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CONTRIBUTED PAPER

Understanding the co-occurrence of tree loss and modern slavery to improve efficacy of conservation actions and policies

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Abstract
Locations where populations are most reliant on forests and their ecosystem services for subsistence and development are also areas where modern slavery persists. These issues are noted within the Sustainable Development Goals (SDGs), both target 15.2 and 8.7 respectively. Often activities using slavery perpetuate deforestation, bolstering a slavery-environment nexus; which has been examined by comparing modern slavery estimates against environmental protection levels. This study assesses the relationship between tree loss and modern slavery focusing on four countries: Brazil, Ghana, Indonesia, and Mozambique. Previously mapped levels of tree loss and predicted future levels of loss have been compared against modern slavery estimates from the Global Slavery Index 2016 and illegal logging analyses to determine an estimate of the risk for slavery related tree loss. These results provide an insight in to the co-occurrence between modern slavery and tree loss due to a number of activities that are highlighted, including mining, illegal logging, and agricultural practices. The co-occurrence is both complex, and yet, beyond coincidental. Implications for both national and global policy are noted assessing the benefits that could be achieved by limiting tree loss and ending modern slavery; of benefit to both the conservation and antislavery communities.

KEYWORDS
conservation management and policy, deforestation, Environmental Performance Index, Global Forest Watch, Global Slavery Index, illegal logging, modern slavery, modern slavery-environment nexus, Sustainable Development Goals, tree loss

1 | INTRODUCTION

Maintained forest environments have the potential to aid in achieving a number of the Sustainable Development Goals' (SDGs) socioeconomic and ecological targets: SDG 15 ("Life on Land"), SDG 13 ("Climate Action"), SDG 1 ("No Poverty"), and SDG 2 ("No Hunger") (Seymour & Busch, 2016; Watson et al., 2018). But globally, areas where populations are most dependent on forests and their ecosystem services for subsistence and equitable sustainable development are also areas where modern slavery persists—often in activities perpetuating deforestation and similarly destructive practices that threaten biodiversity conservation (Bales, 2016; Food and Agriculture Organization [FAO], 2018; Brown et al., 2019). Thus, this modern slavery-environmental degradation nexus may add to anthropogenic pressures on forests, compromising their ability to support the attainment of the afore-mentioned SDGs—as noted in other sectors, including brick making (Boyd et al., 2018), farming, and fishing (Brown et al., 2019).

Defined by the 2012 Bellagio–Harvard guidelines as "constituting control over a person in such a way as to significantly deprive that person of his or her individual liberty with the intent of exploitation through the use, management, purchase, sale, profit, transfer, or disposal of that person," (Research Network on the Legal Parameters of Slavery, 2012) modern slavery is an umbrella term inclusive of varied forms of exploitation (e.g., forced labour, debt bondage, human trafficking, and slavery). In many locations globally, the incidental biodiversity loss associated with deforestation-related tree cover loss contributes to pervasive poverty, loss of livelihoods (associated to livelihood vulnerabilities such as climate change impacts; Obeng et al., 2011), and food insecurity (Seymour & Busch, 2016). These vulnerabilities of forested communities have contributed to the narrative that poverty leads to deforestation (Rai, 2019), yet this has been shown to be more complex with studies noting that poverty can in fact reduce deforestation as people relying on the forests often protect them (Angelsen & Kaimowitz, 1999; Angelsen & Rudel, 2013; Busch & Ferretti-Gallon, 2017). However, external threats to human security can force these already vulnerable populations to make decisions that result in them being exposed to modern slavery and participating in activities that lead to further deforestation (Bales, 2016). Activities associated with tree loss, and concurrently linked with modern slavery include tree harvesting for charcoal production in the Republic of Congo and Brazil; forest clearing for conversion to cattle ranching in Brazil and farmland for oil palm plantations in Indonesia; and gold mining in the Madre de Rios region of the Amazon and the Sahel region of West Africa wherein trees are harvested for lining shafts (Brown et al., 2019; Verité, 2017a). Additionally, many linked modern slavery-environmental degradation activities undermine conservation initiatives. For example, oil palm related deforestation, in countries such as Indonesia and Malaysia, degrades habitat for endangered species; timber for charcoal production is harvested from protected Amazonian areas; and mangroves are cleared for the establishment of illegal fish-processing camps in the Sundarbans Reserve Forest (Bales, 2016; Brown et al., 2019; Verité, 2017a).

Some estimates suggest that global forest cover decreased by approximately 3% from 41,282,694.8 sq. km to 39,991,336.2 sq. km between 1990 and 2015, with rates of tree cover loss highest in low-income countries (FAO, 2016). Tree cover loss, though, is in flux. Some cases classified as tree loss at one period in time may be reclassified as an area of gain the next measurement period because not all forest disturbances are associated with permanent conversion (i.e., deforestation rather than degradation) (Curtis, Slay, Harris, Tyukavina, & Hansen, 2018). However, Global Forest Watch (GFW) data predicted that more than a quarter of global tree loss between 2001 and 2015 was associated with commodity-driven deforestation, and thus likely to be permanent and not reforested (Curtis et al., 2018). Should areas be reforested, attainment of the SDGs and human security may still be at risk as intact forests, rather than restored forests, may exhibit different ecosystem services than restored forests (such as carbon sequestration and biodiversity protection, etc.; Watson et al., 2018). Conservation of forests are vital as deforestation has been noted as a contributor to the release of greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2018); placing the forest-benefits which can be gained through climate change mitigation policies, such as their role as a land-based carbon sink (Krug, 2018), at risk. Forest conservation initiatives have been implemented to undertake this protection, including the United Nation (UN)s' premier development scheme "Reducing Emissions from Deforestation and Forest Degradation" (REDD+) which seeks to protect forests via conservation, sustainable management, and enhancing carbon stocks. However, these policies do not yet consider modern slavery as a potential anthropogenic driver of deforestation. Preventing deforestation is a pertinent conservation goal and because of the association between deforestation and modern slavery (Verité, 2017a), conservation should thus begin to consider the continued presence of modern slavery as a hurdle to overcome in management and conservation plans.

