WORLD RESOURCES INSTITUTE

# CLIMATE BENEFITS, TENURE COSTS

*The Economic Case For Securing Indigenous Land Rights in the Amazon*

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# FOREWORD

With a new climate change agreement from the United Nations Framework Convention on Climate Change (UNFCCC) conference held in Paris last December, attention has shifted to the Nationally Determined Contributions (NDCs)—the post-2020 climate actions that countries intend to take under the new agreement. When the Paris agreement is ratified, the NDCs will become the first greenhouse gas targets under the UNFCCC that applied to both developed and developing countries.

A large number of countries recognize the role of forests in carbon sequestration and committed in their NDCs to protect forests, reduce deforestation rates, and restore forestlands. Few NDCs, however, make any specific commitments to how their forests will be protected or restored on degraded land. It is still unclear if governments will protect forests by expanding the protected estate, improving the management of existing national parks, helping communities safeguard the forests on their lands, or by taking other measures.

The research for this report was designed to help governments make these decisions. It examines the environmental and economic arguments for one specific approach to protecting forests—securing indigenous forestlands.

The research included original matching analysis to determine the effect of secure tenure on deforestation rates in indigenous lands in the Amazon forest in Bolivia, Brazil, and Colombia. Indigenous land covers at least 149 million hectares or almost 24 percent of the Amazon forest in these three countries. The analysis finds that the annual deforestation rates in the tenure-secure indigenous forestlands are significantly lower than on other similar lands in all three countries, suggesting that securing tenure contributes to reducing deforestation in these areas.

The research also involved conducting benefit-cost analysis to examine the economics of securing indigenous land rights in Bolivia, Brazil, and Colombia. While focusing on carbon sequestration benefits, the analysis valued six other critical ecosystem services—hydrological services; nutrient retention; regulation of local climate dynamics and water cycling; pollination; existence value; and recreation and tourism. The analysis shows that securing indigenous forestland tenure is a low-cost, high-benefit investment. Secure indigenous forestlands provide significant global carbon and other ecosystem service benefits in Bolivia, Brazil, and Colombia, estimated at between $679 and $1,530 billion for the next 20 years. Meanwhile, the costs of securing indigenous forestlands amount to less than 1 percent of these benefits.

Equally important, from a financial perspective, investing in securing indigenous forestland tenure is a relatively cost-effective measure for climate change mitigation when compared with other measures. The research shows that the costs of securing indigenous lands are 5 to 42 times lower than the average costs of avoided $CO_2$ through fossil carbon capture and storage for both coal- and gas-fired power plants.

Given these results, investing in securing indigenous forestlands tenure would be a relatively inexpensive action that governments of forested countries could take to help meet the $CO_2$ emissions reduction objectives put forward in their NDCs.

We hope that governments and their partners—communities, civil society organizations, donor agencies, and others—find this report useful as they implement their NDCs and put their countries on a path toward a low-carbon, climate-resilient future.

**Andrew Steer**
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*World Resources Institute*

# EXECUTIVE SUMMARY

Community lands can generate significant social, economic, and environmental benefits for communities and society. They are a primary source of livelihood, nutrition, income, and employment for Indigenous Peoples and other communities in Africa, Asia, Latin America, and elsewhere. Community forestlands provide a suite of ecosystem-service benefits, including carbon sequestration, pollination, and nutrient retention.

A large body of literature shows that community forestlands with secure tenure are often linked to low deforestation rates, significant forest cover, and the sustainable production of timber and other forest products. Titling or other measures to secure land rights do not alone guarantee low deforestation rates, but tenure security is recognized as an important precursor to other factors that promote sustainable management of community forestlands.

Much is known about the local and societal benefits of many community forestlands; questions remain, however, about the economics of securing community forestland tenure. This research report seeks to address this issue by asking: What are the costs compared to the benefits of securing and maintaining tenure for indigenous forestlands in the Amazon basin? Building on WRI's recently published working paper, *The Economic Costs and Benefits of Securing Community Forest Tenure: Evidence from Brazil and Guatemala*, this report focuses on indigenous forestlands in the Amazon basin of Bolivia, Brazil, and Colombia; provides original matching analysis on deforestation rates; incorporates an array of ecosystem services into the benefit-cost analysis; and provides a set of policy and program recommendations.

This report aims to inform technical leads in the land, forest, and financial sectors of governments, as well as funding agencies, on the economic gains achievable from securing community forestlands. Such information can encourage new investments in recognizing and protecting community land rights. It may also help Indigenous Peoples, communities, and their partners to make economic arguments for securing their land rights.

The matching analysis shows:

**Tenure-secure indigenous forestlands exhibit low deforestation rates.** The annual deforestation rates in the tenure-secure indigenous forestlands are significantly lower than on other lands in the three research countries of Bolivia, Brazil, and Colombia, suggesting that securing indigenous forestland tenure contributed to reducing deforestation in these areas between 2000 and 2012.

- In Bolivia, the 12-year average observed actual deforestation rate inside tenure-secure indigenous forestlands was 0.15 percent, while the 12-year average estimated deforestation rate outside indigenous forestlands was 0.43 percent.

- In Brazil, the deforestation rate inside tenure-secure indigenous forestlands was 0.06 percent, while the deforestation rate outside indigenous forestlands was 0.15 percent.

- In Colombia, the deforestation rate inside tenure secure indigenous forestlands was 0.04 percent, while the deforestation rate outside indigenous forestlands was 0.08 percent.

The benefit-cost analysis yields two principal findings:

1. **Securing indigenous forestland tenure is a low-cost, high-benefit investment.**

    - Tenure-secure indigenous forestlands provide significant global carbon benefits in Bolivia, Brazil, and Colombia, amounting to a total of US$25–34 billion over the next 20 years in net present value through the avoided annual release of an estimated 42.8–59.7 Mt $CO_2$ emissions. This is equivalent to taking between 9 and 12.6 million passenger vehicles off the roads for one year.

    - Tenure-secure indigenous forestlands provide significant local and regional ecosystem-service benefits, including regulation of local climate dynamics and water cycling, hydrological services, pollination, nutrient retention, existence values, and recreation and tourism values. These benefits are estimated to range between $679 and 1,530 billion (or $4,559–10,274/ha) for the next 20 years, calculated in net present value resulting from indigenous forestland tenure-security investment.

- Tenure-secure indigenous forestlands provide low-cost forest conservation investments for governments. Investments in tenure security are estimated at $45 per hectare (ha) in Bolivia, $68/ha in Brazil, and $6/ha in Colombia—the calculated sum of discounted total costs for a 20-year period. This amounts to at most 1 percent of the total benefits derived from tenure-secure indigenous forestlands in the three countries. Comparing the total benefits with the costs, securing indigenous forestland tenure can generate a positive net per-hectare benefit for all three countries.

2. **Securing indigenous forestlands tenure has significant potential for cost-effective carbon mitigation.** From a financial perspective, investing in securing indigenous forestland tenure is a relatively cost-effective measure for climate change mitigation when compared with other carbon capture and storage measures. The estimated costs of carbon mitigation through indigenous forestland tenure-security programs in Bolivia, Brazil, and Colombia range from \$2.04–3.66/t$CO_2$, \$8.74–11.88/t$CO_2$, and \$4.75–7.26/t$CO_2$, respectively. These costs are significantly lower than the average costs of avoided $CO_2$ through fossil carbon capture and storage, which are estimated to be about \$58/t$CO_2$ for coal-fired power plants (5 to 29 times more expensive than securing indigenous forestland tenure) and \$85/t$CO_2$ for natural gas-fired power plants (7 to 42 times more expensive).

These findings present a strong economic case for governments, climate change funding agencies, civil society organizations, and other parties to invest in securing indigenous forestland tenure in Latin America. While significant progress has been made in some Amazon basin countries over the last 10–30 years toward formally recognizing community lands, more efforts are needed to secure the community lands that are not documented or protected by government. These efforts include the need for the following:

1. **Secure community land rights.** Governments and their partners should consider reforming their laws and taking other actions to strengthen community land rights. For instance, the laws in Bolivia, Brazil, and Colombia recognize indigenous land rights, but do not provide Indigenous Peoples with sufficient legal protections. Statutory laws that do not adequately protect community land rights should be reformed or replaced by supportive legislation. For Indigenous Peoples and communities to realize their rights, laws that support their lands must also be implemented and enforced. Despite some progress in securing land rights in Bolivia, Brazil, and Colombia, considerable areas of indigenous lands are not mapped, demarcated, or formally registered. Governments should remove administrative hurdles and provide responsible agencies with the human and financial resources needed to document and protect all indigenous and community lands in their country.

2. **Make tenure-secure community forestlands a central climate change mitigation strategy.** The Nationally Determined Contributions (NDCs) of Bolivia, Brazil, and Colombia do not make any specific commitments to securing indigenous land rights, but the research findings show that indigenous lands have helped reduce deforestation rates. Had the Indigenous Peoples not had secure tenure over their lands and forests, the $CO_2$ emissions of each country would have been higher—about 9 percent more per year in Bolivia, and 3 percent more per year in Brazil and Colombia. For Brazil, this emission difference is equivalent to 25–35 percent of Belgium's national $CO_2$ equivalent ($CO_2e$) emissions in 2012. Given these carbon benefits, investing in securing indigenous forestland tenure would be a relatively inexpensive action that governments could take to help meet the emissions reduction objectives put forward in their NDCs.

3. **Utilize international development funds to support securing community forestland tenure.** The research findings provide evidence that governments and their partners should increasingly direct their resources to securing indigenous and community forestland tenure. The funds could support government agencies to formally document community lands as well as the Indigenous Peoples and communities which invest in protecting their forests. In addition to traditional bilateral and multilateral support, governments should look to the global climate finance architecture, such as the Global Environment Facility, Green Climate Fund, and Africa Climate Change Fund. Some analysts have argued that progress in reducing deforestation through these and other climate funds has been limited. This research suggests that climate funds could in some cases meet their climate change and avoided deforestation objectives by supporting efforts to secure community land rights.

Given that many community lands around the world are not secured, these recommendations may also apply to other countries. The recently launched Sustainable Development Goals (SDGs) and new Paris agreement to curb climate change present opportunities for the world to secure indigenous and other community lands and achieve positive development and environment outcomes.

Finally, further analysis is needed on the benefits and costs of securing indigenous and community forestland tenure. For example, additional research is critical to:

- **Address data constraints that limit more comprehensive analysis.** Improved methods for valuing ecosystem services and social benefits, coupled with disaggregated and transparent budgetary data, would help to fill some of the data gaps.

- **Conduct benefit-cost analysis of other community lands.** It is important to assess the economic benefits and costs for non-indigenous community lands in the Amazon basin (e.g., Quilimbola communities in Brazil) as well as community forestlands in other parts of the world, especially Africa.

- **Conduct complementary economic analysis on tenure-secure community lands.** The benefit-cost analysis in this report identified several questions that need further study. For example, additional research is needed on the opportunity costs of different uses of indigenous lands.

# DEFINITION OF COMMONLY USED TERMS

- **Benefit-Cost Analysis is an economic decision-making approach.** In this report, benefit-cost analysis is used to assess whether the continual effort of securing indigenous forestland tenure in the Amazon basin is worth pursuing from an economic perspective, that is, benefits outweigh costs. It involves comparing the total expected costs of establishing and maintaining forest-tenure security against the total expected benefits.

