use changes – is less straight forward than the infrastructure design modification strategies employed to reduce direct impacts. Complementary policies are the preferred strategy for modifying human decision making.

i. Complementary Policies Interact with Transportation Investments

Much as the heterogeneity of impacts from investments in transportation infrastructure already leads to gains from route choice, the targeting of policies also is raised by interactions between types of policies and, in particular, interactions between development investments in transport and conservation policy. The optimal policy blend can generate a 'win-win' outcome from integrated early planning as it can raise the conservation impacts of conservation policy resources, while lowering the environmental risks from development investments and still preserving their *raison d'être*, i.e., benefits of economic connectivity.

Consider that protected areas or payments for ecosystem services often have not effectively addressed environmental threats and thus have low impact (see the literature discussion within IV. Offsets below). In both cases, the problem is that implementation avoids threats. For protected areas, this is common when economic interests deflect intended protection, so that protected areas end up far from pressure, where even perfect enforcement has zero impact. For payment for ecosystem services, this occurs when private actors are paid to maintain forest on unprofitable lands they would have kept in forest anyway.

In contrast to those scenarios, with good integrated early planning public actors may consciously place investments in transport and conservation near each other, e.g., protected areas near to roads or rails. For the longer run, that has impact even if the road or rail investments are traversing relatively pristine areas (e.g., between distant big cities) not previously or currently facing high threat. The future clearly could hold higher threats, as investments create profitable opportunities that lure labor and capital as well as public investments as in schools or health. As such, previously low-pressure frontiers may have high environmental value which could be vulnerable to impact after a rail or road line is established.

ii. Public and Private Actions, Interactions, and Further Responses

While any such policy interactions (above with explicit joint targeting) always involve some public roles, here we also want to highlight the value of considering possible private responses to public policies. Those private reactions may also, in turn, affect the optimal follow-on public responses. Generally, more such interactions again suggest that there are gains from integration of development and conservation.

The logic above concerning protected areas, for instance, could be applied to payments to suggest siting payments for ecosystem services alongside investments in roads or rails. However, for local landowners living alongside the proposed BRI road or track to voluntarily forgo cutting down forests once a new rail or road is in place, we must ask whether there are sufficient private incentives to join any such program. For instance, lands that might have been readily offered for conservation even for a low payment before a road or rail investment occurs may no longer be volunteered after the investment (as is suggested by the past purchasing of lands as speculative investments when possible plans for roads are made public). Yet, nonetheless, there might exist productive combinations of transport investments and protection and payments, a triple integration, if the placing of protected areas immediately around new transport lowers the economic expectations for those parcels nearby which are private and not being protected.

We might similarly consider private incentives if protection is not strict but, instead, permits some use – as in extractive reserves that explicitly allow some smallholder production (and resulting forest losses). They clearly change the political economy by making it easier to have both protection and development. That can make protection more politically feasible. It also could generate local incentive for monitoring. Thus, we may consider what types of conservation policies are best for interactions with roads and rail. Further, in principle much the same could be said for having private rights to logging within concessions.

While in cases such rights have led to rates of forest losses higher than in the background for the region, rights create incentive for actors to defend forest assets – much like smallholders in extractive reserves. For concessions, actors may be firms, who may have incentives and the resources to stop illegal logging. Generally, combinations of development and conservation tools could interact usefully on the frontier.

Sometimes, however, development and conservation would not appear to work well near to each other. For instance, if a strong federal government environmental agency establishes a strict PA nearby a road or rail, it may well function as a signal that, in the future, more development investment is unlikely in this area. Such conservation signals – perhaps federal, though local enforcement is very important – can encourage net private outmigration decisions. In turn, those could discourage any further public actions. For instance, when in-migration slows, less payoff may be perceived from maintaining older small roads. Thus, public actions can, via private responses, lead to complementary public actions (Herrera 2015) and in this scenario, the public-private-public response dynamic serves to improve the local forest outcomes.

In other settings, local public actors such as state or municipal governments are focused more upon the local economic gains from policies than the environmental outcomes. That can remove environmental complementarity across public actions. Federal actions might constrain local agencies' choices − which effectively maximize local interests subject to federal policies. For instance, when a federal "blacklist" in the Brazilian Amazon constrained high-deforestation municipalities, more than one local program with international funding (through The Amazon Fund, e.g.) did not achieve stated objectives to lower local deforestation. That is unsurprising if local programs were essentially to help the locality in question to get off of the costly federal blacklist, i.e., effectively the local programs were aiming simply to achieve the federal requirements yet at a lower local cost to the economy (Correa et al. 2018; Sills et al. 2015). Stepping back, though, even that can help integrated planning by increasing local political feasibility.

III. RESTORE: Activities to Neutralize Net Transport Impacts Locally

Restoration is conducted at project sites to repair direct or indirect impacts to biodiversity or ecosystem services. Restoration is only for when avoidance and reduction are not feasible (Ekstrom, Bennun, and Mitchell 2015). Restoration for BRI road and rail projects would primarily occur during the construction phase and actions would likely be identified during the initial feasibility study with restoration strategies outlined in the EIA. If extensive landscape transformation occurs, for example, through digging tunnels, stabilizing slopes, or building embankments, then vegetative restoration will likely be required. Restoration may also be needed if roads or rail construction disrupt wetlands and waterways.

IV. OFFSET: Compensation Elsewhere for Unavoidable Impacts

Offsets have been defined as: "Measurable conservation outcomes, resulting from actions applied to areas not impacted by the project, that compensate for significant, adverse project impacts that cannot be avoided, minimized and/or rehabilitated/restored" (Ekstrom, Bennun, and Mitchell 2015). Offsets are a last resort, after all other steps in the mitigation hierarchy. They involve restoration, rehabilitation, or protection of biodiversity, carbon, water, or other ecosystem services comparable to the project losses.

Offsets may aim for no net loss. Recently, some net gain has been promoted to address global declines in biodiversity and ecosystem services. In project finance, the International Finance Corporation (IFC) specifies the need for a net gain in biodiversity in critical habitat as a requirement for lending (IFC 2012). The new World Bank framework notes a preference for a net gain of biodiversity as well (The World

Bank 2017). Over 75 major financial institutions have expressed the same preferences via adoption of The Equator Principles for project finance of over US$10 million (Rainey et al. 2015).

Yet there are good reasons to consider offsets a last resort. They can be complex and expensive and yet of uncertain benefit (Bull et al. 2013; IUCN 2016; Pilgrim and Ekstrom 2014). Some argue that offsets give developers a free pass to both destroy and degrade biodiversity (Ledec, Campos, and Reay 2016) and, further, that implementation challenges may in fact prevent effective net mitigation. Another significant issue is compensation of those who suffer loss. Ecosystem services such as watershed services are local and thus offsets may be hard pressed to "make whole" the affected communities if gains are being realized in other locations. Project losses followed by offset gains could involve trade-offs where some services are reduced then others are enhanced (e.g., by soil stabilization after timber production or the relocation of water access) and, as a result, some portions of a community could gain on net while others could still lose out on net.

Below we consider a number of approaches to generating offsets which could, in principle, balance out the net losses that may occur as the result of a transportation infrastructure project – once the rail or road project has been selected and routed and its damages reduced and restored as much as possible.

A. Biodiversity and Habitat Offsets

When a new or upgraded rail or road project results in the destruction of or damages to biodiversity, offsetting can be accomplished by restoring or enhancing comparable biodiversity elsewhere. An offset should "achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity" (BBOP 2009). Biodiversity offsets have taken the form of new protected areas, restoration of degraded or destroyed habitat, or even increased enforcement of existing protected areas (G. Bennett et al. 2017; Ledec, Campos, and Reay 2016). Biodiversity and habitat offsets may focus on particular species (e.g., endangered or threatened) or habitat types (e.g., those hosting particular species communities) or functions (e.g., wetlands/streams).

Biodiversity offsets are relatively unproven, thus it will be important to design such programs well to ensure impact and monitor their performance. There is no best way to design a biodiversity offset because they are so dependent on context, yet there are best practices (IUCN and ICMM 2013). For instance, two interrelated elements that many believe will enhance success in offsets are: planning for offsets within the landscape context (BBOP 2012; McKenney and Wilkinson 2015); and setting up aggregated biodiversity offsets (Ekstrom, Bennun, and Mitchell 2015; ICMM and IUCN 2013; Ledec, Campos, and Reay 2016). These principles suggest that a BRI Economic Corridor may allow for planning at the appropriate scale, with broad and early stage environmental assessments the appropriate tool to plan effective offsets. Aggregated offsets can reduce transaction costs and consider interactions between projects to enhance benefits like landscape connectivity (Ekstrom, Bennun, and Mitchell 2015; Ledec, Campos, and Reay 2016) (Pilgrim and Ekstrom 2014; BBOP 2009). One could envision a roadmap for an offsets corridor, even if the BRI network passes through multiple countries. Few national examples exist, however. Such roadmaps can be seen for Liberia (The World Bank Group 2015), Mozambique (Bechtel and Nazerali 2016), and Mongolia (TNC 2016) though these are new enough that their success cannot be determined. A major blockage seems to be the seed funding required (Ekstrom, Bennun, and Mitchell 2015).

Financing institutions such as the World Bank and IFC have mandatory biodiversity offset polices. These policies have been a “small but significant driver in offset demand.” As of 2017, 9 IFC-financed projects created biodiversity offsets, with 12 more projects planning to implement offsets in the future (G. Bennett et al. 2017). If the World Bank or IFC were to get more involved in co-financing BRI projects, their biodiversity offsetting standards would be applied to any project to which they were lending.

Offsets can be only as effective as their design, implementation, and actual enforcement allows. Clear and detailed policy guidance is required. A lack of oversight is a primary reason offsets fail to achieve their goals (Bull et al. 2013; Pilgrim and Ekstrom 2014). Such effective guidance and oversight could, in principle, be provided by host countries or by BRI oversight organizations in the Chinese government. However, to the extent global finance is involved, there may be gains from including outside parties.

It is hard to generalize the success of mitigation for biodiversity and habitat because programs measure success using different metrics, which make comparisons or the analysis of trends difficult. Analyses of large, standardized programs like the US stream and wetland mitigation program have found that only 30% of offsets are meeting full project objectives (Matthews and Endress 2008; n =76 sites) and 74% of offsets are achieving no net loss (Brown and Lant 1999; n= 68 banks). With this in mind, it is clear that there is high uncertainty of the success of biodiversity offsets. Many projects simply define success as establishing a protected area; as discussed elsewhere in Part 2, that has a wide variety of outcomes.

B. Offset Instruments: Protected Areas (PAs)

The most common conservation policy in terms of area affected is the establishment and maintenance of protected areas (PAs). They contain over 13% of the world’s lands and, in principle, could generate offsets by preserving forest cover, biodiversity, and ecosystem services. While PAs tend to prevent forest loss on average, however, their impact varies substantially by location (Andam et al. 2008; L. N. Joppa and Pfaff 2011; Miteva, Murray, and Pattanayak 2015; A. Pfaff et al. 2009; A. Pfaff, Robalino, Herrera, et al. 2015). Further, a PA’s impact often is less than it seems, since sites are biased towards low-pressure locations.[7] This matters in terms of appropriate quantitative estimates of offsets.

The offsets a PA can generate are limited by the deforestation that would have occurred without the PA. Thus, even a perfectly implemented and enforced PA simply would not avoid deforestation if it is located in an isolated area where no deforestation was expected to occur. Generalizing, many factors affect the net benefits from non-PA land uses, i.e., a PA’s opportunity costs (foregone profits), which creates high variation in the counterfactuals or baseline land uses that the PA could block when creating any offset.

Often the most beneficial non-PA use of a frontier parcel is agricultural use, in which case the lands with steeper slopes, poorer soils, and sites farther from the important markets have lower opportunity costs.

[7] For low-pressure locations, it is easy to overestimate PA impact. For instance, if comparing PAs with randomly chosen controls or average unprotected land, low-pressure PAs are being compared to higher pressure. Andam et al. (2008) find for some Costa Rican PAs, “apples to apples” (using observable land characteristics) comparisons reduce the estimated gains from 44% to 11% . Globally, Joppa and Pfaff (2010) find controls for land characteristics reduce estimated impact on average by about one-half.

We would expect the lobbying efforts against PAs in those locations to be lower.[8] However, it is possible that the most beneficial non-PA use of the land is, instead, for hydropower – in which case steeper slope could increase the opportunity costs of maintaining an undisturbed PA. Indeed, we observe many cases in which creation of hydropower dams has led to the degazettement of existing PAs (Symes et al. 2015).

Thus, understanding the land-use dynamics in a given setting is critical for good estimates of a baseline or counterfactual land-use trajectory that, compared with the outcomes within PAs, determines offsets (in the sense of computing how much area that was going to be deforested was conserved by the PA). Offset calculations are likely to also include computations concerning the density of a desired service – e.g., a hectare of forest in a favored habitat may be weighted more highly than other forest hectares or avoided deforestation that affects water quality upstream of large cities may be especially appreciated.

Distinguishing across PAs, the political calculus involved in site choice for new PAs, as well as choices on both monitoring and enforcement, is likely to vary with the level of government taking the PA decisions. Various studies indicate that federal decisions on the environment can be expected to differ from local decisions, since local actors are expected to put more weight on local costs (A. Pfaff and Robalino 2012). One can imagine that decisions would also differ among countries across a BRI corridor. There is limited such evidence for PAs, in general, though for the Brazilian Amazon this point appears to be supported.

Further, the local and global benefits and costs for different relevant actors in offsets vary with PA type. Strict PAs that do not permit any entry or production vary in their net benefits from multiple-use PAs or sustainable reserves that permit some smallholder production. Offering some local benefits could easily influence lobbying positions. Consequently, multiple-use PAs may be more likely to be in locations with relatively high forest pressure (for global evidence, see Nelson and Chomitz (2011); for a particular case in Brazil, see Pfaff et al. (2014); and for an intermediate regional result for Peru, see Rico et al. (2018)). Whether that implies higher impacts for one type of PA varies, even if mixed-use PAs are in areas which are more threatened (Blackman 2015; Ferraro et al. 2013). Not surprisingly the dynamics vary (see, e.g., Pfaff et al. (2015) and Pfaff, Santiago-Ávila and Joppa (2017)). Understanding land-use dynamics is key.

The same logic concerning local benefits and costs can also affect monitoring and enforcement. As was raised by Albers (2010), local actors with incentives to keep the forests standing can contribute not only through their own land-use choices but also by contributing to monitoring of others. Thus, for example, the multiple-use PAs whose locations are highlighted above might also be better locally monitored. On the theme of private incentives to keep forests standing, it is even possible that logging concessions – whose rights create incentive to defend forest assets – could outperform PAs in terms of avoiding loss should those PAs have fewer resources, less incentives, and poor enforcement (Panlasigui et al. 2017). Consequently, on both the positive and the negative side, in estimating the offsets that are likely to be generated by any given conservation investment of this type, the private incentives clearly do matter.

C. Offset Instruments: Payment for Ecosystem Services

Payments for Ecosystem Services (PES) are a voluntary intervention for preserving forest cover (Engel, Pagiola, and Wunder 2008; Ferraro and Simpson 2002; Wunder 2007). Their typical effectiveness in terms of avoided forest loss has, to date, often been relatively low. Thus, at the least depending upon

[8] Given variation in the benefits and costs of PAs, and which groups in a society incur them, we expect that political economy will affect the location as well as monitoring and enforcement of PAs. If we hold benefits constant, we predict that PAs should go to the locations with the lowest opportunity costs. Globally, it has been confirmed that PAs are disproportionately "high, steep and far" (L. N. Joppa and Pfaff 2009). More generally, characteristics that lower agricultural opportunity costs appear to attract siting of PAs.

program targeting and implementation, one may not be able to count upon PES for significant offsets. Payment for watershed services (PWS) – a specific type of PES –offset services like sediment retention, pollutant filtration, and water retention (to reduce floods) that are affected by construction and operation of roads and rail. PWS or "water funds" offer payments from water users such as water utilities to land owners or users in exchange for improving agricultural land management, including riparian buffers to improve watershed management (Locatelli and Vignola 2009).