The GFW has measured and mapped tree loss yearly through remote sensing sources (Hansen et al., 2013). The antislavery field uses the Global Slavery Index (GSI)—national level estimates of prevalence of, and risk to, modern slavery based on Gallup-style surveys and proxies empirically associated with exploitation (International Labour Organization [ILO] & Walk Free, 2017). While both represent data-limited fields that are reliant on and subjected to disagreements about the rigor and sensitivity of estimations and the role of politically motivated government self-reports, we purport these tools should not be used discreetly (Bales, 2017; Curtis et al., 2018). Instead, it is more efficacious to identify synergies between tools to extrapolate more holistic understandings of conservation challenges associated with social justice concerns. While the GFW data has been demonstrating the where and when of deforestation, only recently has it started answering the question of why (Curtis et al., 2018). This paper extends the argument of why by integrating the GSI with the GFW and associated datasets, elucidating for the first time empirically the contribution that modern slavery could be making to deforestation-related tree cover loss and the challenges it presents for conservation management and planning. This manuscript is intended to provide insight into the connections between tree loss and modern slavery which may be relevant for conservation researchers, practitioners and the antislavery community to support multiple UN SDGs and encourage sustainable development via the indivisibility principle (UN, 2016).

2 | METHODS

Firstly, modern slavery estimates from the GSI 2016 (Walk Free, 2016) were modeled against the Environmental Performance Index (EPI) from the same year (Hsu et al., 2016; Figure 1). This was used to determine which countries require further assessment in relation to the slavery-environment nexus (Brown et al., 2019).

Secondly, to determine the levels of modern slavery associated with tree loss, the ILO & Walk Free (2017) estimate of people enslaved in agricultural, forestry, quarrying, and mining industries was used; totaling 15.3% of those in forced labor globally. These are industries known to contribute to tree loss and degradation. The total country estimates from the 2016 GSI were altered to determine the estimated number enslaved within the sectors noted above (Figure 2). Differing levels of "at risk" countries have been identified. Thirdly, these were compared with the potential losses from deforestation caused by slavery—calculated by identifying rates of illegal logging from a number of sources (see Hoare, 2015: pp. 61–63; INDUFOR, 2004: p. 3; Lawson et al., 2014: p. 122; Seneca Creek Associates & Wood Resources International, 2004; Toyne, O'Brien, & Nelson, 2002; World Bank, 2006: p. 9). The lowest values were used as a proxy for the presence of slavery. These figures were applied to GFW tree loss by deforestation data (2001–2018) to determine the potential area of land deforested per country by slavery practices (Figure 3). All data for this analysis was accessed via the GFW platform—these data included tree cover loss (based on Hansen et al., 2013) and tree cover loss by driver (based on Curtis et al., 2018) (GFW, 2019; The Sustainability Consortium et al., 2019). Countries were split into risk categories based on the quartile ranges of the data and are presented as "low" risk, "low-medium," "medium-high" and "high" risk depending on the rank in which they fell. Finally, the risks of slavery causing tree loss from the illegal logging analysis, and the slavery estimates (Figures 2 and 3) were compared with

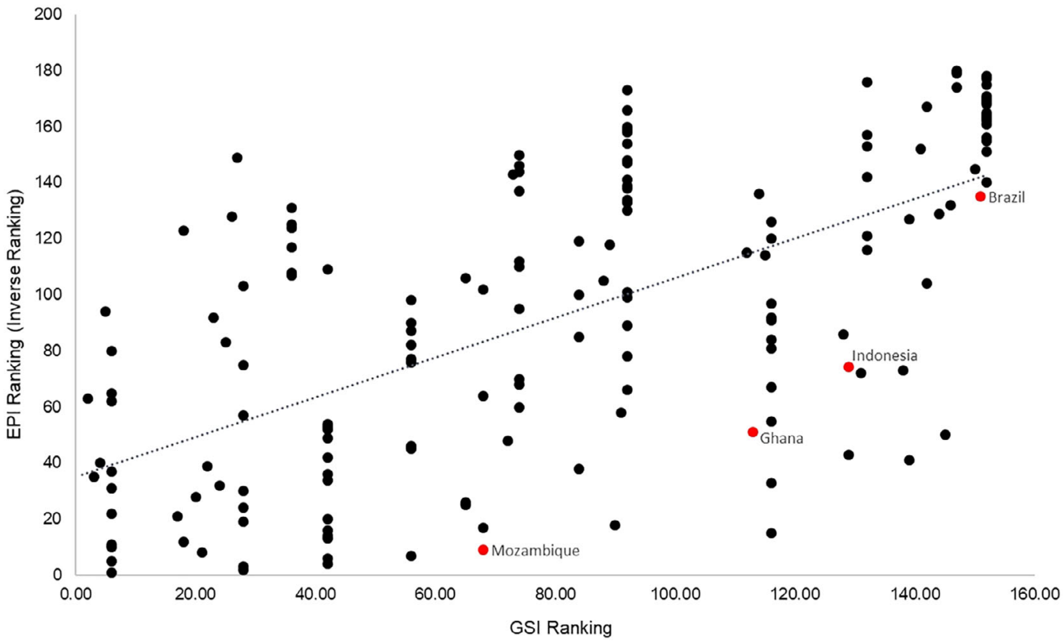

FIGURE 1 Model of the Global Slavery Index (GSI) 2016 modern slavery estimates per country against the Environmental Performance Index (EPI) 2016 score. There is a strong correlation between countries with lower estimated levels of modern slavery and countries with higher environmental protections

