



Authority of Second-Tier Governments to Reduce Deforestation in 30 Tropical Countries

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The authority of state- and province-level governments (“second-tier governments”) to make decisions related to slowing deforestation independently of national governments varies widely across countries. Here we systematically catalog whether second-tier governments in 30 tropical countries with high projected future emissions from deforestation possess 14 distinct types of general and forest-related authority. We compile this information in a free, open-access database. Second-tier governments have broadest authority to reduce deforestation in India, Brazil, Indonesia, Malaysia, Papua New Guinea, Peru, China, Laos, Mozambique, and Vietnam. Second-tier governments have the least authority in Central African Republic, Gabon, Angola, Madagascar, Bolivia, Cambodia, Cameroon, Guyana, Suriname, Thailand, and Venezuela. Second-tier governments have intermediate authority in Democratic Republic of Congo, Ecuador, Mexico, the Philippines, Colombia, Myanmar, Tanzania, Zambia, Mexico, and Republic of Congo. Authorities that second-tier governments most commonly possess include development planning, taxation, budgeting, and roads. Authorities that second-tier governments least commonly possess include land ownership, police, permits for mining, Indigenous affairs, and protected areas. Authorities possessed by an intermediate number of second-tier governments include spatial planning, elections, courts, and permits for agriculture. More than one-quarter of future emissions from deforestation between 2020 and 2050 is projected to come from just seven out of 678 second-tier jurisdictions: Amazonas, Pará, and Mato Grosso (Brazil), Équateur and Orientale (Democratic Republic of Congo), Loreto (Peru), and El Beni (Bolivia). After weighting for authority, our list of the 50 second-tier jurisdictions in the tropics that are the highest priority for reducing emissions from deforestation shifts to include fewer second-tier jurisdictions in Africa (where second-tier governments have 4.2 authorities out of 14 in the average country) and Latin America (6.3 authorities out of 14) and more second-tier jurisdictions in Asia (8.5 authorities out of 14). Second-tier jurisdictions that have formally expressed interest in reducing emissions from deforestation, e.g., through the Governors’ Climate and Forest Task Force, Under2 Coalition, or New York Declaration on Forests, possess greater authority to reduce deforestation on average than other jurisdictions. Information on second-tier governmental authority, when complemented with deeper country-specific knowledge, can help initiatives for reducing emissions from deforestation (REDD+) prioritize support across regions and across sectoral interventions.

Keywords: REDD+, jurisdictional approach, multi-level governance, climate change, decentralization, sub-national government

INTRODUCTION

Reducing tropical deforestation is critical to preventing more than 2°C of global warming (IPCC, 2014). Furthermore, protecting forests prevents extinctions (IPBES, 2019) and contributes to sustainable development goals related to health, agriculture, energy, and climate adaptation (Seymour and Busch, 2016). Because the benefits of deforestation accrue to private land-use decision makers while the costs of deforestation are spread across a broad public, reducing deforestation to socially optimally levels requires interventions by governments.

There are multiple scales of government at which actions to reduce deforestation can take place—national, sub-national, and local. Domestically, national governments have the authority to enact and enforce a wide manner of public policies intended to slow deforestation, from protected areas to recognition of Indigenous territorial rights to payments for ecosystem services to road infrastructure to trade in agricultural products (Busch and Ferretti-Gallon, 2017). Internationally, national governments are the principals in international conventions related to reducing deforestation [e.g., United Nations Framework Convention on Climate Change (UNFCCC); Convention on Biological Diversity (CBD)]. They are the focal points for the provision of pledges to those conventions (e.g., Nationally Determined Contributions; National Biodiversity Strategy and Action Plans). They are the designated recipients of finance under the terms of the UNFCCC Paris Climate Agreement on Reducing Emissions from Deforestation and forest Degradation (REDD+). Meanwhile local governments are most closely adjacent to individual land-users who make decisions directly related to clearing, maintaining, or expanding forest cover (Boyd et al., 2018; Stickler et al., 2018).

In between the scale of national and local governments, sub-national governments have widely varying authority to independently make decisions related to slowing deforestation. Sub-national governments one administrative tier below the national government (“second-tier governments”) are variously termed provinces, states, departments, regions, etc. Sub-national governments two administrative levels below the national government (“third-tier governments”) are variously termed municipalities, districts, provinces, etc.

Although sub-national governments are unlikely to be able to comprehensively solve deforestation in isolation from national governments and local stakeholders, they can play an important role. International forums are increasingly paying attention to the potential for sub-national governments to contribute to reducing deforestation. The UNFCCC Warsaw Framework for REDD+ specifies that the scale for reference levels and monitoring may be sub-national as an interim measure if appropriate (UNFCCC, 2013). The New York Declaration on Forests has been signed by 21 sub-national governments (United Nations, 2014).

Finance for REDD+ has increasingly gravitated toward sub-national scales as well. Less-than-initially-anticipated levels of finance that are insufficient to incentivize actions by national governments have spurred the design of mechanisms to channel funds to sub-national governments, including the Forest Carbon Partnership Facility’s Carbon Fund; Germany’s

REDD Early Movers Program; the Governors’ Climate and Forest Task Force; and the California Tropical Forest Standard. Meanwhile, proponents of REDD+ for voluntary markets have increasingly sought to bolster the environmental integrity of emission reductions by shifting scale from isolated projects to larger jurisdictions, e.g., the Verra Jurisdictional and Nested REDD+ Framework.

Previous studies have explored a wide range of topics related to the potential for sub-national governments to contribute to reducing deforestation. Multi-level governance of REDD+ has been explored by Forsyth (2009), Korhonen-Kurki et al. (2013), Ravikumar et al. (2015), Larson et al. (2018), and di Gregorio et al. (2019). REDD+ and the recentralization of forest governance has been analyzed by Phelps et al. (2010). The relative effectiveness of different scales of government to reduce deforestation through protected areas has been evaluated in Brazil by Herrera et al. (2019). Mechanisms for the effective, efficient and equitable distribution of REDD+ revenues between national and state governments have been designed, e.g., in Brazil (Cattaneo, 2011) and Indonesia (e.g., Busch et al., 2012). Ecological fiscal transfers, which tie the devolution of funding from national to state governments to forest cover, have been evaluated in India (Busch and Mukherjee, 2017) and proposed for Indonesia (Mumbunan, 2018). Sub-national REDD+ programs have been designed, e.g., in Indonesia (Irawan et al., 2019). And a “jurisdictional approach” to low-emission rural development has been put forward, based around public-private collaboration in sub-national jurisdictions (Nepstad et al., 2013a,b; Stickler et al., 2018).

Yet until now, there has been no systematic compilation of which authorities to reduce deforestation are possessed by sub-national governments in which countries. In this paper we construct a database in which we systematically catalog which types of authority to reduce deforestation are possessed by second-tier governments in which countries. We catalog authorities for states and provinces in 30 tropical countries projected to produce 91% of emissions from tropical deforestation from 2020 to 2050 (Busch et al., 2019). For each country we catalog whether or not second-tier governments in that country possess five measures of general authority and nine measures of forest-related authority. No such data set existed previously.