- **Communities** are groupings of individuals and families that share common interests in a definable local land area within which they normally reside. Communities vary in size, identity, internal equity, and land-use systems, and may distribute rights to land in different ways. However, with regard to community lands, communities everywhere are similar in several ways:

  - They have strong connections to particular areas or territories and consider these domains to be customarily under their ownership and/or control.

  - They determine and apply the rules and mechanisms through which rights to land are distributed and governed. The rules themselves alter over time, as do the mechanisms through which they are upheld (e.g., from autocratic chiefs to committees). Many rules are customary, based on tried and tested customs followed by forebears. Others are new, developed by the community to address new challenges (e.g., land shortage) or to be consistent with constitutional rights of members who are also citizens of modern states (e.g., women's land rights).

  - Collective tenure and decision-making characterize the system. Usually, all or part of the community land is owned in common by members of the community, to whom rights are distributed. Sometimes, community lands are traditionally entirely subdivided into family lands over which the community retains authority, establishing the means by which family rights are recognized, held, used, and transferred.

- **Community Forestlands** are community lands with standing forests. In some countries, the law recognizes that community property includes the rights to all trees on the lands. In other places, the law provides that certain trees or forests (often naturally occurring trees or forests) are the property of the state.

- **Community Lands** are all lands that fall under the customary governance of the community, whether or not this is recognized in national law. Community land is variously described as the community domain, communal land, community land area, community territory, or other terms. Some communities hold and use all of their land communally, such as hunter-gatherers. Many communities, however, do not use all of their land communally. While the community exercises jurisdiction over the entire land area, it may be the case that each family possesses its own distinct part of the domain. Or the community may draw a distinction between lands that it has allocated to families for residence and permanent farming, and other lands that remain the shared property of all members, which are referred to as commons, commonage, or common property. Lands for grazing and wildlife, forests and woodlands, mountaintops, sacred localities, and lakes and streams within the community land are usually retained deliberately as collective property commons to which all members have use rights.

- **Customary Tenure** means community-based systems of land ownership and administration that have longstanding origins in the norms and practices (customary law) of communities and may go back centuries. Under customary tenure, it is the community that decides the type of rights allocated within its area and upholds these rights through community-based mechanisms. These mechanisms may be traditional, such as vesting land authority in a chief or a council of elders, or they may be more modern, such as an elected land committee, a village council, a community assembly of members, or procedures adopted into the norms and rules of an official community-level local government. The same customary tenure rules are usually followed by all communities within the same ethnic group or tribe. Practices are also often similar across regions and continents where the same land-use systems are followed. Although the term customary is not uniformly in use, it is important to note because many countries make reference in their constitutions to customary tenure and customary law.

- **Ecosystem Services** are the benefits people obtain from ecosystems. For example, forest-ecosystem services include the provision of fuelwood, timber, plants and other forest products; the regulation of climate and water cycles; carbon sequestration; erosion control; pollination; and important species habitats.

# DEFINITION OF COMMONLY USED TERMS

- **Indigenous Forestlands** are indigenous lands with standing forests.
- **Indigenous Lands** or territories refer to the collectively held and governed lands (and natural resources) of Indigenous Peoples. As with other community lands, some indigenous lands may, with group consent, be allocated for use by individuals and families. Other indigenous land is managed as common property. In a few cases, indigenous land is held by individuals or families (e.g., New Zealand).
- **Indigenous Peoples** are, by precept of international soft law, those sectors of the world's communities that identify themselves as such. They adopt this definition on various grounds, such as having stronger relations to their land than other nationals, longer origins in the locality, or distinctive cultures and ways of life that run special risks of being denied or lost in modern conditions. Many communities consider themselves indigenous to the locality but do not define themselves as Indigenous Peoples. This is especially so in Africa and Asia. Moreover, there are many commonalities in land tenure and governance between Indigenous Peoples and other communities. The distinction between Indigenous Peoples and other communities is often made mainly because their rights may be subject to special national legislation, which must be reviewed distinctly from laws affecting the rights of other communities. In addition, Indigenous Peoples are the subject of specific internationally recognized collective rights, including rights to land and natural resources (e.g., International Labour Organization Convention 169, United Nations Declaration on the Rights of Indigenous Peoples).
- **Land Rights** are the rights of individuals or groups of peoples, including communities and Indigenous Peoples, over land. The bundle of rights can include the rights of access, withdrawal, management, exclusion, and alienation. The bundle can also include rights to various natural resources on and below the surface of the land (e.g., trees, wildlife, water, minerals). The source of these rights can be statutory law or customary law.
- **Land Tenure** is the statutory or customarily defined relationship among people—as individuals or groups—with respect to land. It includes the full range of social relationships between people and communities with regard to accessing, possessing, controlling, and transferring land and natural resources. Land-tenure systems determine who can use what resources for how long and under what circumstances (FAO 2002).
- **Matching Analysis** refers to a statistical impact-evaluation technique widely used in economic evaluations of policy impact. Matching analysis allows for the isolation of a specific policy-change impact (e.g., establishment of tenure security) and seeks to explicitly force "apples to apples" comparisons by pairing protected and unprotected locations that are similar in their landscape characteristics.
- **Non-Use Values** are values that are not related to the current or future uses of an ecosystem service, but are derived from the knowledge that an ecosystem exists and is maintained.
- **Opportunity Costs** refer to the foregone income from alternative land use that Indigenous Peoples and other parties would have received if the indigenous forestlands were converted to another highest-value alternative land use, such as agriculture or cattle pastures.
- **Tenure Security** is the certainty that a person's rights to land will be recognized by others and protected in cases of specific challenges. Tenure security can be promoted and achieved by a range of actions, such as legal recognition, demarcation and mapping, land titling, and eviction of unwanted intruders. People with insecure tenure face the risk that their rights to land will be threatened by competing claims, and even lost as a result of eviction. Without security of tenure, households are significantly impaired in their ability to secure sufficient food and to enjoy sustainable rural livelihoods (FAO 2002).
- **Use Values** are values directly related to the use of ecosystem services by humans. These values include: direct use values that arise from direct interaction with ecosystems (e.g., extractive resource use); indirect use values that are associated with services provided by resources, but without direct use (e.g., carbon sequestration); and option values, which are uses of potential value, reserved for future consumption.

SECTION I

# INTRODUCTION

Community lands can generate significant social, governance, economic, and environmental benefits for communities and society. They are a primary source of livelihoods, nutrition, income, and employment for communities, including Indigenous Peoples, in Africa, Asia, Latin America, and elsewhere. Community lands provide security, status, social identity, and a basis for political relations; for many communities, they are historically, culturally, and spiritually significant (FAO 2014).

Community lands can also provide local economic development opportunities, particularly important benefits in marginalized regions (RA 2015a, 2015b). They can generate local benefits in the form of job creation and community reinvestment in health and education programs. Community lands are often associated with greater social cohesion, which can generate various governance dividends, such as reduced conflict and avoided related costs to society (Larson et al. 2010; Sandler 2000).

Community lands also provide environmental benefits. Community forestlands provide a suite of ecosystem-service benefits, including carbon sequestration, nutrient retention, and pollination, which benefit local populations and society. For example, the forests to which communities have some legal rights—about one eighth of the world's total—contain approximately 37.7 billion tonnes of carbon, which is 29 times larger than the annual carbon footprint of all passenger vehicles in the world (Stevens et al. 2014).

A large body of literature investigates the links between community lands and forest outcomes (Ojanen et al. 2014; Robinson et al. 2014; Stevens et al. 2014). Several recent studies, including matching analysis which controls for multiple variables, find that indigenous lands exhibit low deforestation rates. Some research shows that secure indigenous lands have lower deforestation rates than areas with similar characteristics but without tenure security; others find that indigenous lands have lower deforestation rates than land with other tenure types, such as government protected areas (Nelson et al. 2001; Nepstad et al. 2006; Nelson and Chomitz 2011; Nolte et al. 2013; Pfaff et al. 2014; Vergara-Aseno and Potvin 2014).[1]

This literature dispels the argument that government land or individual private property is required for sustainable forest management and use. Secure indigenous forestlands—hereafter tenure-secure indigenous (or community) forestlands—are often linked to low deforestation rates, significant forest cover, and the sustainable production of timber and other forest products. Land titling or other measures to secure tenure do not alone guarantee lower deforestation rates, at least in the short to medium term. Tenure security, however, is recognized as an important precursor to other factors or initiatives designed to promote sustainable management of indigenous forestlands.

While much is known about the local and societal benefits of many community forestlands, questions remain about the economics of securing indigenous and community forestland tenure. This research report seeks to address these matters by asking, "What are the costs compared to the benefits of securing and maintaining tenure for indigenous forestlands in the Amazon basin?" It builds on WRI's recently published working paper, *The Economic Costs and Benefits of Securing Community Forest Tenure: Evidence from Brazil and Guatemala* (Gray et al. 2015). This report focuses on Bolivia, Brazil, and Colombia, provides original matching analysis on deforestation rates, incorporates an array of ecosystem services into the benefit-cost analysis, and includes a set of policy options and recommendations.

The research focuses on the lands, predominantly forestlands, held by Indigenous Peoples in the Amazon basin in Bolivia, Brazil, and Colombia.[2] Communities that define themselves (self-recognized) as Indigenous Peoples are a critical component in the broader category of all communities. They are often recognized separately from other communities for various reasons. Indigenous Peoples typically are more marginalized and suffer higher rates of poverty and inequality than other communities (IWGIA 2015). Indigenous Peoples also benefit from international (UN 2007) and sometimes national rights that other communities do not enjoy (LandMark 2016).

While focusing on indigenous lands, the research findings have implications for community forestlands around the world. A large literature shows that community forestlands are linked to positive social, economic, and environmental outcomes. In Mexico, many indigenous lands and non-indigenous community lands have low deforestation rates and are engaged in the sustainable production of timber and other forest products (Barry et al. 2010; Bray et al. 2005). Community forestlands are also linked to positive social and environmental outcomes in India, Nepal, Tanzania, and elsewhere (Acharya 2002; Arnold 2001).

## 1.1 Why Now?

Many governments in Africa, Asia, and Latin America recognize that tenure-secure community lands can deliver economic wellbeing, social development, and environmental sustainability at the local scale, although few have made securing community land a development priority (Pearce 2016).

The pressures on indigenous and community lands from different outside groups are growing. New roads and other infrastructure are being built; new hydro-electric power plants are being constructed; more mining, oil, and natural gas concessions are being allocated by governments; and large areas of land are being acquired for industrial agriculture (RRI 2014).[3] Many community forestlands that were not previously under threat are now at risk. Indigenous Peoples and local communities are losing their lands and deforestation rates are increasing in many parts of the world. In Brazil, the deforestation rate dropped nearly 80 percent between 2003 and 2013 (Nogueira et al. 2015) but, in 2015, government data show that the rate of deforestation jumped by 16 percent and an area of forest larger than Delaware was lost (Arsenault 2016). Land conflicts are also on the rise, many turning violent and resulting in a growing number of deaths. More land and environmental advocates are being threatened and slain for their efforts to protect indigenous and community land (Global Witness 2014; 2015; Watts 2016).

At the same time, international efforts designed to promote sustainable development and tackle global environmental matters are increasingly recognizing the contributions of tenure-secure community lands. Two developments are particularly noteworthy.