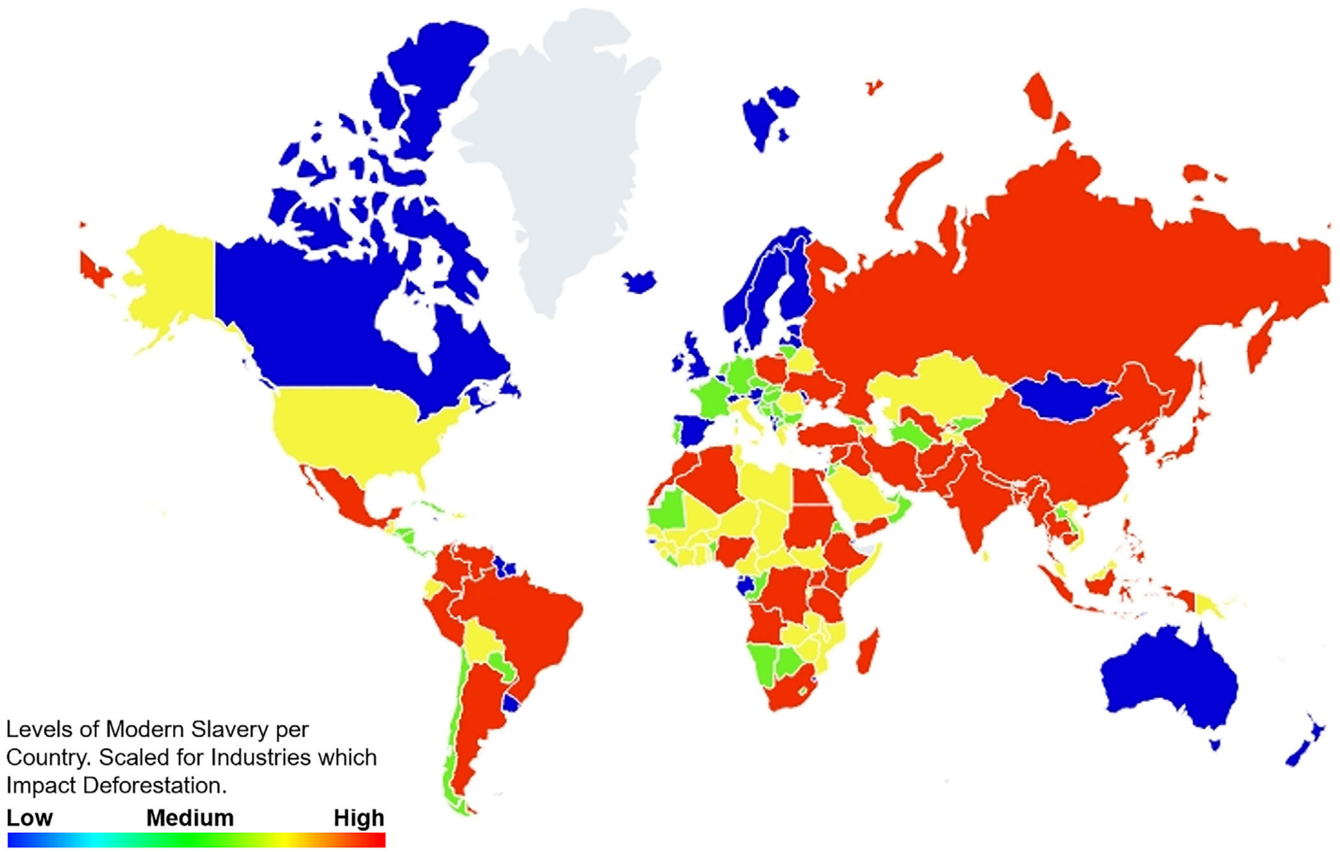

FIGURE 2 Estimated levels of slavery per country which are expected to impact levels of tree loss. Created by determining the activities which affect deforestation using the ILO & Walk Free (2017) "Global Estimates of Modern Slavery" which equated 15.3% of those enslaved and applying this to the 2016 GSI estimates

predicted tree cover loss, modeled at continental and global levels by Hewson, Crema, González-Roglich, Tabor, and Harvey (2019) as part of a new 1 km resolution dataset. These data are freely available to download (from http://futureclimates.conservation.org/index.html). Levels of predicted loss were compared on a global scale before a more detailed analysis of the predicted loss patterns was identified for the four countries investigated in more detail (shown in Figure 4).

The overlap between areas with high levels of predicted tree loss, moderate-high estimated slavery levels and illegal logging, as well as documented evidence of slavery within their forestry sectors were used to determine which countries were to be further assessed. These countries have experienced, and are likely to continue experiencing, tree loss associated with industries known to use slavery. The countries chosen using these parameters are: Brazil, Ghana, Indonesia and Mozambique. While each have differing vulnerabilities; all are found across the tropics where Hewson et al.'s (2019) model predicts some of the highest losses. Past tree loss/tree gains for these countries were then extracted using the Hansen et al. (2013) derived dataset (GFW, 2019; accessed via Google Earth Engine [GEE]). Comparison with the future predicted loss for these nations was enabled, suggesting evidence of whether the pattern of degradation will continue.