We use this database to answer two questions. First, in which countries do second-tier governments have the greatest authority to reduce deforestation? By identifying sub-national jurisdictions that have high *de jure* governmental authority to reduce deforestation, our analysis adds to the suite of information that institutions concerned with jurisdictional-scale initiatives for reducing deforestation can use to prioritize resources across regions. Second, which types of authority to reduce deforestation do second-tier governments most broadly possess? By identifying authorities that are broadly possessed by second-tier governments in many countries, our analysis can help institutions prioritize resources across sectoral interventions.

We present an illustrative example of how data on cross-national variation in second-tier government authority can be used to inform prioritization. We compare the most significant

second-tier jurisdictions for reducing emissions from tropical deforestation based on (i) projected future emissions alone, and (ii) projected future emissions weighted by second-tier government authority.

MATERIALS AND METHODS

Selection of Countries and Jurisdictions

We selected for inclusion in the study the 30 countries with the highest projected emissions from tropical deforestation from 2020 to 2050 under a business-as-usual scenario (Busch et al., 2019). These countries are collectively projected to produce 91% of emissions. Of these 30 countries, 9 are in Latin America; 10 are in Sub-Saharan Africa; and 11 are in tropical Asia.

Within these countries, we looked at the authority of second-tier governments only. Among the 30 countries studied, second-tier governments are variously termed provinces ($n = 14/30$), regions ($n = 7/30$), states ($n = 6/30$), departments ($n = 3/30$), or other terms; the median country has 23 of these (Table 1). Third-tier governments are variously termed municipalities ($n = 12/30$), districts ($n = 10/30$), provinces ($n = 2/30$), or other terms; the median country has 166 of these. The authority of third-tier governments is also significant in some countries, and may even exceed that of second-tier governments for some indicators in some countries. However, we did not extend the scope of the present analysis to third-tier governments as information on these governments is harder to come by for many countries. The authority of third-tier governments would be an interesting topic for future exploration.

Selection of Indicators of Authority

We selected 14 indicators of second-tier government authority to compare across countries. These included five indicators of general authority and nine indicators of forest-related authority.

The five indicators of general authority are intended to measure whether second-tier governments have at least some electoral, fiscal, and judicial independence from higher levels of government, and thus can act at least somewhat autonomously rather than being entirely beholden to or dependent on the national government to take actions. We produced binary indicators of whether second-tier governments do or do not have that authority.

The five indicators of general second-tier government authority are as follows:

1. **Elections.** Whether electoral accountability on its own slows or accelerates environmental degradation is theoretically ambiguous (Li and Reuveny, 2006). But governments that are elected by their citizens will have greater autonomy to reduce deforestation, if they so choose, than those dependent on higher levels of government for their appointment. We coded this indicator as 1 if at least some second-tier government officials, i.e., governors and legislators, are elected by voters within that jurisdiction rather than, e.g., appointed by a president, prime minister, or parliament. We coded this indicator as 0 otherwise.

TABLE 1 | Numbers and names of sub-national jurisdictions in 30 tropical countries with greatest projected emissions from deforestation.

Country	Number and name of second-tier jurisdictions	Number and name of third-tier jurisdictions
Brazil	26 States, 1 Federal District	5,570 Municipalities
Indonesia	34 Provinces	410 Districts, 98 Cities
Dem. Rep. Congo	26 Provinces	145 Territories, 33 Cities
Bolivia	9 Departments	94 Provinces
Colombia	32 Departments, 1 Capital District	1,101 Municipalities
Peru	25 Regions	196 provinces
Papua New Guinea	20 Provinces, 1 Autonomous region, 1 District	89 Districts
Venezuela	23 States, 1 Capital District, 1 Federal Dependency	336 Municipalities
Malaysia	13 States	149 Municipalities
Zambia	10 Provinces	74 Districts
Republic of Congo	12 Departments	94 Municipalities
Angola	18 Provinces	162 Municipalities
Mexico	32 States, 1 Federal District	2,457 Municipalities
Myanmar	7 Regions, 7 States, 1 Union Territory	74 Districts
Central African Republic	16 Prefectures	66 Sub-prefectures
Vietnam	58 Provinces, 5 Municipalities	710 Districts
Thailand	76 Provinces	209 Municipalities
Cameroon	10 Regions	58 Departments
Philippines	81 Provinces	1,489 Municipalities, 105 Cities
India	29 States, 7 Union territories	250,671 Municipalities, 630 Zilla panchayats, 6,614 Block panchayats, 253,163 Gram panchayats
Cambodia	24 Provinces, 1 Municipality	159 Districts, 26 Municipalities, 12 Khans
Tanzania	31 Regions	169 Districts
Laos	17 Provinces, 1 prefecture	141 Districts
Mozambique	11 Provinces	154 Districts
Guyana	10 Regions	6 Municipal, 65 Neighborhood democratic councils, 75 Amerindian village councils
China	31 Provinces	334 Prefectures
Gabon	9 Provinces	47 Departments/prefectures
Ecuador	24 Provinces	221 Municipalities
Madagascar	22 Regions	111 Districts
Suriname	10 Districts	62 Sub-districts

2. **Taxation.** Governments that can raise their own revenue and are at least partially self-financing will have greater autonomy than those dependent on higher levels of government for their fiscal balance. In principle taxation powers can also be used to correct negative environmental externalities such as those arising from deforestation, though this type of taxation is rare in practice (e.g., Müller et al., 2013). We coded this indicator as 1 if the second-tier government has the authority to raise at least some types of taxes, and 0 otherwise.

3. **Budgets.** Governments that can determine their own spending will have greater autonomy than those whose budgets are determined by higher levels of government. Public budgets can be used to finance a wide range of policies or programs to reduce deforestation (e.g., payments for ecosystem services; Wunder, 2005) or accelerate it (e.g., subsidies for agricultural expansion; Mamun et al., 2017). We coded this indicator as 1 if the second-tier government has at least some authority to determine its own budget. This includes countries where second-tier government authority to set budgets is partially constrained by national governments or participatory processes. We coded this indicator as 0 otherwise.
4. **Police.** Enforcement of environmental laws is consistently associated with lower deforestation (Busch and Ferretti-Gallon, 2017). Governments that operate their own police forces will have greater autonomy to enforce laws and policies than those in which police in their jurisdiction report to the national government. We coded this indicator as 1 if the second-tier government maintains their own police force, and 0 otherwise. We did not consider other administrative agencies of second-tier governments that are not police departments but nevertheless might possess some police-like authorities (e.g., to make arrests or use force).
5. **Courts.** As with police, enforcement of environmental laws by courts can reduce deforestation (Busch and Ferretti-Gallon, 2017). Governments that have their own courts will have greater autonomy to enforce laws and policies than those in which justice is administered solely under the national judicial system. We coded this indicator as 1 if the second-tier government has its own court system, and 0 otherwise.

The nine indicators of forest-related authority are intended to measure the degree to which second-tier governments independently oversee processes that can affect the rate of deforestation, e.g., as identified by Busch and Ferretti-Gallon (2017) and related reviews (Angelsen and Kaimowitz, 1999; Geist and Lambin, 2002; Chomitz, 2007; Rudel et al., 2009; Angelsen and Rudel, 2013; Pfaff et al., 2013; Burivalova et al., 2019). We sought double-binary indicators, that is, indicators for which (1) the authority involves a yes/no decision on the part of the second-tier government; and (2) it would be easy to clearly identify whether governments do or do not have the authority.