Even more than for PAs, additional forest beyond baseline is hard to guarantee when PES participation is voluntary. Individuals who were not going to clear the forest on a parcel of land anyway would rationally be the first in line to volunteer that parcel for a contract that pays money if the forest remains standing. That can explain low impact estimates for PES (J. Robalino and Pfaff 2013; Sanchez-Azofeifa et al. 2007).

Estimates of gains tend to be more encouraging if targeting is not entirely up to individuals but rather is determined by other factors, e.g.: biological factors, as in the protection of Monarch butterfly habitats in Mexico (Honey-Rosés, Baylis, and Ramírez 2011); or by government actors or civil society, depending on their formal or effective decision rules; or randomly, as in a trial in Uganda where the location featured high deforestation for low opportunity costs and individuals had to put all their parcels into the PES (Jayachandran et al. 2017). China's Sloping Land Conversion Program is said to be impactful, although not quite voluntary even if adequately covering local opportunity costs (yet distortions may interfere with targeting, depending on incentives of local administrators (J. Xu et al. 2010; Z. Xu et al. 2004)). Under this program, payments for removing sloped lands from agricultural production also resulted in more laborers switching to non-farm employment (M. T. Bennett et al. 2014; Kelly and Huo 2013).

Contract details offer other dimensions of PES design. PES contracts involve asymmetric information, as land-holders know their own opportunity costs and therefore the price at which they would be willing to accept a PES contract. A government or NGO does not have this information (Ferraro 2008), which raises cost and the chance that some of the funding does not lead to additional forest. That can discourage the creation of new programs and could be addressed by auctions. PES designs that pay more to the farmers whose previous willingness to contribute to conservation was low (suggesting high opportunity costs of conservation and the need for incentives), however, can introduce perceptions of unfairness and lower contribution by participants who were originally more willing to contribute (Alpízar et al. 2017b, 2017a).

Collective contracts show some promise, if designed well, using group enforcement and social pressure to potentially increase compliance while lowering the costs of administration (D. Kaczan et al. 2017). Information on baseline land use and behavior under the PES is lower cost at a higher, collective scale. For instance, while not labeled as "PES", the Brazilian Amazon "blacklist" mentioned above provided a conditional incentive from the federal government at the collective scale of the municipality – some of which are huge and all of which have pre-existing political institutions – to be monitored by satellite.

Despite challenges, PES could offer an effective intervention, especially in concert with other policies. Funds transfers within PES may be one element in bundles of interventions, helping to make elements that are locally costly, such as strict PAs, more palatable. For generating offsets too, then, combinations of conservation policies might usefully be considered at the level of the entire BRI Economic Corridor.

D. Carbon Offsets

Carbon storage and sequestration provides an important climate-stabilization ecosystem service (The World Bank 2017). Loss of forests, wetlands, and other habitats due to construction and operation of transportation infrastructure, though, can release carbon and reduce sequestration. Thus, offsetting here should include climate stabilization, i.e., compensating for the emissions and loss of sequestration. To date, there is one example of offsets required for loss of GHG sinks or increases in emissions due to infrastructure, a greenhouse gas regulatory regime in the State of California under state environmental protection (CEQA), where one must assess, minimize and offset shifts in carbon sinks and emissions.

However, it is not enough to do activities and claim offsets if activities did not actually lower emissions. Studies of carbon offsets such as from projects in the Kyoto Protocol's Clean Development Mechanism – the world's largest carbon offsetting program, with many energy and industrial types of offsets – show a lack of impact (Haya 2010). Clearly, some methods for calculating carbon impacts and carbon offsets are imperfect (Harangozo and Szigeti 2017; Johnson, Edwards, and Masera 2010). It is still the case, though, that well-designed and stringently enforced programs could lower emissions and even have co-benefits (e.g., some forest-carbon efforts in the U.S. for the California market (Anderson, Field, and Mach 2017)).

E. Spillovers and Net Impacts

As emphasized, it is a challenge to achieve impacts via interventions of any type and purpose – avoiding, reducing, or offsetting – given that simply announcing a program does not change behaviors. Simply creating a protected area does not guarantee there will be no illegal invasion and deforestation; plus, even if the trees remain standing, it does not guarantee any impact if there were not any threats. Simply creating an incentives program does not guarantee that anybody will sign up or will change any behaviors. If one is paid to keep trees standing, one might simply volunteer agriculturally useless land.

However, sometimes interventions will in fact change behaviors on those lands within their boundaries. Unfortunately, even that does not guarantee a net impact, since interventions might generate spillovers. If a protected area does in fact lower clearing relative to what would have occurred without protection, which many have done on average across the world, unfortunately it could still easily be the case that the individuals who would have cleared inside the protected area just displace their deforestation elsewhere. Within payments programs, even if one parcel that would have been cleared is not, due to payments, there is often nothing preventing a landowner from just shifting the clearing to another such parcel. Should such spillovers – in those cases "leakage" – occur, they can cancel out any positive impacts.

Conceptual models of how market demands for land clearing play out across any landscape certainly suggest that PAs could induce spillover deforestation into nearby locations (Armsworth et al. 2006). Empirical estimates of forest spillovers from PAs find heterogeneities (A. Pfaff and Robalino 2017; J. Robalino, Pfaff, and Villalobos 2015). That is in part because when lacking impact, PAs will not spill over, e.g., if threats are not taken on then they cannot be blocked, for impact, but also will not be displaced.

Spillovers tend to be higher deforestation elsewhere if interventions are nearer to roads (J. Robalino, Pfaff, and Villalobos 2017) – which is obviously relevant when considering integrated policies that place protected areas near BRI projects – and if prices for commodities whose production is displaced are high (Baylis, Fullerton, and Shah 2016). Spillovers may be less negative near PA entrances, where ecotourism tends to concentrate and to raise the value of intact forest parcels (J. Robalino, Pfaff, and Villalobos 2017), as well as when any displaced commodities' prices are low (Baylis, Fullerton, and Shah 2016).

Spillover effects can even be positive, environmentally speaking, for instance in the sense that PAs lower net forest losses nearby. For instance, if PES support introduction of trees into agriculture (agroforestry), it may sometimes be the case that local profits are in fact enhanced (e.g., by shade for coffee and cows). Upon seeing such an increase in profit, neighbors might voluntarily imitate those agroforestry practices.

The existing empirical results for deforestation spillovers from protected areas indicate that not only the size (magnitude) but also even the sign (direction) of spillover effects will depend on comparative rents (Angelsen 2007) and political signaling depending on which agencies take which actions (Herrera 2015). For instance, the creation of a strict protected area by a strong federal agency that is known to currently feature an environmental agenda can signal that the protected region will not be a development focus. That, in turn, should influence private migration choices, public investments, and other public actions.

Spillovers outside interventions' boundaries (distinct from multiple-use PAs) can also be socioeconomic, emphasizing again that they can vary even in sign by context and thus location. A number of studies find PAs have weakly positive economic welfare impacts (Alix-Garcia et al. 2013; Sims 2010; Sims and Alix-Garcia 2015). Sims (2010) finds that decreases in poverty may result from PAs – primarily those PAs found at an intermediate distance from urban areas such that they are far enough that the PA is not substituting for urban land use but close enough that these areas are accessible to paying tourists. In other contexts, the creation of PAs has been tied to significant negative socioeconomic impacts, due for instance to displacement of vulnerable populations (Geisler and de Sousa 2001) and reduced wages (J. A. Robalino 2007) – and it is important to consider the distribution of the associated costs and benefits.

Part 3: Policies to Improve Environmental Net Impacts of BRI Corridors

Because transportation infrastructure dramatically transforms landscapes, policies have been developed over decades to improve environmental and social performance. In Part 3, we review types of polices – including laws, regulations, guidelines, agreements, standards, and safeguards – that can affect how BRI transportation projects address the environment. To the extent possible, we will focus on environmental policies that are distinctly relevant to BRI transportation projects. We focus first on national policies and then on international policies, including Chinese policies related to direct foreign investments. Finally, we discuss how strategic environmental assessments customized to BRI Economic Corridors are well suited to effectively and efficiently address transboundary environmental impacts related to BRI projects and could improve both environmental and social outcomes. While our focus is on environmental policies, it should be noted that many of these policies – especially in recent years – also address social issues.

I. NATIONAL AND PROJECT-LEVEL ENVIRONMENTAL POLICIES

A. Overview of National Environmental Policies

The first line of environmental protections is of course choices by the host countries. China has pledged to follow host-country standards and norms for all Belt and Road projects, so in principle host-country policies provide the minimal protections expected for every infrastructure project (Dollar 2018).

Of the roughly 80 countries involved in the BRI, each one has its own set of environmental policies that must be understood to grasp the full regulatory landscape. There is a wide range of national, provincial, and local regulatory policies that could have a bearing on environmental risks from transportation infrastructure projects including: environmental assessment laws; environmental protection laws for public lands; environmental protection laws from private lands including easement laws; primary protected areas legislation; criminal codes addressing violation of environmental protection laws and related obligation; wildlife laws; construction permitting; wetlands protection and mitigation; vehicle emissions standards; damages law for hazardous materials spills and leaks; indigenous peoples rights laws/territory rights; zoning laws; imminent domain laws; and national procurement rules. In addition to national legislation, countries may have policies, guidelines, and strategies for addressing many of these issues. It is also important to track various complementary laws, regulations, and zoning ordinances from provincial or local governments, since these can sometimes have as much if not more influence over BRI projects than a central government (H. Liu and Lim 2018). There is a growing body of resources that document, archive, and analyze environmental laws. The Green Growth Knowledge Platforms (GGKP) provides an excellent meta-analysis of 24 databases of environmental regulations, financial incentives, overarching policies and frameworks, and voluntary approaches (Booth 2017). Overall these databases provide comprehensive coverage of the electricity, agriculture, forestry, and fishing sectors in OECD countries. Coverage of other sectors and regions of the world – including most BRI countries – is less exhaustive, unfortunately. Legal Atlas is beginning to develop an interactive knowledge platform for all environmental regulations related to infrastructure projects in every BRI country, initially focusing on laws for linear infrastructure. Appendix 10 describes several databases that are particularly valuable for assessing environmental policies that may have a bearing on BRI transportation infrastructure. It should be noted that, while host country laws may constrain all the BRI investments, significant elements of the environmental risks that are associated with BRI transport corridors are transboundary risks, including impacts upon carbon emissions, forest cover, and biodiversity. Limiting these transboundary impacts can fairly be considered to be global or regional public goods provision, so we should not expect host countries to fully take these impacts into account in their own laws (Kaul, Grunberg, and Stern 1999).

B. Environmental Assessments

One element repeatedly featured in many of the national regulations and policies is the environmental assessment, among the most commonly used planning and management tools for addressing environmental risks for many decades. "The ability of countries and communities to achieve sustainable development depends in no small measure on robust and effective EIA/SEA legislation and implementation as a major catalyst for overcoming current implementation gaps and achieving better environmental outcomes." (UN Environment 2018, p vi) In the next two sections we will describe the use of environmental impact assessments (EIA) and strategic environmental assessment (SEA) for BRI transportation projects.

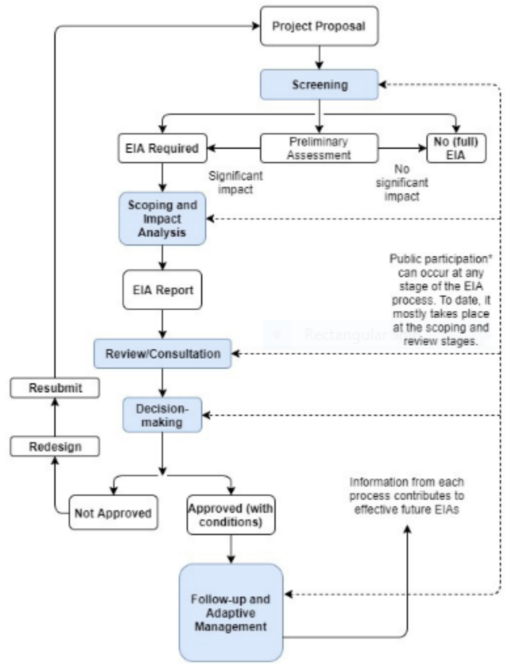

Figure 3: EIA process flowchart. Source: UNEP 2018.

EIAs are typically focused on a specific development project, such as a new highway segment or railway. The EIA dictates a formal administrative process that is aimed at preventing harm to the environment, often also taking into account related social considerations (Figure 3). EIAs should begin in the project planning phase and thus prior to an activity taking place. The EIA identifies potential direct (and less often indirect) environmental impacts of a project and trade-offs between policy goals. EIAs are aimed at informing decision-making on how to proceed (UN Environment 2018a).

In recent years, it has become increasingly evident that EIAs have many shortcomings. Because EIAs often occur "downstream," well into the planning process, most decisions and commitments have already been made and parties tend to be vested in particular outcomes (OECD 2006). Moreover, the continual ratcheting up of EIA standards by the International Finance Corporation (IFC), World Bank, and other multilateral development banks has had the perverse effect of promoting borrowing from other sources with lower EIA standards, even if it means higher lending rates (Humphrey 2016).

To address these shortcomings, governments and multilateral development banks have increasingly begun to encourage or require strategic environmental assessment (SEAs) – early-stage analyses that integrate environmental (and often social) considerations into policies, plans, and programs – rather than solely relying on the single project-based EIAs (World Bank 2012). By comparison to the project-focused EIA, SEAs aim to integrate environmental considerations into policies, plans, and programs (Dusi and Xi 2009; OECD 2006). SEAs are often carried out at the regional or national scale or for an entire sector such as transportation. They can also focus on transboundary projects in two or more countries.

Most significantly, SEAs are carried out early in the planning process when alternative transportation routing is still feasible (Figure 4), and the full mitigation hierarchy can be followed. (See Part 2 for a discussion of the mitigation hierarchy.) SEAs have been characterized, to some degree, as forward-looking, "sustainability driven" instruments, whereas EIAs are more "reactive" (Wingard et al. 2014).

While SEAs are increasingly being adopted and strengthened, as compared to EIAs they are still in a nascent stage of development. At least 40 countries have SEA systems in place including China, Vietnam, Indonesia, Mongolia, Kenya, and Tanzania; however, only some of these 40 countries include a formal legal requirement to conduct SEA (UN Environment 2018a). These assessments are designed to be flexible to allow analysis to meet the needs of decision makers, but as a result there is uncertainty and inconsistency in application (UN Environment 2018a). In China, SEA implementation has been limited by the sharing of information and data, decision-making process (especially the timing of SEA planning), and legislative and political context (T. Li et al. 2016). Gunn and Noble (2011) note that SEA methodologies are still inadequately developed and defined and are not capable of addressing regional cumulative effects adequately. Chaker et al. (2006) found challenges identifying appropriate leverage points in planning and decision-making processes for SEA input, limiting integration of SEA findings into decision making. Despite these limitations the World Bank found sufficient evidence that SEAs can influence and inform decisions to encourage their continued use in bank practice (World Bank 2012).

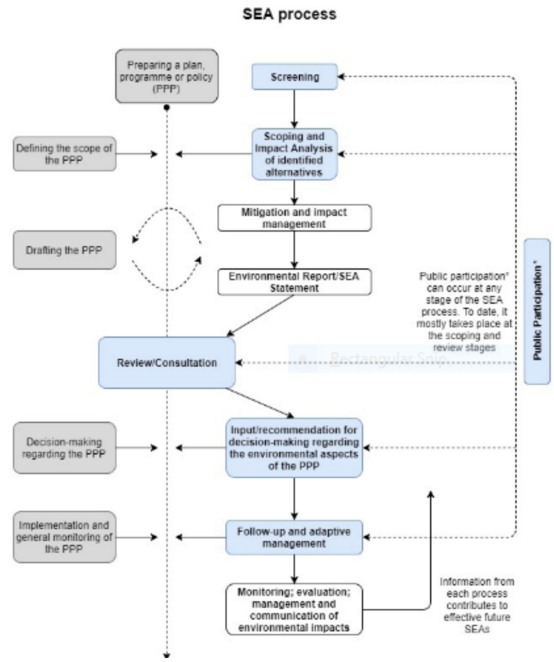

Figure 4: Strategic Environmental Assessment process flowc4art. Source: UNEP 2018.

