Roads and Deforestation: Do Local Institutions Matter?

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ROADS AND DEFORESTATION: DO LOCAL INSTITUTIONS MATTER?*

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ABSTRACT

We study the role of subnational institutions in forest conservation in a context in which areas near roads are prone to deforestation. We develop an index of institutionalism to examine the extent to which local institutions can contribute to mitigate the road infrastructure's adverse effect on deforestation. Using a large dataset from Peru, home to the second largest portion of the Amazon rainforest, we find that a higher value of our index of local institutions is significantly correlated with lower deforestation. However, the effect of our institutions index is not sufficiently large to offset the deforesting effect that closeness to roads has, at least not for relatively short distances to road. These results are robust to different specifications of our institutions index and to the inclusion of a large set of control variables.

Keywords: Environment and development, deforestation, infrastructure, institutions.

JEL Codes: D02, O18, Q56.

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1. INTRODUCTION

Forests stand for 31% of the earth's surface and provide valuable ecosystem services. Forests are one of the most important habitats of biodiversity in the world and are a source of raw materials (timber and non-timber products), food, medicine plants and fuel for more than a billion people. They further provide regulation services such as a carbon sink of greenhouse gases (GHGs) and the hydrological cycle regulation (FAO & PNUMA, 2020).

Despite their importance, forests have been deforested and degraded at an alarming rate. Deforestation, the conversion of forests to a non-forest use, is a driver for biodiversity loss, water scarcity, and climate variability to mention only a few of its detrimental effects (TEEB, 2010; FAO & PNUMA, 2020). Worldwide, around 10 million ha were deforested annually from 2015 to 2020, despite it is a lower rate compared to 16 million ha per year during the 1990's; deforestation is not only increasing but also forests are more vulnerable to fires, invasive species, pests and natural extreme events (FAO & PNUMA 2020).

Deforestation is a global problem, and it is particularly challenging in Peru, where forests stand for 57.3% of the country´s territory. Peru is the ninth country with the largest forest area in the world (with 73.24 million ha–Mha), the fourth country with the largest area of tropical forest in the world and the second one in South America, after Brazil (FAO & PNUMA, 2020; INEI & SERFOR, 2021). Peru is the fifth country most affected by deforestation in South America, after Brazil, Paraguay, Bolivia, and Colombia (GFW, 2019). From 2001 to 2021, Peru reduced 2.77 Mha of tree cover (GEOBOSQUES, 2022);[1] increasing its contribution to land use change which stands for 53% of the national GHG emissions (MINAM, 2021).

In Peru, since the 1990s policies and a suitable institutional framework were established to improve sustainable forest management and to discourage forest loss. In 1990, the Peruvian National System for Natural Protected Areas (SINANPE, for its acronym in Spanish) was created to manage efficiently the protected areas. In 2000, the new Forest and Wildlife Law (Law No 27308), and the latest Forest and Wildlife Law in 2015 (Law 29763) provide a framework for sustainable forest management. Moreover, national agencies were created to support sustainable forest management and investment, such as the Office for Forest Resources and Wildlife Supervision (OSINFOR) in 2008 and the National Forest Service (SERFOR) in 2011.

In early 1990s, in the context of macroeconomic structural reforms, several Latin American countries implemented investments in road infrastructure with the aim to connect people to markets and stimulate regional economic development (Vásquez and Bendezú, 2008). Aware of potential negative side effects of the road network expansion (e.g., increase in incentives to log or convert forested areas into alternative uses) (Chomitz and Gray, 1996; Souza Jr. et al., 2013),[2] national governments executed a number of policies to reduce deforestation, including the creation of programs of payment for ecosystem services (PES), and the formalization of indigenous communities' land rights.

In terms of law implementation and enforcement, especially in the developing world, legal protection may differ from real protection, which renders unsurprising to see that the law, usually enacted at the national or regional levels, can be flouted at the local level, particularly in contexts with weak local institutions.[3] In such scenarios, local organizations, by enforcing national government's laws, may be fundamental to the success of natural resource management schemes. Despite the increasing awareness of the potential importance of local institutions in forest conservation, the literature has markedly focused on institutions established at the national (see e.g., Moreira-Dantas and Söder, 2022) or federal level, which arguably overlooks the complexity of local dynamics that may ultimately affect the forest use and conservation.

Departing from the conventional national-level approach, we study the role of subnational institutions in forest conservation in a context where areas near to roads are prone to deforestation. We develop an index of institutionalism to examine to what extent local institutions can contribute to mitigate the road infrastructure's adverse effect on deforestation. We understand the role of institutions as provider of public services to improve

1 An area slightly great than Haiti and equivalent to two thirds Switzerland.

2 Additionally, growing mega-infrastructure road projects are part of the international multilateral financial agencies' portfolio, valued in 70 billion dollars, and 79% of the projects are in the Andean-Amazonia (Bolivia, Ecuador, and Peru) (Ray et al., 2019).

3 For instance, companies may avoid compliance with laws and regulations due to a sporadic monitoring and enforcement (Dasgupta et al., 2000).

citizens' well-being, following Fung (2015), who propose that governance is effective if it is capable to provide public goods and services such as education, care for indigent people, and a safe environment for the community. For this purpose, we construct an institutional index that includes measurements of services provision at the local level: waste collection, citizenship (identity registration), police control actions, transparency, among others. This novel approach is based on the idea that effective institutions are part of the mechanisms used to exercise governance in a country (Kaufmann et al., 2010; DESA-UN, 2016). We find that deforestation is higher in areas near roads (deforesting effect) and that a higher value of our index of local institutions is significantly correlated with lower deforestation (conservation effect). In areas located within relatively short distances from roads, the deforesting effect outweighs the conservation effect, while such effects cancel out for longer distances from roads.

The remainder of the paper proceeds as follows. Section 2 discusses the related literature. Section 3 provides background information about the Peruvian rainforest and the development of roads in the area under scrutiny. Section 4 presents the data. Section 5 explains the construction of our indices of institutions and describes our empirical strategy. Section 6 discusses our main results and Section 7 concludes.

2. RELATED LITERATURE

The literature investigating the drivers of deforestation in the Amazon has significantly grown over the last few decades. From that literature, we can distinguish between the proximate causes (also called direct drivers) and the underlying driving forces of deforestation (indirect drivers)(Geist and Lambin, 2001). The most frequently cited direct driver of deforestation is agricultural expansion (Barbier, 2001; Gibbs et al., 2010; Leblois et al., 2017), followed by the conversion of forest to pastures, logging, and the construction of infrastructure (Carr, 2004). On the other hand, the indirect drivers include demographic (population density), economic (markets and prices), institutional and policy factors (e.g., development, agricultural, and land use policies) (Armenteras et al., 2017; Zwane, 2007; Geist and Lambin, 2001).

An alternative classification of the drivers of deforestation is to sort them from the most exogenous to the most endogenous, as in Busch and Ferretti-Gallon (2017)'s meta-analysis of 121 studies; namely, biophysical characteristics (slope, elevation, and the like), market demand for commodities (agriculture and timber production), infrastructure (proximity to roads and markets), demographic and socioeconomic characteristics (poverty, income, social programs), and ownership and management rights (protected areas–PAs, payments for ecosystem services–PES, land tenure security, community forest management). Those authors report results in line with the existing literature, confirming the negative role of agriculture on deforestation, as well as that of physical infrastructure (e.g., proximity to roads, more deforestation) and PAs (less deforestation, which comes from remoteness and legal status), among others. No consistent role for community forest management or land tenure security has been found. On the other hand, while the results for PES are encouraging (the link between income in exchange for conservation seems to work), the evidence comes from only 5 studies (out of 121). Moreover, Samii et al. (2014) from 1382 articles on PES programs identify 11 that performed a quantitative impact assessment. These programs are located in Costa Rica, China, México and Mozambique. The authors conclude that the PES programs focus on deforestation reduction have on average reduced the annual rate of deforestation by 0.21 percentage points. Additionally, they point out that PES programs have worse effects in poor areas with lack of institutional capacity.[4]

Regarding road infrastructure in the Amazon, Barber et al. (2014) find that nearly 95% of all deforestation occurred within 5.5 km from roads or 1 km from rivers. Armenteras et al. (2017) review three decades (from 1990 until 2014) of deforestation studies in Latin America and the Caribbean, with a total of 369 studies, including 174 with information on deforestation drivers. The authors report that infrastructure is referred as a driver in 12.5% of them. Damania et al. (2018) is to our best knowledge the only study examining the trade-off between economic progress and the ecological destruction resulting from road infrastructure. The authors reflect on the challenges involved in managing such trade-off, to ensure a positive net impact of economic development, a concern that Asher et al. (2020) address for India,[5] and that we use as motivation in this paper.

There are three important institutional responses implemented by several countries to preserve the biodiversity and protect the forest: the creation of (strict or mixed-use) PAs, land titling, and PES programs. The literature has examined the effect of those responses on forest conservation. For the case of the Amazon, Barber et al. (2014) and Miranda et al. (2016) find that PAs have mitigating effects on forest clearing in Brazil and Peru, respectively. Further, Pfaff et al. (2015) find that PAs reduce deforestation in Brazil, correcting for the location bias (PAs are typically located in less-prone-to-deforestation areas),[6] and Aguirre et al. (2021) find that natural PAs can help reduce deforestation in the presence of a growing road network in Peru. Distinguishing between strict versus mixed-use PAs, Blackman (2015) studies the Guatemala's Maya Biosphere Reserve, the largest park in the country, and finds that mixed-use PAs–which allow sustainable extractive activities–are more effective than strictly PAs, because of the operation of forest concessions. Again, correcting for non-random location yields smaller effects.

Boilat et al. (2022) analyze the relationship between PAs and land tenure regimes on forest loss in Bolivia. They conclude that the enforcement of PAs and well-defined collective and private land property rights are key instruments to reduce deforestation in the tropics. Sims (2010) advances our knowledge of the local socioeconomic

4 To this extent, Giudice and Böner (2021) assess the cost and benefits of the Peruvian Programa Bosques, an incentive-based conservation scheme, to reduce deforestation and conclude that the program had a very small impact on reducing deforestation, while having high implementation and administrative costs

5 These authors find no effects of rural roads but a substantial negative effect of highways on deforestation.

6 The authors find that the effect of PAs on deforestation drops to half when such bias is corrected, and that such impact is greater in locations near roads and cities, as expected.

impact of strictly PAs in the case of Thailand. The author finds that PAs decrease the amount of land available for agriculture (thus reducing deforestation), while increasing consumption and lowering poverty rates, an effect likely driven by an increase in tourism in protected areas. Similarly, Sims and Alix-García (2017) analyze the role of PAs and PES programs in Mexico, not only on forest conservation but also on poverty reduction and population change, at the local level. The authors report the effectiveness of both policies on forest conservation, with the PES programs having small but significant effects on poverty, and PAs displaying a rather neutral effect.