1. In September 2015, the international community launched the Sustainable Development Goals (SDGs) as the blueprint for development for the next 15 years. Land rights are a cross-cutting issue recognized in a number of Goals/Sub-Goals and Targets, including the following (UN GA 2015):

    - **Sub-Goal 1.4.** "By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance."


- **Sub-Goal 2.3.** "By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment."

- **Sub-Goal 5.a.** "Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws."

In March 2016, the UN agreed on 230 indicators to monitor the 17 SDG Goals and 169 Targets (UN ESC 2016). Several indicators address land rights. Indicator 1.4.2 for Sub-Goal 1.4 addresses indigenous and community land rights (customary tenure is a "type of tenure"):

- "Proportion of total adult population with secure tenure rights to land, with legally recognized documentation and who perceive their rights to land as secure, by sex and by type of tenure."

The SDGs provide an important opportunity to mainstream community land rights in development.

2. In December 2015, the Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC), involving almost 200 countries, convened in Paris, France, to finalize a new agreement to curb climate change. In preparation for the negotiations, countries publicly outlined the post-2020 climate actions they intend to take under the new international agreement, known as their Nationally Determined Contributions (NDCs).

This research focuses on indigenous lands, but has implications for community forestlands around the world. A large literature shows that community forestlands are linked to positive social, economic, and environmental outcomes.

The NDCs can help determine whether the world is put on a path toward a low-carbon, climate-resilient future and therefore constitute critically important commitments. Colombia, for example, committed to reducing its emissions by an estimated 67 million tonnes of carbon dioxide equivalent ($MtCO_2e$) by 2030 and, with international support, by an estimated 100$MtCO_2e$ (Government of Colombia 2015). Indigenous lands in the Amazon basin store considerable carbon (Walker et al. 2015) and securing these lands can contribute to meeting national climate change commitments (Stevens et al. 2014). Yet, the NDCs for Bolivia (Government of Bolivia 2015), Brazil (Government of Brazil 2015), and Colombia (Government of Colombia 2015) do not make any specific commitments to securing indigenous or other community land rights (RRI 2016: Appendix 1). In addition to government support, the newly established Green Climate Fund and other climate funds are well positioned to invest in securing indigenous and community forestland tenure to mitigate climate change. These and other milestones provide unique opportunities for global actions to secure land and forest rights for communities.

Research on tenure-secure indigenous and community lands, particularly the economic aspects, can help governments improve policies to maximize social and environmental benefits. Building on the method developed in WRI's *The Economic Costs and Benefits of Securing Community Forest Tenure: Evidence from Brazil and Guatemala* (Gray et al. 2015), this research report shifts the focus to indigenous lands in the Amazon basin. It aims to inform technical leads in the land, forest, and financial sectors of governments, as well as funding agencies, on the economic gains achievable from securing indigenous forestland rights. Such information can encourage these audiences to make new investments in recognizing and protecting community land rights. It may also help Indigenous Peoples, communities, and their partners to make economic arguments for securing their land rights.

Following this introduction (Section 1), Section 2 provides some background on community land rights, including the geographic extent of community lands and forestlands, and the importance of secure tenure for generating social, environmental, and economic benefits. Section 3 provides brief summaries of indigenous land rights in Bolivia, Brazil, and Colombia. Sections 4 and 5 provide an overview of the economic benefits and costs associated with tenure-secure indigenous forestlands. Section 6 presents the economic valuation method and results of the benefit-cost analysis for Bolivia, Brazil, and Colombia. Finally, Section 7 provides a summary of key challenges to indigenous lands in the Amazon basin and presents a number of policy recommendations.


JEPS

SECTION II

# BACKGROUND

The precise amount of community land in the world is not known. The area has been estimated at more than half the world's land (Pearce 2016), or as high as 65 percent or more of the global land area, involving up to 2.5 billion people (Alden Wily 2011). An estimated 22 percent of the world's land is held by Indigenous Peoples (Nakashima et al. 2012; Sobrevila 2008). Communal land is found in all continents of the world except Antarctica, with the largest area located in Africa (Alden Wily 2011).

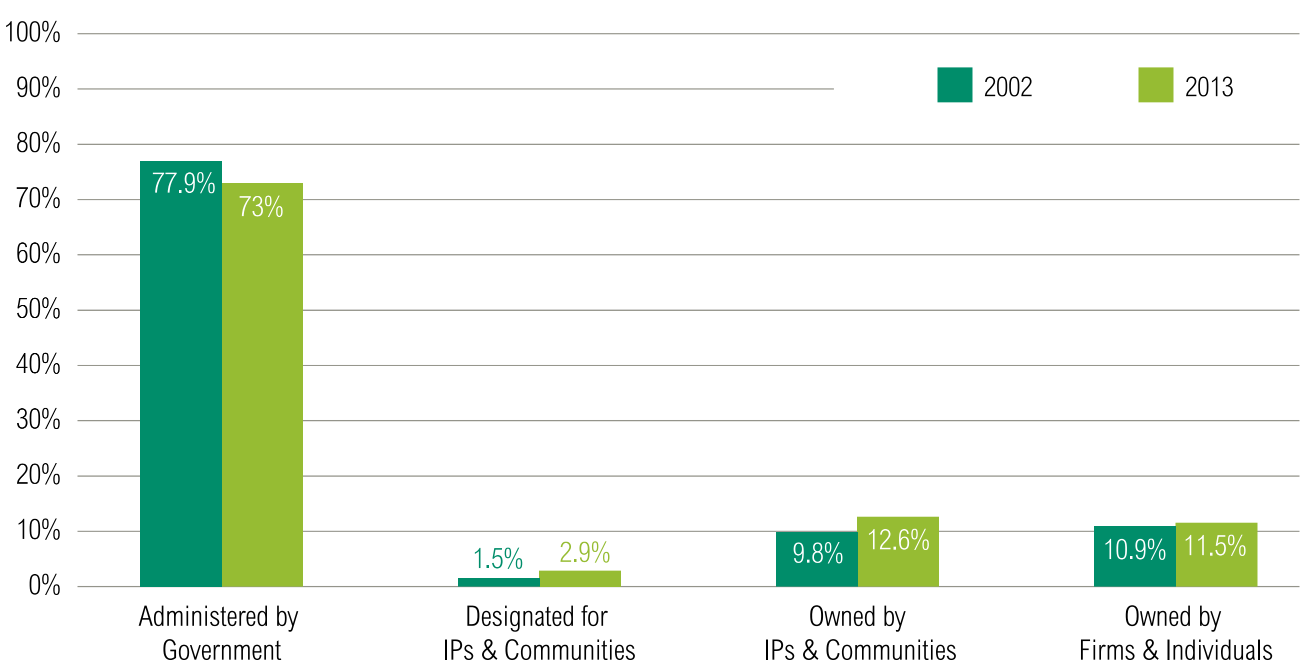
Without strong legal protections and enforcement of rights, communities are vulnerable to losing their land and natural resources. Only 10 percent of the world's land, however, is legally recognized as belonging to communities, with another 8 percent designated by governments for communities (RRI 2015).[4] The remainder of the world's community land is not formally recognized in statutory law.[5]

Forests cover 31 percent of the world's land surface, or just over 4 billion hectares (FAO 2014), with communities holding and using a considerable portion of forests. However, only a small fraction of community forestland is officially recognized by statutory law, and even less is protected and securely held by Indigenous Peoples and communities. In 2013, communities held some legal rights to at least 511 million hectares of forest—about 15.5 percent of the world's forests (RRI 2014) (see Figure 1).[6] This represents an important increase over the last decade: in 2002, communities had formal rights to 11.3 percent of the world's forest (RRI 2014). While governments are increasingly recognizing community rights to forests, in 2013, an estimated 73 percent of the world's forests was still state controlled—down from 77.9 percent in 2002 (RRI 2014). Much of this government forest is actually community forestland held under customary tenure systems.

## 2.1 The Importance of Tenure Security

Secure tenure helps communities to protect their lands from unwelcome threats and challenges. Tenure substantially affects people's ability and incentive to use and manage their land and natural resources. The incentives depend upon expectations of rights over the returns on investments and, therefore, on the nature of land and resource tenure. Clear and secure land tenure can encourage or induce a range of investments of labor, resources, and other assets (Deininger 2003; Goldstein and Udry 2008). Communities often have more incentives to produce goods and services when their lands and resources are secure than when they are at risk (FAO 2002; Place 2009; Sandler 2000).

Figure 1 | **Forest Ownership, 2002–2013 (million hectares)**




*Source:* RRI (2014)

While secure tenure creates incentives for communities to invest in their land, the types of investments and their effects on forests can depend on a range of other factors (Baland and Platteau 1996; Ferretti-Gallon and Busch 2014; Larson and Lewis-Mendoza 2012; Pacheco and Benatti 2015). These investments can support sustainable forest management and lead to the continued provisioning of vital social, economic, and ecosystem-service benefits, or they can usher in alternative land uses that result in the loss or degradation of forestland. In some cases, forestlands generate local benefits sufficient to encourage investments in sustainable land and forest management. Some governments also place restrictions on how community forestlands are used or managed, helping to maintain intact forests. For example, laws may prohibit the commercial exploitation of forest products or prevent communities from leasing or selling their lands. In Brazil, the Forest Crime Law obligates landholders to preserve legal forest reserves in an area equal to 80 percent of total landholding in the Amazon basin (Pacheco and Benatti 2015). Governments can also provide performance payments or other positive incentives (CGD 2015; de Koning et al. 2011), encouraging communities to protect their forests.

Alternatively, public policies or other measures may establish incentives that encourage investments, leading to the clearing of forests for other forms of land use, such as cash crops or pasture for livestock (Ferretti-Gallon and Busch 2014; McFarland et al. 2015). For example, government subsidies for agriculture can exacerbate deforestation (Kissinger 2015). As a consequence, the relationship between land tenure and local wellbeing is complex. In some regions, land-tenure recognition is linked to new investments, and substantial productivity and income gains. In other areas, securing land rights does not guarantee better livelihoods in the form of increased agricultural productivity, income, or other relevant outcomes (Lawry et al. 2016; Ribot and Peluso 2003).

Insecure tenure, however, can lead to expropriation of and encroachment on community lands. As a result, weak tenure commonly discourages people and communities from making long-term investments in their lands and often encourages the over exploitation of the land and natural resources to maximize short-term benefits. Significant, long-term investments are risky when communities have little assurance that they will be able to capture the resulting benefits. And research shows that the degradation or loss of land often leads to local hardships and increased poverty (Barbier 2000; Duraiappah 1998). Insecure tenure also has national and global implications. In addition to the loss of critical ecosystem services, undocumented and contested land rights can adversely affect national economies. The World Bank recently reported that economic growth in Africa was being held back by confusion over land ownership and linked this to the continent's high poverty rates (Byamugisha 2013).

## 2.2 Factors that Can Contribute to Tenure Security

Many factors contribute to tenure security of community lands and these may vary by context and circumstances. Two common factors are:

### Legal Recognition of Community Land Rights

Statutory laws that recognize community lands can help secure tenure. Laws are supportive when they recognize all rights customarily held by communities as lawful forms of land ownership, and protect customary tenure to the same degree as other forms of tenure (e.g., freehold and leasehold). The bundle of land rights may include the rights of access, withdrawal, management, exclusion, and alienation. Each right in the bundle provides communities with certain authorities over their lands (Box 1). Land rights may also include rights to certain natural resources on or below the surface of the land (Veit and Larsen 2013; WRI 2013). Large bundles of rights commonly provide communities with considerable control over their lands and, therefore, often more security. Laws are also supportive if they require the government to provide communities with a formal title to their lands; recognize the community as having legal authority over its land; recognize that customary rights are held in perpetuity; require community consent before any outside actor may acquire community land; and other provisions (LandMark 2016).