For SEAs to fulfill their promise as a format for strategic planning, they will need to be conducted within an integrated economic planning process. The Inter-American Development Bank's guidance concerning sustainable infrastructure contains two key observations related to SEA implementation: sustainability should be considered early, "upstream" in the policy and planning stage of infrastructure development, and environmental considerations should be incorporated into the mainstream of the planning process so that economic development and environmental assessment are not considered within separate silos (Serebrisky et al. 2018; UN Environment 2018b; Watkins 2014). Strategic integration of environmental assessment with infrastructure planning has the potential to decrease the costs that are associated with mitigation of environmental harm by addressing conflicts between environmental goals and economic objectives at an earlier stage, when more options remain on the table. Insofar as the SEA framework encourages early, integrated approaches to planning for sustainable development it appears to be a promising vehicle for improving environmental outcomes associated with infrastructure investment.

C. Environmental Policy Compliance

The adoption of comprehensive policies with appropriate guidance on implementation and monitoring are critical first steps toward positive environmental outcomes. However, these policies are only as effective as their enforcement mechanisms, and the capability and political will to enforce them (Leung et al. 2013; UN Environment 2018a). BRI countries not only differ in their environmental policy frameworks, but there are also enormous differences in their capabilities and political will to enforce environmental policies. Limited institutional capacity and generally a lack of legal requirements often limit follow up on both EIAs and SEAs (UN Environment 2018a). Given that EIAs occur late in the planning process, the likelihood of cancelling a project or making dramatic alterations as a result of findings in the environmental assessment report is low. There are typically no provisions in national legislation regarding the process for cases of non-compliance with an environmental report or in a case when mitigation measures prove to be ineffective (UN Environment 2018a).

D. Comparisons of National Environmental Policies and Compliance

Countries vary tremendously in the coverage and strength of their environmental and social policies that address transportation infrastructure. Cross-country comparisons mostly evaluate the differences among national environmental assessment policies, in part due to their widespread use. A global review by UN Environment of EIAs and SEAs found that, though virtually every country studied in the report[9] has adopted EIA systems based on legislation and an increasing number of countries now have SEA systems in place, the depth and application vary significantly among countries. The report identified trends in EIA national legislation, including: a movement by some countries towards decentralized oversight and implementation of EIA, though a small group of countries have moved in the opposite direction by establishing dedicated central authorities to deal specifically with EIAs; increased public participation requirements (but mostly limited to the scoping and review stages); increased focus on climate change and human health and, though non-binding, ecosystem services; and a shift from EIAs to Environmental and Social Impact Assessments (ESIAs). Emerging trends among SEA legislation include: the increased adoption of non-binding procedural SEA guidelines but rarely legal requirements; little attention to public participation; and regional rather than national level guidelines to facilitate assessing impacts related to climate change, biodiversity, ecosystem services, and human health (UN Environment 2018a).

In a more targeted legal analysis aimed at developing guidelines for mitigating the impact of linear infrastructure on large migratory mammals in Central Asia, Wingard et al. (2014) compared components of EIA and SEA legislation as it relates to linear infrastructure in eight Central Asian countries.[10] Overall, they found that, although all eight countries had EIA legislation, there were few direct references to linear infrastructure, migratory species, or transboundary impacts within any of the legislation. EIAs in five countries mentioned wildlife impacts, but only Kazakhstan's legislation explicitly mentioned migratory species and requires their consideration during the construction of linear infrastructure. Kazakhstan, Kyrgyzstan, Tajikistan, and the Russian Federation all required the assessment of transboundary impacts. In terms of SEAs, all Central Asia countries except Russia and China have national legislation for both plans and program, though not all covered policies. China's SEA provisions are limited only to the assessment of plans and the Russian Federation assessment legislation does not currently address SEAs. Clearly, at least along the China-Central Asia-Western Asia BRI Economic Corridor, there is significant variation in national environmental legislation including some serious gaps

[9] The report focused on the following case study countries: Australia, Austria, Bhutan, Brazil, Cameroon, Canada, China, Colombia, Denmark, the European Union, Fiji, France, Germany, India, Indonesia, Kenya, Lebanon, Mexico, Mongolia, Oman, Panama, Peru, South Africa, Tanzania, the United States, and Vanuatu (UN Environment 2018a).

[10] The report focused on Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Mongolia, China, and the Russian Federation (Wingard et al. 2014).

in coverage. While the presence of comprehensive national legislation is not the only factor responsible for environmental performance of a country – Esty and Porter (2002) found that other important factors include regulatory structures responsible for compliance and enforcement; availability of environmental information; civil society presence and empowerment; administrative, scientific, and technical infrastructure – it is clear that cross-country differences in environmental performance are associated with the rigor and structure of environmental regulations as well as a country's willingness and ability to enforce these regulations (Esty and Porter 2002).

The enormous variation in countries' environmental policies and enforcement capabilities has real implications for BRI transportation investments. One of the repeated concerns of environmental critics is that BRI investors will show a preference for infrastructure projects and routes in countries with lower standards and enforcement in order to avoid the upfront costs of carrying out a comprehensive EIA or SEA (W. Laurance 2017; Moran et al. 2018; Shinn 2016). As China tightens its own environmental standards, the difference between standards at home and those in many BRI countries are becoming increasingly stark. Will China follow its longstanding commitment to rely on host-country legislation and norms to dictate how BRI investments address environmental impacts? Or will it require its investment to adhere to more stringent international or Chinese standards in order to achieve its vision of a sustainable and green Belt and Road? In the next section we will explore some of the international "best practice" standards that could help attain a sustainable and green BRI.

II. GLOBAL ENVIRONMENTAL POLICIES

The Good Industry International Practice (GIIP) standards established by international entities – whether international agreements, international lending safeguards, or voluntary standards from nonprofit organizations or industry – are often more restrictive than those of individual nations, especially countries with weak environmental policies. In this section we review a range of these standards, from binding requirements from international lending institutions to voluntary standards that may be advantageous to follow when considering net economic benefits or reputational enhancement. This section also reviews the environmental standards of Chinese policy banks. Critically, while as just noted often international practices go beyond the standards of host countries, if those practices are not implemented in ways that actually constrain the impacts of all BRI investments, including with significant consequences for failing to carry out improved and agreed practices, then their benefits are not realized. Consequential monitoring and the enforcement of agreed conditions is a necessary part of all projects.

A. International Agreements

Though there are many fewer international environmental policies than the myriad national laws, there are still far too many that potentially bear on BRI transportation infrastructure to describe individually here (and see Monteiro and Trachtman *in review* for provisions within trade agreements). These international agreements are not likely to affect BRI transportation projects directly but through their work with governments, international institutions, and NGOs to create appropriate relevant policies. Appendix 11 provides an overview of some of the critical agreements with the greatest overlap. For more detailed information, the Green Growth Knowledge Platform meta-analysis of environmental databases is a good source (Booth 2017). The Ecolex (www.ecolex.org/), Environmental Treaties and Resource Indicators (http://sedac.ciesin.columbia.edu/entri/index.jsp), and International Environmental Agreements Database (https://iea.uoregon.edu/) also provide useful references along these same lines.

B. Lending Institution Environmental Policies

An effective means of influencing BRI transport projects has been conditions set by funding sources.

i. Multilateral Development Banks

While the majority of BRI transportation project loans are coming from China, sometimes multilateral development banks (MBDs) provide co-financing for these projects. All MDBs now have their own set of environmental and social standards, which place specific requirements on loan recipients regarding the minimum social and environmental standards required for investments to be allowed to progress, and BRI projects with MDB co-financing adopt the standards of the MDB partner (Cader et al. *in preparation*). Even if there is no financing from MBDs, environmental and social standards established by MDBs – and, in particular, the IFC's Performance Standards or the World Bank's new Environmental and Social Framework (ESF) – are often considered the Good Industry International Practice (GIIP) or best practice standard for multilateral, bilateral, or commercial loans. Appendix 12 provides an overview of these environmental and social safeguards for MDBs engaged in BRI infrastructure loans. Still, clearly, they would have to be strongly monitored and enforced, with consequences, to provide good incentives.

The World Bank, which was among the first MDBs to address environmental and social safeguards in the 1990s, adopted revised environmental and social safeguards in 2018 to strengthen their protections for the environment and for people while making it easier for borrowers to comply with relevant standards. These reforms were a response, in part, to growing demand for lending operations to be more efficient, for due diligence to be more flexible, and for greater reliance on host country environmental and social standards (Dollar 2018), which again are likely to be less strict. These standards parallel, to some degree, the founding vision of the two recently established MDBs, the New Development Bank (NDB) of BRICS countries and the Asian Infrastructure Investment Bank (AIIB). Both NDB and AIIB clearly have pledged their commitment to sustainable development as well as efficiency gains in project processing – which might conflict. AIIB, for example, has committed to be "lean, clean, and green," meaning cost effective and efficient, have zero tolerance for corruption, and a respect for sustainability and the environment. NDB, as compared to the other multilateral development banks, depends more heavily upon the host country policies, with the aim of strengthening those policies when feasible instead of imposing bank standards (New Development Bank 2016). This policy of "country system plus" allows for host country regulations to be used for environmental and social safeguards except in projects or countries deemed high risk, in which case NDB would draw on IFC Performance Standards. Some critics worry that both AIIB and NDB efforts focus so much on improving efficiency and relying extensively on existing corporate or host-country standards that environmental and social safeguards may well prove to be inadequate in practice. Critics of these policies recommend improving the definition of sustainability, increasing clarity about how adverse impacts will be mitigated once assessed, and including a more transparent policy about how country and client systems will be assessed and incorporated into the plan (Weiss 2017).

ii. Chinese Policy Banks

The two largest lenders for BRI projects are both Chinese policy banks: Export-Import Bank of China (China Exim) and China Development Bank (CDB), which have issued $100 bln and $170 bln respectively towards BRI projects (Gallagher and Qi 2018; Shinn 2016). Chinese policy banks are state-owned banks that are responsible for infrastructure lending as well as promoting foreign trade.

The environmental and social safeguards of these two Chinese policy banks are still nascent and less rigorous than those of the MDBs (Appendices 12 and 13; Dollar 2018; FOE 2016; Ren et al. 2017)). CDB was one of the first banks in China to have environmental and social policies, though. By 2005, e.g., the CDB was requiring EIAs to be conducted in accordance with the law (Ren, Liu, and Zhang 2017). Specific environmental regulations are not publicly available, although some of the basic environmental rules issued by the CDB can be inferred from past lending, such as the requirement to complete EIAs by an independent evaluator and obtain approval through the EIA process (FOE 2016). The Chinese financial institutions investing in overseas infrastructure are also subject to environmental guidelines put in place through the China Banking and Regulatory Commission (CBRC, now the China Banking and Insurance Commission—CBIRC). In 2012, the CBRC issued strengthened *Green Credit Guidelines* (GCG) that compel Chinese banks' overseas lending to follow host country laws but also international norms, though this is assessed at the institutional not the project level and implementation is still a key challenge (FOE 2017). Again, at the project level, monitoring and consequential enforcement are likely to be needed for impact.

Overall, environmental policies of Chinese policy banks are less mature than those of other international financial institutions such as the World Bank and IFC. The policy banks have not developed customized and specific policies for environmental and social issues while the adopted environmental policies are not strict enough; significantly, they lack environmental departments to oversee environmental issues (Ren et al. 2017). Critics have urged the policy banks to strengthen the entire process, including the pre-loan review, the complaint mechanism, public consultancy with affected communities, and information disclosure system (GEI 2018). While all banks require clients to follow host country standards, IFC and other MDBs generally have their own standards that, when stricter than those of the host country, must also be followed to have their expected impacts. In the case of the China Exim Bank, only when no host country standards exist would the bank consider applying Chinese and international standards (Ren, Liu, and Zhang 2017). CDB's environmental and social standards are also mainly based on the host country laws and policies (Ren, Liu, and Zhang 2017). IFC and other international institutes have worked with Chinese officials recently to build capacity in these policy banks to manage environmental and social risks (Leung et al. 2013). The policy banks have made progress in several areas, including developing requirements for environmental and social risk control, more stringent punishments for violating environmental regulations,[11] and measures to promote green investment (Ren, Liu, and Zhang 2017).

C. Foreign Direct Investment Policies

Chinese state-owned companies are so far the primary firms executing BRI projects. Besides environmental regulations imposed by their funders, what other environmental restrictions are Chinese firms subject to? In addition to host country laws and policies, Chinese firms – especially state-owned firms but also private companies – are potentially subject to regulations by their own government.

Over the last decade -- and particularly since 2015 – domestic environmental policies have been greatly expanded and their enforcement strengthened within China. In March 2018 the government announced institutional reform that provided expanded responsibilities to the Ministry of Ecology and Environment (MEE) and the Ministry of Natural Resources (MNR). Appendix 14, which provides an abbreviated list of the major Chinese national environmental policies. Two of the most significant laws, *Environmental Protection Law of the People's Republic of China* and *Law of the People's Republic of China on*

[11] For example, if an environmental impact is discovered and not rectified during monitoring, the China Exim Bank will stop providing credit and consider the project as a non-performing loan and bad debt. If the CDB discovers a project is violating environmental regulations, it downgrades the project's asset levels and limits or stops providing loans (FOE 2016; Ren et al. 2017).

Environmental Impact Assessment, require environmental impact assessments and plan environmental impact assessment (otherwise known as strategic environmental assessments) for plans which affect the environment within China. The *Environmental Protection Law* was strengthened in 2014 and enforcement and monitoring has been substantially increased since then (Leung et al. 2013). However, these laws do not apply to foreign investments outside China. Following the example of many developed countries that have extended their national environmental standards to foreign investments, the NGO community has been pressing for Chinese firms to be required to operate under the same regulations for foreign projects that they must follow within China. At a minimum, some analysts feel habituation of these firms to regulation at home will affect their work abroad. Other critics suggest that, without strict regulations, Chinese firms are likely to "outsource" their polluting industries to other countries as domestic environmental laws tighten (Moran et al. 2018).

Though generally Chinese domestic environmental regulations do not apply to overseas investments, environmental regulations specific to Chinese firms investing abroad have been expanded in recent years. The key policy that relates to Chinese overseas infrastructure construction projects, *Guidelines on Environmental Protection for Overseas Investment and Cooperation,* was released in 2013 by the Ministry of Commerce (MOFCOM) and the former Ministry of Environmental Protection (now the Ministry of Ecology and Environment—MEE). These guidelines encourage but do not require Chinese companies to complete environmental impact assessments (EIAs), develop environmental mitigation measures, and work with local communities to identify potential negative environmental and social impacts when overseas (Leung et al. 2013; Shinn 2016). What would require those steps is not clear.

In addition to environmental and social policies addressing foreign direct investment, there is a growing body of policies that are specific to the Belt and Road Initiative. The initial vision for a Green Belt and Road was released in 2015, followed in 2017 by a guidance document and cooperation plan. All three documents are ambitious and paint a picture of the BRI being able to, "…promote ecological progress in conducting investment and trade, increase cooperation in conserving eco environment, protecting biodiversity, and tackling climate change, and join hands to make the Silk Road an environment friendly one." (Chinese National Development and Reform Commission, Chinese Ministry of Foreign Affairs, and Chinese Ministry of Commerce, 2015) All three documents are still high-level and lack critical details on implementation, monitoring, and enforcement (Chun 2017). These policies do depict, however, how BRI projects with appropriate environmental mitigation mechanisms and enforcement could serve as a model of good development practices throughout the region. On the other hand, it is quite clear that positive statements without enforced implementation achieve little. Again, the question is raised concerning how compliance with related promises should be enforced.