On the other hand, while the literature acknowledges the importance of institutions for forest conservation, its empirical evaluation is scant (Sills and Jones, 2018) and has mostly followed a macro approach. For instance, Bhattarai and Hammig (2001) study the Environmental Kuznets Curve hypothesis–the relationship between environmental quality and income–and the role of political institutions[7] and macroeconomic policies in 66 countries from Latin America and the Caribbean–LAC, Africa and Asia during the period 1972-1991. The authors find that an improvement in institutions would reduce the level of tropical deforestation worldwide, particularly in LAC and Africa. Likewise, Barbier (2001) analyzes the influence of institutional factors–measured by indices of corruption, property rights, and political stability, borrowed from Levine et al. (2000)–on land use in tropical countries around the world, for the period 1961-1994. In this case, the political stability index is the only that is positively correlated with the increase in agricultural land expansion for the Latin American countries.[8]

Evidently, it is difficult to properly capture the micro dynamics of deforestation using macro-level data. However, the analysis of the role of local institutions for reducing deforestation is quite scarce in the literature, and the existing studies only address partially the issue. This is especially serious in Latin America, where despite some attempts made by Bolivia, Ecuador and Peru to implement forest concessions in the Andean Amazon region (Barrantes et al., 2005), an effective forest management remains a crucial challenge for governance (Nolte et al., 2017). To our best knowledge, Bonilla-Mejía and Higuera-Mendieta (2019) and Benzeev et al. (2022) are two of the very few studies that highlight the importance of local institutions for forest conservation in the region. However, the former study only examines a very particular mechanism–strict-use PAs–in Colombia and does not address the role of institutions in a comprehensive manner, while the latter study does examine the relationship between certain local-level governance variables and municipal-level deforestation in Brazil but finds no clear relationship between governance and deforestation.[9]

To sum up, though some of the existing literature does examine the effect of some institutional interventions, such as PAs, PES, forest concessions, and property rights on forest conservation, and does highlight the importance of national level institutions in this pursuit, limited studies assess the role of institutions measured at a local level in forest conservation. To overcome this limitation, we construct an index that measures institutions' performance at the local level focusing on the services local governments provide to citizens. This approach is aligned with recent literature that advocates placing the citizen at the center of the governance concept (DESA-UN, 2016; Fung, 2015). If institutions are effective in providing public services, citizens will be willing to comply with regulations and laws, and in the context of this study, to reduce or avoid deforestation. Thus, we analyze the role of this novel index in the reduction of deforestation in a context in which areas near roads are more prone to deforestation.

7 The authors use the Freedom House indices of political rights and civil liberties to construct a simple aggregate index of political institutions (measured in a 2-to-14 scale).

8 On another angle of the problem, Afawubo and Noglo (2019) study the role of international remittances on deforestation for 106 developing countries. The authors highlight the importance of institutional quality in enhancing the deforestation-reducing effect of international remittances for the period 1996-2004. Using four macro measures of institutional quality–political stability, control of corruption, government effectiveness, and rule of law–the authors find an effect of institutional quality for middle-income countries but not for low-income countries.

9 Some variables have a negative relationship with deforestation (e.g., the existence of an environmental fund, non-agricultural employees and a female major), while others (e.g., the number of agricultural companies) show the opposite correlation. These results show the complications that arise when using variables that proxy for governance, instead of an index.

3. BACKGROUND

Peru is home to the second largest rainforest extension in Latin America, the fourth largest area of tropical forests in the world, and the tenth largest extension of trees on the planet (FAO, 2016). With 73.28 million hectares (Mha) of forest, which account for 57.3% of its territory (Peruvian Ministry of Environment, 2016), Peru has 15 regions (out of 25) with some forest cover.[10] The forest cover is heavily concentrated in three regions (Loreto, Ucayali and Madre de Dios), with 76.36% of the forest cover (FAO and SERFOR, 2017).

As in other countries, the forest cover loss in Peru has increased during the last decade. With an average forest loss of 105,221 ha in the period 2002-2010, the figure increased to 156,578 ha in 2010-2021. The 137,976 hectares lost in 2021 are equivalent to 192,401 soccer fields or 51.3% of the area of Metropolitan Lima, the heart of the country's capital. Interestingly, using data from the Andean Amazon (Peru, Colombia and Ecuador) for the last 17 years, MAAP (2018) reports that most of the forest loss is small-scale: 74% of the deforestation events occurred in areas smaller than 5 ha, 24% took place in areas with between 5 and 100 ha, and only 2% happened in areas with over 100 ha (mainly related to agro-industries).

Our study area includes the 9 regions with rainforest that registered some deforestation in the period under study, 2001-2017: Amazonas, Cusco, Huánuco, Junín, Loreto, Madre de Dios, Puno, San Martín and Ucayali, which jointly account for 93.4% of the total forest loss in that period. The regions under scrutiny comprise the entire Peruvian Amazon and some part of the Andean regions which have rainforest.[11] Figure 1 shows the events of deforestation registered in those regions during 2010-2017,[12] by quintiles of percentage of deforested area, at the grill level (we used cell grills of 25 km2, whose details are provided in Section 4). We can see that four regions, Huánuco, San Martín, Ucayali, and Madre de Dios, comprise the largest deforested areas, as a percentage of the total forest.

[Figure 1 here]

We will focus our statistical analysis on the situation prevailing in 2017. Figure 2 reports how the intensity of deforestation by district (per quintiles of deforested hectares) progressed from 2001 to 2017 for the 9 regions under study. As shown in the figure, the largest areas of forest loss in 2001 were registered in Huánuco (with a total of 2.535 ha), Cusco (2.335 ha) and Junín (2.242 ha) regions located in the central and southern Peru. In 2010, with an increased deforestation, the largest areas of forest cover loss moved to the regions of San Martín (6.519 ha), Huánuco (3.705 ha), and Madre de Dios (3.479 ha). Then, in 2017, the forest loss was concentrated in Madre de Dios (6.824 ha), Ucayali (3.590 ha) and Cusco (3.275 ha). These figures account for the geographic variation in deforestation levels at the district level that occurred over the period of study.

[Figure 2 here]

On the other hand, the road infrastructure significantly grew in the Peruvian Amazon during the period 1955-1965: 440%, vis á vis the 72% growth rate registered in the rest of the country. The following three decades, there was a modest growth in road infrastructure in the country, but the expansion of the road network resumed during the first decade of the 21st century, reaching a pace comparable to that registered in 1955-1965. Although the expansion of the road network in the Amazon was unequal across regions, its overall goal was to complement the navigable river network, enable the extraction of natural resources, and promote access to markets (Barrantes et al., 2014). Still, large areas of the country remain non-connected to roads, as shown in Appendix Figure A1, especially in the remote areas of the Amazon (in particular, Loreto, Ucayali and Madre de Dios) where roads are substituted by navigable rivers.

10 The political division of Peru includes 25 regions (akin to a US State), 196 provinces, and 1,874 districts. Each district and province have a mayor and each region has a governor, all elected for four years. The regional governments are public offices with political, administrative and economic autonomy, in charge of the administration of the regions. These governments were created to gradually take on functions of the central government amidst of a regionalization process that started in year 2000 in Peru.

11 It is possible to think that the Andes and the rainforest are eco-zones with different dynamics between institutions and deforestation patterns. This may be true even though a given region or province may comprise Andean and rainforest areas. Our analysis will address this concern in Section 6.2.

12 While we could update the deforestation figures until 2019 or later, the main variables used in our analysis (e.g., road network, protected areas, crops information, socioeconomic information) would remain practically unchanged (there is almost no more recent district level information), which explains why we examine the prevailing conditions as of 2017.

4. DATA AND DESCRIPTIVE STATISTICS

We use geospatial data on forest cover loss for 9 Peruvian regions mentioned earlier which comprise 96.97% of the total forest cover in the country, as of 2017. These data come from the Geobosques Landsat TM satellite. We created cell grills of 25 km2, which allows us to get 32,685 observations, spanning 610 districts, which represent 33% of all the country's districts.

For each grill in our sample, we compute the deforested area per km2 and the Euclidean distance (in km) from the centroid of each grill to the nearest (national, regional, and local, paved and unpaved-gravel and dirt) road in ArcGis. We use several sources to gather information for variables that the literature reports as potential correlates of deforestation (Table 1 reports the sources of information). We compute the percentage of the grill located in a natural protected area–NPA, a regional conservation area–RCA or a private conservation area– PRICA.[13] Weather information–annual average temperature and precipitation–comes from satellite data. Elevation data (altitude of the centroid of the grill), in meters above the sea level, come from a Digital Elevation Map. Distances (in km) to the nearest navigable river (which proxy for access to markets, especially in the rainforest areas) and to town were calculated from the centroid of each grill analogously to distance to roads. Further, we use the location of indigenous communities (indicator variable), which could be thought of as a mechanism to protect the forest, and data on forest concessions[14] (whether the grill is located in this area).

District-level data include: population density; inequality (Gini coefficient of expenditures); the United Nations Development Programme's human development index (HDI) (which includes data on life expectancy, education, and per capita income), and access to water, to proxy for the districts' socioeconomic development; the area sown with crops that could be thought of as detrimental to the forest: coca (as in Cantillo and Garza (2022) for Colombia), coffee, cocoa, and specially oil palm; and information about mining activity. The index of local institutions is constructed using a large set of variables at the district level as explained in Section 5.

4.1 Summary statistics

Table 1 presents descriptive statistics for all variables used in the analysis. At the grill level, our *deforestation* variable indicates that the mean area deforested between 2001 and 2017 is 0.59 km2 (or 2.36% of the grill); the average distance to the nearest road is 47 km, and the maximum is 358.13 km (we see a large dispersion in this variable). We provide information on paved and unpaved roads for reference only. As expected, the distance to the nearest river is smaller than that to roads: 9.77 km, on average, while that to the center of the town is a bit longer: 12.91 km. In terms of the different levels of protection of a geographic area, for the average grill, 17.6%, 3.5%, and 0.26% of it lies within a NPA, a RCA, or a PRICA, respectively. Also, 1.56% of the average grill lies in a private concession area. Further, 14% of our grills lies on an indigenous community settlement. In terms of weather information, the annual average temperature and precipitation are 24.55 °C and 2,193.6 millimeters, respectively. Finally, the altitude varies between 70 and 4,524 meters above the sea level, with an average of 796.

At the district level, we include population density, which is rather sparse (9.77 inhabitants per square kilometer, on average), the Gini coefficient (with an average of 0.29), households' access to water (67.29%), mining activity (4.67% of the cases), and several agricultural variables, including the total area sown and area sown with coca (representing 2%, on average), coffee (12.8%), cocoa (6.5%) and oil palm (0.9%). We include these crops because their cultivation requires large fields (especially oil palm), which may encourage deforestation. Finally, 53% of our grills are in Loreto and Ucayali; while the remaining regions comprise individually only between 4% and 10% of the grills.