3 | RESULTS

There is a positive relationship ($R^2 = .401$) between stronger environmental protections and lower estimated cases of slavery (Figure 1). The four countries studied in more detail are spread along the GSI/EPI relationship with Brazil performing the best and Mozambique (which may also be considered an outlier) the worst. This provides an important insight into the slavery-environment nexus, identifying a link between the two sectors which has only recently begun to be explored (Brown et al., 2019). Although the relationship is assessed in terms of tree loss within this paper, there is scope for analysis within other sectors known to employ practices of modern slavery and cause environmental damage, for example, mining, quarrying, fish processing, and brick manufacture, and so forth.

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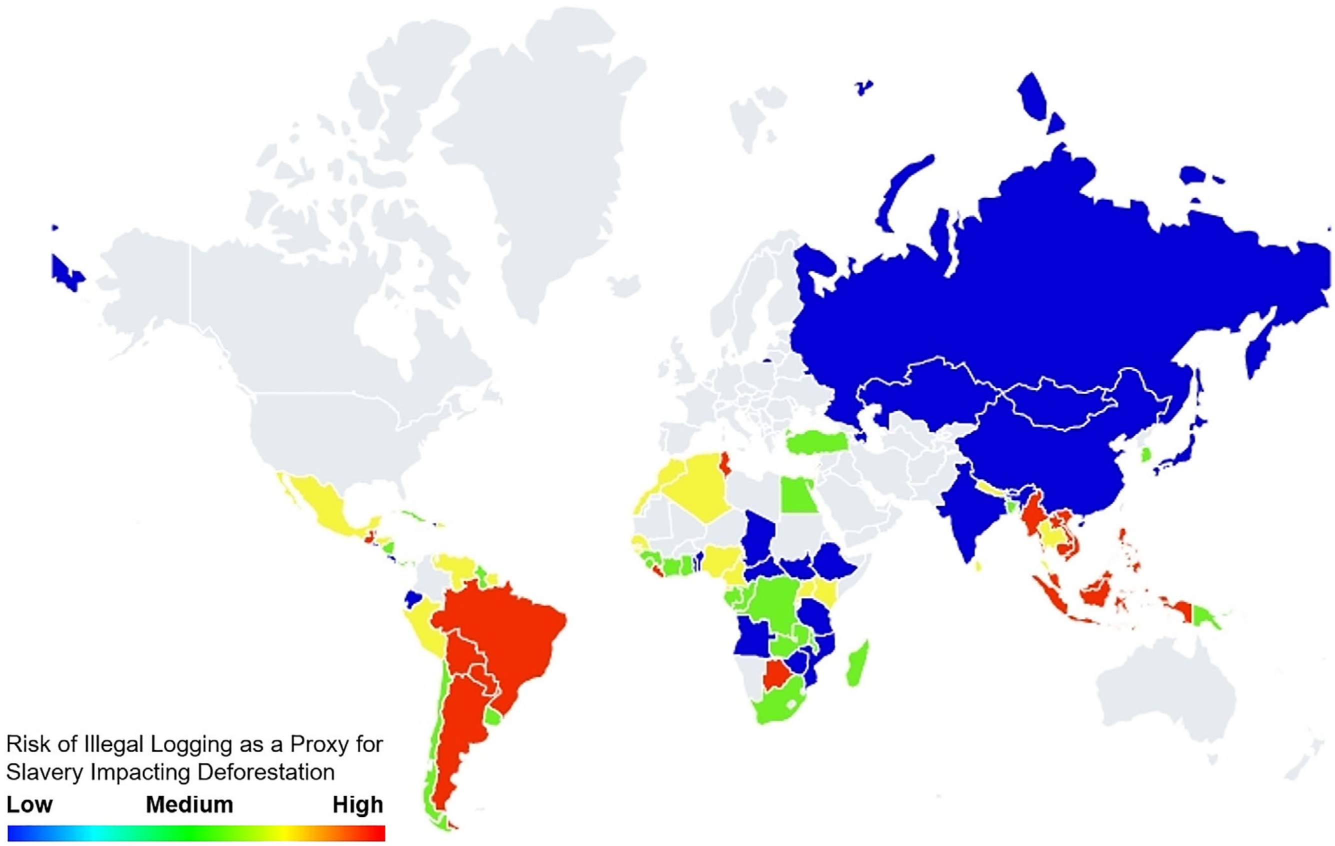

FIGURE 3 Risk of illegal logging (as a proxy for slavery) impacting on the proportion of deforestation measured by Global Forest Watch (GFW) 2001–2018

Hewson et al.'s (2019) global tree loss maps predict high rates of loss across vast swaths of the tropics, as well as Canada and Russia—where legitimate commercial logging industries dominate (Curtis et al., 2018); however, some of these countries exhibit lower risk overall when compared with the modified GSI figures (Figure 2). All four countries assessed in further detail have estimated rates of slavery in the "medium-high" range, both overall (Table 1), and when assessed in relation to tree loss related activities (Figure 2), particularly when assessed against illegal logging levels (Figure 3). High rates of predicted tree loss by 2029 are found in Brazil (Figure 4) this is reflected in the illegal logging analysis (Figure 3). Southeast Asia is set to experience losses associated with the oil palm industry (Verité, 2017a), which may be connected to illegal logging (Figure 3). Across central Africa high rates of tree loss are expected, despite past reductions (Rudel, 2013). The drivers of previous tree loss here have been attributed to land settlements (due to population growth), agri-business, logging, and cattle-ranching. Only the very center of the Congo rainforest is likely to be lower risk. The extraction of resources to maintain living standards in the current climate crisis is also expected to have a damaging effect (Serdeczny et al., 2017).