While many governments around the world now recognize customary tenure systems, few have established the strong legal protections needed to secure community land. The laws in most countries do not provide Indigenous Peoples and communities with complete bundles of land rights. In general, the laws in Latin American countries provide communities with larger bundles of land rights than those in other regions of the world. The laws in African countries recognize small bundles of land rights (RRI 2012). Few African countries provide communities with any rights to subsurface minerals, oil, or natural gas (WRI 2013), and 95 percent of the world's governments restrict community use of forest resources (RRI 2012).

In addition to providing communities with limited bundles of rights, some governments are also increasingly exercising their authority to restrict (police powers) or extinguish (expropriation) land rights, including community land rights. The use of these powers is commonly restricted to public purposes, such as building public roads and other infrastructure but, around the world, governments are widening the scope of developments that can be considered public purposes, further threatening tenure security (Tagliarino and Verstappen 2016; Veit 2010). In Tanzania and other countries, the laws authorize the President to declare any development a public purpose.

### BOX 1 | BUNDLE OF LAND RIGHTS

There are several rights that communities may enjoy and that governments have the power to legally recognize. The bundle of rights framework developed by the Rights and Resources Initiative (RRI) includes:

- **ACCESS:** right to enter or pass through the forest.
- **WITHDRAWAL OR USE:** right to benefit from the forest's resources.
- **MANAGEMENT:** right to make decisions about forest resources and for a forest area over which the community has rights of access and withdrawal or use.
- **EXCLUSION:** right to refuse access to and use of the forest.
- **DUE PROCESS AND COMPENSATION:** right to legally challenge a government's efforts to take one, several, or all of the community's forest rights.
- **DURATION:** the length of time a community may exercise its rights—either limited or recognized in perpetuity.
- **ALIENATION:** right to transfer the forest to another by sale, lease, or some other means.

*Source:* RRI (2012)

## Protection of Land Rights

While supportive laws provide communities with a layer of tenure security, they must be effectively implemented to actually protect land rights when community lands are threatened. Implementation can be achieved in various ways. Well-resourced government agencies with explicit responsibilities to monitor and protect community lands from unwanted intruders and illegal activities can help to ensure that communities realize their land rights. Communities that understand their land rights and have capable village institutions can patrol and monitor their lands. Civil society organizations and development assistance agencies can help secure tenure by supporting community efforts to map and demarcate their lands, prepare land-use and management plans, and acquire formal land documents. In practice, however, many governments lack the political will or the human and financial resources needed to document and adequately protect community lands. Many actually undermine tenure security by allocating long-term concessions for agricultural plantations, mining operations, and oil and natural gas extraction on indigenous and community land (Land Matrix 2016).

While supportive laws provide communities with a layer of tenure security, they must be effectively implemented to actually protect land rights when community lands are threatened.

SECTION III

# OVERVIEW OF STUDY AREAS IN BOLIVIA, BRAZIL, AND COLOMBIA

Research for this report focuses on indigenous land in the Amazon basin—the majority of which is forestland—in Bolivia, Brazil, and Colombia. Each country includes a significant portion of the Amazon forest, and the governments have formally recognized many indigenous lands and granted Indigenous Peoples relatively large bundles of land rights.

Research for this report focuses on indigenous land in the Amazon basin—the majority of which is forestland[7]—in Bolivia, Brazil, and Colombia (Figure 2) for four principal reasons:

- Each country includes a significant portion of the Amazon forest, the largest remaining tropical forest expanse in the world (Box 2).

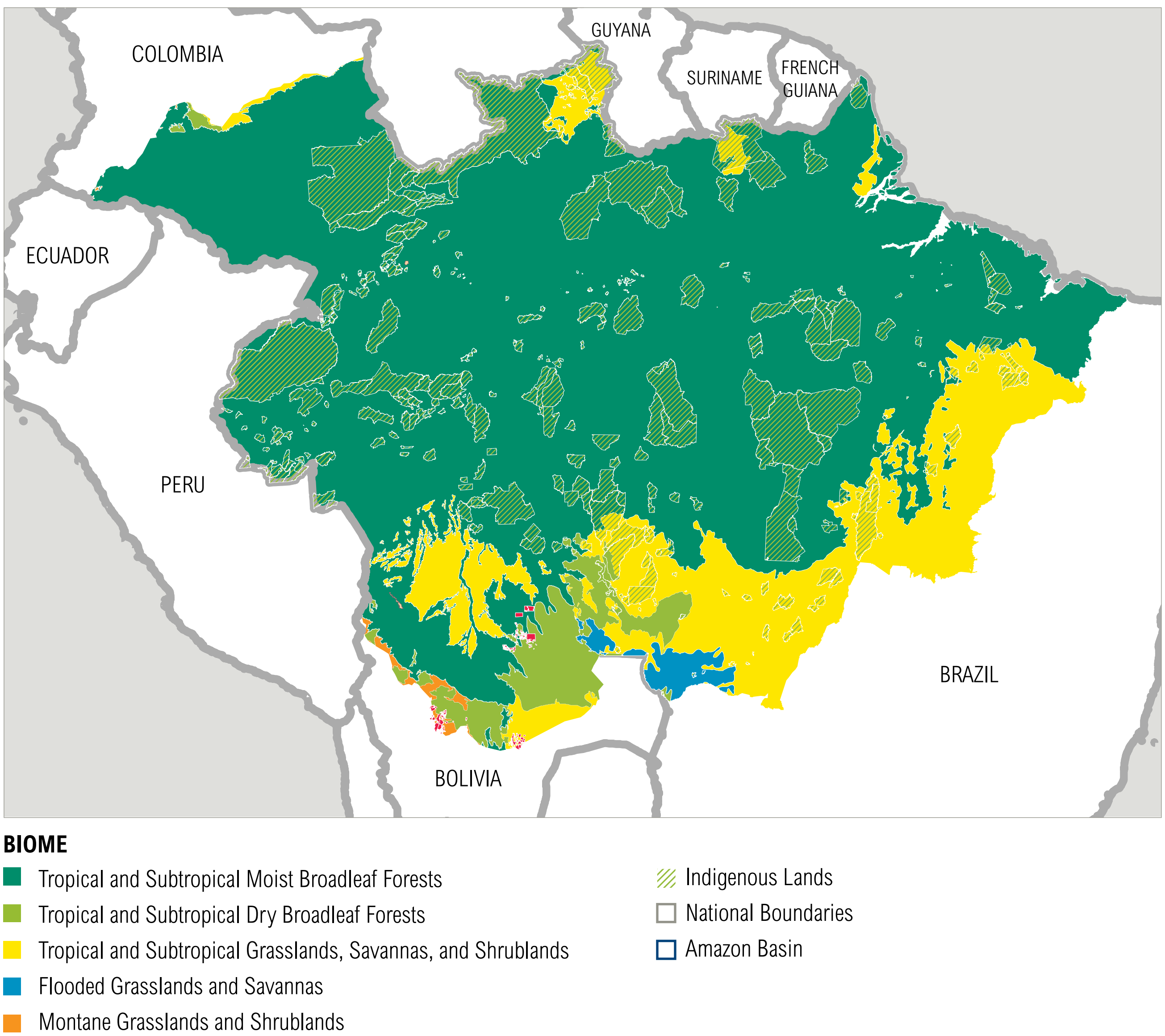
- Governments in these countries formally recognize indigenous lands, and grant Indigenous Peoples relatively large bundles of land rights (RRI 2012; Stevens et al. 2014).

- The three countries include diverse Amazon biome types with unique ecosystem services as well as different procedures and associated costs for securing tenure.

- Many indigenous lands in Bolivia, Brazil, and Colombia have been mapped and the spatial data are available for analysis.

The study area for each country is described below:

Figure 2 | **Map of the Amazon Basin Showing the Indigenous Lands in Bolivia, Brazil, and Colombia**



### Bolivia

Indigenous people account for 62 percent of Bolivia's total population of about 10.5 million and belong to 36 recognized ethnic groups. An additional 30 percent of the population is mestizo, having mixed European and indigenous ancestry (IWGIA 2015). *Tierras Comunitarias de Origen* (TCOs or Native Community Lands) are formally recognized indigenous lands in the Bolivian Amazon basin.[8] Indigenous Peoples are entitled to obtain TCOs, which recognize their exclusive and perpetual rights to use, manage, and benefit from the land and many natural resources. The government retains no formal ownership of these lands. Indigenous Peoples are prohibited from dividing or selling their land (Cano et al. 2015; Vidal 2015a). They have the right of Free, Prior, and Informed Consent (FPIC)[9] although it is often not well implemented. While there are no restrictions on the use of forest resources for traditional and subsistence uses, the commercial use of forest products is subject to conditions described in a government-approved sustainable management plan and the annual payment of a fee.[10] Indigenous Peoples are not subject to tax on agricultural property (Cano et al. 2015; Vidal 2015a).

The Bolivian Amazon basin covers about 67,348,000 ha or 62 percent of the country's total area. The research for this report focused on the TCOs for which maps are publicly available (Figure 2). These maps represent a total area of about 10,964,600 ha (Box 2). The Bolivian Amazon basin (boundaries defined using hydrographic criteria) includes four distinct biomes and TCOs are present in each biome: 65 percent of TCOs are located in the tropical and subtropical moist broadleaf forests biome; 16 percent in the tropical and subtropical dry broadleaf forests biome; 16 percent in the tropical and subtropical grasslands, savanna, and shrublands biome; and the remaining 3 percent in the montane grasslands and shrublands biome.

## BOX 2 | THE AMAZON BASIN IN BOLIVIA, BRAZIL, AND COLOMBIA

| | AREA (HA) OF INDIGENOUS LAND IN BIOME (PERCENTAGE OF INDIGENOUS LAND) | | |
|---|---|---|---|
| | **Bolivia** | **Brazil** | **Colombia** |
| Tropical and Subtropical Moist Broadleaf Forests | 7,133,300 (65%) | 97,631,700 (88%) | 26,004,400 (97%) |
| Tropical and Subtropical Dry Broadleaf Forests | 1,772,900 (16%) | 669,800 (1%) | 200 (<1%) |
| Tropical and Subtropical Grasslands, Savanna, Shrublands | 1,720,400 (16%) | 12,906,700 (12%) | 727,400 (3%) |
| Montane Grasslands and Shrublands | 338,000 (3%) | 0 | 3,000 (<1%) |
| Flooded Grasslands and Savannas | 0 | 30,400 (<1%) | 0 |
| Total Area of Indigenous Land in Amazon Basin | 10,964,600 | 111,238,600 | 26,752,500 |
| Total Area of Amazon Basin | 67,348,000 | 509,490,100 | 49,609,800 |

Calculated at WRI using the following geospatial datasets: INCODER (2015); Instituto Nacional de Reforma Agraria (2012); FUNAI (2014); Olsen et al. (2001).