[Table 1 here]

13 NPAs contracts are managed by SERNANP, while RCAs are managed by regional governments under the supervision of SERNANP and PRICAs are managed by their owners (who can be individuals, companies, or indigenous or peasant communities) and are granted for a minimum of 10 years.

14 Through a forest concession, the Peruvian Forestry Authority grants the right to use a particular forest and/or wildlife resource, for wood and non-wood production, including non-extractive uses such as ecotourism and conservation, as well as the right to profit from the ecosystem services arising from their management (RDE 105-2017-SERFOR-DE).

5. METHODOLOGY

5.1 Measuring institutions at the subnational level

Institutions are part of the way that governance is exercised in a country. However, there is no consensus about how to measure governance systems (Kaufmann et al., 2010). North (1991) defines institutions as the informal constraints (sanctions, traditions, and codes of conduct) and formal rules (constitutions, laws, property rights) that shape the political, economic and social interactions. From a broader perspective, Kaufmann et al. (2010, p.4) define governance as: (a) the process by which governments are selected, monitored and replaced; (b) the government's capacity to propose and implement policies; and (c) the citizen's and the state's respect for the institutions that rule the economic and social interactions.

Clearly, while those definitions provide a general view of what a governance system entails, they offer little guidance on how to measure the role of institutions on the ground (Beer and Lester, 2015). Among the studies that do provide some guidelines, Scrieciu (2015) proposes to construct indicators measuring environmental policy stringency, and then sort them according to the stage of the decision-making under scrutiny: policy formulation, implementation, operation, and outcomes. Greenstone and Hanna (2014) for India, Hering and Poncet (2014) for China, and Greenstone et al. (2012) for the United States, all perform an intra-country analysis following this approach to evaluate the role of institutions.

Whether one follows a specific approach or not, two methods are available for measuring institutions: to use individual indicators and to construct a composite index. In the former case, the individual variables may include democracy (Laegreid and Povitikina, 2018), policies for urban development, property rights, and management (Geist and Lambin, 2002). In this regard, a meta-analysis by Wehkamp et al. (2018) highlights the use of variables such as environmental policy, NGOs participation, political rights, regulation compliance, and democracy. In the case of composite indices related to governance, examples include the Worldwide Governance Indicator (WGI), which comprises six clusters: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption. While it is typical that indices weigh equally all variables, this practice overlooks the relative importance of each variable. For instance, Bhattarai and Hammig (2001) build a political institution index as the sum of 14 categorical variables that measure political rights (fair election laws, the role of the opposition party in the political process) and civil liberties (free press and media, rule of law, open public discussion, and protection of personal property rights). A common feature in this literature is the focus on institutions measured at the national level, because data are readily available, which makes it easier to define an institutional setting at that geographical level.

However, none of those indicators measures the role of institutions at the local level although this is the level where most institutions, formal or informal, operate. In fact, measurements of institutions at a subnational level are quite scarce.[15] One of the few exceptions is Beer and Lester (2015), who measure indices of institutional thickness (referred to the richness and government processes in a locality)[16] and institutional effectiveness (which measures the interaction between institutional processes and economic development outcomes) for Australia at the local level, using thirteen variables (aggregated linearly), including business accessibility score, percentage of volunteering, education level, per capita spending in local roads, and unemployment rate, among others. A related index is the Regional Competitiveness Indicator (INCORE, for its acronym in Spanish) developed for Peru, which uses 40 indicators measured at the regional level, assembled in six pillars (economic environment, infrastructure, health, education, labor, and institutions), where the institutional component includes variables such as citizens' safety, social conflicts, level of public investment execution, judiciary cases resolutions, and per capita tax collection (IPE, 2020).[17] To our best knowledge, no other regional-level institutional index has been developed for Peru. And we are not aware of any local-level index, either.

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15 A more common approach is to include variables that capture some dimensions of institutions in the analysis. For instance, in a recent study, Fischer et al. (2021) examine the interplay between governance elements (land tenure, forest management, law enforcement, institutions, and participation) and deforestation for a reduced sample of landscapes in Ecuador.

16 'Thickness' means that institutions promote growth and provide numerous pathways to development (Amin and Thrift, 1995) as cited in Beer and Lester (2015).

17 INCORE replicates the methodology used by the World Economic Forum to construct the Global Competitiveness Index and is used to monitor the regional socioeconomic progress in Peru (IPE, 2020).

Given our aim to construct an institutional index at the district (municipal) level, we will adapt the variables measuring institutions at the national governance indicators to the ones that are more related to the citizens' living standards and services received from local public organizations. Based on data availability, we choose variables related to three dimensions: social conditions (education, life expectancy, low weight at birth); beliefs, values and culture (participation in elections, and transparency of information); and local performance (public expenditure, infrastructure, waste and environmental management, safety, and citizenship). We were able to collect information for 1851 out of the 1874 existing districts in Peru. Table 2 shows the descriptive statistics of the variables selected and Appendix Table A1 presents the sources of information. Some descriptive statistics of the local government data, show that on average people have 6.3 years of education (meaning they finished elementary school); the life expectancy is 74.4 years; only 19% of the districts has a working Web page (for transparency); an average of 73% of the budget is actually spent in the district, and only 40% of the waste is collected in the rural area of the districts. In general, we see a significant variation across districts in the variables used for the index.

[Table 2 here]

As explained below, we follow two complementary approaches to develop our index of local institutions: construct a typical linear index and a composite index applying a principal components analysis.

5.2 Constructing a local institutions index

A critical issue in measuring institutions using a composite index is how to aggregate the selected variables (Nardo et al., 2005). As mentioned earlier, we use two methods to construct our institutions index: an equally weighted linear combination of a set of variables selected following the literature (e.g., Beer and Lester, 2015; IPE, 2020; Kaufmann et al., 2010), and the Principal Components Analysis (PCA). For the linear index, we use several specifications, depending on the number of variables included. Our base case uses 17 variables (I-17), and additional indices use from 19 (I-19) to 23 variables (I-23). In all cases, each variable is transformed in an indicator that is equal to one, if a district registers a value for that variable that falls in the upper (or lower) quartile among all observations in our sample, if the variable represents a positive (or a negative) trait of institutional quality.[18] By construction, a greater value of this index is related to a stronger institutional effectiveness, and vice versa. The average of the index for our base case (I-17) is 5.81, with values ranging between 1 and 12, while that for our most extended case that uses 23 variables (I-23), has a mean of 7.73 and values ranging between 1 and 17 (see bottom of Table 2).

On the other hand, outside the institutional topic, a more common methodology of aggregating variables to build a composite index is to use a Principal Components Analysis (PCA),[19] which reduces the dimensionality of a large set of variables, minimizing information loss (Jolliffe and Cadima, 2016). The technique creates a set of new orthogonal variables, called principal components, as linear combinations of the original variables. The first component has the largest possible variance (the second one has the second largest variance, and so on), meaning that it explains the largest part of the variance of the data. The second component needs to be orthogonal to the first one and the subsequent components are calculated analogously (Abdi and Williams, 2010; Jolliffe and Cadima, 2016). The importance of each component is reflected by the proportion of the total variance explained by the component. This technique allows to use loadings as weights to build a composite indicator (Nardo et al., 2005; OECD, 2008).

There are several ways to choose the number of components to keep in the estimation. Two of the most common ones include to keep the components with eigenvalues greater than 1 (Kaiser, 1974; Nardo et al., 2005) or those that jointly explain more than 60% or 70% of the total variance in the model (Abdi and Williams, 2010; Nardo et al., 2005). As shown at the bottom of Appendix Table A2, in our 6 specifications (PC-17 to PC-23), between 5 and 7 components have eigenvalues greater than 1, and those components explain between 57.3% and 57.7% of the total variance. We use the criterion of eigenvalues being greater than 1 to keep the principal components, which leads

18 While the threshold used is arbitrary, it serves well the purpose of reflecting the intensity of the indicator variable we selected. Furthermore, based on recent literature on governance and deforestation (e.g., Wehkamp et al., 2018), we know that some variables constitute a positive institutional trait (e.g., voting rates), while others may represent the opposite (e.g., corruption). We take this into consideration in the construction of our index.

19 The PCA is a well-known multivariate statistical technique formalized and named by Hotelling (1933); see Abdi and Williams (2010) for details. The PCA has been used by some previous studies on deforestation (e.g., Fischer et al., 2021).

us to prefer indices PC-17, PC-20 and PC-22. Another important indicator used in the PCA is the Kaiser-Meyer Olkin (KMO) index, which measures the sampling adequacy, the degree to which each of the variables, is predictable from the other, with values ranging between 0 and 1 (Kaiser 1970, 1974). The minimum KMO index value for an adequate factor analysis is around 0.60 (Abdi and Williams, 2010; Nardo et al., 2005; Tabacknick and Fidell, 2001) while 0.80 guarantees reliable results (Kaiser, 1974). As Appendix Table A2 shows, the overall KMO is greater than 0.80 in each of our 6 specifications.

On the other hand, the loadings in the PCA show the correlation between the variable and the component; values between 0 and 1, and their size indicates the importance of the variable in the component. As an example, Figure 3 shows the loadings for the first component in PC-17 and PC-20 (similar loadings are obtained for PC-22). As seen in the figure, variables providing services–number of workers in the local government, number of police stations, number of kids younger than 30 days of birth with an identification document (ID), and the existence of a portal with information that increases transparency–have loadings larger than 0.3. The second group of variables, with loadings between 0.20 and 0.30, is also related to services, such as police actions and control, and waste collection. Education, which is a variable that measures social conditions, is also important in the first component, with a correlation close to 0.3. The figure also shows that the loadings are very similar among the two specifications.

[Figure 3]

An unexpected result is the negative but small loading for the budget effectiveness (percentage of the total budget actually spent at the end of the year) in each district. A possible interpretation is that this variable is less important for the citizens than the services provided with that budget. On the other hand, the variable "infrastructure project" has a small loading. This result is justified because those type of projects are developed more by the regional or national governments and it is not perceived as part of the local government institutions' effectiveness. Appendix Figure A2 shows the geographic distribution of our institutional index at the district level using the specifications PC-17 and PC-20. We can see that districts along the coastal line are more likely to fall in the top quintiles, in contrast to those in the Amazon, which is a sensible result.