Figure 4 shows the variation of predicted tree loss that is expansive across much of Ghana and Mozambique. Higher predicted losses within Indonesia are found in areas where oil palm plantations dominate (Figure 4) and illegal logging as a proxy for slavery is high (Figure 3). The inaccessibility of the protected Brazilian Amazon means that the widespread damage predicted across the rest of the country is limited in this region; however, there is clear encroachment along the southern and eastern forest edges. The Hansen et al. (2013) derived data from the GFW (2019) showed that all nations have experienced net-tree cover loss from 2000–2018 (Table 2) with little recovery indicating Hewson et al.'s (2019) predicted loss values are likely unless practices are altered.

4 | DISCUSSION

Based on the results, the four nations of Brazil, Ghana, Indonesia, and Mozambique were further investigated. Tree loss in these sectors associated with slavery is likely to continue. As a result, conservation activities that do not consider the effects of modern slavery may be less

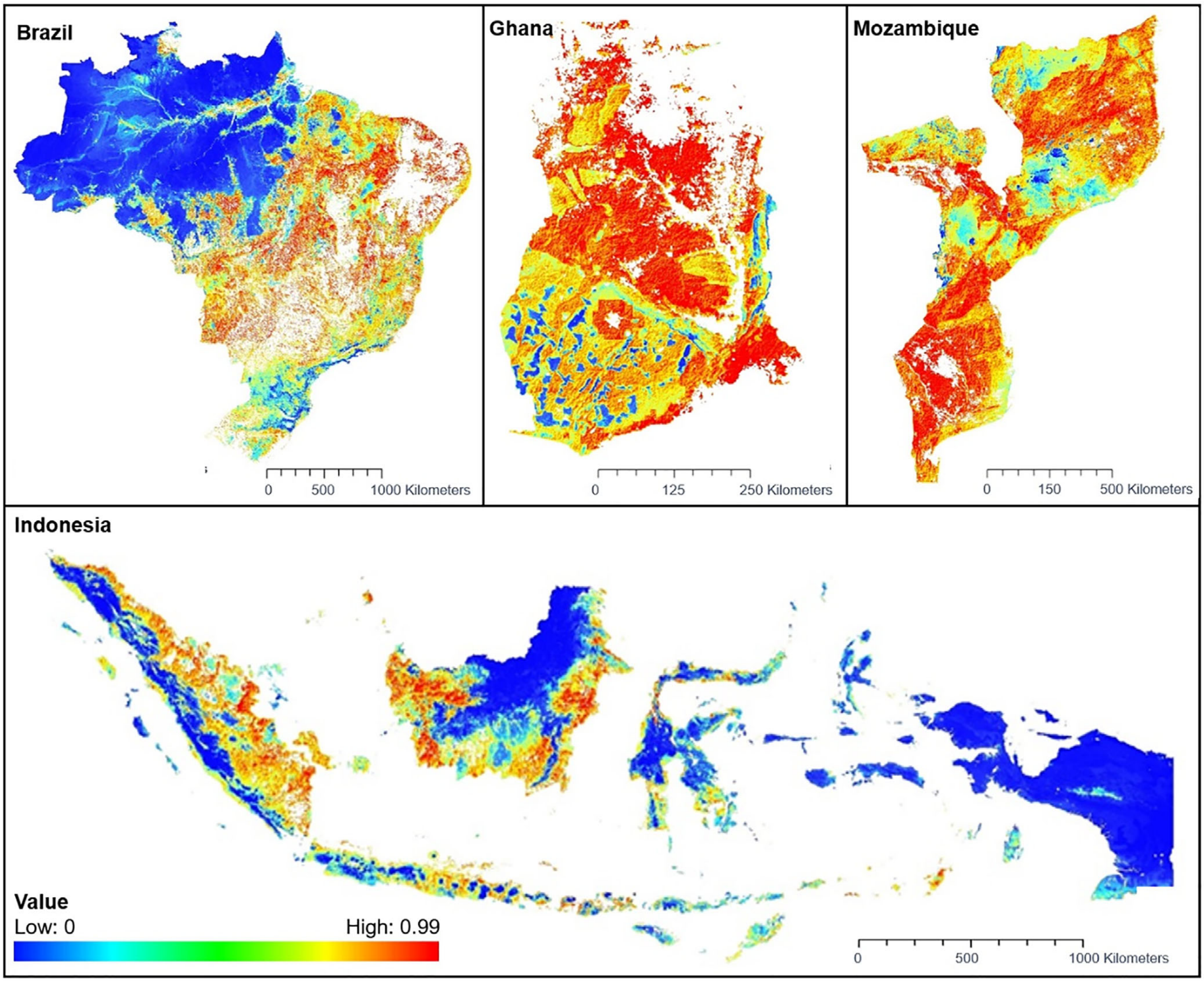

FIGURE 4 The four countries which have been investigated in the discussion. Clips of the global prediction model by Hewson et al. (2019) clearly demonstrate the areas of these nations which are most at risk of tree cover loss through their prediction of tree loss transitional potential