The nine indicators of second-tier governments' forest-related authority are as follows:

6. **Land ownership.** Governments that own land have direct responsibility for forest management, including some control over the rate of deforestation and degradation on that land. We coded this indicator as 1 if the second-tier government owns at least some land or forest, and 0 otherwise. We did not consider the provenance of second-tier government-owned land; e.g., whether it was obtained through the dispossession of local groups.
7. **Agricultural permits.** Agriculture is the leading driver of deforestation across much of the tropics (Curtis et al., 2018). Control over the issuing of licenses for agriculture in

forest areas is a direct way that governments can accelerate or curtail deforestation. We coded this indicator as 1 if second-tier governments have at least some authority to issue licenses or concessions for agricultural activity, and 0 otherwise.

8. **Mining permits.** Mining is a significant driver of deforestation in some tropical regions (e.g., Butsic et al., 2015). As with agriculture, control over the issuing of licenses to mine in forest areas is a direct way that governments can accelerate or curtail deforestation. We coded this indicator as 1 if the second-tier governments have at least some authority for issue licenses or concessions for mining, and 0 otherwise.
9. **Logging permits.** Logging and timber operations have a mixed effect on deforestation across the tropics (Busch and Ferretti-Gallon, 2017). In some regions the roads and forest degradation associated with logging are precursors to more widespread deforestation afterward (e.g., Rice et al., 1997). Elsewhere, logging companies have rights and incentives to manage forests for long-term production rather than short-term liquidation (e.g., Putz and Romero, 2015). In either case government oversight of logging can lead to more environmentally sustainable operations. We coded this indicator as 1 if second-tier governments have at least some authority for issuing licenses or concessions for logging, and 0 otherwise.
10. **Roads.** The construction of roads is an important driver of deforestation throughout the tropics, both directly by increasing access to previously remote forest areas (Barber et al., 2014) and indirectly by reducing the cost of transporting agricultural products to urban markets (Cropper et al., 2001). Building or prohibiting roads is a direct way that governments can accelerate or curtail deforestation. We coded this indicator as 1 if second-tier governments have authority for the construction and maintenance of at least some roads, and 0 otherwise.
11. **Protected areas.** Protected areas, whether strict or multiple-use, are consistently associated with lower rates of deforestation across the tropics (Busch and Ferretti-Gallon, 2017). Designating protected areas in threatened forests is a direct way that governments can curtail deforestation. We coded this indicator as 1 if second-tier governments have authority to designate areas within its territory as protected, and 0 otherwise.
12. **Indigenous affairs.** Forests in which Indigenous peoples' territorial claims have been recognized are consistently associated with lower rates of deforestation (Busch and Ferretti-Gallon, 2017). Recognizing and protecting the territorial rights of indigenous peoples and other traditional communities is a direct way for governments to curtail deforestation. We coded this indicator as 1 if second-tier governments have authority to recognize indigenous territories or affairs, and 0 otherwise.
13. **Spatial planning.** Zoning of where specified economic activities can take, even if non-binding, has the potential to accelerate or curtail deforestation (e.g., Vasconcelos et al., 2013). We coded this indicator as 1 if second-tier

governments have at least some responsibility for territorial planning, and 0 otherwise.

14. **Development planning.** Planning which economic activities will be encouraged or discouraged within a jurisdiction can affect deforestation (e.g., Pedlowski et al., 1997). We coded this indicator as 1 if second-tier governments have at least responsibility for development planning, and 0 otherwise.

We coded a country-authority combination as 1 if second-tier governments in that country possessed that authority. We did so even in cases in which that authority was not exclusive, i.e., even when second-tier governments shared the authority with another level of government. We coded a country-authority combination as 0 if second-tier governments do not possess that authority, i.e., it rested entirely with another level of government. We coded partial authority as 1; e.g., when some second-tier governments in a country have the authority while other second-tier governments in the same country don't; when the authority is being phased out or being phased in; or when second-tier governments only possess that authority for certain aspects of the indicator (e.g., second-tier governments have the authority to grant mining permits for organic materials but not minerals; or to set value-added taxes but not income taxes). By deliberately coding partial or underused authorities as 1, we erred on the side of inclusivity. In this way we avoided errors of omission (i.e., not ascribing authorities that exist) even while remaining prone to errors of commission (i.e., ascribing authorities that are not fully devolved or used).

This list of indicators is not a comprehensive overview of all authorities that second-tier governments possess that could affect deforestation. We did not compile information on, e.g., second-tier governments' authority to oversee forest monitoring systems or social and environmental safeguard information systems, nor extent of enforcement of regulations. Nor did we attempt to assess second-tier governments' capacity or political will to undertake processes that they have authority for.

Data

Some sources of information were particularly useful. For example, the *Constitute Project* (2019) hosts up-to-date versions of all countries' constitutions, many of which are explicit about which general and forest-related authorities rest with which level of government. *Landlinks* (USAID, 2019), an initiative of USAID related to land tenure and property rights, maintains country profiles with useful information related to many forest-related indicators. The *World Database on Protected Areas* (UNEP-WCMC, 2014), which maintains a nearly comprehensive and current map of protected areas worldwide and their management agency, was our primary resource for the indicator on second-tier governments' authority to declare protected areas. The *World Factbook* (CIA, 2019) provides information on many countries' court systems, as well as on the number of second-tier jurisdictions. The *African Policing Civilian Oversight Forum* (APCOF, 2019) provides information related to second-tier governments' police authority for many African countries. OECD country profiles provided information related to planning and land ownership for some countries.

World Resources Institute's Forest Legality Initiative (WRI, 2019) provided information related to land ownership and logging permits for some countries.

Furthermore, some previous publications provided useful information related to second-tier governments' authorities for individual countries. A publication series commissioned by the Center for International Forestry provided useful information for Indonesia (Ardiansyah et al., 2015), Mexico (Carrillo Fuentes and Velasco Ramirez, 2016), Peru (Wieland and Farfan, 2015), Tanzania (Mbwambo, 2015), and Vietnam (Trung et al., 2015). The 12 sources mentioned above provided information on 243 out of 420 (58%) of country-authority combinations; we obtained information on the remaining 42% country-authority combinations from other sources.

In attempting to code country-authority combinations accurately we faced several persistent challenges. Data were obtained from multiple heterogeneous sources, making standardization difficult. In some cases, available information was ambiguous as to the possession of authority. In some cases, available information may not have been current, raising the possibility that the information might be outdated and might have been superseded. In some countries there could be important differences between authorities as described on paper (*de jure* authorities) and authorities as they exist in practice (*de facto* authorities). This difference could occur at all times, or in times of war or civil unrest. We coded based on *de jure* authority. In some cases, multiple sources conflicted in their description of which levels of government hold certain authority. Semantically, source texts did not always clearly differentiate between "states" (i.e., second-tier governments) and "the state" (i.e., the national government). These challenges meant that some judgment calls and margin for error were inherent in the coding process. Representative examples for the coding of each indicator are shown in **Box 1**.

We compiled information on all 30 countries and 14 authorities in a database. The database contains both elaborated data (with the full relevant information quoted along with its source) and simplified data (1 or 0 only). The database is freely available online as **Supplementary Table 1**.

Aggregation

For each country, we produced a second-tier government authority score out of a maximum of 14 by summing the binary scores for all 14 indicators. In our method of aggregation, all 14 authorities contributed equally to the second-tier government authority score. In reality, some authorities contribute more strongly than others to a second-tier government's ability to reduce deforestation. For example, spatial planning is generally a non-binding exercise rather than a strong legal tool, while roads permanently and substantially alter the geographic benefits and costs of converting forest cover to agriculture or other land uses. Nevertheless, in the absence of a quantitative basis for weighting authorities heterogeneously, we weighted all 14 authorities equally.