5.3 Estimation

Our base specification to measure the role of institutions that mediates the relationship between deforestation and road infrastructure, examines the role of closeness to roads, the importance of institutions and an interaction term, as follows:

$$Y_{idr} = \alpha_0 + \alpha_1 Distance\ to\ road_i + \alpha_2 Institutions_d + \alpha_3 Institutions_d * Short\ Distance_i + \alpha_x X_i + \alpha_z Z_d + \varphi_r + \varepsilon_{idr}, \quad (1)$$

where Y_{idr} represents the forest loss (in km²) registered in cell grill i, located in district d, region r in the period 2001-2017; $Distance\ to\ road_i$ denotes the nearest distance (in km) to roads, from the centroid of cell grill i (considering paved and unpaved national, regional, and local roads); and $Institutions_d$ represents our institutional index (in its linear version or in its PC version), measured at the district level. $Short\ Distance$ is an indicator that equals 1, if the centroid of the grill lies within the 25th percentile of all distances to road; and 0, otherwise (we consider alternative distances as well). The interaction term between $Institutions$ and $Short\ Distance$ assesses the complementarity between the two variables in reducing deforestation. Thus, a negative (or positive) α_3 would imply that both variables, acting together are negatively (positively) correlated with larger deforestation levels, with the effect of institutions dominating (being dominated by) that of the closeness ('short' distance) to roads.[20]

The set of correlates of deforestation are measured at different levels. First, at the grid level, X_i includes indicators of whether the grid is in a Natural Protected Area, a Regional Conservation Area, or a Private Conservation

20 We chose this indicator variable, instead of the continuous variable distance to road, to better assess the role of local institutions in the vicinity of roads. We consider alternative definitions of this indicator in the robustness analysis performed in Section 6.1.

Area;21[21] in addition to altitude (in meters above the sea level), annual average temperature (in Celsius degrees), and annual average rainfall (in millimeters). Second, at the district level, z_d includes population density, total agriculture acreage, hectares sown with coca leaves, coffee, cocoa, and oil palm (these crops, especially oil palm, are land intensive, and its profitability may be correlated with greater deforested areas), the Gini coefficient of expenditures (to proxy for the district's inequality). Third, we include region fixed effects, φ_r, to control for different (social, economic, political) dynamics across regions.[22] In our robustness analysis, we consider alternative specifications and focus on relevant subsamples (Section 6.1). Furthermore, unlike most of the literature, we correct the standard errors for clustering at the district level in all estimations.[23]

6. Results

Given the results from Section 5, we use four specifications for our institutions index, two using our linear version, with 17 (I-17) and 20 (I-20) equally-weighted indicator variables and two using the weighted combinations given by the corresponding PC loadings (PC-17 and PC-20). Similar results are obtained using alternative indices (I-22, PC-22). We use the same set of control variables in all specifications. Table 3 shows the results from the estimation of equation 1 for all sample.

The first main result is that the presence of stronger local institutions is significantly correlated with lower deforestation levels. And this holds for both the linear version of the index and the principal component versions, regardless the number of variables included in the index.[24] This is in consonance with previous studies (e.g., Fischer et al. (2021) for Ecuador). Given the higher weight given to the variables related to services received by the population in the institutional index (e.g., police services, number of public workers at the district level), this negative coefficient of the institution index, may imply that when services are provided, people tend to avoid deforestation. Further, for all specifications (columns 1 to 4), the interaction term that measures the effect of institutions in the relationship between roads and deforestation is significantly positive, meaning that the deforesting effect that access to roads has dominates the protecting role of stronger institutions, for all sample.

[Table 3]

Further, areas located near roads are more deforested, which supports the usual negative correlation between infrastructure and deforestation (e.g., Armenteras et al., 2017; Bax et al., 2016; Scrieciu, 2007; Vergara et al., 2014). On the other hand, grills located in National or Regional Protected Areas are less deforested, a common result in the literature (e.g., Barber et al., 2014; Bonilla-Mejía and Higuera-Mendieta, 2019); however, the private protected areas have no effect on deforestation. The aforementioned results control for agricultural production of main crops (coffee, coca, cocoa, and oil palm), altitude, weather (temperature and precipitation), population density, and inequality.

6.1 Robustness checks

We conduct four robustness checks, related to: our definition of 'short distance', the set of control variables used in the estimation, the type of road examined (paved or unpaved), and the use of distances within a province instead of all distances in our sample. First, we consider alternative definitions of what we mean by 'short distance'. Since as we increase the length of 'distance', the role of closeness to roads (the coefficient on distance to road) weakens, we should focus on changes in the coefficients of institutions and the interaction term in this case. Using six (arbitrary) versions of distance—within the first decile (1.06 km), 10 km, 20 km, 29 km (the median distance), 50 km (slightly more than the mean distance), and 79 km (the percentile 75)—we see that the role of

21 Though NPAs were created to preserve biodiversity, and not to prevent deforestation, prior studies have found an effect of protected and conservation areas on deforestation (e.g., Barber et al. (2014), Miranda et al. (2016), and Boillat et al. (2022)). We thus include those three variables that capture different types/levels of protection and conservation, as they may serve as natural deterrents of overexploiting the forest.

22 While we could have used province fixed effects, this administrative level does not have as much influence as the regional level has in political terms (the regional governments are autonomous entities elected every four years, in charge of implementing the regional planning, executing public investment projects, and promoting economic activities). In regard to district fixed effects, this is not implemented because several districts in the sample have few grills-observations.

23 Using the typical robust (only to serial autocorrelation and heteroscedasticity) standard errors would yield smaller standard errors than the ones we obtain in this paper.

24 Though we report results for two versions of our linear index for the sake of space, we considered six specifications in total. Our main result, in terms of the importance of institutions, is robust to using any of those indices or their PC versions. Results are available upon request from the authors.

institutions, measured by the linear index, is the strongest when distances to road are between 1.06 km and 50 km: the coefficient of Local institutions remains significant, as seen in panels A to E, columns 1 and 2 of Appendix Table A3, but weakens for longer distances (see panel F: 79 km). Interestingly, when we look at the PC index instead (columns 3 and 4), for all definitions of 'short distance', the coefficient of Local institutions is always significant and the point estimates do not vary much. This could indicate that the data aggregation using this technique is more robust than when we use a linear method.[25]

Second, we could worry that our base specification left some relevant correlates of deforestation out. Following the literature, we add a large set of variables at the grill and district levels, namely: (i) measures of remoteness of the grill and further connection to markets (distance to the nearest river and distance to downtown), (ii) the presence of activities or settlers that may affect deforestation (whether the grill is located in a settlement occupied by a native community, or in a forest concession, or whether the district registers any mining activity), and (iii) measures of the district's socioeconomic development (the human development index and the households' access to water). Appendix Table A4 shows that adding this set of correlates, validates our original finding about the importance of institutions: The point estimates of local institutions increase in absolute value, which goes hand in hand with a reduction in the magnitude of the coefficient of the interaction term. Thus, the new coefficients, estimated with more precision, do not involve a weaker role in the mitigation of the deforesting effect of closeness to roads than in our base specification.[26] This applies to all four specifications of the index used.

Third, we could think that the connection between deforestation and closeness to roads may depend on the type of road infrastructure under scrutiny: paved or unpaved.[27] As shown in Appendix Table A5, when we consider only the distance to paved (national, regional, and local) roads, the coefficients of institutions and the interaction term continue to be highly significant (at 99%) for both types of institution indices (columns 1 to 4). Moreover, the negative coefficient of distance to road is now significant at 99% in all specifications, a result that reflects the importance of paved road infrastructure (versus unpaved) in the increase of deforestation.[28]

Fourth, we may want to consider only distances within a province (and not with respect to the entire sample) to account for the heterogeneity in the size of a province or its remoteness (e.g., a province in Loreto, region where the average distance to road is 91.56 km, is much less connected than a province in Huánuco, a region where such figure is 5.53 km). As seen in Appendix Table A6, the coefficients of *local institutions* and those of the interaction term between institutions and distance remain highly significant in all specifications (though with smaller point estimates). In regard to the coefficient of distance to road, while still negative, it losses significance when we consider the linear index of institutions (columns 1 and 2), but not when we use the PC index (columns 3 and 4). Again, this result may reflect that the latter index captures better the connection among institutions, distance to road, and deforestation.

6.2 Heterogeneity analysis

In this section, we examine whether the results found for all sample hold when we constrain the sample to the Amazonian regions only and whether the magnitude and significance of the coefficient of the interaction term between institutions and distance to road remain for different sections of the density of distances to road. First, as seen in Table 4, when we exclude the sections from the *Andes* with rainforest from the sample (we do this since we may worry that the deforestation patterns differ between the Amazonian regions and those sections from the *Andes*), the coefficient estimates of *institutions* and the interaction term are similar to those of the entire sample. The significance of the rest of variables is also similar to those in Table 3. Considering that the Andes sections explain only 13.7% of the sample, we can say this is a highly expected result.

25 In fact, the densities of the first principal components for the six indices look similar.

26 We acknowledge that we would need a statistical test to claim that the coefficient of the interaction term is now smaller (stronger role of institutions), but the smaller point estimates suggest a stronger role of institutions in the presence of roads.

27 However, it is unclear whether we should expect a stronger effect on deforestation of paved vis-á-vis unpaved roads. On the one hand, paved roads could make easy to transport logged timber but on the other hand the greater connection to markets may reduce the need for logging as a means to earn income.

28 Performing the analysis considering only unpaved roads yields similar results, except that the coefficient of distance to road is significant at 90% in the specifications that use the linear index (the PC index always yields significant coefficients at 99%).

[Table 4]

Second, we wanted to examine at which distances the protecting role of local institutions is stronger, by using indicators for quintiles of distance (and computing quintiles for each province) and their interaction with our institution index. We explore this issue in Table 5. Looking at column 1, we observe that the institutions' protecting role increases with the quintile of distances: the point estimates of the interaction term between institutions and distance to road decrease monotonically, from 0.1037, significant at 99% for quintile 1 (shortest distance: average of 15.6 Km) to 0.0020, non-significant for quintile 4 (average distance of 64 Km), with the quintile 5 as the base category (average distance of 81.8 Km). This pattern is similar in the rest of specifications of our institutional index (columns 2 to 4).[29] This means that while for shorter distances closeness to roads dominates institutions in their relationship with deforestation, for longer distances institutions offset closeness to road. Furthermore, in terms of the relationship between distance to road and deforestation, in general, longer distances are associated with less deforestation, as shown by the decreasing trend in the coefficient estimates for quintiles 1 to 4 (see columns 1 and 2); this pattern is even clearer when we use the PC index (columns 3 and 4).[30]

[Table 5]

29 If we estimate these specifications using the quintiles of distance for all sample, the patterns are similar, though the negative coefficient of local institutions is not significant using the linear index (but it is using the PCA index), and that of the interaction between institutions and quintile 1 of distance is not significant, either. Results are available from the authors upon request.

30 Performing the analysis by deciles of distance confirms that the interaction term between institutions and deciles of distance is only significant and positive until the second decile (decile 10 is the base category), for all specifications of the institutions index we used. Results are available upon request to the authors.