## Brazil

According to the 2010 census for Brazil, there were almost 900,000 people who self-identify as indigenous, or 0.47 percent of the total population. There are 305 different ethnic groups, speaking 274 indigenous languages (IWGIA 2015). In 2007, the government confirmed the presence of 67 uncontacted tribes living in voluntary isolation, more than any other country in the world.

About 60 percent (509,490,100 ha) of Brazil is recognized in national law to be part of the "Legal Amazon" (boundaries defined by using administrative criteria). This research focuses on the approximately 111,238,600 ha of land in the Brazilian Amazon basin that is formally recognized as indigenous land and for which maps are publically available (Figure 2). Brazil has the largest land areas under statutorily recognized community control in South America, most by Indigenous Peoples.[11] Indigenous lands are located throughout the country but most reside in the Amazon basin.

Brazil's "Legal Amazon" includes four biomes; about 88 percent of indigenous lands are found in the tropical and subtropical moist broadleaf forest biome; 12 percent are found in the tropical and subtropical grasslands, savanna, and shrublands biome; 1 percent in the tropical and subtropical dry broadleaf forests biome; and a very small fraction in the flooded grasslands and savannas biome (Box 3).

The indigenous lands in the Brazilian Amazon basin are formally recognized and mapped in one of four types of collective tenure (Box 3): about 111,057,000 ha (99.8 percent of indigenous lands) are formally recognized as *Terra Indígena*; 14,000 ha are recognized as *Dominial Indígena*; 43,000 ha are recognized as *Interditada*; and 253,000 ha are *Reserva Indígena*. Terra Indígena are inhabited exclusively by Indigenous Peoples and are legally recognized as conservation or sustainable-use protected areas. While these lands are public property, Indigenous Peoples have perpetual rights to the soil and water, the rights to use and manage

### BOX 3 | TYPES OF TENURE ON INDIGENOUS LANDS IN BRAZIL

Under current legislation (CF/88, Law 6001/73 - Indian Statute, Decree n.º1775/96), indigenous lands can be categorized as follows:

**Terra Indígena** (Indigenous Lands Traditionally Occupied): These lands are legally recognized as indigenous lands referred to in art. 231 of the 1988 Constitution, original right of Indigenous Peoples, whose demarcation process is regulated by Decree No. 1775/96.

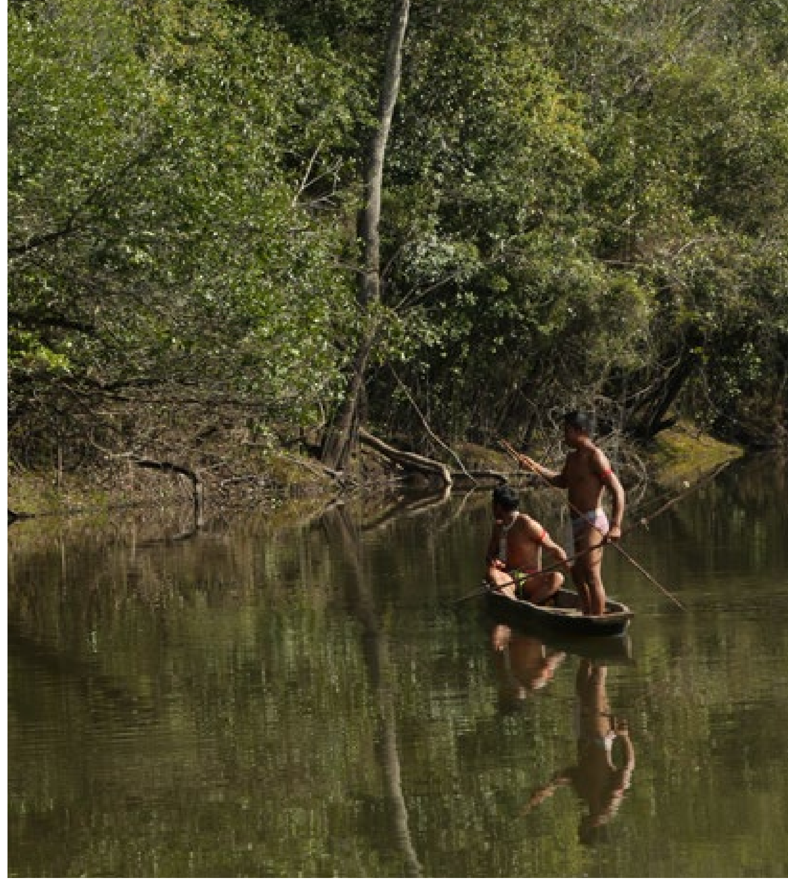
**Reserva Indígena** (Indigenous Reserves): These lands are donated by third parties or acquired by the federal state from anywhere in the country. They are intended for permanent occupation, use, and benefit by Indigenous Peoples (Law Nº 6.001/19 December 1973, art. 26). The lands belong to the state, but are reserved as indigenous lands. Many indigenous reserves were established in the first half of the twentieth century. An important difference between indigenous lands and indigenous reserves is in the procedures to recognize the land; the process to establish indigenous land is strictly regulated.

**Dominial Indígena** (Proprietary Land): These private lands are the property of Indigenous Peoples; the designation constitutes full ownership by the Indigenous Peoples or individual members. Proprietary lands are regulated by the terms of the civil code (Law 6001/73, art. 32).

**Interditada (Interdicted):** These lands are reserved (blocked) for the use of Indigenous Peoples in isolation; they may or may not become indigenous land. These lands are interdicted by the Fundação Nacional do Índio (FUNAI) to protect isolated Indigenous Peoples from third-party interference (restrictions are placed on third parties' access to and use of these lands). These lands are governed by Decree No. 1775/96.

*Sources:* FUNAI (2015); Heck et al. (2005)

the forest, and the right to exclude others from their land. Many forest resources may be used for commercial purposes subject to a government-approved sustainable forest management plan, but cutting trees for sale also requires authorization by statute (e.g., National Congress) (Clay et al. 2000; Fearnside 2003a). The Constitution (Arts. 176, 231(3)) provides that minerals belong to the state, but no party can access them unless authorized by statute. The government has not generally authorized access to mineral resources in indigenous lands, but this is the subject of perennial legal maneuvers, legislative bills, and constitutional arguments (Davis 2013; RRI and ISA 2014). The Constitution (Art. 231(3)) permits the legislature to authorize dams on indigenous lands. Roads are generally barred from indigenous lands, but have been built on some lands.



## Colombia

The National Statistics Department estimates the indigenous population (pueblos indígenas) in 2012 at around 1,450,000 people or 3.5 percent of the national population (IWGIA 2015). About 80 percent of the indigenous population is located in the Andean departments of Cauca, Nariño, and La Guajira (Belazelkoska 2013). The Amazon basin of Colombia is sparsely populated, but is home to over 70 different Indigenous Peoples (IWGIA 2015).

Approximately 44 percent (49,609,800 ha) of Colombia is in the Amazon basin (boundaries defined using hydrographic criteria). About 54 percent (26,752,500 ha) of the Colombian Amazon basin is formally recognized as indigenous land (Figure 2).[12] The vast majority of this indigenous land (97 percent) is in the tropical and subtropical moist broadleaf forests biome; 3 percent is located in the tropical and subtropical grasslands, savanna, and shrublands biome; and small fractions are located in the tropical and subtropical dry broadleaf forests and the montane shrublands and grasslands biomes (Box 2).

Indigenous lands in the Colombian Amazon basin are formally recognized as *Resguardo Indígena* (Indigenous Reserves). The inhabitants of *Resguardo Indígenas* have legal rights similar to those in the *Terra Indígena* in Brazil, including the rights to use and manage their forests, to benefit from timber and non-timber forest resources for subsistence and traditional uses, and to exclude outsiders. Commercial use of forest products requires government approval. The law recognizes the right of Indigenous Peoples to govern their lands with autonomy according to their own customary rules, although the lands are state-owned and cannot be sold (Vidal 2015b). The 1991 Constitution defines political, administrative, and financial decentralization in Colombia, including Indigenous Territorial Entities. *Resguardo Indígena* can become Indigenous Territorial Entities but few have been established. In 2011, Colombia's Constitutional Court "unconditionally" recognized FPIC for Indigenous Peoples and halted several industrial projects for not properly consulting or gaining the consent of affected Indigenous Peoples (Schertow 2011).

SECTION IV

# ECONOMIC BENEFITS OF TENURE-SECURE INDIGENOUS FORESTLANDS

Secure tenure over forestlands creates incentives for Indigenous Peoples to protect forests and sustainably produce goods and services. Secure tenure can also promote other economic benefits by reducing conflict and enhancing mechanisms for collective action, and by encouraging job creation and actions that support local populations (e.g., local reinvestment in education and health programs).

## 4.1 Overview of Benefit Categories

This research report identifies three principal types of economic benefits: ecosystem-service benefits, collective-action benefits, and other social benefits. It does not attempt to assess the total economic value of all benefits provided by the Amazon forests. Rather, it quantifies a few ecosystem-service benefits resulting from reduced deforestation on forestlands where land rights are clearly recognized for Indigenous Peoples. To investigate the effectiveness of tenure-secure indigenous forestlands in reducing deforestation, an original matching analysis is conducted for the study areas. It compares and estimates the annual deforestation rates of forestlands with similar characteristics within and outside indigenous forestlands. The differences between deforestation rates inside and outside indigenous forestlands are used to calculate the total forest areas that are protected from deforestation each year under land-rights regimes, as well as the associated multiple ecosystem-service benefits, with a primary focus on carbon benefits.

### 1. Ecosystem-Service Benefits

Ecosystem services are the benefits that people obtain from ecosystems. Forests in the Amazon basin provide a variety of goods and services that benefit humankind both locally (local benefits) and globally (global benefits). Global ecosystem-service benefits provided by Amazon forests include, for example, carbon sequestration. Locally, forests contribute to livelihoods in the form of both monetary benefits (e.g., employment and direct income generation) and non-monetary benefits (e.g., strengthened climate resilience).

The Millennium Ecosystem Assessment (2005) organizes ecosystem services into four categories: supporting, regulating, provisioning, and cultural services. Examples of forest-ecosystem services for each category are described in Table 1.

Despite challenges of measuring and valuing ecosystem services, many studies have attempted to estimate the total value of forest-ecosystem services for demonstrating the multiple co-benefits of forest conservation and supporting sustainable forest management policies. For example, The Economics of Ecosystems and Biodiversity (TEEB 2009) estimates that the average value of ecosystem services from tropical forests (including climate regulation) is $6,120 (2007 US$) per hectare per year, with a maximum value range to $16,362 per hectare per year.[13] Among the valued ecosystem services, the provisioning of food and raw materials represents only a small portion (about 8 percent) of the total value, whereas the highest values are found associated with climate regulation (about 32 percent), regulation of water flows (about 22 percent), and erosion prevention (11 percent). These value estimates were taken from 109 original studies that have reported representative values for different ecosystem-services categories. Similarly, de Groot et al. (2012) estimated the total economic value of tropical forests at an average value of $5,264 (2007 US$)[14] per hectare per year and Costanza et al. (2014) estimated an average value of forest-ecosystem services at $3,800 per hectare in 2011.[15]

### 2. Collective-Action and Conflict-Resolution Benefits

In addition to ecosystem services, tenure-secure indigenous forestlands can also produce other economic benefits by reducing conflict and enhancing mechanisms for collective action.[16] When Indigenous Peoples have clear and enforceable rights, they may be better able to work with each other as well as with external stakeholders to manage their forests. This can generate extra benefits by reducing some of the transaction costs of forest management (e.g., reduced need for meetings and staff) both for Indigenous Peoples and for other stakeholders.