For each authority, we produced a score out of a maximum of 30 by summing the scores across all 30 countries.

BOX 1 | Representative examples for each indicator.

Elections: *Do states in Brazil have independent elections?* “Each of Brazil’s 26 states has its own constitution and popularly elected legislature and governor” (Nations Encyclopedia, 2019). Coded as 1 (yes).

Taxation: *Do provinces in the Democratic Republic of Congo have taxation authority?* “Without prejudice to the other provisions of this Constitution, the following matters are of the exclusive competence of the Provinces: provincial and local taxes, and duties and assessments [droits], notably property tax, tax on local revenue and the tax on motor vehicles” (Constitute Project, 2019). Coded as 1 (yes).

Budgets: *Do states in Venezuela have budget authority?* “The Legislative Power is exercised in each State by a Legislative Council...The Legislative Council has the following attributions:...To approve the Law of the Budget of the State” (Constitute Project, 2019). Coded as 1 (yes).

Police: *Do departments in Bolivia have police authority?* “Police [are] subordinate to the [National] Ministry of Interior, Migration, and Justice” (Hudson et al., 1991). Coded as 0 (no).

Courts: *Do provinces in Papua New Guinea maintain courts?* “Subordinate courts [include] district, village, and juvenile courts, military courts, taxation courts, coronial courts, mining warden courts, land courts, traffic courts, committal courts, grade five courts” (CIA, 2019). Coded as 0 (no).

Land ownership: *Do states in Mexico own land?* “According to the constitution, all land and water in Mexico belongs to the nation and the national government is in charge of providing legislation to operationalise this principle” (OECD, 2016). Coded as 0 (no).

Agricultural permits: *Do regions and states in Myanmar have authority to issue agricultural permits?* “With the enactment of the Farmland Law, those seeking rights to farmland must obtain permission and a land-use certificate (LUC) from the [national] state (USAID, 2019)” (WRI, 2019). Coded as 0 (no).

Mining permits: *Do departments in Colombia have authority to issue mining permits?* “All non-renewable natural resources in Colombia belong to the state, which can undertake exploration and exploitation on its own or grant concession rights to private parties to undertake exploration and exploitation” (USAID, 2019). Coded as 0 (no).

Logging Permits: *Do regions in Peru have authority to grant logging concessions?* “The [National] Forestry and Wildlife Agency has the power to grant forest concessions over all regions, except for the powers transferred to the regional governments... Regional governments grant forest concessions in areas inside the regions where functions have been transferred” (Fernandini and Sousa, 2015). Coded as 1 (yes)

Roads: *Do provinces in the Philippines have authority to build roads?* “Infrastructure facilities intended to service the needs of the residents of the province and which are funded out of provincial funds includ[e], but [are] not limited to, provincial roads and bridges...” (Chan Robles Virtual Law Library, 2019). Coded as 1 (yes).

Protected areas: *Do regions in Tanzania have authority to declare protected areas?* “[National] authority to establish and gazette protected areas” (Mbwambo, 2015). Coded as 0 (no).

Indigenous affairs: *Do provinces in Angola have authority to recognize Indigenous territories or affairs?* “The state shall recognize the status, role and functions of the institutions of the traditional authorities founded in accordance with customary law which do not contradict the Constitution” (Constitute Project, 2019). Coded as 0 (no).

Spatial planning: *Do provinces in Zambia conduct spatial planning?* “Concurrent national and provincial functions: Nature conservation, provincial spatial planning and development, public transport, agriculture” (Constitute Project, 2019). Coded as 1 (yes).

Development planning: *Do provinces in Indonesia conduct development planning?* “[Provincial governments have] lawmaking authority in a number of fields of governance. These fields are development planning and control; spatial planning, use and monitoring; peace and order; public facilities and infrastructures” (Ardiansyah et al., 2015). Coded as 1 (yes).

Caveats

There are several notable caveats to our analysis. We developed binary scores in order to facilitate quantitative cross-national and cross-sectoral comparisons. But simple binary scores belie often-complex realities. Our database includes more nuanced and elaborate descriptions of every country-authority combination, on which the binary scores are based. For actual institutional decision-making, our assessments of the extent to which particular second-tier governments possess specific authorities should be followed up with deeper country-specific information gathering, e.g., through country-specific case studies.

We have identified second-tier jurisdictions in which governments have greater authority to reduce deforestation relative to their peers. While this data may be useful to institutions supporting state- and province-level initiatives for reducing emissions from deforestation to consider as they prioritize support across regions, it is by no means the only important information to consider. Other considerations include the values of local constituents and decision-makers, and regional history and politics surrounding land use (e.g., Myers et al., 2018).

There can be differences between *de jure* possession of authority and *de facto* exercise of those authorities. The degree to which second-tier governments exercise their authorities to

reduce deforestation in practice can be hampered by, e.g., lack of capacity (DeFries et al., 2013), weak governance (Korhonen-Kurki et al., 2014), corruption (Sundstrom, 2016), or lack of political will to take on entrenched interests or illegal activities (Seymour and Busch, 2016).

While second-tier governments can play an important role in curtailing deforestation, they are not the only important stakeholders. In most if not all cases national governments possess more authority than second-tier governments. In some cases third-tier governments or local governments possess more authority than second-tier governments. In many places, Indigenous peoples and local communities, private companies, and non-governmental organizations are relevant stakeholders as well.

Many of the above considerations are beyond the scope of this paper and suggest avenues for complementary research.

RESULTS

Second-Tier Governments With Most Authority

The authority of sub-national governments to reduce deforestation varies widely across countries (**Figure 1** and

Table 2. The countries in which second-tier governments have greatest authority, i.e., are in the top third, include India (with 14 out of 14 authorities); Brazil, Indonesia, and Malaysia (each with 12/14); Papua New Guinea and Peru (10/14); and China, Laos, Mozambique, and Vietnam (8/14). These are countries with substantial devolution of authority to second-tier governments.

The countries in which second-tier governments have the least authority, i.e., are in the bottom third, are Central African Republic and Gabon (each with 1 out of 14 authorities); Angola and Madagascar (2/14); Bolivia (3/14); Cambodia, Cameroon, Guyana, Suriname, Thailand, and Venezuela (4/14). These are countries with strong central control.

In between are Democratic Republic of Congo, Ecuador, Mexico, and the Philippines (7/14); Colombia, Myanmar, Tanzania, and Zambia (6/14); and Republic of Congo (5/14). These are countries where authorities are more balanced between national and second-tier governments.

On average, second-tier governments in the 11 countries within Asia have the most authority

(8.5/14). Second-tier governments in the 10 countries within Africa have the least authority (4.2/14). And second-tier governments in the 9 countries within Latin America have intermediate authority (6.3/14).

Projections of future unweighted emissions from tropical deforestation are distributed unevenly across second-tier jurisdictions (**Table 3**). More than one-quarter of future emissions from tropical deforestation between 2020 and 2050 are projected to come from just seven of 678 second-tier jurisdictions: the states of Amazonas, Pará, and Mato Grosso in Brazil, the provinces of Équateur and Orientale in Democratic Republic of Congo, the region of Loreto in Peru, and the department of El Beni in Bolivia.