7. CONCLUDING REMARKS

We develop an index of institutions measured at a subnational level to study the role of institutions in the reduction of deforestation. This allows to examine if, in addition to being correlated with less deforestation (first order effect), the protecting role of institutions exceeds the deforesting effect of closeness to roads (second-order effect). Using data from Peru, we find a significant first order effect but an insignificant second-order effect: the effect of closeness to roads dominates that of institutions. This latter result is explained for what happens at grills lying within the quintile of closest distances within a given province; for longer distances, institutions do offset the deforesting effect of closeness to roads. These findings, which are robust to alternative specifications of our institutions index and to the inclusion of a large set of covariates, highlight the importance of a strong institutional setting in remote areas, where the presence of the rule of law may be weaker than in areas nearer to roads.

While our findings apply only to the specific Peruvian regions under scrutiny, the methodology used to construct the institutions index can be replicated to study deforestation in other emerging economies, where the analysis of significant problems at the subnational level is insufficient, partly due to information constraints. Moreover, the discussion about how to determine the weights to build a composite index needs to be deepened, since it could affect the study of the relationship between the institutional index and variables such as deforestation.

A topic for future research is the study of the importance of inter-sectoral policies and coordinated monitoring between the economic sectors and different levels of government (national, regional, local) involved in forest conservation. We leave the analysis of formal vis-à-vis informal institutions in this setting for future research

Furthermore, our analysis could be complemented with the construction of an index of economic pressure for deforestation, as Figueroa et al. (2021) do for Mexico. Together, both indices could provide insights to encourage a broader discussion about the role of public policy in the protection of the environment that should be pursued in the future.

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TABLES

Table 1: Descriptive Statistics

Variable	Description	Source	Year	Obs.	Mean	St. Dev.	Min	Max
Grill level information								
Deforestation	Area deforested of the grill (km^2), 2001-17	Geobosques - MINAM	2017	32,685	0.59	1.63	0.00	23.58
Distance to nearest road	Distance from centroid of grill to nearest road (km)[a/]		2016	32,685	47.04	53.01	0.00	358.13
Distance to paved national road	Distance from centroid of grill in km		2016	32,685	107.08	87.84	0.00	465.37
Distance to unpaved national road	Distance from centroid of grill in km		2016	32,685	239.78	166.90	0.09	812.96
Distance to paved regional road	Distance from centroid of grill in km	Ministry of Transportation & Communications	2016	32,685	118.35	90.50	0.00	471.02
Distance to unpaved regional road	Distance from centroid of grill in km		2016	32,685	181.03	174.30	0.00	700.59
Distance to paved local road	Distance from centroid of grill in km		2016	32,685	108.24	71.95	0.15	456.37
Distance to unpaved local road	Distance from centroid of grill in km		2016	32,685	82.85	80.09	0.00	470.13
Distance to the nearest river	Distance from centroid of grill in km	National Geographic Institute	2016	32,685	9.77	9.03	0.00	75.35
Distance to center of town	Distance from centroid of grill in km	Census data	2017	32,685	12.91	14.50	0.01	92.82
Natural Protected Area (NPA)	Grill is located in a NPA (%)	SERNANP	2017	32,685	17.64	36.96	0.00	100.00
Regional Conservation Area (RCA)	Grill is located in a RCA (%)	SERNANP	2017	32,685	3.53	17.50	0.00	100.00
Private Conservation Area (PRICA)	Grill is located in a PRICA (%)	SERNANP	2017	32,685	0.26	4.13	0.00	100.00
Private Concession Area	Grill is located in a concession area (%)[b/]	SERFOR	2017	32,685	1.56	12.38	0.00	100.00
Indigenous community	Grill is located in an indigenous community settlement	Common Good Institute	2017	32,685	0.14	0.34	0.00	1.00
Temperature	Annual average of temperature (C°)	SENAMHI	2017	32,685	24.55	8.67	0.00	38.16
Precipitation	Annual average of precipitation (mm)	SENAMHI	2017	32,685	2,193.63	828.34	0.00	4,926.70
Altitude	Meters above the sea level of the centroid of the grill	Geophysics Institute of Peru	2017	32,685	796.06	1224.86	70.00	4,524.00
District level information								
Population density	Total inhabitants per km^2	Census data	2017	32,685	9.77	76.72	0.11	10,526.26
Inequality	Gini coefficient (consumption)	Census data	2017	32,685	0.29	0.03	0.20	0.43
HDI	UNDP's Human Development Index	UNDP	2017	32,685	0.35	0.10	0.15	0.72
Household access to water	Access to water in the district (%)	Census data	2017	32,685	0.67	0.27	0.00	1.00
Mining district	District has mining activity	Ministry of Energy and Mining	2017	32,685	0.05	0.21	0.00	1.00
Farming land	Total hectares sown	Census data	2017	32,685	7,986.12	9,851.69	0.51	57,691.90
Coca	Total hectares sown with coca	Census data	2012	32,685	161.39	515.98	0.00	6,564.00
Coffee	Total hectares sown with coffee	Census data	2012	32,685	1,021.45	3,567.51	0.00	20,528.64
Cocoa	Total hectares sown with cocoa	Census data	2012	32,685	519.28	1,376.14	0.00	6,637.80
Oil palm	Total hectares sown with oil palm	Census data	2012	32,685	74.29	482.56	0.00	5,294.42
Regional level information								
Amazonas	= 1, The grill is located in Amazonas		2017	32,685	0.05	0.21	0.00	1.00
Cusco	= 1, The grill is located in Cusco		2017	32,685	0.09	0.28	0.00	1.00
Huánuco	= 1, The grill is located in Huánuco		2017	32,685	0.04	0.21	0.00	1.00
Junín	= 1, The grill is located in Junín		2017	32,685	0.05	0.21	0.00	1.00
Loreto	= 1, The grill is located in Loreto		2017	32,685	0.40	0.49	0.00	1.00
Madre de Dios	= 1, The grill is located in Madre de Dios		2017	32,685	0.10	0.30	0.00	1.00
Puno	= 1, The grill is located in Puno		2017	32,685	0.07	0.26	0.00	1.00
San Martin	= 1, The grill is located in San Martin		2017	32,685	0.06	0.24	0.00	1.00
Ucayali	= 1, The grill is located in Ucayali		2017	32,685	0.13	0.34	0.00	1.00

Note:[a/] Considering national, regional, and local paved and unpaved (dirt and gravel) roads. [b/] Types of concessions included are those for conservation, ecotourism, and forestation.

Table 2: Descriptive Statistics for the variables used in the construction of the institutional index at the district level (N=1851)

Dimension	Variable	Definition	Mean	Min	Max	S. Dev.
SOCIAL CONDITIONS						
Education	**1. Education**	Average education (years)	6.3	1.8	13.8	2.07
Health	**2. Expectancy**	Life expectancy (years)	74.4	36.5	103.4	8.95
	3. Weight	Pct. of kids with no low weight at birth	0.93	0.33	1.0	0.05
BELIEFS, VALUES AND CULTURE						
Voting	**4. Voters**	Pct. of participation in last municipal election	0.84	0.0	1.0	0.05
Participation in local management	**5. Participation**	Number mechanisms for citizen's participation in local management	4.23	0.0	10.0	2.25
Communication and transparency	**6. Channels**	Number of communication channels available to citizens	2.29	0.0	6.0	1.35
	7. Transparency	Existence of a functioning local government Web (=1)	0.19	0.0	1.0	0.39
INSTITUTIONAL PERFORMANCE FOR CITIZENS						
Public expenditure	**8. Budget**	Percentage of local budget used in 2017	0.73	0.1	1.0	0.17
	9. PPR	No. of local government's actions immerse on budgeting for results	4.59	0.0	14.0	3.72
Projects and Facilities	**10. Infrastructure**	Number of projects in infrastructure	1.65	0.0	13.0	1.62
	11. Social projects	Number of social projects	1.14	0.0	11.0	1.51
	12. Facilities	Number of sport facilities available	0.36	0.0	19.5	1.17
Waste management (WM)	**13. Waste**	Waste collection (= 1)	0.40	0.0	1.0	0.49
	14. Waste in capital	% of WM in the district's capital	0.75	0.0	0.9	0.20
	15. Waste out capital	% of WM out of the district's capital	0.40	0.0	0.9	0.32
Personnel and Equipment	**16. Workers**	Number of workers in the district	118.88	2.0	4,930.0	316.40
	17. Systems	Number of computerized systems used by the municipality	1.94	1.0	9.0	1.13
Safety	**18. Police actions**	Number of police interventions in the district	125.48	0.0	39,514.0	1,106.20
	19. Police stations	Number of police stations in the district	0.80	0.0	13.0	1.06
	20. Police control	Integrated police action (=1)	0.46	0.0	1.0	0.50
Environmental planning	**21. Plan**	Environmental plan (= 1)	0.61	0.0	1.0	0.49
	22. Action Plan	Environmental activity plan (= 1)	0.30	0.0	1.0	0.46
Citizenship	**23. Citizenship**	Number of newborns with ID at 30 days of birth	173.05	0.0	10,351.0	519.69
Linear index I-17 (17 variables)			5.81	1	12	2.61
Linear index I-19 (19 variables)			6.68	1	14	2.84
Linear index I-20 (20 variables)			7.38	1	15	3.00
Linear index I-21 (21 variables)			7.53	1	15	2.94
Linear index I-22 (22 variables)			7.63	1	16	2.93
Linear index I-23 (23 variables)			7.73	1	17	2.89

Source: Own calculations based on information from several sources.