D. Industry and Nonprofit Standards

Firms engaged in BRI projects may voluntarily adhere to best practice environmental standards – typically stricter than those prescribed by lenders or governments – from industry associations or nonprofit organizations. Firms might elect to follow these guidelines because they calculate that it is in their financial interest to invest sustainably or because they receive external pressure – from their customers, governments, or the general public – and reputational benefit from adopting these criteria.

One useful reference concerning such voluntary standards, codes of conduct, and audit protocols relating to sustainability in supply chains is the Standards Map database (www.standardsmap.org), created by the International Trade Centre (Booth 2017). Again, their impact is another question in light of the fact that many positive and well-intentioned statements are made that do not shift outcomes.

Appendix 15 lists a sample of such voluntary best practice standards that are especially relevant to transportation infrastructure projects. These can range from broad principles that firms pledge to follow – such as the Equator Principles – to extremely detailed requirements that must be met in order to obtain certification of sustainability, such as the CEEQUAL, Envision®, SuRe®, and Greenroads® standards. The authors are not aware of any BRI transportation project that has received sustainable infrastructure certification or has utilized the Natural Capital tools in their planning process, steps that in principle could shift outcomes. The two Chinese firms that are currently members of the Equator Principle Association, Bank of Jiangsu and Industrial Bank Co., Ltd., are both private companies.

While the adoption of best practices is still lacking for Chinese outbound infrastructure investments, the China Chamber of Commerce for Minerals, Metals and Chemicals Importers and Exporters developed standards that could serve as a prototype: *Guidelines for Social Responsibility in Outbound Mining Investments.* These comprehensive but voluntary guidelines aim to direct Chinese mining companies toward improving corporate social responsibility (CSR) and sustainability strategies. The original version was produced in 2010; in 2015 a revised and more transparent version of the guidelines was released and is currently being rolled out (CCCMC 2015; Chun 2017). Again, impacts of adoption are unclear.

Analysts generally believe that the large Chinese state-owned enterprises (SOEs), as compared to the smaller provincial and municipal SOEs and private firms, are more likely to have both the capacity and inclination to follow voluntary best practices and other forms of CSR (Maurin and Yeophantong 2013; Xu 2014; Sun and Tang 2015; Wang and Hu 2017; Yuan and Landry 2018). This is due in part to the fact that the larger SOEs have the easiest access to Chinese state financing and the most oversight from central authorities. They are seen as representing the policies of the government. Furthermore, large SOEs are the type of Chinese firm most likely to invest in BRI infrastructure through joint partnerships or public-private partnerships (PPP) rather than engineer, procurement and construction (EPC) service contracts or build, operate and transfer (BOT) contracts. Because of the long-term commitment, the companies investing joint partnerships and PPPs are more likely to be responsive to some pressures for long-term sustainability investments (Myxter-Iino et al. in prep). Large SOEs are also sensitive to their international reputation, given that they do business across the globe. Because most of the large BRI projects are carried out by large SOEs, their actions – positive or negative – do drive BRI infrastructure investing.

III. RECOMMENDATIONS: BRI CORRIDOR ENVIRONMENTAL ASSESSMENT

China's commitment to a sustainable Belt and Road certainly is suggested by the growing body of vision statements and guidelines outlining various conditions for green BRI investments. However, to date, these recommendations remain high-level and voluntary, though policy instruments and planning tools do exist that could help achieve this vision. Whether and how they are implemented will be critical.

We recommend that policies be developed for the Belt and Road Initiative that require incorporating environmental assessment procedures into early-stage planning of entire BRI Economic Corridors. A *BRI Corridor Environmental Assessment* (BRICEA) would focus on entire transportation corridors, thereby taking advantage of the scale and connectivity of BRI to effectively address the cumulative direct and indirect environmental risks from transportation infrastructure projects and following many of the principles already developed for SEAs and regional environmental assessments. While a formal BRI Corridor Environmental Assessment process does not currently exist, the United Nations Office for Project Services (UNOPS) has developed a framework for sustainable infrastructure planning and development which could provide many of the tools to support such a process (UNOPS 2017). Such a process could follow many of the protocols already established for China's domestic Plan for Environmental Impact Assessments, as set forth under its EIA Law in 2003. Further, since we know that the perfect BRICEAs will not always occur – in part because some projects are already underway – we strongly recommend that a similar approach be applied to latter stages of required reviews of projects over time, such as due diligence assessments.

The following attributes of a BRICEA make it distinctly well suited to reduce environmental risks from BRI's transportation infrastructure network:

Spatial scale Many environmental effects associated with BRI transportation projects – such as impacts on wildlife migration, carbon emissions, and forest cover – are widespread, even transboundary. For example, the impact of a rail or road network as a barrier to wildlife migration can only be understood in the context of the entire migratory paths of disrupted species and all the existing and proposed linear infrastructure within the species range. Similarly, the assessment of indirect impacts of road and rail networks on deforestation from land use changes is only meaningful at the scale of an entire BRI Economic Corridor. When planning the most critical mitigation activities – avoidance actions – the scale of a BRICEA is indispensable: Planners can identify acceptable routes that avoid sensitive areas within a corridor and, for each of the alternative routes, prioritize their viability by their net benefits that include economic, environmental, and social inputs (Kiesecker et al. 2010). Such an analysis could also identify areas appropriate for restoration and compensatory offsets, which should improve the efficiency and effectiveness of mitigation for the corridor as a whole. Each individual BRI transportation segment would be expected to contribute to prescribed corridor-wide mitigation actions, either directly or indirectly (through compensatory offsets). For wide-ranging risks such as deforestation and biodiversity extinction, mitigation actions can only be efficient and effective at this regional scale.

Temporal scale BRI Economic Corridors start with a series of pre-defined endpoints and major hubs, but have some flexibility concerning how to connect the hubs. Integrating SEAs into early-stage planning for BRI Economic Corridors – before individual projects have been advanced – can provide direction on how to place transportation infrastructures where they are likely to cause the least environmental harm while maintaining most of the economic and connectivity benefits. It is critical that this process be holistically integrated into the early-stage economic planning for the corridor, including all affected sectors. Knowing early in the process which sensitive areas or infrastructure designs are off limits as well as which investments have positive net benefits should result in productive investments of time, money, and political capital and reduce risks of disruption and delay.

Regional connectivity A BRICEA will be most effective if it includes input from all stakeholders affected within an economic corridor. Following the SEA-type model developed for the Mekong Basin Regional Commission, a regional commission could be established for each BRICSEA that includes government representatives from all affected countries and a process for public participation (see Keskinen and Kummu 2010). This commission could also collect, analyze, and process information from each host country's regulatory and legal systems, allowing all stakeholders to coordinate the complex governance issues of a transboundary transportation network. A highly visible and transparent BRICEA process should promote good relations between lenders and host country governments and reduce potential local community opposition (Leung et al. 2013).

Investor participation A BRICEA process could help lenders reduce time, money, and obstacles dealing with serious environmental issues downstream during the EIA process. While individual EIAs would still need to be carried out for BRI transportation projects to address local impacts, the likelihood is that the major obstacles and need for late-stage adjustments would have already be addressed through the BRICEA process. With input of existing expertise from international financial institutions and Chinese agencies such as MEE, NDRC, and policy banks, BRICEAs should allow lenders to recognize the highest international environmental standards while at the same time minimizing the bureaucracy, time, and cost of downstream EIAs. A well conducted BRICEA should allow BRI transportation projects to achieve the highest GIIP standards while at the same time minimizing the bureaucracy, time, and cost of downstream EIAs (AIIB 2016). In other words, SEAs could provide lenders such as AIIB the opportunity to be "lean" and "green."

SUMMARY AND CONCLUSION

Environmental Risks from BRI Transportation Infrastructure

We distinguish direct effects – abiotic, ecosystems, wildlife – from indirect effects induced by changes in transport costs and land use. The former tend to be localized and unambiguously linked to a road or rail project. The latter often have more complex connections but, still, potentially more pervasive impacts.

Direct Effects Direct environmental impacts include *abiotic impacts* like air and water pollution as well as soil erosion; *ecosystem impacts* such as habitat destruction and fragmentation; and *wildlife impacts* such as vehicle collisions, barriers to migration, and illegal wildlife trafficking. BRI transportation investments may be especially prone to such risks because many of the BRI Economic Corridors pass through steep terrain that is vulnerable to erosion, soil degradation and sedimentation, and contain sensitive ecosystems with high levels of species endemism.

Indirect Effects Historically, road and rail projects can set in motion indirect and unintended consequences. Changes in transport costs shift markets and human populations, which can open frontiers to settlements with habitat loss, deforestation, wildlife and timber trafficking, among other effects. The magnitudes of effects differ by context. Deforestation – a straightforward proxy for environmental risks – has heterogenous responses to transportation investments depending on their ecological and development settings. BRI transportation projects that are sited in highly developed regions with extensive prior deforestation such as southwest China, Bangladesh, and parts of Cambodia and Kazakhstan may have less of a rise in deforestation and it is even possible that increased economic development spurred by lowered transport costs could result in reforestation or afforestation. BRI transport projects located in areas of medium development – that is, areas at the margin of development frontiers that may be profitable with further investments – can expect significant forest loss from transportation projects near existing forests such as in Myanmar, Lao PDR, the Malay peninsula, and western Russia. Finally, in regions with low development and little prior deforestation, such as in eastern Russia and northwest Thailand, the short-term deforestation effects of BRI road or rail projects may be small though there remains a high degree of risk − and uncertainty − about long-term impacts. Roads – especially undivided highways with unrestricted access to surrounding frontiers – are especially vulnerable to such pressures. Divided highways and railways may experience less pressure due to their restricted access.

Environmental Mitigation

The mitigation hierarchy distinguishes four types of actions – *avoid risks, reduce risks, restore ecosystems*, and *offset damages* – to diminish impacts while allowing economic gains from transport investments. They are ordered in terms of desirability. In short, adjusting projects upfront to avoid losses is crucial.

Avoidance Avoidance is by far the most important category. Selecting road or rail routes that avoid environmentally sensitive areas is usually the most effective and least expensive way to minimize environmental harm. Early in infrastructure planning, routes can be selected with minimal cost to economic efficiency. Yet as planning progresses, mitigation – even minor shifts to road or rail routes – becomes increasingly difficult. Late in the process, there are no more wholesale avoidance options but only remediation is available. That can be costly and often ineffectual.

Reduction When full avoidance is not possible, mitigation should reduce environmental harms. Engineering and design solutions are among the frequent strategies to address direct impacts of transportation infrastructure on abiotic conditions, ecosystems, and wildlife. Reducing indirect impacts from transport projects – such as induced land use changes – is less straightforward. Complementary policies are the preferred strategy for modifying human decision making.

Restoration Restoration is conducted at project sites to repair either direct or indirect impacts to biodiversity or ecosystem services. If extensive landscape transformation has occurred during construction, then vegetative, wetland, or waterway restoration is often required.

Offsets Compensatory offsets are a final strategy, after the other actions have been exhausted. Establishing protected areas or buying carbon or water credits can in principle counteract the local losses of forests, biodiversity, carbon, or other environmental services due to transport infrastructure. Because it may be difficult to fully anticipate indirect effects such as changes in land use over the long term, and because comparing damages at project sites to gains from offsite offsets can be difficult, we believe offsets are inherently risky and, thus, that taking this approach should include aiming for positive environmental net impacts from BRI investments.

Environmental Policies

Policies largely determine which environmental risks are addressed and how. For large BRI transport investments, policies of national governments, international agreements, lending institutions, corporations, and civil society organizations all can influence the mitigation actions taken.

National Environmental Policies In principle, host-country policies provide at least the minimal environmental protections for every transportation infrastructure project. China has pledged to follow host-country policies and norms for all Belt and Road projects, for instance. However, the

BRI countries differ considerably in their environmental policy frameworks and, crucially, in their capabilities and political will to enforce even their own such policies. Policies mandating the use of environmental impact assessments (EIA) are among the most prevalent requirement of host country governments concerning environmental protection from infrastructure development. However, EIA's ability to address environmental risks is hampered because they are typically conducted relatively late in the infrastructure planning process, when most important decisions have already been made. Consequently, some governments have adopted early-stage planning such as strategic environmental assessments (SEAs). SEAs done well can address policies and plans at a program, landscape or sector-level, before individual projects have been advanced.

Global Environmental Policies Best practice standards established by international entities – agreements, lending safeguards, voluntary standards from nonprofit organizations or industry – are often more restrictive than those of nations. An effective means of influencing BRI projects has been conditions established by funding sources. IFC Performance Standards or the World Bank Environmental and Social Framework are often considered Good Industry International Practice standards for multilateral, bilateral, or commercial loans. The environmental safeguards of the two Chinese policy banks – the largest BRI funding sources – are less comprehensive and rigorous, however, than those of the multilateral development banks (MDBs). Yet when MDBs have co-financed BRI transport projects, their more stringent standards are applied. Domestic Chinese environmental policies, regulations, standards, and institutional reforms have been greatly strengthened since 2015. Some regulations and standards specific to Chinese policy banks and firms investing abroad have also been expanded in recent years. However, much work still needs to be done for China to expand its national environmental standards to foreign investments, especially in the areas of monitoring and enforcement.

Recommendation: BRI Corridor Environmental Assessment

Given its scope, the BRI's potential environmental impacts are extensive. While mitigation of these risks is daunting, policy instruments and planning tools do exist to dramatically decrease them. We strongly recommend that the BRI incorporate regional versions of SEA-style approaches into the earliest-stage planning for entire Economic Corridors. A *BRI Corridor Environmental Assessment* (BRICEA) would focus upon the entire transportation corridor, taking advantage of the scale and connectivity of the BRI to address the cumulative direct and indirect risks from these projects. Many of the elements of a BRICEA already exist within China's domestic national environmental policies and could be extended to encompass foreign investments. Further, since we know that perfect BRICEAs will not always occur – in part because some projects are already underway – we strongly recommend that a similar approach be applied to later stages of required reviews of projects over time, such as due diligence assessments.

The following attributes make an Environmental Assessment focused on BRI Economic Corridors distinctly well suited to reduce risks:

Spatial scale For wide-ranging, cumulative risks such as deforestation and extinction, mitigation actions are most effective at a regional scale. For avoidance, the scale of a Corridor Environmental Assessment is indispensable, as planners can identify routes to avoid sensitive areas and, across alternative routes, prioritize by net benefits. One can also identify areas appropriate for restoration and offsets. Each segment would be expected to contribute to compliance directly or indirectly (via compensatory offsets).

Temporal scale Integrating environmental assessments into the very earliest planning stages, before individual projects advance, best permits guidance on how to place transport infrastructure where it causes least environmental harm while maintaining most economic-connectivity benefits. It is critical that early-stage corridor planning integrate all affected sectors. Knowing early which sensitive areas should be off-limits, and which investments have greatest net benefit, should yield productive investments of time, money, and political capital and reduce risks of disruption and delay.

Regional connectivity A BRI Corridor Environmental Assessment (BRICEA) will be most effective with input from all stakeholders in an economic corridor. A regional commission could be established for each BRICEA with government representatives from all affected countries, plus broad public participation. A highly visible and transparent BRICEA process should promote good relations between lenders and host country governments and reduce potential opposition from local communities.

Investor participation A well conducted BRICEA should allow lenders to insist upon the highest international environmental standards while at the same time minimizing the bureaucracy, time, and cost of downstream EIAs. While individual EIAs would still need to be carried out to address specific technique choices with local impacts, the likelihood is that the major obstacles and need for late-stage adjustments would already be addressed through such an SEA process.