On average, pairs of countries had the same score on 8.6 out of 14 indicators (**Figure 2**; standard deviation = 2.5). The greatest commonality between any pair of countries was between Gabon and the Central Africa Republic with the same score for all 14 indicators, as well as between Cameroon,

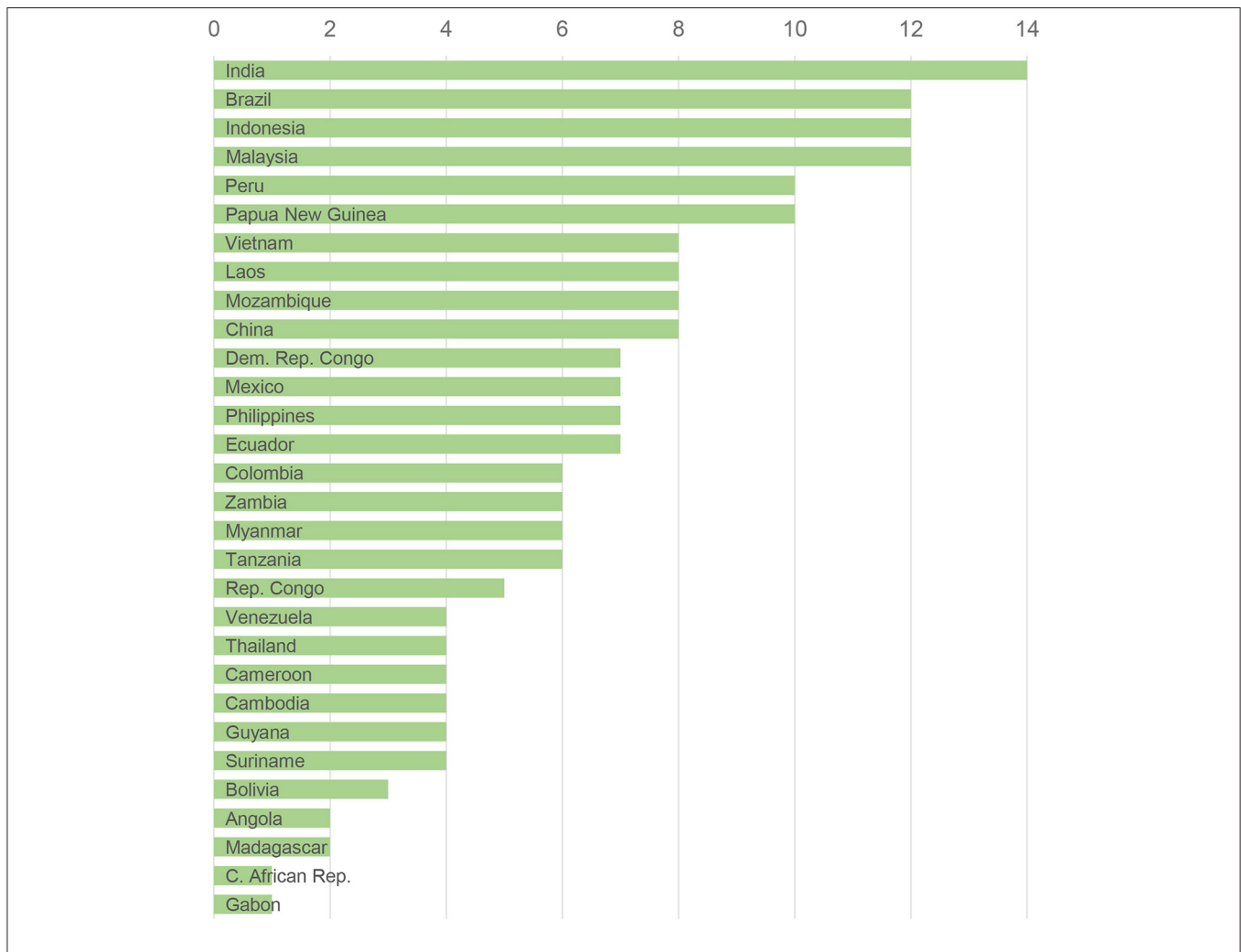


FIGURE 1 | Number of authorities (out of 14) held by second-tier governments in each country.

TABLE 2 | Authorities of second-tier governments, by country.

	Total Elections (/14)	Taxation	Budgets	Police	Courts	Land ownership	Agricultural Permits	Mining Permits	Logging permits	Roads	Protected areas	Indigenous affairs	Spatial planning	Development planning
TOTAL (/30)	15	25	23	4	13	3	12	6	11	21	8	8	16	27
Brazil	12	1	1	1	1	1	1	0	1	1	1	0	1	1
Indonesia	12	1	1	1	0	1	1	1	1	1	1	1	1	1
D.R. Congo	7	1	1	1	0	0	0	1	0	0	1	0	1	0
Bolivia	3	0	0	0	0	1	0	0	0	1	0	0	0	1
Colombia	6	1	1	1	0	0	0	0	0	1	0	0	1	1
Peru	10	1	1	1	0	0	0	1	1	1	1	0	1	1
PNG	10	1	1	1	0	0	0	1	0	1	1	1	1	1
Venezuela	4	1	1	1	0	0	0	0	1	0	0	0	0	0
Malaysia	12	1	1	1	0	0	1	1	1	1	1	1	1	1
Zambia	6	0	1	1	0	0	0	1	0	0	1	0	0	1
R. Congo	5	0	0	1	0	0	0	1	0	0	1	0	0	1
Angola	2	0	0	0	0	1	0	0	0	0	0	0	0	1
Mexico	7	1	1	0	1	1	0	0	0	0	0	1	0	1
Myanmar	6	0	1	1	1	1	0	0	0	1	0	0	0	1
C. Afr. Rep.	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Vietnam	8	0	1	1	0	1	0	0	1	1	1	0	1	1
Thailand	4	0	1	1	0	0	0	0	0	1	0	0	0	1
Cameroon	4	0	1	1	0	0	0	0	0	1	0	0	0	1
Philippines	7	1	1	1	0	0	0	0	0	1	1	0	1	1
India	14	1	1	1	1	1	1	1	1	1	1	1	1	1
Cambodia	4	0	1	1	0	1	0	0	0	0	0	0	0	1
Tanzania	6	1	1	1	0	0	0	0	1	0	0	0	1	1
Laos	8	0	1	1	0	1	0	1	0	1	0	1	0	1
Mozambique	8	0	1	1	0	1	0	1	0	1	0	0	1	1
Guyana	4	1	1	1	0	0	0	0	0	0	0	0	0	1
China	8	0	0	0	0	1	0	1	1	1	0	1	1	1
Gabon	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Ecuador	7	1	1	1	0	1	0	0	0	1	0	0	1	1
Madagascar	2	1	0	0	0	0	0	0	0	0	0	0	0	1
Suriname	4	0	1	1	0	0	0	0	0	1	0	0	0	1

Suriname, and Thailand, also with the same score for all 14 indicators. The least commonality was between Central African Republic and India, with the same score on only 1 indicator.

Pairs of countries within the same continent were slightly more likely to have the same score than countries on different continents, sharing a score on 9.0 out of 14 indicators on average. Pairs of countries within Africa shared a score on 9.6 indicators on average; pairs of countries within Latin America shared a score on 8.8 authorities on average; and pairs of countries within Asia shared a score on 8.6 indicators on average.