Table 3: OLS Regression on deforestation, all sample

	(1)	(2)	(3)	(4)
	Linear index		PC index	
	I-17	I-20	PC-17	PC-20
Local institutions	-0.0859***	-0.0686***	-0.1290***	-0.1264***
	(0.0169)	(0.0147)	(0.0438)	(0.0403)
Local institutions*Short distance[a/]	0.1506***	0.1319***	0.1736***	0.1997***
	(0.0144)	(0.0122)	(0.0597)	(0.0529)
Distance to nearest road[b/]	-0.0024**	-0.0021*	-0.0038***	-0.0036***
	(0.0011)	(0.0011)	(0.0012)	(0.0012)
National protected area[c/]	-0.0046***	-0.0043***	-0.0058***	-0.0058***
	(0.0009)	(0.0009)	(0.0011)	(0.0011)
Regional conservation area[c/]	-0.0045***	-0.0044***	-0.0053***	-0.0052***
	(0.0012)	(0.0011)	(0.0014)	(0.0014)
Private conservation area[c/]	0.0010	0.0015	-0.0020	-0.0017
	(0.0023)	(0.0024)	(0.0026)	(0.0027)
Controls[d/]	Y	Y	Y	Y
Observations	32685	32685	32685	32685
Adjusted R^2	0.339	0.342	0.292	0.295

Note: All specifications include region fixed effects and a constant term. [a/] *Short distance* is an indicator variable for distances that lie within the 25th percentile of the minimum distance to paved and unpaved national, regional and local roads in our sample (which equals 5.0613 Km). [b/] Nearest distance to paved and unpaved national, regional and local roads. [c/] Percent of the grills located in the respective area (protected or conservation). [d/] *Controls* include altitude, precipitation, temperature, population density, inequality and agricultural variables (total area, and those dedicated to growing coffee, cocoa, coca, and oil palm). Robust standard errors clustered at the district level in parenthesis. *** *p<0.01, ** p<0.05, * p<0.1.*

Table 4: OLS Regression results on deforestation: Excluding the *Andes* sections from the sample

	(1)	(2)	(3)	(4)
	Linear index		PC index	
	I-17	I-20	PC-17	PC-20
Local institutions	-0.0766***	-0.0576***	-0.1327***	-0.1284***
	(0.0188)	(0.0167)	(0.0476)	(0.0443)
Local institutions*Short distance[a/]	0.1837***	0.1604***	0.2109***	0.2473***
	(0.0169)	(0.0141)	(0.0746)	(0.0634)
Distance to nearest road[b/]	-0.0021*	-0.0019*	-0.0038***	-0.0037***
	(0.0011)	(0.0011)	(0.0013)	(0.0012)
National protected area[c/]	-0.0043***	-0.0039***	-0.0056***	-0.0056***
	(0.0009)	(0.0009)	(0.0011)	(0.0011)
Regional conservation area[c/]	-0.0049***	-0.0048***	-0.0056***	-0.0056***
	(0.0013)	(0.0012)	(0.0016)	(0.0016)
Private conservation area[c/]	0.0011	0.0013	-0.0012	-0.0008
	(0.0028)	(0.0029)	(0.0033)	(0.0034)
Controls[d/]	Y	Y	Y	Y
Observations	28204	28204	28204	28204
Adjusted R^2	0.351	0.355	0.295	0.298

Note: All specifications include region fixed effects and a constant term. [a/] *Short distance* is an indicator variable for distances that lie within the 25th percentile of the distance to the nearest paved and unpaved national, regional and local roads in our sample (which equals 5.0613 Km). [b/] Distance to nearest paved and unpaved national, regional and local roads. [c/] Percent of the grills located in the respective area (protected or conservation). *Controls* include altitude, precipitation, temperature, population density, inequality and agricultural variables (total area, and those dedicated to growing coffee, cocoa, coca, and oil palm). Robust standard errors clustered at the district level in parenthesis. *** *p<0.01, ** p<0.05, * p<0.1.*

Table 5: OLS regression on deforestation, using interactions per quintile of distances (considering each province)

	(1)	(2)	(3)	(4)
	Linear index		PC index	
	I-17	I-20	PC-17	PC-20
Local institutions	-0.0682***	-0.0558***	-0.1466***	-0.1342***
	(0.0217)	(0.0204)	(0.0367)	(0.0328)
Local institutions*Distance quintile 1[a/]	0.0843***	0.0799***	0.1756***	0.1633***
	(0.0312)	(0.0280)	(0.0485)	(0.0435)
Local institutions*Distance quintile 2[a/]	0.0426	0.0387	0.0668	0.0548
	(0.0272)	(0.0248)	(0.0490)	(0.0463)
Local institutions*Distance quintile 3[a/]	0.0318	0.0251	0.0384	0.0279
	(0.0226)	(0.0202)	(0.0371)	(0.0348)
Local institutions*Distance quintile 4[a/]	0.0023	0.0015	-0.0016	-0.0061
	(0.0166)	(0.0149)	(0.0218)	(0.0212)
Distance to nearest road quintile 1[a/]	0.3396	0.2497	0.8712***	0.8445***
	(0.2193)	(0.2317)	(0.0995)	(0.0995)
Distance to nearest road quintile 2[a/]	0.2084	0.1858	0.4803***	0.4740***
	(0.1820)	(0.1963)	(0.0880)	(0.0874)
Distance to nearest road quintile 3[a/]	0.0681	0.0832	0.2692***	0.2676***
	(0.1484)	(0.1572)	(0.0752)	(0.0747)
Distance to nearest road quintile 4[a/]	0.0591	0.0701	0.0710	0.0754
	(0.1034)	(0.1099)	(0.0518)	(0.0513)
National protected area[b/]	-0.0054***	-0.0053***	-0.0051***	-0.0052***
	(0.0009)	(0.0009)	(0.0009)	(0.0009)
Regional conservation area[b/]	-0.0071***	-0.0072***	-0.0068***	-0.0068***
	(0.0015)	(0.0015)	(0.0015)	(0.0015)
Private conservation area[c/]	0.0002	0.0005	0.0001	0.0001
	(0.0030)	(0.0030)	(0.0029)	(0.0029)
Controls[d/]	Y	Y	Y	Y
Observations	32685	32685	32685	32685
Adjusted R^2	0.315	0.314	0.320	0.320

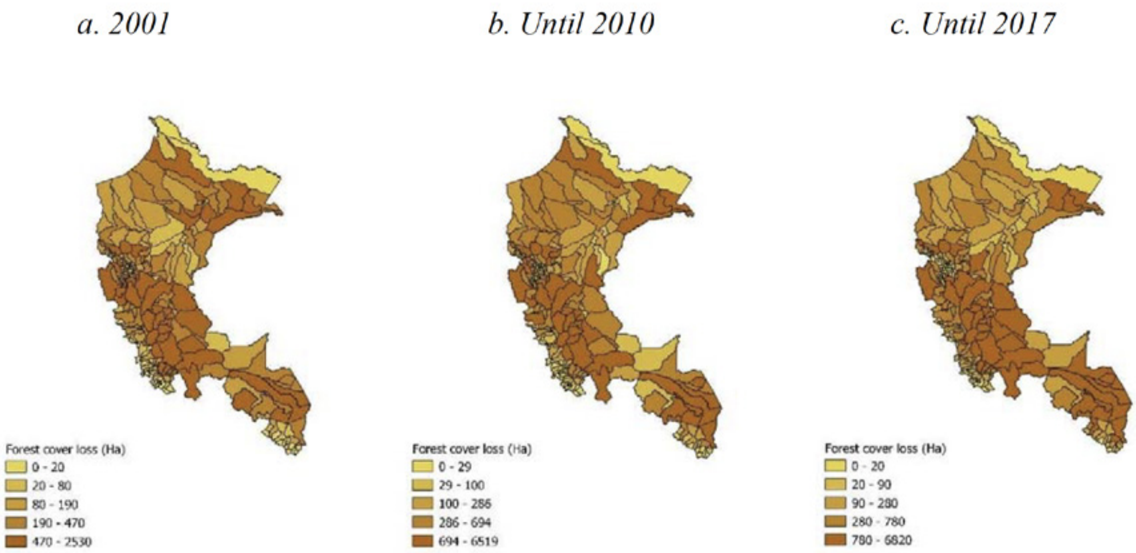
Note: All specifications include region fixed effects and a constant term. [a/] Quintiles of distance computed considering all distances to paved and unpaved national, regional, and local roads for *each* province; the omitted quintile (quintile 5) denotes de longest distance. Average distances are 15.6 Km (for quintile 1), 32.3 Km (for quintile 2), 47.5 Km (for quintile 3), 64.0 Km (for quintile 4), and 81.8 Km (for quintile 5). [b/] Percent of the grills located in the respective area (protected or conservation). [c/] *Controls* include altitude, precipitation, temperature, population density, inequality and agricultural variables (total area, and those dedicated to growing coffee, cocoa, coca, and oil palm). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at the district level in parenthesis.

FIGURES

Figure 1: Deforestation by quintiles of the percentage of deforested area at the grill level, 2001-2017

Source: Own elaboration based on Geobosques data from the Peruvian Ministry of Environment (2017).

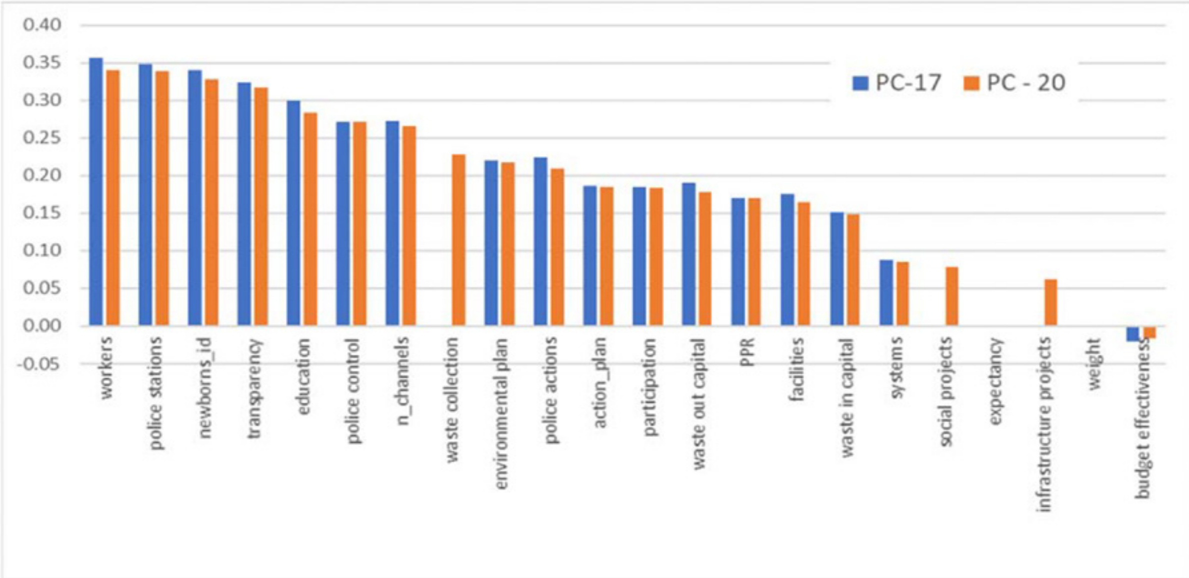
Figure 2: Spatial evolution of accumulated deforestation by district, 2001, 2010, 2017



Note: Categories are quintiles of deforested area in the referred year.

Source: Own elaboration based on *Geobosques* data from the Peruvian Ministry of Environment (2017).