effective as slavery frequently provides the labor force needed to illegally clear land and deforest (Bales, 2016), as explored in Figure 3. This must be considered when advocating for global tree restoration potential to provide benefits around, for example, climate change mitigation (Bastin et al., 2019), particularly within tropical forests (Brancalion et al., 2019). There will only be limited success without the mainstream incorporation of slavery impact understanding within conservation management schemes. This acknowledgement supports the achievement of interdisciplinary social justice in conservation, as advocated for by Bennett et al. (2017). With the addition of an antislavery framework, more narrow conceptualizations of resource users are challenged and understanding of the social justice dimensions of the relationships between people, forests, and conservation is enriched and broadened to include the often peripheral or unconsidered social domains of agency and dignity—which in the case of modern slavery and tree loss are indivisible from attaining the more frequently considered social justice objective of equality. Moreover, advocating for "just conservation" (Vucetich et al., 2018) in this manner would also support the achievement of the "freedom dividend" (Bales, 2012) which promotes the economic, social, cultural and environmental benefits that may be gained from ending modern slavery. As Figure 1 showed, there is a connection between environmental protections and modern slavery. While antislavery tools alone will not halt all tree cover loss, they could help mitigate illegal clearing and deforesting—activities that undermine conservation policies and make sustainable goals and targets difficult to achieve. What follows is an assessment of

TABLE 1 Further details of the case study countries' Global Slavery Index (GSI) figures (Walk Free, 2016) and their Environmental Performance Index (EPI) scores (Hsu et al., 2016)

	Prevalence figures from GSI 2016				Vulnerability scores from GSI 2016					Government response GSI 2016	EPI figures	
Country	**2016 Global slavery prevalence rank**	**Estimated percent of population in modern slavery**	**Estimated number in modern slavery**	**Estimated number of people in modern slavery working in activities related to tree loss**[a]	**Civil and political protections**	**Social, health and economic rights**	**Personal security**	**Refugees and conflict**	**Mean score**	**Total score**	**2016 Global EPI rank**	**2016 Global EPI score**
Brazil	51	0.078	161,100	24,648	37.98	20.46	45.88	30.74	33.77	56.85	46	78.9
Ghana	34	0.377	103,300	15,805	51.89	38.42	47.45	28.26	41.51	28.43	130	58.89
Indonesia	39	0.286	736,100	112,623	39.15	43.35	50.38	36.01	42.22	40.61	107	65.85
Mozambique	22	0.520	145,600	22,277	39.91	48.46	54.40	35.86	44.65	40.85	172	41.82

[a]Estimated calculated by taking the occurrence of tree loss related activities identified within the literature, including agriculture, forestry, mining and quarrying from the "Global Estimates of Modern Slavery" (ILO & Walk Free, 2017: p. 26) occurring at a rate of 15.3% and applying these to the estimated number in modern slavery from GSI 2016. This is likely an overestimation due to the use of global figures, but provides a proportion closer to a real value that the overall slavery estimates for each nation. Rounded to the nearest whole number.

TABLE 2 Tree loss and gain between the year 2000 and 2018 as calculated within Google Earth Engine (GEE) using the Hansen et al. (2013) and Global Forest Watch (GFW) dataset (GFW, 2019)

Country	Tree loss 2000–2018 (ha)	Tree gain 2000–2018 (ha)	Net loss 2000–2018 (ha)
Brazil	47,000,000	2,864,414.315	−44,135,585.69
Ghana	671,806.7597	57,439.39172	−614,367.368
Indonesia	21,300,000	3,479,720.101	−17,820,279.9
Mozambique	1,764,314.836	55,368.62182	−1,708,946.214

these areas and industries vulnerable to modern slavery in relation to tree cover, a review of their political response and where the barriers and leverage points may exist to eradicate the effects of the modern slavery-environment degradation nexus. While focus is placed on these four nations within this article, going forward, it will be important to address the wider trends of tree loss, illegal logging and slavery outside of the tropics.

4.1 | Brazil

As an upper-middle income country, Brazil has developed substantive antislavery legislation (Brazilian Penal Code 2003 Article 149) and conservation policies (e.g., protected reserves, new forests [Frederico & Anderson, 2016] etc.). Yet much of Brazil's money is not distributed to large portions of the population; this inequality is necessary in the continued exploitation of people and the environment. Deforestation activities known to use exploited workers have been noted to persist in cattle-ranching (fuelling the leather and beef sectors) and the timber industry (Brown et al., 2019). Areas of tree loss in the protected Amazon are expected to be low as accessibility is difficult, whereas there is increasing risk along "agriculture-forest frontiers" which is expected to have harmful long-term effects (Figure 4; Garrett et al., 2018), thus limiting the climate change mitigation benefits that the forest provides. Contrastingly, Santos de Lima et al. (2018) suggest that unprotected areas are expected to experience losses of up to 40% by 2050 due to illegal harvesting, noted previously to use enslaved workers (Bales, 2016).