Second-tier jurisdictions that are participating in prominent international climate and forest initiatives have greater authority on average than other second-tier jurisdictions. Within the 30 countries studied, the 32 second-tier jurisdictions in the Governors’ Climate and Forest Task Force have an average authority score of 10.3; the 49 second-tier jurisdictions in the Under2 Coalition have an average

authority score of 9.1; and the 17 signatories to the New York Declaration on Forests have an average authority score of 9.8. The authority scores for these jurisdictions greatly exceed the average authority score across the 30 countries studied (6.4) and the average authority score of the 759 second-tier jurisdictions within those 30 countries (7.0).

Authorities Possessed by the Most Second-Tier Governments

The types of general authority that second-tier governments have in the most countries, i.e., are in the top third, include taxation (possessed by 25/30 countries) and budgeting (23/30) (Figure 3 and Table 2). This suggests second-tier governments can consider funding programs as a way to reduce deforestation. In principle tax policy could also be used to discourage deforestation, although in many countries second-tier governments

TABLE 3 | Top 50 second-tier jurisdictions by projected emissions from deforestation, unweighted vs. weighted by authority.

	Top 50 states, unweighted	Cumulative projected emissions, unweighted %	Top 50 states, weighted	Cumulative projected emissions, weighted %
1	Amazonas (Brazil)	8	Amazonas (Brazil)	11
2	Pará (Brazil)	14	Pará (Brazil)	19
3	Mato Grosso (Brazil)	17	Mato Grosso (Brazil)	24
4	Équateur (DRC)	20	Loreto (Peru)	27
5	Loreto (Peru)	22	Riau (Indonesia)	29
6	Orientale (DRC)	24	Kalimantan Tengah (Indonesia)	31
7	El Beni (Bolivia)	26	Équateur (DRC)	33
8	Santa Cruz (Bolivia)	28	Kalimantan Barat (Indonesia)	35
9	Riau (Indonesia)	30	Papua (Indonesia)	37
10	Katanga (DRC)	32	Orientale (DRC)	39
11	Kalimantan Tengah (Indonesia)	33	Sumatera Selatan (Indonesia)	41
12	Kalimantan Barat (Indonesia)	35	Kalimantan Timur (Indonesia)	42
13	Papua (Indonesia)	36	Minas Gerais (Brazil)	44
14	Sumatera Selatan (Indonesia)	37	Roraima (Brazil)	45
15	Kalimantan Timur (Indonesia)	38	Sarawak (Malaysia)	46
16	Minas Gerais (Brazil)	39	Maranhão (Brazil)	48
17	Bandundu (DRC)	40	Katanga (DRC)	49
18	Roraima (Brazil)	41	Bahia (Brazil)	50
19	Sarawak (Malaysia)	42	Western (PNG)	51
20	Western (PNG)	43	Rondônia (Brazil)	52
21	Maranhão (Brazil)	44	Mato Grosso do Sul (Brazil)	53
22	Bahia (Brazil)	45	Tocantins (Brazil)	54
23	Kivu (DRC)	46	Ucayali (Peru)	55
24	North-Western (Zambia)	47	Sumatera Utara (Indonesia)	56
25	Shan (Myanmar)	48	Bandundu (DRC)	57
26	Rondônia (Brazil)	48	Jambi (Indonesia)	58
27	Ucayali (Peru)	49	Amapá (Brazil)	58
28	Mato Grosso do Sul (Brazil)	50	Acre (Brazil)	59
29	Likouala (Rep. Congo)	50	Goiás (Brazil)	60
30	<i>Bolívar (Venezuela)</i>	51	Kivu (DRC)	61
31	Tocantins (Brazil)	52	El Beni (Bolivia)	61
32	Sumatera Utara (Indonesia)	52	Santa Cruz (Bolivia)	62
33	Kasai-Occidental (DRC)	53	Piauí (Brazil)	63
34	Jambi (Indonesia)	54	Madre de Dios (Peru)	63
35	Kasai-Oriental (DRC)	54	North-Western (Zambia)	64
36	Madre de Dios (Peru)	55	Kalimantan Utara (Indonesia)	64
37	<i>Amazonas (Venezuela)</i>	55	Papua Barat (Indonesia)	65
38	<i>Cuvette (Rep. Congo)</i>	56	Shan (Myanmar)	66
39	Amapá (Brazil)	56	Kalimantan Selatan (Indonesia)	66
40	Acre (Brazil)	57	Kasai-Occidental (DRC)	67
41	Goiás (Brazil)	57	Pahang (Malaysia)	67
42	<i>La Paz (Bolivia)</i>	58	Aceh (Indonesia)	68
43	<i>Moxico (Angola)</i>	58	Sumatera Barat (Indonesia)	68
44	<i>Delta Amacuro (Venezuela)</i>	59	East Sepik (PNG)	69
45	<i>Est (Cameroon)</i>	59	Kasai-Oriental (DRC)	69
46	<i>Sipaliwini (Suriname)</i>	60	Sabah (Malaysia)	69
47	<i>Amazonas (Colombia)</i>	60	Kerala (India)	70
48	Piauí (Brazil)	61	Sulawesi Tengah (Indonesia)	70
49	<i>Pando (Bolivia)</i>	61	Gulf (PNG)	71
50	Kalimantan Utara (Indonesia)	62	Likouala (Rep. Congo)	71

Italics, Only in top 50 jurisdictions in unweighted projected emissions, 2020–2050 (Busch et al., 2019). Bold, only in top 50 jurisdictions in projected emissions weighted by authority score.