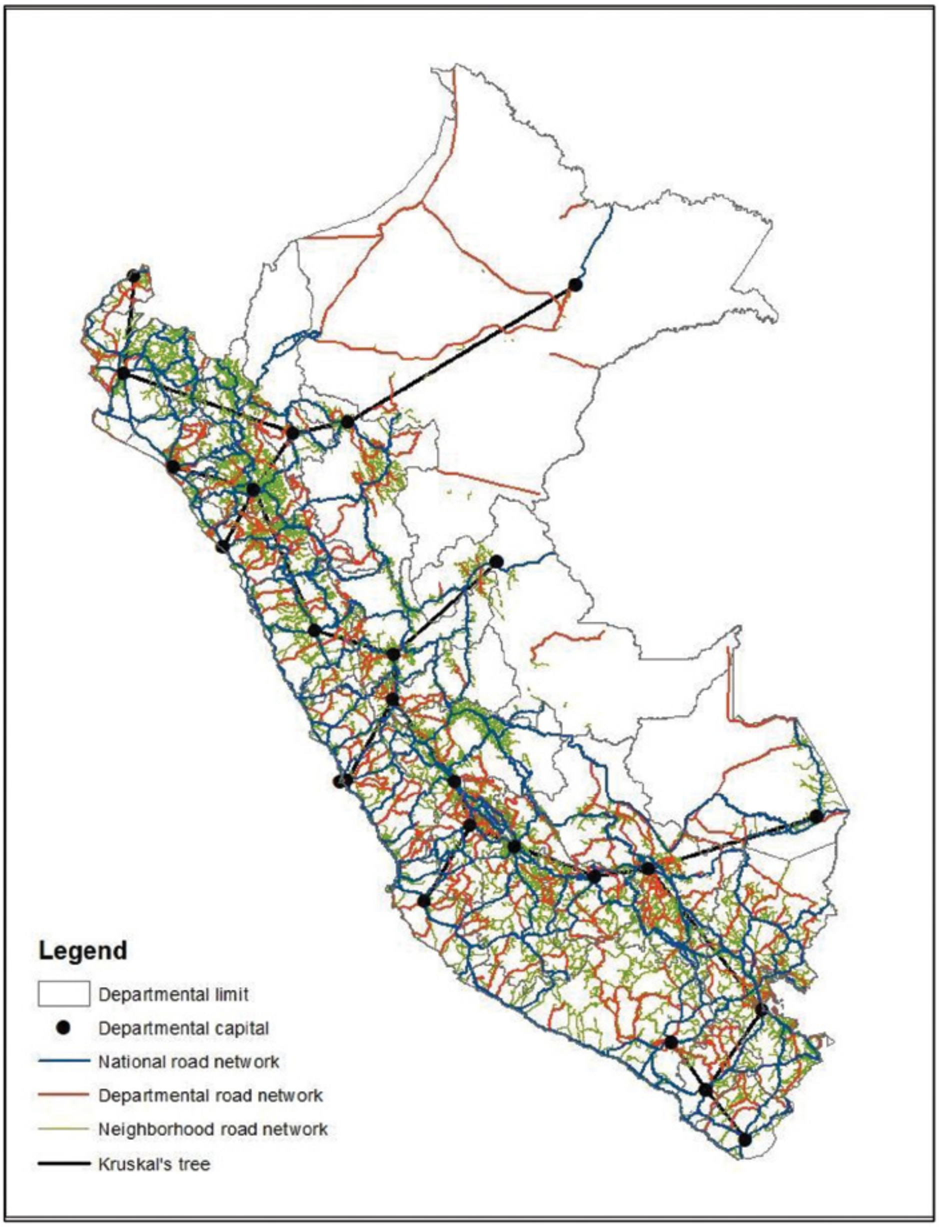
Figure 3: Loadings for PC-17 and PC-20



Source: Own calculations.

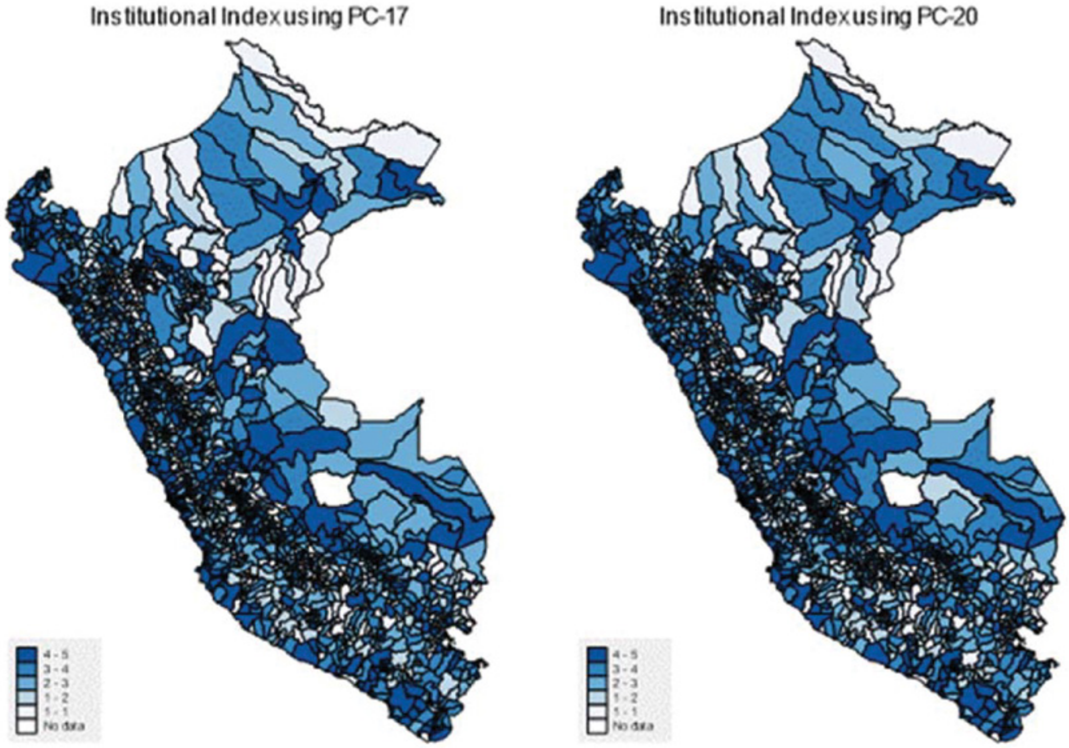
APPENDICES

Appendix Figure A1: Peru: Road network by type (national, regional, and local), 2016



Source: Aguirre et al. (2018), with information from the Peruvian Ministry of Transportation and Communications (2016).

Appendix Figure A2: Distribution of the institutional index at the district level, by quintile: PC-17 and PC-20



Source: Own elaboration.

Appendix Table A1: Source of information of variables used in the construction of the institutional index

Dimension	Variable	Source of Information*
SOCIAL CONDITIONS		
Education	1. Education	CEPLAN
Health	2. Expectancy	CEPLAN
	3. Weight	CEPLAN
BELIEFS, VALUES AND CULTURE		
Voting	4. Voters	JNE
Participation in local management	5. Participation	RENAMU
Communication and transparency	6. Channels	RENAMU
	7. Transparency	RENAMU
INSTITUTIONAL PERFORMANCE FOR CITIZENS		
Public expenditure	8. Budget	MEF
	9. PPR	RENAMU
Projects and Facilities	10. Infrastructure	RENAMU
	11. Social projects	RENAMU
	12. Facilities	RENAMU
Waste management (WM)	13. Waste	RENAMU
	14. Waste in capital	RENAMU
	15. Waste out capital	RENAMU
Personnel and Equipment	16. Workers	RENAMU
	17. Systems	RENAMU
Safety	18. Police actions	RENAMU
	19. Police stations	RENAMU
	20. Police control	RENAMU
Environmental planning	21. Plan	RENAMU
	22. Action Plan	RENAMU
Citizenship	23. Citizenship	CEPLAN

*CEPLAN is the National Strategic Planning Center in the country. JNE is the National Electoral Institution. RENAMU is the National Register of Municipalities (districts) in the country, and MEF is the Ministry of Finance.

Appendix Table A2: Indicators from the principal component analysis

VARIABLES	PC-17	PC-19	PC-20	PC-21	PC-22	PC-23
			KMO indicator			
Action plan	0.7539	0.7620	0.7701	0.7699	0.7707	0.7711
Environmental plan	0.7885	0.7964	0.8026	0.8029	0.8034	0.8020
Budget	0.5028	0.5255	0.5028	0.5084	0.4946	0.4827
PPR	0.8413	0.8569	0.8654	0.8660	0.8661	0.8637
Education	0.8768	0.8677	0.8740	0.8770	0.8769	0.8757
Channels	0.9340	0.9349	0.9396	0.9389	0.9386	0.9387
Facilities	0.8252	0.8266	0.8303	0.8327	0.8332	0.8329
Citizenship	0.8474	0.8487	0.8553	0.8564	0.8565	0.8545
Participation	0.8645	0.8735	0.8806	0.8756	0.8756	0.8757
Police actions	0.7418	0.7411	0.7432	0.7437	0.7437	0.7405
Police control	0.9073	0.9098	0.9065	0.9067	0.9069	0.9066
Police stations	0.8754	0.8742	0.8816	0.8821	0.8811	0.8835
Infrastructure		0.5713	0.5753	0.5776	0.5778	0.5811
Social Projects		0.5960	0.6005	0.6011	0.6007	0.6021
Systems	0.8582	0.8672	0.8658	0.8665	0.8653	0.8681
Transparency	0.9240	0.9240	0.9287	0.9295	0.9297	0.9295
Expectancy				0.8454	0.8412	0.8367
Voters						0.7011
Waste			0.9175	0.9174	0.9126	0.9116
Waste in capital	0.7950	0.7980	0.8064	0.8034	0.7969	0.8001
Waste out capital	0.8185	0.8226	0.8196	0.8192	0.8787	0.8206
Weight					0.5813	0.5969
Workers	0.8246	0.8235	0.8297	0.8305	0.8305	0.8281
Total	**0.8484**	**0.8323**	**0.8240**	**0.8426**	**0.8416**	**0.8404**
Number of components with eigenvalues > 1						
	5	5	6	6	7	7
Percent of variation explained by those components [a/]						
	57.3%	54.3%	57.7%	55.4%	57.7%	55.7%

Note: a/ For example, in the PC-17 estimation, the three components that have eigenvalues greater than 1 explained the 54.0% of the total variation in the dataset. For a description of variables, see Table 2.

Source: Own calculations.