APPENDICES

APPENDIX 1: Forest Cover Change across the Entire Belt and Road

Change in forest cover[12] can be used as a proxy for environmental risks related to a wide range of environmental variables of interest, including species' habitats, healthy ecosystems, carbon storage, water provision, and other ecosystem services. Because satellite data on forest cover are relatively easy to obtain, this is one of the simplest and most straightforward tools to help identify the impact of transportation infrastructure on ecosystems.[13]

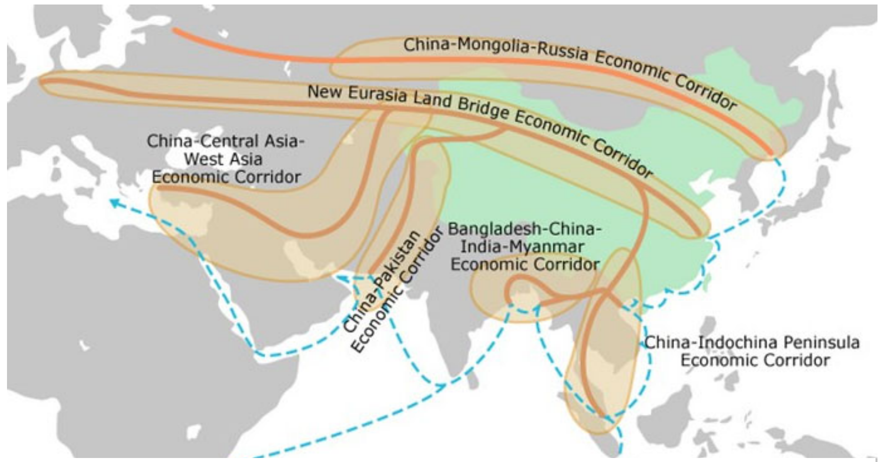

Figure 5. Six economic corridors of the Belt and Road Initiative

Source: china-trade-research.hktdc.com/business-news/article/The-Belt-and-Road-Initiative/The-Belt-and-Road-Initiative/obor/en/1/1X000000/1X0A36B7.htm

When examining forest cover change at the scale of the entire Belt and Road, some distinct patterns emerge that invite further exploration. The variations in forest cover and loss, for instance, highlight two important questions: Within which of the BRI Economic Corridors (Figure 5) are forests most vulnerable to infrastructure development? And is this change in forest cover a good proxy for vulnerability to other environmental risks?

A cursory evaluation indicates that some corridors generate more risk than others based on the simple fact that not all affected areas have much forest. The China-Indochina Peninsula Economic Corridor (CICPEC) and China-Mongolia-Russia Economic Corridor (CMREC) are among areas at greatest risk with large areas facing active deforestation in the last 15 years (Figure 6). Further, across and within potential economic corridors, we can take into account levels of prior development − e.g., high versus medium or low – when considering impacts of transportation investment. (See Part 1, Section II.B.i.b for a theoretical framework concerning deforestation in relation to economic development.) Within highly developed (and deforested) regions such as southwest China, Bangladesh, and parts of Cambodia and Kazakhstan, little natural forest remains to be cleared for agriculture. Hence, little forest impact is expected from BRI transportation projects in these highly developed regions. It is even possible that increased economic development spurred by lowered transport costs in such regions leads to rural

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[12] "Forest" for continental Southeast Asia and southwest China refers to a range of different tropical forest types, including some moist rain forests but mostly evergreen forests occupying the mountainous zones; seasonal or deciduous forests in the monsoon dominated sub-region; very dry forests and woodlands occupying plains, plateaus, and other water-limited sites; and mangrove forests along the coast (H. Stibig et al. 2007).

[13] While vegetation cover is relatively easy to distinguish from barren areas in satellite imagery, primary forests can be difficult to distinguish from tree plantations, degraded forests, and regenerating forests, thus complicating the ability of satellite imagery to provide good estimates of changes to habitats, carbon, and other ecosystem services (Harris et al. 2012).

transformations that result in reforestation or afforestation via tree plantations or natural regrowth (see Kazcan 2016).

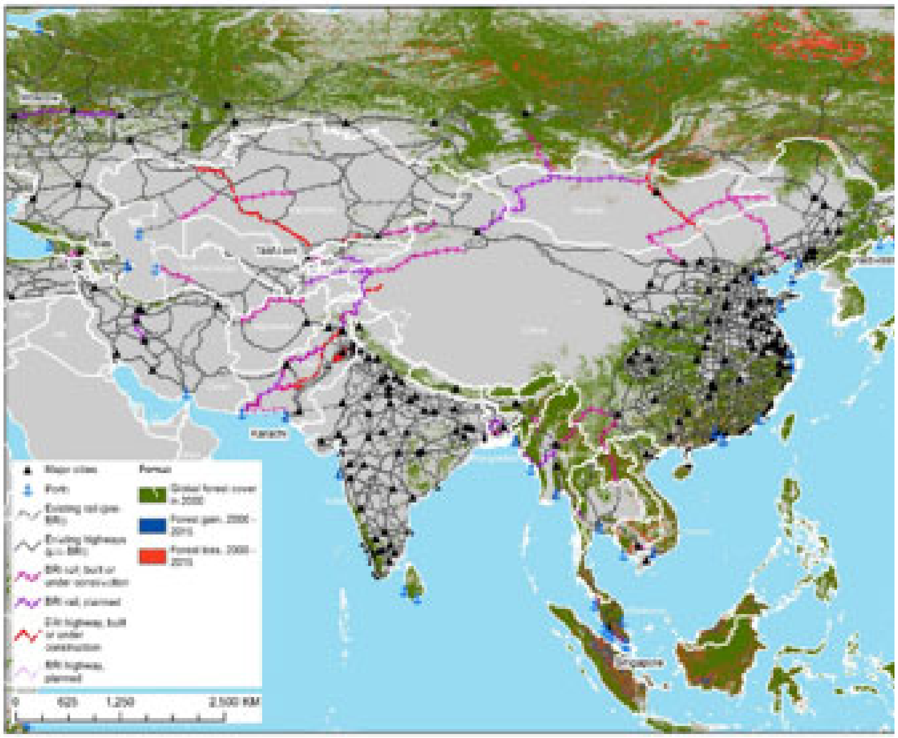

Figure 6. Rail and road projects (existing, under construction, and planned) across entire Belt and Road region in relation to forest cover, forest loss, and forest gain

On the other hand, within areas of medium development – that is, areas at the margin of development frontiers that are close to profitable now and will be profitable with further investments – significant forest loss can be expected from BRI transportation projects near existing forests. Such areas can be found within CICPEC (in Myanmar, the Lao People's Democratic Republic, the Malay peninsula) and CMREC (near Moscow).

Finally, in regions with low development and prior deforestation, such as in eastern Russia Federation and northwest Thailand, the short-term effects of BRI road or rail projects may be small though there remains a high degree of risk − and uncertainty − about long-term impacts. Should BRI road and rail projects trigger development dynamics, with complementary investments across a decade or more make these areas attractive for increased settlement, then such areas may experience considerable long-term forest loss. However, if other factors (e.g., topography, climate, and policies) dissuade such dynamics, there could be little change.

Other environmental features – such as watershed protection which is highly valued, e.g., within big cities, or biodiversity hotspots that are critical havens for clusters of unique and threatened species – are not necessarily closely correlated over space with forest cover dynamics. As seen in Figure 7, identified biodiversity hotspots may provide additional guidance at a corridor scale. At such a broad level, the CMREC corridor, e.g., faces fewer specific hotspot risks from BRI transportation projects than does the CICPEC corridor. Meanwhile, planned BRI road and rail projects of the China-Central-and-West-Asia Corridor cut through biodiversity hotspots within all of Kyrzgystan, Tajikistan, and Uzbekistan.

Even such coarse patterns clearly illustrate great heterogeneities for environmental risks facing the BRI, due to variations in both economic and ecological factors affecting the individual and cumulative risks from transportation projects within different BRI Economic Corridors. Consequently, it is imperative that integrated planning processes at early stages of corridor development should not consider the average or the modal BRI project but, instead, all the corridor details relevant for assessing the cost-effective means for reducing environmental risk within each corridor. This can contribute greatly, at low cost, to avoiding societally inefficient investments in which, e.g., even minor economic gains (or no gains or net financial losses from investments) could generate significant environmental risks, i.e., a 'lose-lose'. Such assessments are eminently possible, for instance along the lines illustrated for road investments across varied landscapes in Dasgupta and Wheeler (2016) and Danyo, Dasgupta and Wheeler (2018). Towards application of such thinking within the BRI, in the succeeding appendices we will explore some of these potential risks and approaches to their potential mitigation in greater detail for one corridor, CICPEC.

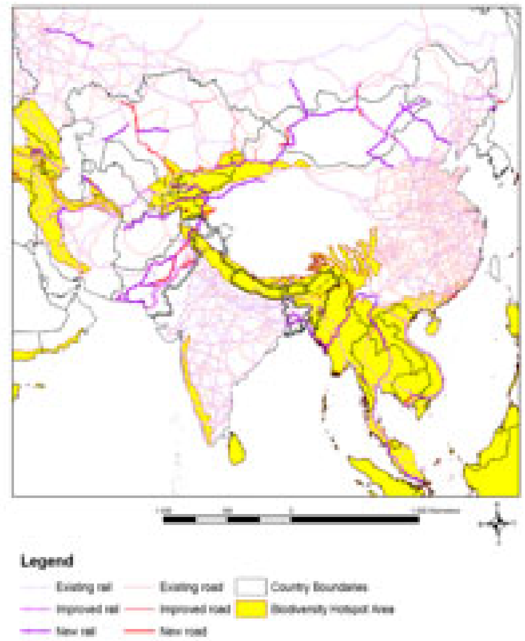

Figure 7. Rail and road projects (existing, under construction, and planned) across entire Belt and Road region in relation to Conservation International's Biodiversity Hotspots

APPENDIX 2: Assessing Environmental Risk from Transportation Infrastructure Development in the China-Indochina Peninsula Economic Corridor (CICPEC)

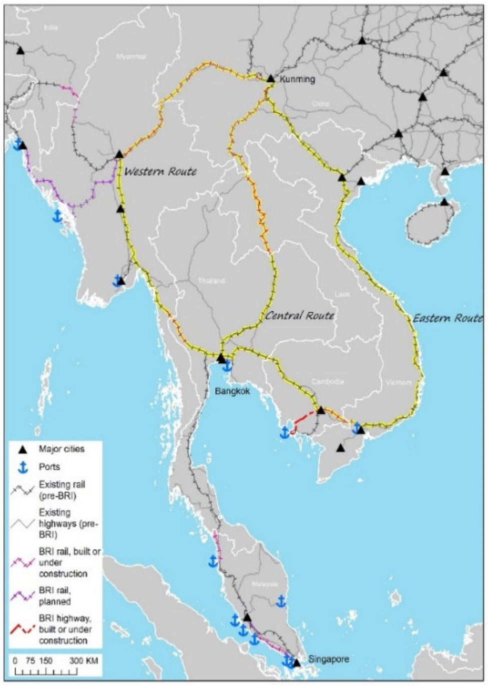

Figure 8. Existing and BRI road and rail segments along the eastern, central, and western transportation routes connecting Kunming, China and Bangkok (highlighted in yellow).

Many individual transportation projects or segments are required to connect an entire BRI Economic Corridor. While each of these segments of rail or road may cross a relatively short distance, as a whole the full economic corridor can traverse many different ecosystems and political boundaries. At what scale should environmental risks be assessed – at the level of the entire corridor or the individual projects? There is not one answer to this question, as it will depend on the types of risks being evaluated; invariably assessments need to be made at multiple scales to truly capture all risks. Carrying out an assessment at the project level through an environmental impact assessment makes sense when considering the impacts of construction on localized harms such as particulate pollution or changes in soil stabilization. However, the effect of infrastructure operations on many of the most pervasive and long-lasting factors – such as habitat fragmentation and land use change – can only be properly evaluated at the broader landscape or entire-corridor scale, ideally through an early-stage strategic environmental assessment process. Over the course of a series of Appendices we take a closer look at one of the BRI Economic Corridors, the China-Indochina Peninsula Economic Corridor (CICPEC), to illustrate a few of the potential environmental risks from alternative rail and road routes at the scale of the entire corridor. Specifically, we will analyze recently constructed and planned BRI high-speed rail and highway projects connecting Kunming, China to Singapore, via Bangkok, Thailand.

The vision of improving the transportation network between Kunming and Singapore is not new to BRI and CICPEC. Efforts to connect southwest China and Southeast Asia through a rail network go back to the early 1900s during the colonial period. Three potential routes have been envisioned: A western route passing through Myanmar; a central route running through the Lao People's Democratic Republic and Thailand; and an eastern route that crosses through Vietnam and Cambodia (Figure 8). All three routes are currently passable at least by road for passengers but none of the three routes has a complete a high-speed rail line capable of efficient freight transportation.

In the following appendices, we focus primarily on risks to forests and biodiversity conservation. This is one group of risks among many, including environmental and social risks related to water provision and quality, air and noise pollution, GHG emissions, fire vulnerability, earthquake vulnerability, resettlement, and indigenous rights. We focus on biodiversity and conservation as distinctive and vulnerable natural assets of CICPEC. It has by far the highest levels of biodiversity of any of the BRI Economic Corridors. In addition, habitat and biodiversity risks are sometimes quite spatially specific, offering the opportunity to avoid or at least greatly reduce damages through choices across routes or adjustments in chosen routes.

To assess the conservation risks from rail and road improvements or new construction along these three alternative routes, we will explore five potential indicators across the entire CICPEC corridor: forest cover, intact frontier landscapes, biodiversity hotspots, umbrella species, and illegal wildlife trafficking.

APPENDIX 3: Environmental Indicator: Ecosystem Effects as Measured by Forest Cover Change

Change in forest cover[14] can be used as an indicator of environmental risk that relates to a wide range of environmental variables of interest, including species' habitats, healthy ecosystems, carbon storage, water provision, and other ecosystem services. Because satellite data on forest cover are relatively easy to obtain, this is one of the simplest and most straightforward tools to help identify the impact of transportation infrastructure on ecosystems.[15]

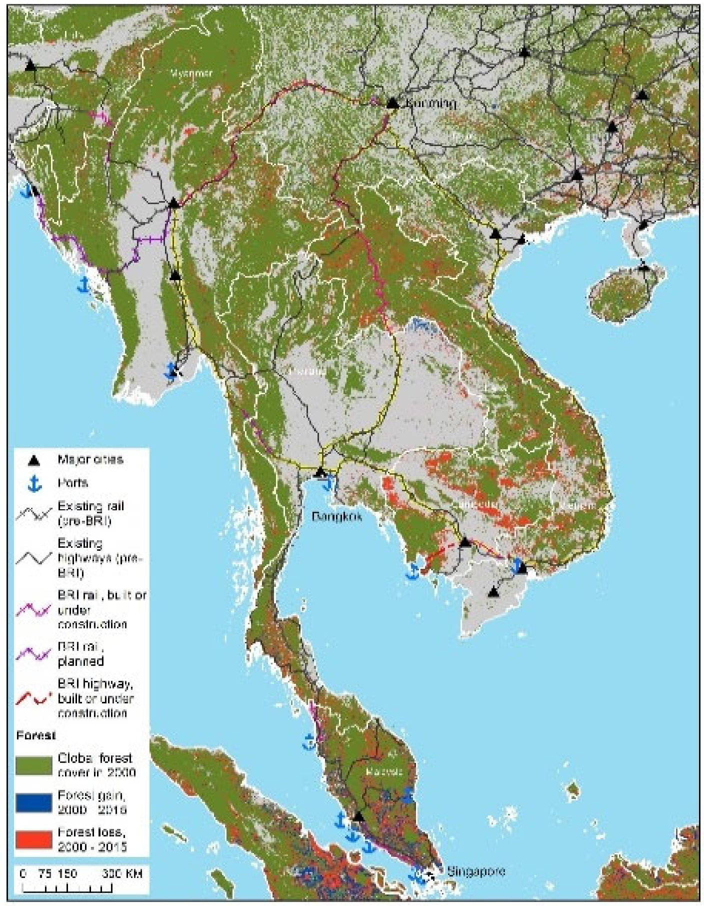

Figure 9. Rail and road projects within CICPEC and forest in relation to forest cover, forest loss, and forest gain

In recent years, most of the change in forest cover within the CICPEC corridor has occurred in Cambodia, the Lao People's Democratic Republic, and Myanmar, especially in mountainous areas (H. Stibig et al. 2007; H. J. Stibig et al. 2014; Zeng et al. 2018; Figure 9). Interestingly, many of the most affected areas have been along the boundaries between countries, such as between Yunnan Province, China and Myanmar; Lao PDR, Cambodia and Vietnam; and between Cambodia and Thailand. Most afforestation and reforestation has occurred in Vietnam and northern Thailand. The primary driver of change in forest cover is the conversion to cash crop plantations, followed by conversion to timber plantations and logging (H. Stibig et al. 2007; H. J. Stibig et al. 2014).