Table 1 | **Forest-Ecosystem Services**

| ECOSYSTEM-SERVICE TYPE | EXAMPLES OF ECOSYSTEM SERVICES | VALUE TYPE | SCALE OF THE BENEFITS |
|---|---|---|---|
| **Regulating** | Carbon sequestration; regulation of local climate dynamics; hydrological services; water-flow regulation; water filtration; erosion prevention; pollination | Indirect use value | Mainly local but also global (e.g., carbon sequestration) |
| **Provisioning** | Food; water supply; timber and non-timber products; medicinal products; genetic resources | Direct use value | Mainly local but also global |
| **Supporting** | Habitat for species; genetic diversity | Indirect use value | Local and global |
| **Cultural** | Recreation and tourism; sacred ritual and burial sites; habitat; educational uses; existence | Direct and indirect use value; non-use value | Mainly local and to some extent global |

*Source:* Based on TEEB (2009)

Clear land rights and land governance roles can also reduce conflict costs for Indigenous Peoples and other stakeholders. Many forest-related conflicts result from differing interpretations of rights and tenure and many such conflicts turn violent. Examples include disputes between Indigenous Peoples and other communities over boundaries, and disputes between forest concession-holders and Indigenous Peoples over access to forest products, decision-making, and benefit sharing (De Koning et al. 2008).

Conflicts over weak land rights can disrupt economic growth in many ways. Indigenous Peoples may spend resources guarding and protecting their lands rather than using them for productive activities. Further, Indigenous Peoples may have less incentive to produce goods and services if their lands are at risk (Sandler 2000). Indigenous Peoples with secure tenure who act together to manage forestlands can also help reduce transaction costs of coordinating actions and communications with secondary and external stakeholders (Larson et al. 2010). Indigenous forestland networks are known to increase their access to forest resources and markets, build capacity of local groups, and expand their interface with decision-makers (Larson et al. 2010).

### 3. Other Social Benefits

Secure tenure can encourage job creation and actions that support Indigenous Peoples and other communities (e.g., local reinvestment in education and health programs). A multitude of other social benefits is possible when forest productivity is increased and ecosystem services are maintained through avoided deforestation. For example, when Indigenous Peoples are better able to manage their forests and increase the provision of ecosystem-service benefits, they can create more jobs and generate more revenues to support social programs. In many countries, indigenous forestlands serve as regional employment centers, supporting livelihoods for indigenous people as well as migrants who come seeking work. Often, local forestry enterprises reinvest a portion of their profits from timber sales into education, health, or other social programs.

In sum, the benefits of tenure-secure indigenous forestlands can support Indigenous Peoples and other communities locally and globally. Forest ecosystems may directly benefit Indigenous Peoples in the form of income generation from selling forest products, or indirectly support local livelihoods by providing regulating and supporting ecosystem services. Forests can also help regulate and retain soil nutrients, and contribute to regulating local climate dynamics that are important for biodiversity conservation and agricultural productivity. In addition, these ecosystems can generate global benefits, such as carbon sequestration, along with other climate regulating services, contributing to global climate change mitigation efforts.

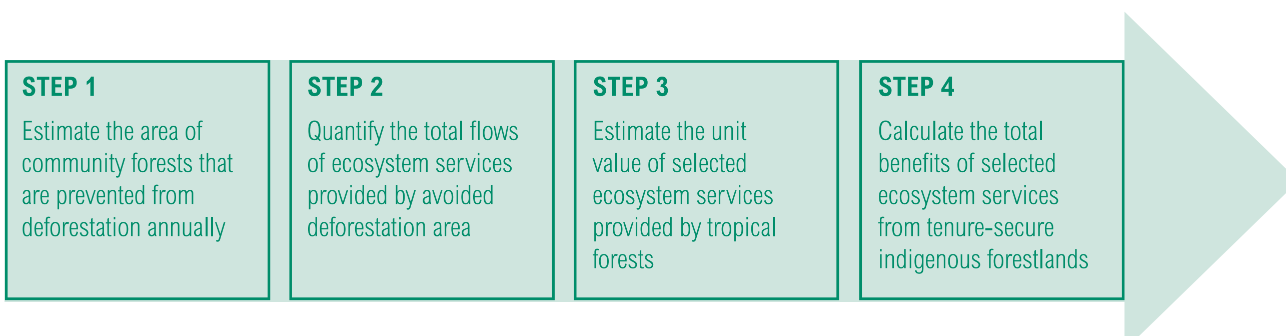
Collective-action and conflict-resolution benefits accrue principally to communities, and to the local and national stakeholders who interact with them directly. Similarly, social benefits apply mostly to communities that benefit from improved education and health care, but may also be felt regionally and nationally because governments may need to invest less in health care and education subsidies. However, the collective-action benefits and social benefits from indigenous forestlands are not as well documented as some ecosystem-service benefits. For instance, the potentially avoided transaction costs of forest management associated with tenure-secure indigenous forestland, and the amount of income generated—whether by direct extractive uses of indigenous forestland resources (e.g., timber harvest) or other conservation activities (e.g., payments for ecosystem services)—that is reinvested in health and education programs by communities, are not well known. As a result, this research does not include these benefits in the benefit-cost analysis.

## 4. 2 Assessing the Ecosystem-Service Benefits of Tenure-Secure Indigenous Forestlands

The assessment of ecosystem-service benefits of tenure-secure indigenous forestlands consists of four steps (Figure 3). First, a matching analysis is conducted to estimate the total area of indigenous forestlands that is saved annually from deforestation due to the presence of tenure security. Second, selected ecosystem services provided by the annually avoided deforestation area are quantified. Third, the unit values of the selected ecosystem services (measured in $/ha) provided by indigenous forestlands are estimated based on the literature. Last, the unit value of ecosystem services is multiplied by the quantity of these services to calculate the total economic benefits of tenure-secure indigenous forestlands.[17]

Additional information regarding each of the four steps is provided below.

Figure 3 | **Four Steps for Assessing the Ecosystem-Service Benefits of Tenure-Secure Indigenous Forestlands**



### 4.2.1 Matching Analysis for Estimating the Impacts of Tenure-Secure Indigenous Forestlands on Deforestation

The main challenge faced in measuring the effect on deforestation of tenure-secure indigenous forestlands lies in not being able to observe the counterfactual—what the rate of deforestation on indigenous forestlands would be absent tenure security. A common solution is to use the contemporaneous rate of deforestation on untitled land as a proxy for the counterfactual. But this strategy is complicated by the fact that Indigenous Peoples are not randomly sited. Rather, as the data illustrate, Indigenous Peoples tend to be sited on land with preexisting geophysical and socioeconomic characteristics that stem deforestation. Therefore, measuring the effect of tenure security on deforestation by simply comparing the average deforestation rate inside indigenous forestlands and outside—with the latter average serving as the counterfactual—would conflate the effects on deforestation with the effects of the preexisting characteristics of the land, thereby generating a biased result. For example, in Bolivia, compared to land outside, land inside indigenous forestlands tends to be further from large population centers, less populated, and in areas with relatively low opportunity costs, all characteristics that typically slow deforestation. Unless these variables are controlled for, the research would attribute the relatively low rates of deforestation inside indigenous forestlands to the security of these lands, when at least part may be due to these other characteristics.

To help control for such bias, a matching analysis is conducted. Matching analysis refers to a statistical impact-evaluation technique widely used in economic evaluations of policy impact. Matching analysis seeks to explicitly force “apples to apples” comparisons by pairing protected and unprotected locations that are similar in their landscape characteristics (Joppa and Pfaff 2010), in order to allow for the isolation of a specific policy-change impact (e.g., establishment of tenure security).

The effect of tenure security is measured by comparing the rate of deforestation inside indigenous forestlands with the rate on forestland outside that

is similar in terms of the characteristics that drive deforestation. More specifically, following Andam et al. (2008), Blackman et al. (2015) and others, a quasi-random sample of points inside and outside of tenure-secure indigenous forestlands is selected in a study area. Next, a subsample of matched control points outside indigenous forestlands is selected that are observationally similar to the points inside and the effect of tenure security is measured (known as the average treatment effect on the treated—ATT) by comparing the average rates of deforestation on points inside indigenous forestlands and matched points outside.

A variety of techniques can be used to match points with tenure security with points not secure and to compare outcomes on each subsample (Caliendo and Kopeinig 2008; Stuart 2010). To ensure robustness, three estimators are used: nearest neighbor one-to-one propensity score matching,[18] nearest neighbor one-to-eight propensity score matching, and a probit regression[19] with matched control points. In addition, a “naïve” estimator is used that does not control for pre-existing land characteristics—the simple difference between the average rates of deforestation on all tenure-secure and tenure-insecure points in the sample. The purpose of this effort is to shed light on the value of the matching approach.

Table 2 | **Variables Used in Matching Analysis**

| VARIABLE | DESCRIPTION | SOURCE | UNITS |
|---|---|---|---|
| **Outcome** | | | |
| CLEAR | Cleared during 2000–2012 | Hansen et al. (2013) | 0/1 |
| **Treatment** | | | |
| TITLE | Location of indigenous lands | LandMark | 0/1 |
| **Control** | | | |
| ALTITUDE | Elevation | Farr et al. (2007) | m |
| SLOPE | Slope (100*tan(n angle/180)) | Farr et al. (2007) | % |
| NORTHFACE | Aspect = N, NW or NE | Farr et al. (2007) | 0/1 |
| CARBON | Above-ground biomass density | Saatchi et al. (2011) | mg/ha |
| TRAVEL TIME | Time to nearest city w/pop. >50K | Nelson (2008) | min |
| POPULATION | Population density | CIESIN–CIAT (2005) | person/ha |
| OPPORTUNITY COSTS | Gross potential agricultural revenue | Naidoo and Iwamura (2007) | US $/ha |
| RAIN | Average monthly precipitation | Hijmans et al. (2005) | mm |
| TEMPERATURE | Average monthly temperature | Hijmans et al. (2005) | °C |
| BIOME | Terrestrial biome (forest, grassland, etc.) | Olson et al. (2001) | n/a |
| PROTECTED | Protected area | IUCN–UNEP (2007) | n/a |

The deforestation data are derived from Hansen et al. (2013), a data set covering the global tropics that maps forest loss each year from 2001–2012 at a scale of 30m × 30m (Table 2). A variety of data is used to control for the pre-existing characteristics of land that may affect deforestation, including information on altitude, slope, directional orientation, biomass density, travel time to large population centers, opportunity costs of retaining land in forest, historical precipitation and temperature, and forest biome.

The difference in deforestation rates between tenure-secure areas and matched plots (i.e., the no-policy scenario) is estimated. The annual avoided deforestation impact in a country is the difference between these rates, which is then applied to the total area of tenure-secure indigenous forestlands located in each forest biome to estimate the annual area of avoided deforestation by different Amazon biomes in Bolivia, Brazil, and Colombia. Accounting for biome difference is essential for valuing the carbon sequestration benefits due to the variation of carbon stocks. The area to which the deforestation-rate impacts can be applied shrinks every year because the estimated deforestation rate is not zero and thus the annual total avoidable deforestation decreases over time.