Appendix Table A3: Regression on deforestation, using different definitions of 'short distance' to roads

	(1)	(2)	(3)	(4)
	Linear index		PC index	
	I-17	I-20	PC-17	PC-20
A. Distances within 1.06 km (percentile 10)				
Local institutions	-0.0503***	-0.0349**	-0.1047**	-0.0987**
	(0.0170)	(0.0161)	(0.0406)	(0.0390)
Local institutions*short distance[a/]	0.0762***	0.0660***	0.1416***	0.1595***
	(0.0118)	(0.0103)	(0.0531)	(0.0484)
Minimum distance to road[b/]	-0.0038***	-0.0037***	-0.0040***	-0.0039***
	(0.0012)	(0.0012)	(0.0012)	(0.0012)
Adjusted R^2	0.293	0.292	0.288	0.289
B. Distances within 10 km				
Local institutions	-0.0967***	-0.0787***	-0.1353***	-0.1336***
	(0.0170)	(0.0142)	(0.0437)	(0.0396)
Local institutions*short distance[a/]	0.1520***	0.1336***	0.1534***	0.1770***
	(0.0145)	(0.0121)	(0.0498)	(0.0434)
Minimum distance to road[b/]	-0.0013	-0.0010	-0.0038***	-0.0036***
	(0.0011)	(0.0011)	(0.0012)	(0.0012)
Adjusted R^2	0.343	0.347	0.292	0.295
B. Distances within 20 km				
Local institutions	-0.0888***	-0.0722***	-0.1311***	-0.1298***
	(0.0165)	(0.0140)	(0.0435)	(0.0392)
Local institutions*short distance[a/]	0.1105***	0.0974***	0.1033***	0.1208***
	(0.0130)	(0.0107)	(0.0397)	(0.0341)
Minimum distance to road[b/]	-0.0008	-0.0004	-0.0038***	-0.0036***
	(0.0011)	(0.0011)	(0.0012)	(0.0012)
Adjusted R^2	0.316	0.318	0.289	0.290
B. Distances within 29 km (median)				
Local institutions	-0.0809***	-0.0654***	-0.1291***	-0.1276***
	(0.0162)	(0.0144)	(0.0424)	(0.0383)
Local institutions*short distance[a/]	0.0815***	0.0724***	0.0821***	0.0953***
	(0.0116)	(0.0094)	(0.0316)	(0.0274)
Minimum distance to road[b/]	-0.0010	-0.0006	-0.0038***	-0.0036***
	(0.0012)	(0.0012)	(0.0012)	(0.0012)
Adjusted R^2	0.301	0.301	0.288	0.289
B. Distances within 50 km				
Local institutions	-0.0682***	-0.0526***	-0.1321***	-0.1284***
	(0.0169)	(0.0163)	(0.0411)	(0.0369)
Local institutions*short distance[a/]	0.0430***	0.0384***	0.0665**	0.0724***
	(0.0108)	(0.0091)	(0.0270)	(0.0242)
Minimum distance to road[b/]	-0.0020	-0.0017	-0.0039***	-0.0037***
	(0.0014)	(0.0014)	(0.0012)	(0.0012)
Adjusted R^2	0.287	0.286	0.287	0.287
B. Distances within 79 km (percentile 75)				
Local institutions	-0.0276	-0.0129	-0.1307***	-0.1204***
	(0.0284)	(0.0271)	(0.0477)	(0.0420)
Local institutions*short distance[a/]	-0.0137	-0.0136	0.0499	0.0466
	(0.0220)	(0.0196)	(0.0360)	(0.0305)
Minimum distance to road[b/]	-0.0047**	-0.0047**	-0.0040***	-0.0038***
	(0.0018)	(0.0019)	(0.0012)	(0.0012)
Adjusted R^2	0.284	0.282	0.286	0.286
Observations	32685	32685	32685	32685

Note: All specifications are the same as those in Table 3 in the text. [a/] *Short distance* is an indicator variable for distances that lie within the 25th percentile of the minimum distance to paved and unpaved national, regional and local roads in our sample (which equals 5.0613 Km). [b/] Nearest distance to paved and unpaved national, regional and local roads. Robust standard errors clustered at the district level in parenthesis. *** *p<0.01, ** p<0.05, * p<0.1.*

Appendix Table A4: OLS regression on deforestation, with full controls, all sample

	(1)	(2)	(3)	(4)
	Linear index		PC index	
	I-17	I-20	PC-17	PC-20
Local institutions	-0.0936***	-0.0736***	-0.1713***	-0.1582***
	(0.0170)	(0.0151)	(0.0426)	(0.0392)
Institutions*short distance to road[a/]	0.1398***	0.1229***	0.1572***	0.1823***
	(0.0140)	(0.0119)	(0.0541)	(0.0486)
Distance to nearest road[b/]	-0.0015	-0.0013	-0.0025**	-0.0024**
	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Distance to nearest river[c/]	0.0067**	0.0078**	0.0094***	0.0093***
	(0.0032)	(0.0031)	(0.0035)	(0.0034)
Distance to downtown[d/]	-0.0138***	-0.0130***	-0.0176***	-0.0170***
	(0.0029)	(0.0028)	(0.0035)	(0.0035)
National protected area[e/]	-0.0033***	-0.0031***	-0.0042***	-0.0042***
	(0.0010)	(0.0010)	(0.0011)	(0.0011)
Regional conservation area[e/]	-0.0036***	-0.0036***	-0.0041***	-0.0041***
	(0.0013)	(0.0013)	(0.0015)	(0.0015)
Private conservation area[e/]	0.0006	0.0011	-0.0027	-0.0023
	(0.0023)	(0.0024)	(0.0026)	(0.0026)
Grill lies in a forest concession	-0.0037*	-0.0034	-0.0053**	-0.0053**
	(0.0022)	(0.0022)	(0.0025)	(0.0025)
Grill lies within a native community	-0.0980	-0.0897	-0.1648*	-0.1623*
	(0.0833)	(0.0815)	(0.0870)	(0.0867)
District has mining activity	0.0169	0.0329	-0.0047	-0.0116
	(0.1271)	(0.1293)	(0.1271)	(0.1316)
Altitude (m.a.s.l.)	-0.0002***	-0.0002***	-0.0002***	-0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Temperature (annual average °C)	0.0450***	0.0427***	0.0402***	0.0396***
	(0.0102)	(0.0103)	(0.0111)	(0.0110)
Precipitation (annual average mm)	0.0000	0.0000	0.0000	0.0000
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Population density (inhabit./km^2)	-0.0004*	-0.0005*	-0.0001	-0.0002
	(0.0003)	(0.0003)	(0.0001)	(0.0001)
Inequality (Gini)[f/]	1.8599	1.4930	2.0219	1.7528
	(1.5191)	(1.4995)	(1.5205)	(1.5339)
Human Development Index (HDI)[g/]	0.9783**	0.8389*	1.6888***	1.5378***
	(0.4649)	(0.4756)	(0.5572)	(0.5454)
Households' access to water	-0.0689	-0.0871	-0.1623	-0.1604
	(0.1410)	(0.1449)	(0.1459)	(0.1491)
Total sown area (ha)	0.0001***	0.0001***	0.0001***	0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Sown area with coca (ha)	0.0002	0.0002	0.0002	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Sown area with coffee (ha)	-0.0001***	-0.0001***	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Sown area with cocoa (ha)	-0.0002***	-0.0002***	-0.0003***	-0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Sown area with oil palm (ha)	0.0003*	0.0003*	0.0003**	0.0003**
	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Constant	0.1262	0.2824	-1.6173**	-1.4464**
	(0.5273)	(0.5240)	(0.6273)	(0.6123)
Adjusted R^2	0.352	0.354	0.315	0.317
Observations	32685	32685	32685	32685

Note: All specifications include region fixed effects. [a/] *Short distance* is an indicator variable for distances that lie within the 25th percentile of the minimum distance to paved and unpaved national, regional and local roads in our sample (which equals 5.0613 Km). [b/] Distance to nearest paved and unpaved national, regional and local roads. [c/] Nearest distance to navigable river. d/ Nearest distance to the center of town. [e/] Percentage of the grill located in the respective area (protected or conservation). [f/] Gini of expenditures. [g/] UNDP's HDI. Robust standard errors clustered at the district level in parenthesis. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Appendix Table A5: OLS regression on deforestation, with only paved roads, all sample

	(1)	(2)	(3)	(4)
	Linear index		PC index	
	I-17	I-20	PC-17	PC-20
Local institutions	-0.0719***	-0.0543***	-0.1383***	-0.1298***
	(0.0166)	(0.0153)	(0.0390)	(0.0363)
Institutions*short distance to road[a/]	0.1060***	0.0905***	0.1992***	0.2039***
	(0.0153)	(0.0132)	(0.0487)	(0.0439)
Distance to nearest road[b/]	-0.0027***	-0.0026***	-0.0036***	-0.0035***
	(0.0006)	(0.0006)	(0.0007)	(0.0007)
National protected area[c/]	-0.0051***	-0.0048***	-0.0057***	-0.0057***
	(0.0010)	(0.0010)	(0.0011)	(0.0011)
Regional conservation area[c/]	-0.0054***	-0.0054***	-0.0058***	-0.0058***
	(0.0015)	(0.0014)	(0.0017)	(0.0017)
Private conservation area[c/]	-0.0012	-0.0010	-0.0015	-0.0013
	(0.0023)	(0.0023)	(0.0025)	(0.0026)
Controls[d/]	Y	Y	Y	Y
Adjusted R^2	0.318	0.318	0.302	0.303
Observations	32685	32685	32685	32685

Note: All specifications include region fixed effects and a constant term. [a/] Short distance is an indicator variable for distances that lie within the 25th percentile of all distances to national, regional and local paved roads (18.02 Km). [b/] It only considers distances to national, regional, and local paved roads. [c/] Percentage of the grill located in the respective area (protected or conservation). [d/] Controls include altitude, precipitation, temperature, population density, inequality and agricultural variables (total area, and those dedicated to growing coffee, cocoa, coca, and oil palm). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at the district level.

Appendix Table A6: OLS regression on deforestation, with the indicator of 'short' distance computed using the distances for *each* province

	(1)	(2)	(3)	(4)
	Linear index		PC index	
	I-17	I-20	PC-17	PC-20
Local institutions	-0.0598***	-0.0447***	-0.1366***	-0.1308***
	(0.0160)	(0.0151)	(0.0428)	(0.0395)
Local institutions*short distance[a/]	0.0849***	0.0716***	0.1839***	0.1942***
	(0.0111)	(0.0091)	(0.0508)	(0.0453)
Nearest distance to road[b/]	-0.0016	-0.0014	-0.0038***	-0.0035***
	(0.0011)	(0.0011)	(0.0012)	(0.0012)
National protected area[c/]	-0.0056***	-0.0055***	-0.0057***	-0.0058***
	(0.0009)	(0.0009)	(0.0011)	(0.0011)
Regional conservation area[c/]	-0.0064***	-0.0066***	-0.0051***	-0.0052***
	(0.0016)	(0.0016)	(0.0016)	(0.0016)
Private conservation area[c/]	-0.0011	-0.0008	-0.0030	-0.0029
	(0.0026)	(0.0027)	(0.0025)	(0.0025)
Controls[d/]	Y	Y	Y	Y
Adjusted R^2	0.308	0.307	0.293	0.295
Observations	32685	32685	32685	32685

Note: All specifications include region fixed effects and a constant term. [a/] Short distance is an indicator variable for distances that lie within the 25th percentile of all distances to national, regional and local paved and unpaved roads, computed for each province. [b/] Distance to nearest paved and unpaved national, regional and local roads. [c/] Percentage of the grill located in the respective area (protected or conservation). [d/] *Controls* include altitude, precipitation, temperature, population density, inequality and agricultural variables (total area, and those dedicated to growing coffee, cocoa, coca, and oil palm). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at the district level.