What role have roads played in forest conversion? Stibig and colleagues (2007) found that road construction was responsible for some forest change, particularly in the region from China to Thailand through the northwest of Lao PDR; from eastern Thailand through Lao PDR to the coast of central Vietnam; and in Cambodia. These authors did not identify any forest change that resulted from rail

[14] "Forest" for continental Southeast Asia and southwest China refers to a range of different tropical forest types, including some moist rain forests but mostly evergreen forests occupying the mountainous zones; seasonal or deciduous forests in the monsoon dominated sub-region; very dry forests and woodlands occupying plains, plateaus, and other water-limited sites; and mangrove forests along the coast (H. Stibig et al. 2007).

[15] While vegetation cover is relatively easy to distinguish from barren areas in satellite imagery, primary forests can be difficult to distinguish from tree plantations, degraded forests, and regenerating forests, thus complicating the ability of satellite imagery to provide good estimates of changes to habitats, carbon, and other ecosystem services (Harris et al. 2012).

construction (H. Stibig et al. 2007). This may be because there have been many fewer railways than roads constructed in the last two decades in continental Southeast Asia; because roads were more likely to be built into previously inaccessible frontier landscapes; or because railways provide less access to open forested areas because passengers and freight are limited to station access.

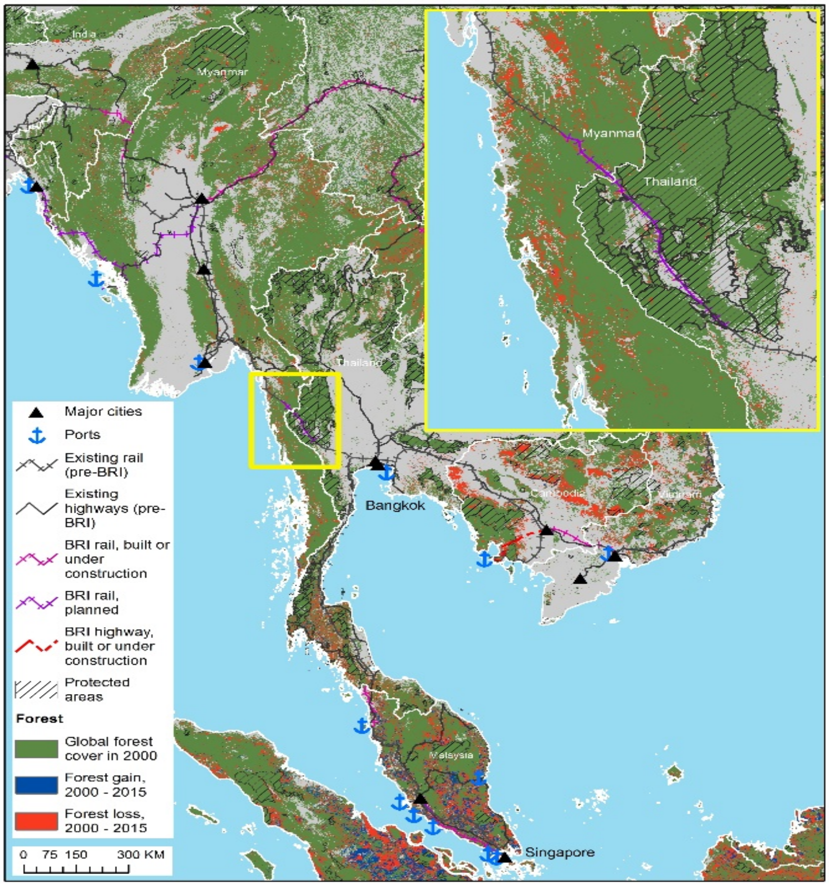

Figure 10. Rail and road projects within CICPEC in relation to forest cover, forest loss, forest gain, and protected areas. Inset of proposed BRI Burma rail Nam Tok - Thanbyuzayat project

Looking forward, would forest cover be equally affected by BRI transportation projects along the eastern, central, and western routes? Many of the recent and proposed BRI projects along these three corridors are sited in areas of high prior deforestation or on top of footprints of existing smaller roads or rail (Figure 9), which lessens the degree to which they could further fragment the landscape, degrade existing forests, or provide new access. All three of these routes, though, pass through some forested habitats that may be vulnerable to habitat destruction as a result of a new or upgraded rail or road. As can be seen in Figure 9, BRI rail lines could create extensive risk of deforestation in northern Myanmar (Western route) and Lao PDR (Central route). One segment that merits particular flagging for careful and early investigation is the proposed BRI Burma rail Nam Tok - Thanbyuzayat project in the Thailand section of the western route crosses one of the most forested and biologically important areas of Thailand (Figure 10 inset), cutting through a national park and skirting alongside several other protected areas. By contrast, the Thailand segment of the central route passes through areas with extensive prior deforestation (Figure 9) and poses no threat of further forest cover loss.

APPENDIX 4: Environmental Indicator: Ecosystem Effects as Measured by Intact Frontier Landscapes in CICPEC

Intact forest landscapes (IFLs) can be among the most critical areas to conserve because they frequently serve as refuges for native biodiversity and produce extensive ecosystem services. Because of extensive logging and land use change over many decades throughout continental Southeast Asia, few IFLs remain within CICPEC (Figure 11). It is not surprising that BRI rail or road lines mostly avoid these scarce IFLs because the eastern, central, and western routes are largely built along the footprint of existing, though less developed, transportation corridors.[16] Because the tropical region of Southeast Asia is among the most diverse and productive regions of the world for biodiversity and carbon productivity (Li et al. 2016), it is especially critical to safeguard the integrity of the few remaining IFLs in the region. Of the BRI rail and road projects along the CICPEC corridor, two are of concern: The upgrading and widening of a highway project and potential HSR projects continue to expand near the UNESCO World Heritage site Dong Phayayen-Khao Yai Forest Complex (a rare IFL near Bangkok) and the proposed Burma rail Nam Tok- Thanbyuzayat project that bisects several Thai national parks near the Myanmar border.

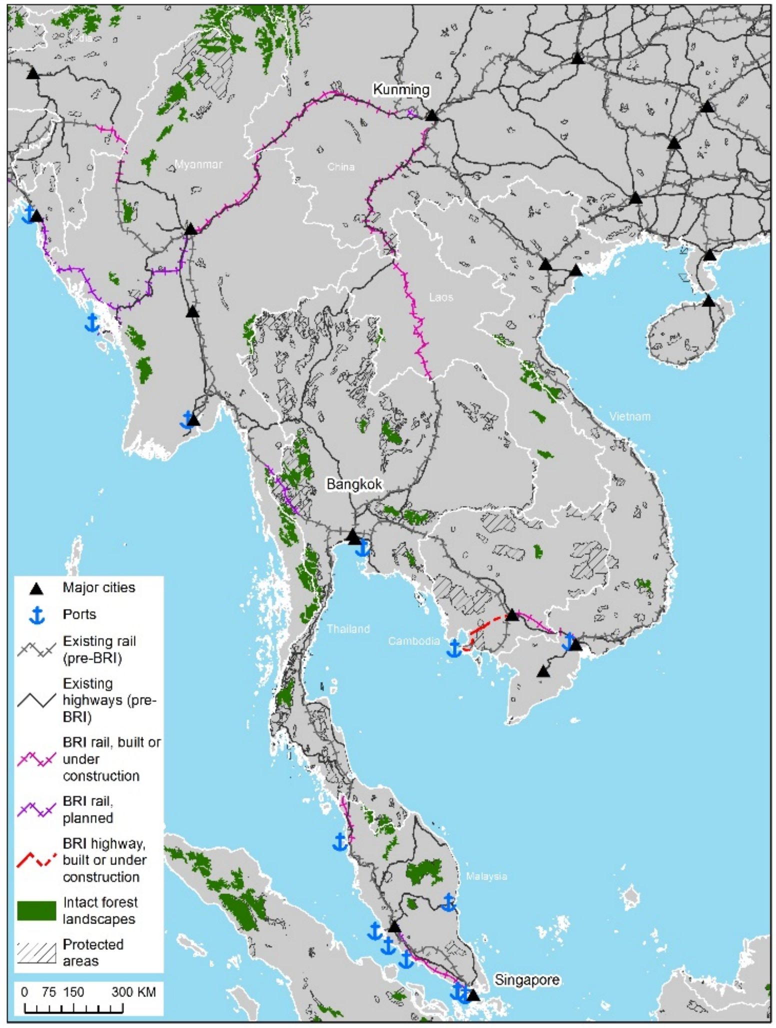

Figure 11. Rail and road projects within CICPEC in relation to intact frontier landscape and protected areas.

[16] By definition, an IFL is roadless.

APPENDIX 5: Environmental Indicator: Wildlife Effects as Measured by Biodiversity Hotspots and Umbrella Species

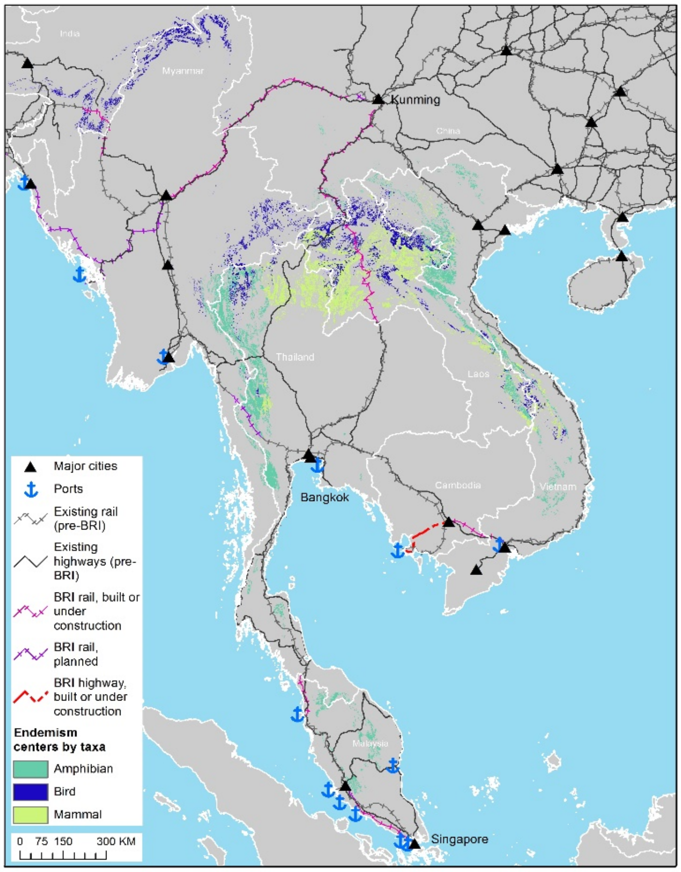

Figure 12. BRI roads and rail projects in CICPEC as they intersect with hotspots9 of biodiversity endemism for threatened species (after Li et al. 2017)

While forest cover change can be a good indicator of wildlife habitat, animals are not equally distributed across these areas. Other, complementary indicators are needed to identify high-value biodiversity habitats. IFLs capture high-value areas that serve as critical refuges for many animal species that require extensive undisturbed habitat, but there are other species that might be threatened precisely because their habitat has been reduced in size and are not found in IFLs (many of which are mountainous). Here we introduce two alternative indicators that can help identify some of the most high-value biodiversity areas that should be prioritized when mitigating risks created by transportation corridors. The first indicator, "biodiversity endemism hotspots," delineates areas with high levels of faunal species richness, species endemism, and species endangerment. Li and colleagues (2016) developed such a metric for continental Southeast Asia utilizing data from the IUCN Red List of Species of Concern for mammals, birds, and amphibians, augmented with existing, publicly available remote sensing data (Figure 12). Overlapping distributions of species of concern, Li and colleagues prioritized areas for conservation. For the CICPEC corridor, the highest value, most sensitive areas for birds, mammals, and amphibians mostly occur in mountainous areas of Southeast Asia due to their high endemism and species richness but can also be found in lower elevations, especially in northern regions of the Lao People's Democratic Republic, Vietnam, and Thailand. The planned BRI rail projects along the central route in Lao PDR clearly would cut directly through this biodiversity endemism hotspot while the other two routes largely skirt these hotspots.

The distribution of umbrella species can serve as an alternative indicator for identifying high-value areas for wildlife. "Umbrella species" are wildlife species that have large habitat needs or other requirements and whose conservation results in many other species being conserved at the ecosystem or landscape level. For the CICPEC corridor, large cats such as tigers (*Panthera tigris*) and clouded leopards (*Neofelis nebulosi*) can serve this role nicely (Figure 13). For many decades, tigers have been threatened due to the expansion of human development including an extensive road system throughout most of the tigers' range that created access for poachers and fragmented tiger habitat (Mcmillan 2018; WWF 2016). Due to overhunting and loss of habitat, fewer than 3,500 tigers lived in the wild, occupying less than 7% of their historical range despite extensive efforts to set up protected areas to conserve these large cats. Tigers are listed as endangered by the IUCN Red List (Mcmillan 2018; Walston et al. 2010). The smaller clouded leopard is also threatened with extinction, but less so than tigers. The clouded leopards are listed as vulnerable because the species has lost an estimated 30% of its adult population in the last two decades due to poaching, habitat loss, fragmentation, and other human pressures (Mcmillan 2018). The only places where BRI projects intersect with the tiger habitats are the Burma rail Nam Tok-Thanbyuzayat near the Thailand-Myanmar border and the Bangkok-Kuala Lampur HSR project in Malaysia. The former project bisects the tiger range, potentially separating populations while the latter skirts the side of the tiger range, thus potentially further restricting tiger habitat. Clouded leopards have a larger range and more populations that are more resilient to human development; their habitats are at risk from BRI transportation projects along all three corridors. Of greatest concern are the Kunming-Vientiane railway that would bisect extensive clouded leopard habitat in Laos and the Kunming-Mandalay corridor bisecting the cat's range in Myanmar.

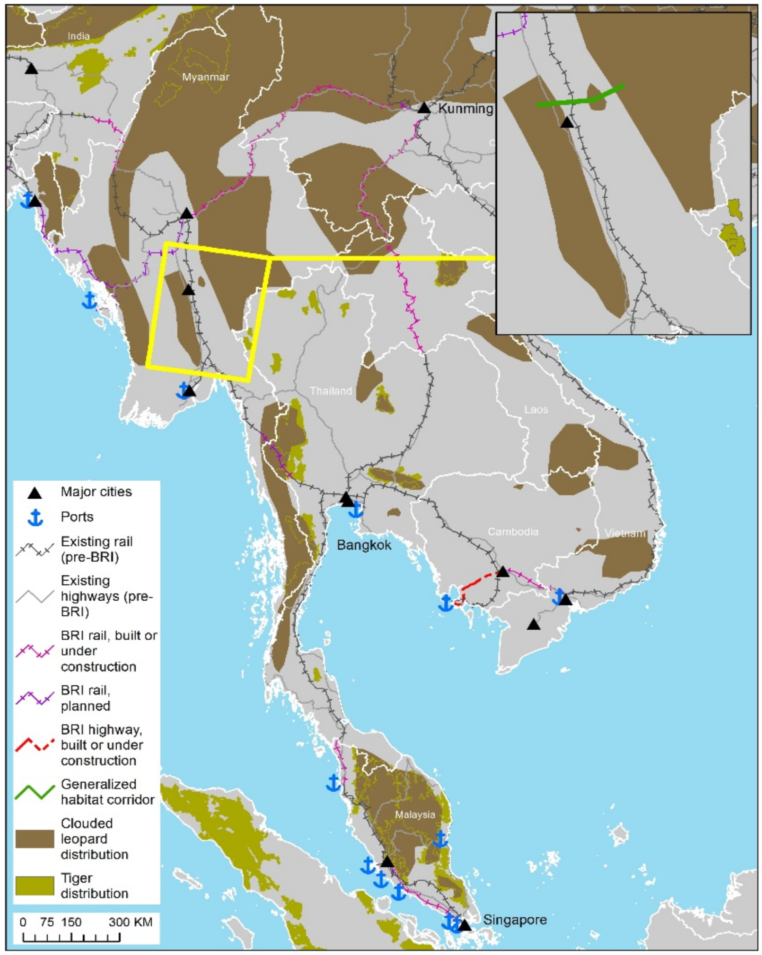

Figure 13. Tiger and clouded leopard ranges and BRI road and rail infrastructure in CICPEC. Inset show potential habitat corridor that could connect two disjunct habitat ranges.