Results from the matching analysis undertaken for this report are presented in Table 3 (technical details are included in Appendix 2). The average annual deforestation rates are the annual average of the deforestation rates estimated by matching analysis for a period of 12 years between 2000 and 2012. Overall, after controlling for the other factors (see Appendix 2), tenure-secure indigenous forestlands are correlated with substantially lower rates of deforestation in Bolivia, Brazil, and Colombia. That is, the annual deforestation rates inside the tenure-secure indigenous forestlands are significantly lower than those outside in all three countries, suggesting that securing indigenous forestland tenure contributed to reducing deforestation in these areas between 2000 and 2012. Further, these countries have undertaken a regularization and titling process to recognize indigenous lands since the 1990s and in particular in the past decade. The effects on reducing deforestation in many areas are already observable, which suggests that deforestation rates have declined over time and that these effects will likely continue if the indigenous forestlands remain secure.

Table 3 | **Estimated Effect of Tenure-Secure Indigenous Forestlands on Deforestation in Bolivian, Brazilian, and Colombian Amazon Basin, 2000–2012**

| COUNTRY | OBSERVED ACTUAL DEFORESTATION (INSIDE INDIGENOUS FORESTLANDS) | | ESTIMATED COUNTERFACTUAL DEFORESTATION (OUTSIDE INDIGENOUS FORESTLANDS) | | EFFECT (AVERAGE TREATMENT EFFECT ON THE TREATED) | | | |
|---|---|---|---|---|---|---|---|---|
| | (12-year total, %) | (12-year average, %) | (12-year total, %) | (12-year average, %) | (12-year total, % point) | (12-year average, % point) | (total, % change) | (12-year average, % change) |
| Bolivia | 1.77 | 0.15 | 5.2 | 0.43 | -3.43 | -0.28 | -63.69 | -5.31 |
| Brazil[20] | 0.67 | 0.06 | 1.74 | 0.15 | -1.07 | -0.09 | -57.33 | -4.78 |
| Colombia | 0.43 | 0.04 | 1.01 | 0.08 | -0.58 | -0.05 | -48.20 | -4.02 |

*Source:* Matching analysis detailed in Appendix 2. Estimated counterfactual deforestation is the deforestation rate on observationally similar areas outside of indigenous lands. Effects estimated using probit model with matched controls. The last two columns are the estimated percentage change in deforestation using the observed actual rate of deforestation as a baseline. All effects are statistically significant at the 5 percent level.

In this study, matching analysis provides a fundamental basis for assessing the deforestation rates for the Amazon forests in Bolivia, Brazil, and Colombia. Although the method has a solid scientific foundation and relies on statistical analysis of historically observed data, it is important to note that different runs of matching analysis may lead to varying results due to the specific timeframes and variables defined in different studies. In the present study, the deforestation rates estimated for inside and outside indigenous forestlands in Brazilian Amazon forests are lower than the deforestation rate used in Gray et al. (2015),[21] a precursor to the present report that was based on the deforestation rates estimated by Nepstad et al. (2006). There has been an overall declining trend in deforestation in Brazil (as well as Bolivia and Colombia) over the past two decades, therefore the annual deforestation rates estimated in the present matching analysis, using more updated data, are lower than the ones estimated in Nepstad et al. (2006). That study reported that, between 1997 and 2000, the annual deforestation rate in Brazil was 1.45 percent outside indigenous lands and 0.17 percent inside indigenous forestlands.

### 4.2.2 The Benefits of Global Carbon Sequestration Services

The Amazon forests contain one-tenth of the global carbon stored in land ecosystems (86±17 Pg of carbon) (Saatchi et al. 2011), and account for one-tenth of global net primary production, sequestering 0.49±0.18 Pg of carbon in an average climatic year (Phillips et al. 2008). Securing indigenous and community forestland tenure can reduce deforestation rates and the incidence of fire, avoid transforming forests from carbon sinks to carbon sources, and contribute to global $CO_2$ mitigation efforts. These carbon benefits make securing indigenous forestland tenure an effective carbon-mitigation and climate-regulation tool.

When the annual deforestation rates inside tenure-secure indigenous forestlands in Bolivia, Brazil, and Colombia are determined by matching analysis, the total avoided deforested areas can then be calculated to determine the total carbon stored in these forests. A common deforestation rate is assumed for all indigenous forestlands in one country, but the carbon density (i.e., total carbon stored per hectare of forestland) will differ depending on the type of Amazon biome and its current status (i.e., intact, partially deforested, or deforested). Along with the size of that biome held by Indigenous Peoples, these

factors determine the total avoided $CO_2$ emissions that can be stored by each biome. Finally, the estimated avoided $CO_2$ emissions from different Amazon biomes are summed to calculate the total carbon sequestered by total avoided deforested forestlands that are held securely by Indigenous Peoples in Bolivia, Brazil, and Colombia. This approach yields a smaller quantity of total carbon saved from avoided deforestation in Brazilian indigenous forestlands than that reported by Gray et al. (2015), because the latter applied one average carbon density to the entire forest area included in the analysis.

Finally, to monetize these carbon benefits—the avoided damages from the avoided deforestation in tenure-secure indigenous forestlands—various estimates of the social cost of carbon (SCC) are used. The SCC is an estimate of the economic damages associated with an incremental increase in carbon dioxide ($CO_2$) emissions in a given year. More information on these methods is presented below.

### 1. ESTIMATING THE TOTAL CARBON STORAGE IN THE AMAZON BASIN INDIGENOUS FORESTLANDS

The estimation of the total carbon stored through avoided deforestation is based on the difference in carbon-stock values (including both the above- and below-ground biomass content in a given forest biome) between intact forest and partially deforested or totally deforested areas (i.e., a carbon-storage difference). Depending on whether forests are partially deforested or deforested, a range of carbon-storage gaps can be calculated for the different Amazon biomes. Using publicly available data sourced from the respective government of each country, the total area of indigenous forestlands within specific Amazon biomes is calculated, as well as the corresponding upper- and lower-bound estimates of the carbon differences (see Table 4). More specifically, the **lower-bound carbon gap** refers to the difference between carbon stocks in intact forests and in partially deforested forests. This is the minimum amount of stored carbon that may be released to the atmosphere if a given area of intact forests is partially deforested. The **upper-bound carbon gaps** refer to the difference between carbon stocks in intact forests and completely deforested lands. This is the maximum amount of stored carbon that may be released to the atmosphere if a given area of intact forests is completely deforested. Therefore, the carbon sequestration benefits are equivalent to damages avoided by preventing $CO_2$ emissions release from either partially or fully deforested indigenous forestlands.

To calculate the total reduced $CO_2$ emissions through avoided deforestation on all relevant Amazon biomes, the per-hectare carbon-storage values (presented in Table 4) were converted to the equivalent $CO_2$ emissions, using a conversion factor of 3.677,[22] and then multiplied by the area of annually avoided deforestation by biome under indigenous forestland management. The avoided deforestation is calculated based on the difference between deforestation rates within and outside indigenous forestlands (estimated through the matching analysis previously discussed).

Table 4 | **Estimated Area of Indigenous Forestlands and Carbon-Storage Difference for the Amazon Basin of Bolivia, Brazil, and Colombia**

| COUNTRY | AMAZON BIOMES | TOTAL AREA OF INDIGENOUS LANDS ('000 HA) | AVERAGE CARBON GAP (MG C/HA) | |
|---|---|---|---|---|
| | | | Lower bound* | Upper bound** |
| Bolivia | Tropical and subtropical moist broadleaf forests | 7,133 | 69 | 114 |
| | Tropical and subtropical dry broadleaf forests | 1,773 | 88 | 104 |
| | Tropical and subtropical grasslands, savanna, and shrublands | 1,720 | 87 | 106 |
| | Montane grasslands and shrublands | 338 | 44 | 80 |
| Brazil | Tropical and subtropical moist broadleaf forests | 97,632 | 86 | 120 |
| | Tropical and subtropical dry broadleaf forests | 670 | 83 | 101 |
| | Tropical and subtropical grasslands, savanna, and shrublands | 12,907 | 113 | 127 |
| | Flooded grasslands and savannas | 30 | 15 | 30 |
| Colombia | Tropical and subtropical moist broadleaf forests | 26,004 | 64 | 98 |
| | Tropical and subtropical dry broadleaf forests | 0.21 | 131 | 162 |
| | Tropical and subtropical grasslands, savanna, shrublands | 727 | 79 | 101 |
| | Montane grasslands and shrublands | 3 | 17 | 30 |

*Lower-bound estimate assumes the carbon gap between intact and partially deforested area
**Upper-bound estimate assumes the carbon gap between intact and deforested area

*Source:* Estimated at WRI using geospatial analysis and the following datasets (see References for full citations): INCODER (2015) (Colombia); INRA (2012) (Bolivia); FUNAI (2014) (Brazil); Olson et al. (2001) (biomes).

### 2. CHOOSING SOCIAL COSTS OF CARBON AS THE UNIT PRICE OF CARBON

To understand the broader societal economic gains related to tenure-secure indigenous forestlands, the economic value of carbon storage resulting from avoided deforestation is estimated by multiplying the annual carbon-stock values by an estimate of the social cost of carbon (SCC), which internalizes global externalities caused by $CO_2$ emissions.

The SCC, calculated based on a global damage function, is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It can be interpreted as the value of avoided climate damages at the margin—the marginal benefit to society associated with 1 tonne $CO_2$ emissions reduction (Ding 2011; Pearce 2003). The damage calculus includes (but is not limited to) changes in net agricultural productivity, human health, property values given increased flood risk, and the value of ecosystem services that result from climate change. Using SCC to calculate carbon benefits allows the calculation of total economic benefits (or avoided global damages) to be based only on the quantity of total $CO_2$ emissions reduced by a variety of carbon-mitigation technologies (including ecosystem-based methods), regardless of their respective implementation costs.[23] It can help with understanding the potential global carbon benefits (or avoided global damages of climate change) attributable to tenure security of the indigenous forestlands in the Amazon basin.

The U.S. Government's latest estimate of the global social cost of carbon (SCC) of $41/t$CO_2$ (estimated at a 3 percent discount rate and adjusted to 2015 US$) (U.S. Government 2015) was used for this research (Table 5). This is the most comprehensive recent assessment available. To represent the higher-than-expected economic impacts from

Table 5 | **Estimated carbon Storage Benefits from Avoided Deforestation on Indigenous forestlands (US$/ha/yr, estimated with SCC=$41/tCO2)**

| COUNTRIES | AVERAGE | LOWER BOUND | UPPER BOUND |
|---|---|---|---|
| Bolivia | 40 | 32 | 48 |
| Brazil | 14 | 12 | 16 |
| Colombia | 6 | 5 | 7 |

*Note:* Lower-bound estimates the carbon storage benefits obtained from protecting partially deforested area.
Upper-bound estimates the carbon storage benefits obtained from protecting completely deforested area.

climate change further out in the tails of the SCC distribution, the interagency working group also reported an upper-bound value estimate of $121/tCO_2$ emissions in the year 2015 (2015 US$), which is applied in this research as part of the sensitivity analysis to understand the robustness of the benefit-cost analysis results. In addition, a carbon-market price of $6/tCO_2$ is used as a lower-bound estimate to complete the sensitivity analysis. While the interagency report shows an increasing SCC value through 2050, to reflect the expected increasing costs of climate damage, the SCC value is held constant over time in the present report to be more conservative.