Brazil's comparatively high levels of environmental protections are reflected within the nation's EPI score (Table 1) with a rank of 46 out of 180. Although there has been some evidence of reduced deforestation (Amin et al., 2019), overall tree cover has declined (Table 2) and is predicted to continue declining (Figure 4; Hewson et al., 2019). However, both climate change and deforestation have been noted as destabilizing the Amazon rainforest ecosystem (Lenton et al., 2019). Additionally, Brazil's environment ministry has reported recent periods of accelerated deforestation and land clearing in Mato Grosso, Rodônia, and Amazonas states (Escobar, 2019; Watts, 2015). These findings are likely related to the relaxation of environmental policies amid the current socio-political context (Escobar, 2019) which has also seen restrictions of the modern slavery definition (Scott, De Andrade Barbosa, & Haddad, 2017) by removing the classification of forced labor from under the umbrella of modern slavery. This is expected to weaken the response of labor inspectors and limit the response to end economic exploitation (Mendes, 2017; Phillips, 2017). Despite extant legislation, Brazil is ranked 51 of 167 countries in the GSI (Table 1; Walk Free, 2016); Brazil's current status in the GSI/EPI rankings (Figure 1) could therefore change as a result of these political decisions and declining protections. Although legislation exists for both issues, a lack of resources for labor enforcement, legal loopholes, corruption, and a declining economy (Watts, 2015) have stalled Brazil's progress on meeting the SDG targets to end both deforestation and slavery by 2030. Training provided by antislavery organizations for front-line responders undertaking labor inspections and conservation activities, to simultaneously respond to deforestation and modern slavery, would enable them to provide pastoral support and assistance to survivors of exploitation. This training would primarily support these actors with the identification of key modern slavery signs, build collaborative networks and trust between groups, and inform conservationists of which authorities to notify should they encounter exploitative practices. Following the example of integrated training in the fisheries sector of the Pacific Island states (United States Department of State, 2018), could be one option for maximizing the limited resources available to reach isolated sites for enforcement purposes. Cross-sectoral collaboration could introduce more checks and balances to curb some forms of corruption; this is pertinent in light of the August 2019 Amazon fires and the refuting of deforestation figures by President Bolsonaro (Escobar, 2019).

4.2 | Ghana

Ghana has approximately 15,000 people estimated to be working in conditions of slavery within activities related to tree loss (Table 1)—this is "medium-high" risk when compared to our global analysis (Figure 2). As a lower-middle income country, agricultural forest products are highly depended upon for subsistence (Appiah et al., 2009). Tree losses have been widespread and will continue to be so (Figure 4); this is more likely as droughts occur in the region as a result of climate change where Dwomoh, Wimberly, Cochrane, and Numata (2019) found that the degraded forests had the highest burned area, concluding that both drought and degradation affected the location of the fires. Cocoa (Verité, 2017a) and rubber plantations (Verité, 2017b) are drivers of commodity driven deforestation and land clearing, known to use forms of slavery. Specifically, in the west of Ghana, mining is the dominant cause of forest loss (Schueler, Kuemmerle, & Schröder, 2011), often done illegally, and associated with slavery—including forced and child labor and human trafficking (Bales, 2016; Verité, 2017a). Additional losses to the forests are caused by illegal logging (estimates suggest that 34–70% of tree loss is caused by illegal logging practices in Ghana: Seneca Creek Associates & Wood Resources International, 2004; Hoare, 2015), and disturbance from fire (Janssen et al., 2018), which limit vegetation recovery.

The Ghanaian authorities have ratified legislative efforts, with a number focusing on child labor, and programs to address these concerns have also been introduced (Delta 8.7, 2019). However, as noted in the low GSI government response score (Table 1), these policies and programs are not being fully implemented and most Ghanaian family units lack the capital to participate in the artisanal and formal mining sector; therefore, limiting the response for the largest tree loss driver in the country. As a result, adults and children are forced to work in illegal mines (Verité, 2017a). In response to deforestation and land clearing, the REDD+ program is active (Forestry Commission, 2016)—aiming to combat environmental destruction by reducing the burden of poverty and supporting sustainable development. Because the modern slavery-environmental degradation nexus occurs in the context of poverty and a lack of sustainable jobs, it is plausible to consider integrating antislavery tools into REDD+ frameworks to fully achieve their intended environmental and social benefits.

4.3 | Indonesia

The expansion of Indonesian agricultural practices are causing tree cover removal, biodiversity loss and the monopolization of crop production in the form of oil palm—vital for this lower-middle income economy, and yet auditors assessing the oil palm sector recently found 19% of the country's plantations to be operating within forest areas without the appropriate permits (Listiyorini & Rusmana, 2019). Moreover, 81% of oil palm plantations violated numerous state regulations, including operation of sites in protected areas and noncompliance with sustainable production standards (Listiyorini & Rusmana, 2019), including environmental damage; such as deforestation and fires (Carlson et al., 2018). These factors compound the risks related to exploitation and forest degradation within Indonesia; the growth of oil palm plantations affect carbon sequestration by trees and within peatland that has been drained for production, which increases the risk of flooding thus limiting their value (Sumarga, Hein, Hooijer, & Vernimmen, 2016). Alongside oil palm agri-business, illegal logging is a driver of tree loss (Palmer, 2001) and the risk of modern slavery activities contributing to this loss is high (Figure 3). The highest levels of predicted tree loss (Figure 4) correspond to noted locations of oil palm milling operations (FoodReg & World Resources Institute, 2019), suggesting that the commodity is the primary driver of deforestation (an assertion supported by Curtis et al., 2018). However, since the introduction of certification schemes the rates of deforestation have declined (Carlson et al., 2018).

Palm oil is used extensively in the production of numerous goods, despite evidence the industry degrades the environment and workers experience conditions which leave them vulnerable to discrimination, exploitation, and modern slavery (Verité, 2017a). The economic importance of this crop (Indonesia is the top producer and exporter of palm oil worldwide) belies the limited political action to lower the expansion of production (UNComtrade, 2018). However, antislavery programs have been implemented to support transnational and domestic migrant workers in the sector (Hasan, Rukmana, Dr, & Morris, 2018). Unfortunately, as the government response score indicates (Table 1), often only minimal protections are legislatively implemented. As there has been some impetus towards eradicating labor abuses, the Indonesian oil palm sector may present an opportunity to trial the integration of conservation actions into antislavery tools.