Which of these two indicators – biodiversity endemism hotspots or umbrella species – is a better tool for identifying sensitive and high-value areas when assessing transportation infrastructure risks? The umbrella species ranges are relatively simple to use because they require the range of only single or several species. They have the added value of generating public awareness and potentially greater public support because of the high-profile nature of these species. However, individual species will invariably have ranges that are specific to their habitat requirements and threats. The absence of tigers from Lao PDR, a hub of biodiversity endemism, shows the limitation of using only umbrella species. As a composite indicator, biodiversity hotspots are more likely to capture areas of high value to a wider community of species at risk. Ideally, both indicators would be used, utilizing their comparative advantages.

APPENDIX 6: Illegal logging and wildlife trade

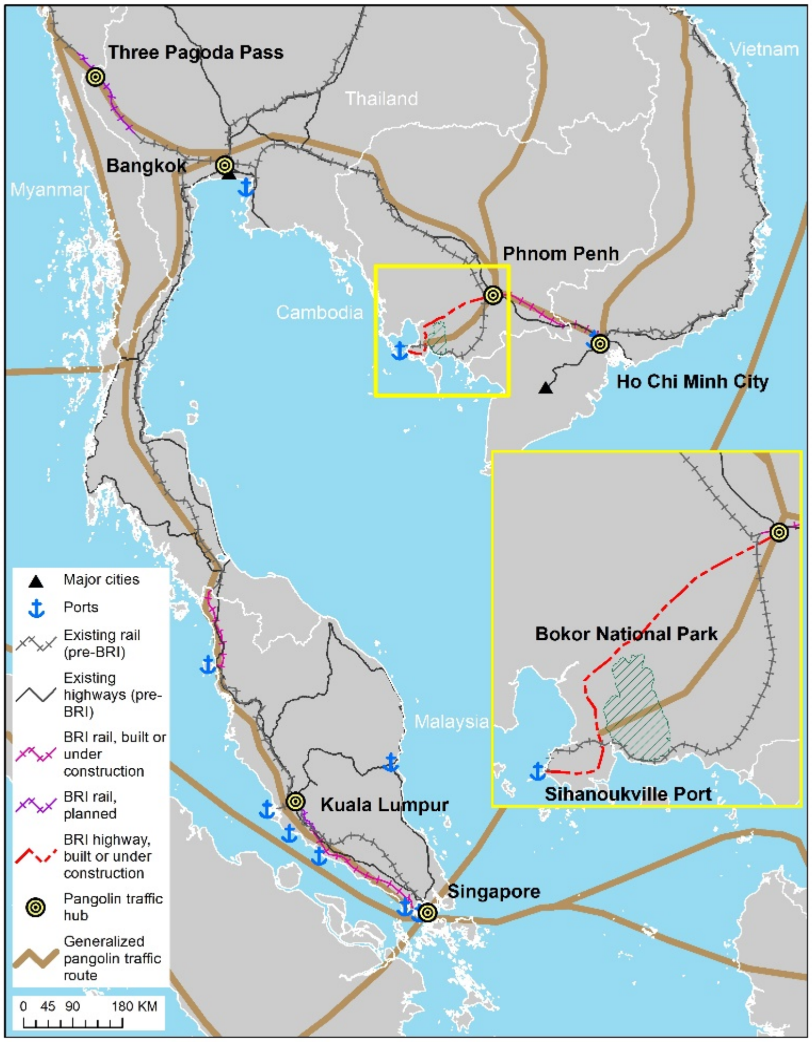

Figure 14. Pangolin trafficking routes and BRI infrastructure in CICPEC. Inset shows proximity of proposed BRI Sihanoukville Port Connector Road to the Bokor National Park, a source of pangolins (after Chouvy 2013).

Improving transportation corridors can contribute significantly to Illegal logging and wildlife trade, especially along the CICPEC corridor. The Southeast Asia region is both a source for illegal wildlife and timber and a hub for international trafficking (Broussard 2017; Chouvy 2013; Felbab-Brown 2013a). The threat posed by transportation infrastructure development is twofold: First, new and improved roads in Southeast Asia have been opening up new frontiers for illegal logging and wildlife poaching (Clements et al. 2014; Felbab-Brown 2013b, 2013a). Additionally, these improved transportation networks facilitate the movement of timber and wildlife (BenYishay et al. 2016; Felbab-Brown 2013b, 2013a). Given that much of the illegal timber and wildlife trade are destined for East Asia, facilitating the movement of goods along BRI transportation corridors in CICPEC will undoubtedly also facilitate wildlife smuggling. Consider the particular case of the pangolin, a species highly endangered primarily because of extensive poaching for the international illegal wildlife markets. As can be seen in Figure 14, the proposed BRI Sihanoukville Port Road and Rail extensions in Cambodia are located very close to one of the prime source areas for illegal pangolin poaching, the nearby Bokor National Park and surrounding forests (Chouvy 2013; Felbab-Brown 2013a). An upgraded port link would not only facilitate smuggling access to the current pangolin trafficking routes, it could potentially open a new maritime hub for smuggling traffic.

APPENDIX 7: Environmental Indicator: Indirect Effects as Measured by Forest Cover Change

Southworth et al. (2011) find evidence for a scarcity-based regional forest transition in continental Southeast Asia by comparing Cambodia – the country with the highest proportion of intact frontier landscape in the region and also the fastest rate of deforestation – with Thailand as well as Nepal and India – where deforestation appears to have slowed as forest becomes scarcer. Cropper et al. (2001) also find suggestive evidence that forest transition effects may be present in Thailand where they find that the roads built farther away from intact forest fringes have little effect on forest clearing (consistent with Amazonian evidence). As can be seen in Figure 15, reforestation in northern Thailand and the contrasting deforestation across the border in the Lao People's Democratic Republic provides further support that the forest transition is underway in Thailand but Lao PDR and Cambodia are still in the early stages of deforestation. Meyfroidt and Lambin (2009) give an account of forest transition in Vietnam, which is characterized by approximately 40% leakage to nearby Lao PDR and Cambodia where illegal forest harvesting is more common. This regional experience of weaker protection within some countries, particularly those with weaker states, such as Cambodia, underscores the role of trade in displacing deforestation. It could be expected that improved transportation would increase the salience of this mechanism as the region becomes more connected. What does this imply for the proposed BRI transportation projects? Three planned projects have been highlighted in earlier appendices for their high conservation value: The Nam Tok-Thanbyuzayat rail along the western route in Thailand for its extensive forest cover, IFLs, and big cat habitat; the Lao PDR section (Boten-Vientian) of the central route for its endemism biodiversity hotspot and extensive forest cover; and the Cambodian Sihanoukville Port road and rail extension in the western route for its IFL and role in supporting endangered pangolin habitat. While all of these deserve careful attention and carefully planned mitigation strategies, the increased pressure for land use change and deforestation created by BRI transportation network improvements, increased trade, and urbanization would likely result in more deforestation in the Cambodian and Lao PDR sites. The Thai and Cambodian sites both have existing protected areas in place, but much greater enforcement is needed in Bokor National Park to effectively safeguard this area.

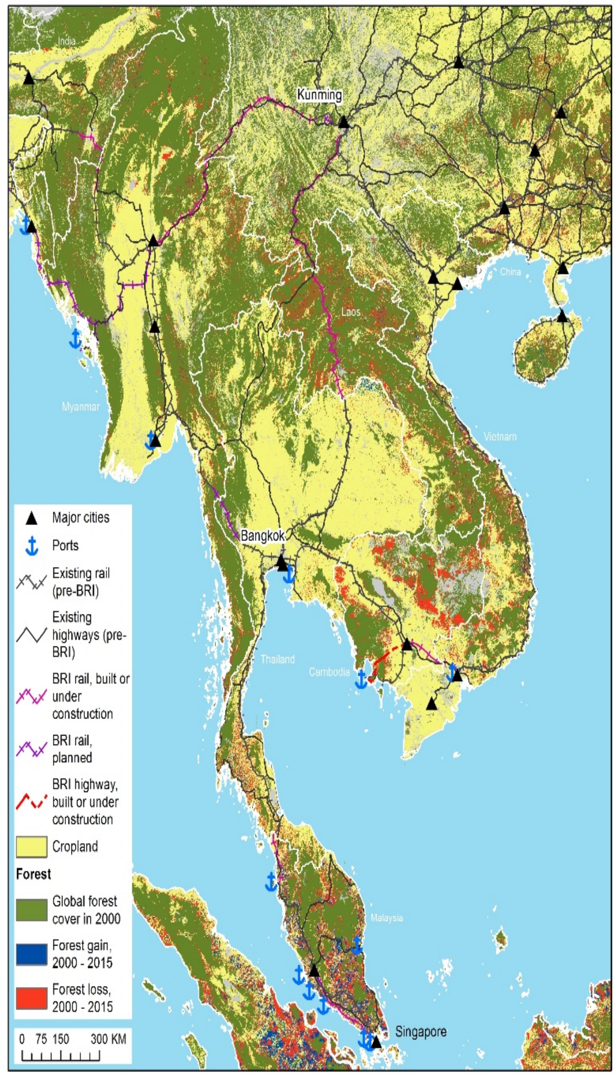

Figure 15. Rail and road projects within CICPEC in relation to cropland, forest cover, forest loss, and forest gain

APPENDIX 8*:* Mitigation Strategies: Protected Areas

Protected areas can provide an important tool for mitigating environmental risks from BRI rail and road projects. Establishment or increased enforcement of a protected area near a transportation corridor can help reduce the potential impact from land use change from human settlement, illegal timber extraction, and wildlife poaching. Figure 16 shows that, while there are many protected areas along existing roads and rail in CICPEC as well as those under construction or planned, they are strikingly absent from the Lao People's Democratic Republic.[17] This clearly flags the need to consider this as part of a mitigation strategy for the planned rail line that will pass through areas of high endemism for threatened biodiversity.

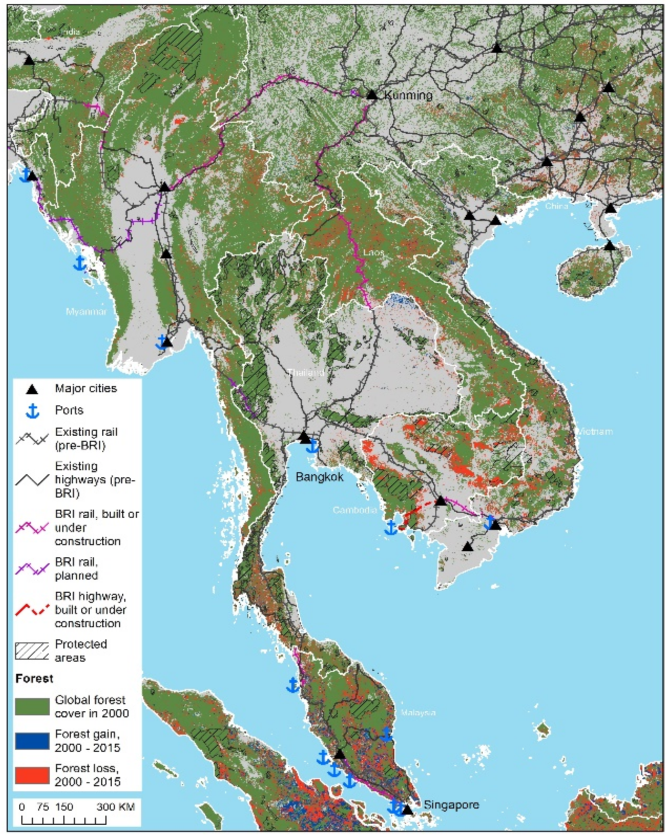

Figure 16. Rail and road projects within CICPEC in relation to protected areas (IUCN Categories I-IV), forest cover, forest loss, and forest gain

Establishing a protected area does not provide automatic safeguard against human settlement and destructive activities such as wildlife poaching and illegal logging. A road or rail bisecting a protected area will create an edge effect that can penetrate deep into the zone. Moreover, the protected status is only as strong as its enforcement. Consider the case of Snuol Wildlife Reserve in Cambodia. Landsat imagery reveals that in less than a decade after a road was constructed passing directly through the park, extensive clearing occurred within the park along the road in part due to poor enforcement (Clements et al. 2014; Figure 17).

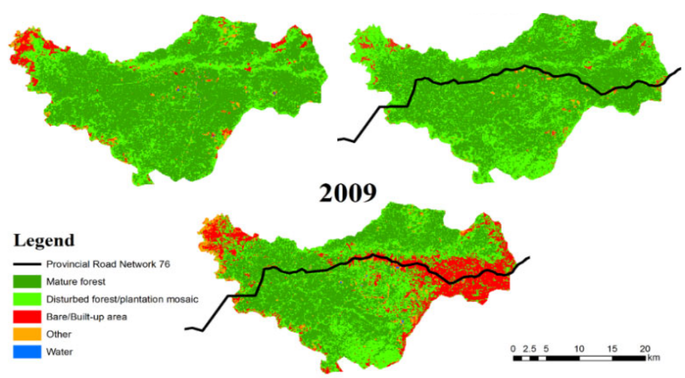

Figure 17. Land cover change of Snuol Wildlife Reserve, Cambodia. Landsat images were obtained for three time points: when the road was (1) absent (1990), (2) recently completed (2001), and (3) had existed for some time (2009). From Clements, et al. 2014.

Two of the planned BRI projects – a segment of the Thai Nam Tok- Thanbyuzayat rail (Figure 10 in Appendix 3) and the Cambodian Sihanoukville Port road (Figure 11 in Appendix 6) – both pass through existing national parks. The degree to which these parks can provide sufficient

[17] While there are a few areas protected within Lao PDR, none is within the IUCN Categories I-IV with its higher levels of protection.

deterrence will depend largely on enforcement capacity.

APPENDIX 9: Mitigation Strategies: Using Umbrella Species for Mitigation Planning

Appendix 5 described how umbrella species ranges could be used to help identify high-value areas for wildlife, using the example of tiger and clouded leopard ranges. This same information can be used to help guide the development of mitigation strategies using a mitigation hierarchy framework (Figure 1). Given the critically endangered status of tigers, their habitats should be considered no-go or "avoidance" areas, with no BRI road or rail projects permitted within a several kilometer buffer of their range. Clouded leopards, with substantially larger populations, a lower endangerment status, and more resilience to human development may allow for more flexible mitigation strategies. When possible, BRI rail and road projects should also avoid the clouded leopard ranges and buffers, but if not, strategies should be put in place to reduce impacts. Possible reduction options include designating or strengthening protected areas that safeguard habitat affected by the range and creating tunnels or overpasses for passage around transportation corridors. Because these reductions in the threat may not completely eliminate the risk from transportation infrastructure on the affected clouded leopard populations, compensatory offset action can also be considered. One potential offset might be the creation and protection of habitat corridors that link disjunct habitat patches within the CICPEC region but are distant from the busy transportation corridors (Figure 18).