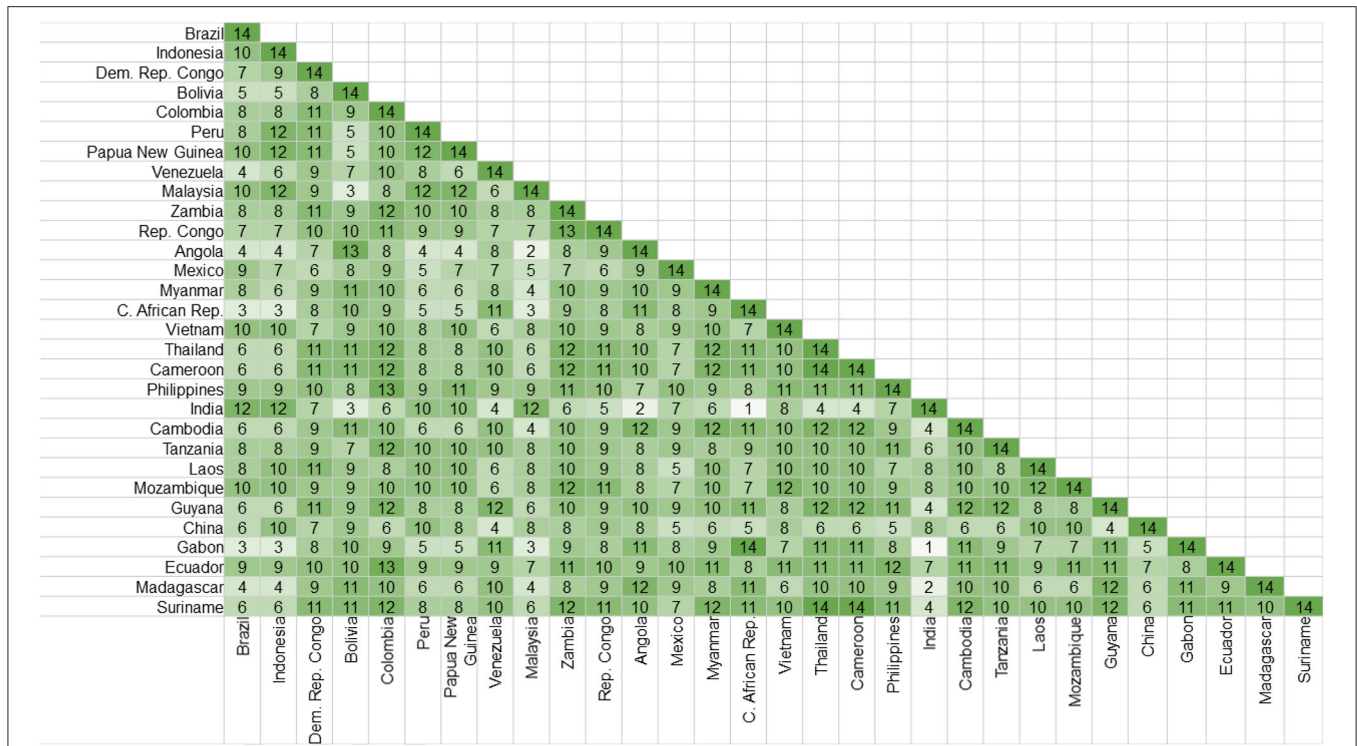


FIGURE 2 | Number of authorities (out of 14) with the same score in both countries, for each pair of countries.

are constrained in the type of taxes they are able to levy.

The type of general authority that second-tier governments have in the fewest countries, i.e., in the bottom third, is police (4/30). This suggests that law enforcement as a mechanism for reducing deforestation is more commonly the purview of the national government. In the middle third of general authority are courts (13/30) and elections (15/30).

The types of forest-related authority that second-tier governments have in the most countries, i.e., in the top third, include development planning (27/30) and road infrastructure (21/30). This suggests that some of second-tier governments' greatest leverage for avoiding deforestation lies in the redirection of planned development away from forests, especially through road networks.

The types of forest-related authority that second-tier governments have in the fewest countries include land ownership (3/30), permits for mining (6/30), Indigenous affairs (8/30), and protected areas (8/30). Thus, forest conservation strategies related to these authorities would be better directed to other levels of government, typically national.

In an intermediate number of countries, i.e., in the middle third, second-tier governments have authority for spatial planning (16/30), permits for agriculture (12/30), and permits for logging (11/30), suggesting that forest conservation strategies related to these authorities may be appropriate for some countries but not others.

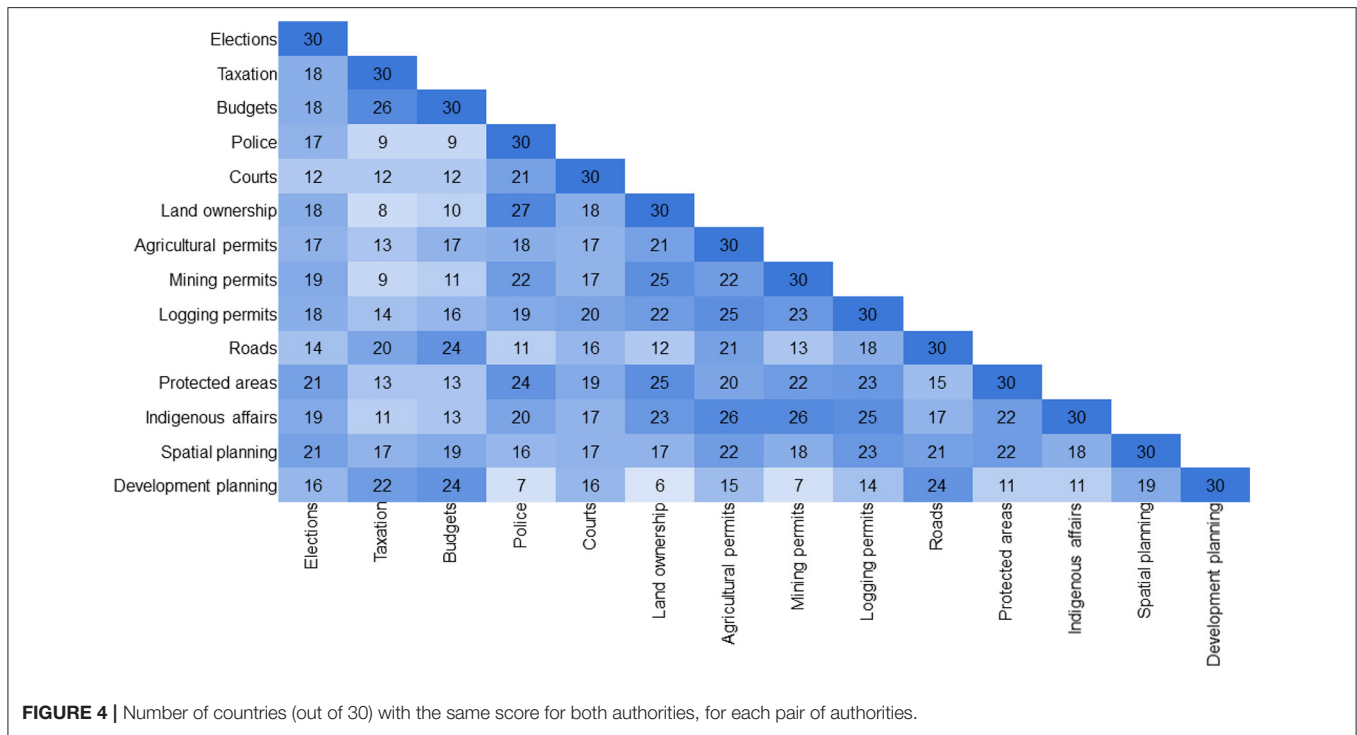
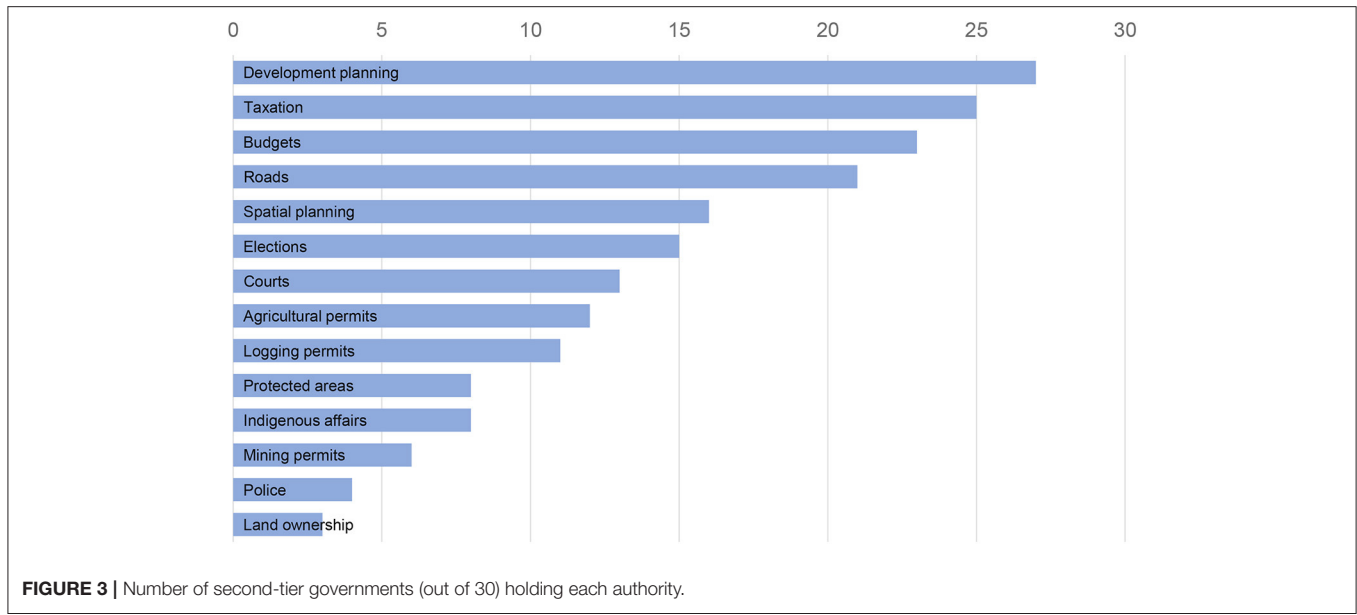
On average, a pair of authorities had the same score in 17.6 out of 30 countries (Figure 4; standard deviation = 5.1).