4.4 | Mozambique

Mozambique is both the country with the lowest income, and lowest EPI score (Hsu et al., 2016), of the four nations. It also has some of the highest vulnerability scores and low government response (Table 1). Analysis suggests illegal logging driven by slavery within Mozambique is lower risk (Figure 3). However, the country exhibits vulnerabilities to enslavement within the forestry sector that are high. The leading drivers of deforestation include: small-scale and commercial agriculture, construction, logging, and charcoal production (Ryan, Berry, & Joshi, 2014). Logging has recently been the dominant cause of tree loss due in part to China's demand for timber (93% of all timber exports from Mozambique are destined for China, which contributed to 48% of the total illegal logging rate in 2012 for Mozambique: Macqueen, 2018; EIA 2013) and the increased presence of Chinese companies operating in rural communities, which is leaving people vulnerable to the enhanced effects of climate change (Mambondiyani, 2019). Timber is also being lost through cross-border smuggling with neighbouring nations en route to China (EIA, 2013). Environmental protections are necessary within Mozambique as the country is increasingly dependent on forests to mitigate the effects of climate change (Serdeczny et al., 2017); whilst stronger legislation surrounding the movement of timber products are necessary in limiting the economic losses from the exploitation of those goods.

The lack of funds available to the Mozambique government to establish these protections is one of the reasons the removal of resources is likely to continue, particularly in the southern and north-eastern provinces (Figure 4; Hewson et al., 2019); perpetuating a cycle of economic and environmental profiteering from outsiders and corrupt officials. China's expanding influence across Africa and the effects of the climate crisis mean landcover change and adaptation is likely to be forced, risking further vulnerabilities to enslavement associated with the slavery-environmental nexus (noted in: Bales, 2016; Brickell, Parsons, Natarajan, & Chann, 2018; Brown et al., 2019). Risks include an increased level of damage from natural hazards, such as cyclones, as the forests are no longer present to limit the impact. The proportion of intense tropical storms events are likely to increase as anthropogenic climate change persists (Walsh et al., 2015) which is likely to raise the presence of climate-induced forced migration; this increases the risk of exploitation and has been noted in other regions affected by cyclones (International Organisation for Migration, 2016), it is therefore also likely to occur in this region. The predicted tree loss by Hewson et al. (2019) in Figure 4 is a business-as-usual model, and therefore these vulnerabilities are likely to be more damaging faster, unless they are addressed within land management plans. Some of these plans are being supported by the World Bank; they aim to protect forests, their biodiversity and ecosystem services, through programs such as REDD+, alongside limiting climate change impact (Kaechele, 2019).

5 | LIMITATIONS

Limitations are associated with the use of secondary data and the differences in time between the two datasets were difficult to avoid. Although tree loss data are collected regularly via satellite data, modern slavery data is more sporadic. We do not have exact slavery figures at present, though the best estimates available (those from the 2016 GSI) were used. Although the EPI scores are weighted, they do not account for environmental load displacement placed on the Global South, in terms of reducing environmental damage and limiting emissions, whilst the Global North, may also demand natural resources. This is a critique of the EPI and should be corrected for future use going forward. The predicted tree loss figures were formed through a model, and the limits of the process have been noted by Hewson et al. (2019: p. 11). Changes to modeling method (Goldman & Weisse, 2019) for the Hansen et al. (2013) GFW dataset dictated the scope of analysis. Combining these analyses with other data sources, such as the Global Forest Resources Assessments (GFRA; FAO, 2020), could strengthen some of the limitations of using the GFW data. However, this was not used within this assessment due to the temporal availability of the GFRA data, which is collected every five years. The use of illegal logging as a proxy can only provide a part of the story and a deeper understanding is required going forward. Many countries had no data for illegal logging and a regional figure was used for those countries without specific rates of loss in Africa, Asia, and Latin America—ultimately there are many data gaps particularly in the Global North which need to be filled in future analyses. Finally, the countries investigated here are by no means the only ones affected by tree loss and modern slavery; nor is all tree loss deforestation. Primary data collected with ground-partners will enable the problem's scale to be fully understood.

6 | CONCLUSION

The co-occurrence of modern slavery and tree cover loss—particularly that associated with illegal deforestation and land clearing—suggests a complex relationship between the phenomena that is beyond coincidental. Yet, a two-way cyclical relationship between modern slavery and tree loss within forests is present. When biological diversity decreases due to tree cover loss, vulnerability to slavery increases in turn increasing modern slavery's contributions to tree cover and biodiversity loss. Therefore, forest related conservation actions and policy must become socially just, and account for slavery and its associated illegal and environmentally destructive practices. As a result of the United Nations 2030 agenda, approximately a decade remains to abolish both slavery (SDG 8.7) and deforestation (SDG 15.2). Thus, novel approaches to action and policy are needed in these data-limited areas. Identifying synergies between conservation and antislavery action and policy could accelerate and/or improve the likelihood of attaining the SDGs. Due to the breadth of disciplinary expertise and the presence and influence of the conservation marketing and social science working groups, the Society for Conservation Biology is poised to lead the field on these innovative, transdisciplinary, and cross-sectoral approaches.

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The links to the data and code used will be uploaded to the University of Nottingham's Data Repository (https://rdmc.nottingham.ac.uk/).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

B.J. and J.S. constructed and designed the concept for the paper, with BJ processing the data. The EPI/GSI methodology was created by DB and implemented by B.J. C.B. assisted with the Mozambique analysis. Writing was predominantly undertaken by B.J. and J.S. with assistance from C.B. and D.B.

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