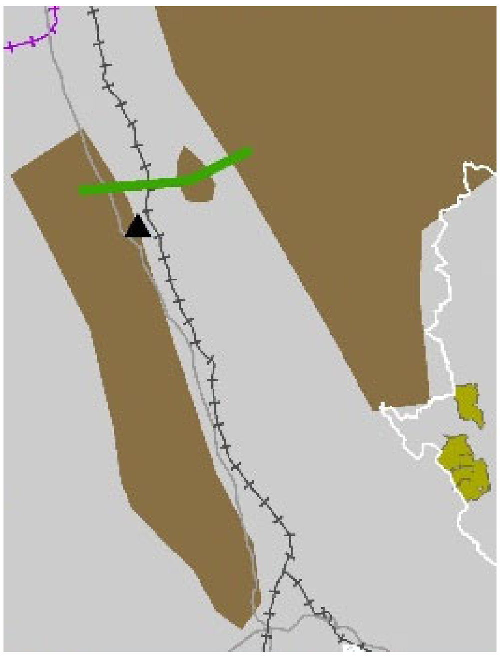

Figure 18. Potential habitat corridor that could connect two disjunct habitat ranges for clouded leopards.

APPENDIX 10: Databases of National Environmental Policies

Databases of national environmental regulations, financial incentives, overarching policies and frameworks, and voluntary approaches

Database	Website	Data Description
Faolex	faolex.fao.org	National laws, regulations and policies relating to food, agriculture, and renewable natural resources
Ecolex	www.ecolex.org	National environmental legislation, court decisions, and literature
Climate Change Laws of the World	web.law.columbia.edu/climate-change/resources/climate-change-laws-world	Information on country-specific climate change policies, laws, plans, and initiatives by sector (climate, energy, air pollution, forest and land use, environmental impact assessments, and adaptation and resiliency)
New Climate Policy Database	climatepolicydatabase.org	Information on GHG mitigation policies by sector (electricity and heat, industry, buildings, transport, and agriculture and forestry)
Legal Atlas	www.legal-atlas.net/	Dynamic database of national environmental legislation that can be compared across topics and countries

APPENDIX 11: International Agreements

Agreement	Description	Date Signed
Convention on wetlands (Ramsar Convention)	Treaty established by UNESCO for the classification, conservation, and sustainable use of wetlands. The convention identifies wetlands of international importance (especially those important for waterfowl) and places restrictions on development at those sites.	1971*
Convention concerning the protection of the world cultural and natural heritage	Treaty to protect natural and cultural heritage through the designation of World Heritage Sites (WHS). WHS are overseen by UNESCO. Signatory countries must "take the appropriate legal, scientific, technical, administrative and financial measures necessary for the identification, protection, conservation, presentation and rehabilitation of this heritage."	1972*
Convention on international trade in endangered species of wild fauna and flora (CITES)	International agreement to ensure that international trade of plant and animal species does not threaten their survival. Species covered by CITES are listed in three appendices, with each appendix requiring a different level of protection. Trade of species in Appendix I is prohibited completely, while trade of Appendix II and III species is closely regulated but allowed within certain limits and with proper permitting.	1973*
European agreement on main international traffic arteries (AGR)	AGR defines the E-road network of routes of strategic importance for international traffic flows within Europe. The agreement sets the standards, including consideration of the direct and indirect effects of roads and traffic on people, fauna and flora; soils, sub-soils, water, air, microclimate; landscape, physical property and cultural heritage. EIAs are mentioned as measures to address adverse impacts.	1975
Basel convention on the control of transboundary movements of hazardous wastes and their disposal (Basel Convention)	Aims of the Basel convention are threefold, 1) to reduce the generation of hazardous waste and promote sound management of any hazardous waste that is generated, 2) to restrict transboundary movement of hazardous waste, unless moving the waste across borders is for environmentally sound management, and 3) to develop a regulatory system for the transboundary movement of hazardous waste.	1989*
The convention of environmental impact assessment in a transboundary context (Espoo Convention)	The treaty was created by the United Nations Economic Commission for Europe. It obligates Parties to conduct Environmental Impact Assessments at an early stage of planning for certain activities that are expected to cause environmental harms. It also requires that States must notify each other when activities are expected to result in transboundary environmental harms.	1991*
United Nations framework convention on climate change (UNFCCC)	The objective of the treaty is to stabilize the greenhouse gas concentration of the atmosphere to prevent anthropogenic interference with the climate system by limiting country-level emissions of these gasses. UNFCCC Conferences of the Parties are held annually to address current issues of climate change and have resulted in the Kyoto Protocol and the Paris Climate Agreement.	1992 (Kyoto Protocol)* 2015 (Paris Agreement)*
Convention on biological diversity (CBD)	The treaty has the goals of conserving biodiversity, sustainably using the components of biodiversity, and equitably sharing the benefits provided by genetic resources of biological diversity. Signatories must develop national strategies detailing how the country will achieve these goals. The 2011-2020 strategic plan for biodiversity (created by the CBD) includes the Aichi biodiversity targets, which are measurable targets for 2020 that will help achieve the convention's goals.	1992*
United Nations convention to combat desertification	The convention aims to combat desertification and mitigate the effects of drought through sustainable land management. The convention encourages cooperation between developed and developing countries to enhance knowledge sharing and technology transfer for sustainable land management. The treaty calls for national and regional action programs to implement the convention; these programs call for specific measures that can be taken to combat desertification.	1994*
UNECE convention on access to information, public	The convention establishes rights of the public (individuals and their associations) to receive environmental information that is held by public authorities; to participate in environmental decision-making by commenting on and receiving feedback on, for	1998

participation in decision-making and access to justice in environmental matters (Aarhus Convention)	example, proposals for projects, plans, and programs affecting the environment; and to challenge public decisions that have been made without respecting the two aforementioned rights or environmental law in general.	

* China is a signatory to agreement.

APPENDIX 12: Multilateral Development Bank Environmental Policies

MDB	Key Aspects of Relevant Environmental Policy	Year Introduced
International Finance Corporation (IFC) Performance Standards	The IFC *Performance Standards on Environmental and Social Sustainability* (PS) have gained recognition as the global best practice standard for assessing and mitigating negative environmental and social outcomes related to large infrastructure projects. The standards adhere strictly to the mitigation hierarchy, placing high importance on avoidance of impact if possible. Especially relevant for the environment risks related to transportation infrastructure are *Resource Efficiency and Pollution Prevention* (PS3) and *Biodiversity Conservation and Sustainable Management of Living Natural Resources* (PS6). Each performance standard has an accompanying guidance note that provides more technical details about how borrowers should adhere to the PS.	Revised 2012
World Bank Environmental and Social Framework	In addition to protecting the poor and the environment and ensuring sustainable development, WB's *Environmental and Social Framework* (ESF) addresses, among other things, transparency, non-discrimination, social inclusion, public participation, and accountability. The Environmental and Social Standards mirror the IFC's Performance Standards very closely.	Revised 2018
Asian Development Bank (ADB)	ADB's *Safeguard Policy Statement* (SPS) governing the environmental and social safeguards of ADB's operations are a cornerstone of its support to inclusive economic growth and environmental sustainability in Asia and the Pacific. The objectives of the SPS are to avoid, or when avoidance is not possible, to minimize and mitigate adverse project impacts on the environment and affected people, and to help borrowers strengthen their safeguard systems and develop the capacity to manage environmental and social risks.	Revised 2009
African Development Bank (AfDB)	AfDB's *Integrated Safeguards System* consists of four interrelated components: Integrated Safeguards Policy Statement (PS), Operational Safeguards (OS), Environmental and Social Assessment Procedures. The PS describes common objectives of the Bank's safeguards and lays out policy principles. The OS are a set of five safeguard requirements that Bank clients are expected to meet when addressing social and environmental impacts and risks. The Impact Assessment Guidance Notes provide technical guidance to the Bank's borrowers or clients on standards of sector issues, such as roads or fisheries, or on methodological approaches clients or borrowers are expected to adopt to meet OS standards. OS3, *Biodiversity, Renewable Resources, and Ecosystem Services*, is especially relevant to addressing environmental risks from BRI transport infrastructure.	2013
European Bank for Reconstruction and Development (EBRD)	EBRD's *Environmental and Social Policy* (ESP) puts safeguards in place to prevent or minimize any adverse environmental or social impacts, to improve the project's efficiency, and maximize benefits for the wider community and future generations. ESP outlines how the EBRD will address the environmental and social impacts of its projects by defining the respective roles and responsibilities of both the Bank and its clients in designing, implementing and operating projects; setting a strategic goal to promote projects with high environmental and social benefits; and mainstreaming environmental and social sustainability considerations into all its activities.	Revised 2014
Asian Infrastructure Investment Bank (AIIB)	The recently established AIIB released the first draft of its *Environmental and Social Framework* in February of 2016, which includes an Environmental and Social Exclusion List—a list of project types or activities that the bank refuses to finance on environmental or social grounds. In many ways, the AIIB Environmental and Social Framework aligns with similar standards released by other banks, but it also relies heavily on its partners' standards (Weiss 2017).	2016
New Development Bank (NDB)	The NDB's *Environmental and Social Framework (ESF)* includes an environmental and social policy as well as environmental and social standards (ESS). ESS1, the Environmental and Social Assessment, is particularly relevant.	2016

APPENDIX 13: Chinese Policy Bank Policies

China Policy Banks	Key Aspects of Relevant Environmental Policy	Year Introduced
Export-Import Bank of China (China Exim Bank)	The 2007 *Guidelines for Environmental and Social Impact Assessment of China Export and Import Bank's Loan Projects* requires environmental impact assessments, monitoring, and review of project impacts for all projects before a project gains approval. When deemed necessary, environmental and social responsibilities may be included in the loan contract. The Exim Bank also has the right to monitor the client's implementation of the mitigation activities (FOE 2016; Leung et al. 2013).	2007; 2015
China Development Bank (CDB)	CDB has transparent sustainable development objectives – including an objective on environmental protection for climate, ecology, clean energy, and low-carbon living – but specific environmental policies and their content are not available to the public (FOE 2016). In 2006, CDB pledged to abide by the United Nations Global Compact 10 principles in human rights, labour standards, environment, and anti-corruption. CBD produced a series of non-binding frameworks to promote environmentally-friendly businesses, including an annual *Work Plan for Loans to Reduce Pollution and Emissions, Guidelines on Environmental Protection Project Development Review*, and *Guidelines on Special Loans for Energy Conservation and Emission Reduction* (Friends of the Earth (FOE) 2016; Ren et al. 2017).	2004

APPENDIX 14: Chinese Policies

Domain	Specific Policies	**Key Aspects of Relevant Environmental Policy**	**Year Introduced**
General Environmental Laws and Guidelines	Environmental Protection Law of the People's Republic of China	The original 1989 law provided the impetus for environmental impact assessments for construction projects within China. The EIA process was administrative, not statutorily. In 2014, China updated the law to include, among other provisions, stricter penalties and greater opportunities for public environmental litigation.	1989/ amended 2014
	Law of the People's Republic of China on Environmental Impact Assessment (EIA Law)	The EIA Law sets forth requirements for several types of strategic environmental assessments (SEAs) within China. Under this law, plan environmental Impact assessments (PEIA) are legally required for major economic development activities, integrated plans (such as land use, regional development, and watershed development). These PEIAs is used to integrate environmental considerations into all phases of the preparation of spatial and land use plans. A second type of strategic environmental assessment are required for sectoral plans (for example, industry, agriculture, husbandry, forestry, energy, water conservancy, transportation, and natural resources development) within China (Dusi and Xi 2009; Wu et al. 2010).	2003
	Guidelines on Environmental Protection for Overseas Investment and Cooperation	These voluntary guidelines represent a key policy released in 2013 by MOFCOM and the former MEP (now MEP). These guidelines recommend that companies complete EIAs, develop environmental mitigation measures, and work with local communities to identify potential negative environmental and social impacts (Leung et al. 2013).	2013
	Guidelines for Social Responsibility in Outbound Mining Investments	The China Chamber of Commerce of Metals, Minerals and Chemicals Importers and Exporters (CCCMC) developed these guidelines to assist Chinese companies improve their environmental and social performance in overseas mining investments. Though these guidelines are not strictly focused on transportation infrastructure, they represent the first detailed voluntary standards for foreign infrastructure investment by Chinese companies.	2014
	Guidelines of Sustainable Infrastructure for Chinese International Contractors	The China International Contractors Association (CHINCA) developed guidelines to assist Chinese international contractors in building infrastructure that meets leading sustainability standards. The guidelines cover five major phases of infrastructure development: funding, planning and design, building, operation and maintenance, and closure.	2017
BRI-Specific Guidelines	Vision and Actions on Jointly Building Silk Road Economic Belt and 21st Century Maritime Silk Road	This vision document outlines China's vision and mission of the BRI, highlighting sustainable development, cooperation between nations, and the importance of free trade. Issues related to the environment are mentioned only briefly in document, signaling priorities for cooperation in natural resource investments and industries; cooperation in ecological conservation, biodiversity protection, and strategies for climate change; and organizing public interest in ecological protection for the benefit of the public.	2015
	Guidance on Promoting Green Belt and Road	The high-level and non-binding document outlines a broad range of significant environmental issues that will be addressed under BRI. The document directs Chinese enterprises engaged in BRI projects to "voluntarily obey local environmental protection laws, regulations, standards, codes, honor environmental and social responsibilities and release annual environmental reports." The documents promote a range of tasks including green supply chains; partnerships with NGOs and research	2017

		organizations; environmental protection platform cooperation; capacity building; green technology transfers; sharing of environmental protection information and big data; and enhancing green guidance for corporate behavior.	
	Vision for Maritime Cooperation under the Belt and Road Initiative	This vision document acknowledges that oceans as an ecosystem contributes valuable natural assets. The document provides specific, non-binding recommendations for the protection of the marine environment. The green development section (4.1) highlights ensuring the health of the ocean for present and future generations; cooperation among nations to undertake conservation and preservation of marine ecosystem services, ecosystems, and species; establishing efforts to monitor, evaluate, preserve, and restore marine and coastal systems; jointly tackling marine pollution issues; demonstrating low-carbon development in maritime sectors; supporting small-island nations in adapting to climate change; and strengthening cooperation for international blue carbon programs.	2017
	Belt and Road Ecological and Environmental Cooperation Plan	This cooperation plan was written to fit in with the previous *Vision and Actions on Jointly Building Silk Road Economic Belt and 21st Century Maritime Silk Road*, *Guidance on Promoting Green Belt and Road*, and China's 13th Five-Year Plan. The Environmental cooperation plan promotes activities such as cooperation between countries for environmental protection, applying and establishing green financial instruments, increasing NGO and think-tank involvement in environmental planning and partnerships, strengthening green corporate behavior, and enhancing green supply chains.	2017

APPENDIX 15: Industry and NGO Environmental Standards

Standard	Description
Equator Principles	The Equator Principles (EPs) is a risk management framework for private financial institutions to determine, assess, and manage environmental and social risk in projects. The EP framework is modelled closely on the IFC's performance standards. Currently 94 global financial institutions from 37 countries have adopted the framework for managing environmental and social risk.
SuRe® Standard	The Standard for Sustainable and Resilient Infrastructure (SuRe®), developed by Global Infrastructure Basel, is a global voluntary standard which integrates key criteria of sustainability and resilience into infrastructure development and upgrade, through 14 themes covering 61 criteria across governance, social and environmental factors.
CEEQUAL assessment rating	CEEQUAL is an evidence-based sustainability assessment, rating, and awards scheme for civil engineering, infrastructure, landscaping, and public realm projects.
Envision® rating system	The Envision® system provides a set of guidelines to aid and quantify the sustainability of an infrastructure project during the planning and preliminary design phases.
Greenroads® rating system	The Greenroads Rating System is measures and manage sustainability on transportation projects using environmental, social, and economic performance measures. Projects are evaluated by an independent, expert, third-party review.
Natural Capital Protocol	Framework created by the Natural Capital Coalition to provide guidance on how to incorporate human interaction with nature and natural capital into actionable information for business managers to inform decisions.

DATA LINKS/CITATIONS FOR MAPS

All maps were created by Dr. Andrew Jacobson, Duke University, unless otherwise noted.

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