The greatest commonality between any pair of authorities was between budgets and taxation, with the same score in 26 out of 30 countries. The least commonality was between land ownership and development planning, with the same score in only 6 out of 30 countries.

Illustrative Prioritization

The set of second-tier governments that are the highest priority for reducing climate emissions shifts after their authority to reduce deforestation is considered (Figure 5). Forty second-tier governments are among the top 50 second-tier jurisdictions based on both *unweighted* projected emissions from deforestation, and projected emissions from deforestation *weighted* by government authority. These 40 second-tier jurisdictions include 14 states in Brazil, 9 provinces in Indonesia, 7 departments in Democratic Republic of Congo, 3 regions in Peru, 2 departments in Bolivia, 1 department in Republic of Congo, 1 province in Papua New Guinea, 1 state in Malaysia, 1 state in Myanmar, and 1 province in Zambia. Initiatives to reduce emissions from deforestation in these jurisdictions are important whether or not government authority is considered.

After weighting for the authority of second-tier governments to reduce deforestation, the list of the 50 second-tier jurisdictions in the tropics that are the highest priority for reducing emissions from deforestation shifts to include 3 fewer states in Venezuela, 2 fewer departments in Bolivia, 1 less province in Angola, 1 less region in Cameroon, 1 less department in



Colombia, 1 less department in Republic of Congo, and 1 less district in Suriname. Within these second-tier jurisdictions, initiatives to reduce emissions from deforestation are still among the most important, but should emphasize the role of national governments.

After weighting for the authority of second-tier governments, the list of the 50 second-tier jurisdictions in the tropics that are the highest priority for reducing emissions from deforestation shifts to include 5 more provinces in Indonesia, 2 more

states in Malaysia, 2 more provinces in Papua New Guinea, and 1 more state in India. Initiatives to reduce emissions from deforestation in these jurisdictions represent potentially underappreciated opportunities.

There is substantial overlap between second-tier jurisdictions that we identified as high priority for reducing emissions from deforestation and second-tier jurisdictions that are participating in prominent international climate and forest initiatives. Of the 35 tropical second-tier jurisdictions in the Governors' Climate

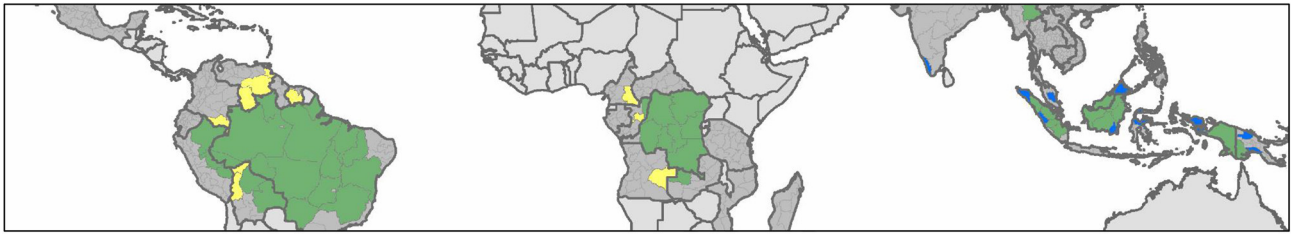


FIGURE 5 | The top 50 second-tier jurisdictions for projected emissions from deforestation shifts with and without consideration of authority score. Green=top 50 jurisdictions in both unweighted and weighted projected emissions. Yellow=top 50 jurisdictions in unweighted projected emissions, 2020–2050 (Busch et al., 2019) only. Blue=top 50 jurisdictions in projected emissions weighted by authority score only.

and Forest Task Force (GCF, 2019), 18 are among the top 50 unweighted, while 19 are among the top 50 weighted. Of the more than 200 second-tier jurisdictions worldwide in the Under2 Coalition (The Climate Group, 2019), 12 are in the top 50 unweighted, while 13 are in the top 50 weighted. Of the 21 second-tier jurisdictions that are signatories to the New York Declaration on Forests (United Nations, 2014), 8 are in the top 50 unweighted, while 9 are in the top 50 weighted.

DISCUSSION

Second-tier governments possess a range of authorities that can be used to reduce deforestation. But there is a great deal of variation across countries. The countries where second-tier governments possess the most authority for reducing deforestation, among the 30 we studied, are India, Brazil, Indonesia, Malaysia, Papua New Guinea, Peru, China, Laos, Mozambique, and Vietnam. International initiatives focused on supporting second-tier governments to reduce deforestation would do well to upweight support toward states and provinces in these countries, while also taking into account deeper country-specific knowledge.

In contrast, second-tier governments possess the least authority in Central African Republic, Gabon, Angola, Madagascar, Bolivia, Cambodia, Cameroon, Guyana, Suriname, Thailand, and Venezuela. In these countries international support for reducing deforestation might be best directed toward the national governments. Consideration of the authority of second-tier governments shifts the list of jurisdictions that could be a priority away from jurisdictions in Africa (Angola, Cameroon, Republic of Congo) and Latin America (Bolivia, Colombia, Suriname, Venezuela) and toward jurisdictions in Asia (India, Indonesia, Malaysia, and Papua New Guinea).

Authorities also vary considerably in the degree to which they are possessed by second-tier governments. The authorities most often possessed by second-tier governments include development planning, taxation, budgeting, and road infrastructure. Initiatives for reducing deforestation would generally do well to focus support on second-tier governments' commitments and actions in these sectors.

In contrast, the authorities least often possessed by second-tier governments include authority for land ownership, police, permits for mining, Indigenous affairs, and protected areas. Initiatives for reducing deforestation would do well to focus support in these sectors on national governments.

Our data set on the relative authority possessed by second-tier governments in different countries, when complemented with deeper country-specific knowledge, can be used by forest conservation initiatives to prioritize support across countries and sectors.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/**Supplementary Material**.

AUTHOR CONTRIBUTIONS

JB designed the study and wrote the paper. OA collected the data and constructed the database.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/ffgc.2020.00001/full#supplementary-material>

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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