In addition to global carbon benefits, multiple local and regional benefits arise from indigenous forestlands in the Amazon basin. These benefits are essential to local livelihoods, but are mostly public in nature and cannot be sold in the market. The difficulty of measuring and accounting for these benefits causes them to be largely overlooked by policymakers.

### 4.2.3 Other Ecosystem-Service Benefits of Tenure-Secure Indigenous Forestlands in the Amazon Basin

Economists distinguish between use and non-use values of ecosystem services. These values are essential for local livelihoods, but may or may not contribute directly to local income generation.

Use values are values directly related to the use of ecosystem services by humans. There are three types of use values, including: direct use values that arise from direct interaction with ecosystems (e.g., extractive resource use); indirect use values that are associated with services provided by resources, but without direct use (e.g., carbon sequestration); and option values, which are goods or services of potential value that are held in reserve for future consumption.

Non-use values are values that are not related to the current or future uses of an ecosystem service, but are derived from the knowledge that an ecosystem exists and is maintained. Non-use values can be further divided into existence value, bequest value, and altruistic value. Existence value is the satisfaction derived from the knowledge that ecosystems exist and will continue to exist, regardless of whether or not they have any use value. Bequest value is the satisfaction derived from ensuring that ecosystems will be passed on to future generations to use and enjoy. Altruistic value is the satisfaction derived from ensuring that ecosystems are available to other people in the current generation.

The valuation of some use values is relatively straightforward because many ecosystem services are sold directly in the market place. Some others, like non-use values, cannot be measured or valued directly. Examples include ecosystem supporting services and some regulating services, such as water retention and soil-erosion regulation services provided by forest ecosystems. When it is not possible to account for important ecosystem-service benefits, there is a risk of underestimating the true value of forest ecosystems that should be internalized when developing cost-efficient forest conservation policies. To reveal these non-market values, economists tend to use production function methods to value the related outputs of a biophysical production process that have market value. Alternatively, they use stated- and revealed-preference methods to value ecosystem services (e.g., biodiversity) in surrogate markets. The former method is built upon biophysical models and the latter often involves surveys at the site level to assess people's willingness to pay for some specific ecosystem service. The valuation of even a few essential ecosystem services in the forestland for the entire Amazon basin across three countries can be extremely demanding on time and resources.

For this reason, valuation of these ecosystem services relies mainly on the findings reported in the literature. Table 6 presents a summary of the value ranges of ecosystem-service benefits (see Box 4 for more details) of Amazon forests, derived from a review of various peer-reviewed and grey literature. These values are presented in the form of per-hectare values covering the average, lower- and upper-bound estimates that were found for the Amazon forests in the literature.

In the present study, the average per-hectare values of ecosystem services are used to assess the average regional and local non-carbon benefits (mostly non-market values) that can be generated from the avoided deforestation in the indigenous forestlands. Using the range of value estimates can also account for the uncertainty around different valuation methodologies and research scopes used for assessing these numbers (Box 5).

Unlike the carbon sequestration assessment, value estimates reported in this section are averaged of different ecosystem services for the Amazon forests as a whole. Hence, they can be used only as supporting material in relevant international policy debates, not for site-specific policy decision-making.[24]

Table 6 | **Value Ranges of Local Ecosystem-Service Benefits from the Amazon Forest (US$/ha/yr)**

| ECOSYSTEM SERVICES | AVERAGE | LOWER BOUND | UPPER BOUND |
|---|---|---|---|
| Hydrological services | 287 | 175 | 400 |
| Nutrient retention | 150 | 100 | 200 |
| Regulation of local climate dynamics and water cycling | 113 | 55 | 170 |
| Pollination | 45 | 40 | 50 |
| Existence value | 15 | 5 | 25 |
| Recreation and tourism | 5 | 3 | 7 |

*Source:* van Beukering (2015) Table 5.1, based on Verweij et al. (2009)
*Note:* US$ in 2015 US$

## BOX 4 | UNDERSTANDING THE LOCAL AND REGIONAL ECOSYSTEM-SERVICE BENEFITS REPORTED IN TABLE 6

### 1. HYDROLOGICAL SERVICES AND NUTRIENT RETENTION

Forest ecosystems provide hydrological services such as regulation of runoff, sediment control, and regulation of flooding that ultimately contribute to erosion control (Bonnel and Bruijnzeel 2005; Bruijnzeel 2004; Verweij et al. 2009). The estimated cost of on-site soil erosion in the Amazon basin is $68/ha/yr, but downstream or off-site costs are difficult to estimate. Torras (2000) applied a ratio of 2:5 to obtain $170/ha/yr. As a result, the total value of on-site and off-site soil erosion prevention is estimated at $238/ha/yr. Furthermore, the presence of flooding implies a loss of nutrients. Using a replacement-cost method, Uhl et al. (1993) estimated the value of nutrients removed by forest clearance at $3,480/ha, based on the market prices of nitrogen/phosphorus/potassium (NPK) fertilizers. Such economic losses can be avoided if deforestation is effectively prevented, but it should also be noted that the type of land use that follows deforestation influences the quality of such estimates.

### 2. REGULATION OF REGIONAL CLIMATE DYNAMICS AND WATER CYCLING

Deforestation can influence global warming through its carbon impact. In turn, the effect of atmospheric warming and a decrease in evapotranspiration can weaken moisture cycling and deep convection in the atmosphere over the Amazon basin (Verweij et al. 2009). As the world's largest tropical forest (5.4 million km$^2$), the Amazon forest plays a central role in maintaining the global carbon balance and regional climate regimes; its forests cool the air by pumping about 7 trillion tonnes of water per year into the atmosphere via evapotranspiration (Moutinho and Schwartzman 2005). In essence, the forest functions as a giant air conditioner that keeps the regional climate humid and rainy by cycling atmospheric water in the form of aerial rivers to the southeast and center of the South American continent (Fearnside 2003b). Fearnside (1997) estimated the value of water cycling at $19/ha/yr by estimating the economic damage to Brazilian agriculture outside the Amazon basin per hectare of forest loss. Andersen (1997) estimated the Net Present Value of water cycling at $1,000–3,000, based on productivity loss.

### 3. POLLINATION

Reduced deforestation can also bring other important ecosystem-service benefits, such as pollination services. Coffee, for example, is grown in the Amazon basin, albeit not on a large scale. Evidence has shown that deforestation can cause a direct reduction of coffee yields of up to 18 to 20 percent and a decline of net revenues per hectare of up to 14 percent over a period of two decades (Olschewski et al. 2006). Based on the potential damages to yield, Olschewski et al. (2006) calculated that, for a plantation in southern Manabí in Ecuador, the value of pollination averages $49/ha (2006).

### 4. EXISTENCE VALUE

Only a few studies venture to monetize the existence value of the Amazon forest by assessing people's willingness-to-pay for protecting it. Pearce (1991) estimated a range of existence values of $10–16/ha/yr. Horton et al. (2003) evaluated willingness-to-pay of Italian and British citizens for the implementation of a proposed program of protected areas in the Brazilian Amazon basin. Households of both countries were willing to pay on average $45.60/yr to protect 5 percent of the Brazilian Amazon, and $59.28/yr to protect 20 percent.

### 5. RECREATION AND TOURISM

Tourism is one of the largest industries and employers in the world. It currently accounts for 10.7 percent of the world's gross domestic product (GDP), and employs 260 million people (Verweij et al. 2009). In some places, forest visits have become a major tourist attraction. Based on the principle that biodiversity must pay for itself by generating economic benefits, community-based ecotourism has become a popular tool for biodiversity conservation (Kiss 2004). One method of calculating the tourism value is to take the gross revenues from visitors to the Amazon and translate these into per-hectare values.

## BOX 5 | CHALLENGES AND LIMITATIONS OF COLLECTING AND ANALYZING BENEFIT DATA

### 1. NON-CARBON ECOSYSTEM-SERVICES VALUATION

The valuation of ecosystem services is challenged by data constraints in the reported study areas. Many marketed forest ecosystem-services generate different economic returns in different countries, depending on the market prices and labor costs. The values of some non-marketed ecosystem services are estimated based on preferential or willingness-to-pay data, which again may vary significantly across regions depending on the socio-economic characteristics of the study area. Relevant studies in the literature have either a narrow focus on some specific marketed forest products, or have a broad scope covering many ecosystem services provided by the Amazon forest as a whole. New original valuation studies for specific indigenous forestlands are needed, or more detailed meta-analysis (based on the benefit transfer method) can be used to transfer the value estimates obtained by original valuation studies at the policy sites to the study sites of interest. In the latter case, site-specific data to help identify local preferences (e.g., gross domestic product and population) would be required.

### 2. COLLECTIVE-ACTION AND CONFLICT-RESOLUTION BENEFITS VALUATION

These benefits are often difficult to quantify because they necessitate an understanding of the number of conflicts occurring, and the transaction and other costs associated with these conflicts (e.g., number of deaths/injuries, cost of establishing conflict-resolution programs or initiatives, and wages for staff who work to address conflicts). Additionally, while Indigenous Peoples and other communities may be better able to organize and work with secondary and external stakeholders, it is difficult to capture transaction costs that may include, for example, a reduction in the number of meetings or hours spent working with communities. Finally, it is difficult to capture forest-production-improvement data that may result from behavioral changes following collective action and conflict resolution. These data are often neither collected by relevant stakeholders nor disaggregated from government budgetary data in a way that enables a proper interpretation of scale of benefits. As a result, collective-action and conflict-resolution benefits are excluded from this research.

### 3. MATCHING ANALYSIS

This research has at least three limitations. First, matching analysis does not control for unobserved confounding variables that could bias results. This issue is especially pertinent in light of the fact that the research used the same covariates for each country and therefore is not able to control for idiosyncratic confounding factors in each country. For example, the matching analysis does not control for policy interventions such as payments for ecosystem services, technical extension for managed forestry, land-use change regulations, and natural resource extraction. If these interventions affect deforestation differentially inside and outside tenure-secure indigenous forestlands, they may bias the results. Second, the analysis does not take advantage of temporal variation in the securing of indigenous forestlands and in forest loss to help to identify its effect. Finally, the outcome data—the Hansen et al. (2013) forest loss data—have limitations in that they measure only deforestation. Forest degradation resulting from selective logging and other forms of disturbance may be at least as important a cause of environmental damage and carbon emissions in some parts of the Amazon basin. In addition, while the deforestation data used have significant strengths, they also have limitations including the fact that they do not differentiate between natural and other types of forests and agroforests (Burivalova et al. 2015; Tropek et al. 2014).

SECTION V

# ECONOMIC COSTS OF TENURE-SECURE INDIGENOUS FORESTLANDS

International organizations play an essential role in financing and supporting the land regularization and titling process in many Amazon basin countries. While there are some differences across countries, after initial and often relatively high up-front costs, maintenance costs can be quite low for governments due to the monitoring efforts of Indigenous Peoples and their organizations (e.g., Xingu Indigenous Land Associations).

## 5.1 Overview of Cost Categories

Processes for establishing and maintaining tenure vary within and across countries, depending on governmental infrastructure, institutional capacity, land management, and ownership regimes, among other factors. Furthermore, land tenure may comprise different bundles of rights and therefore the processes for establishing and maintaining those rights may vary (Robinson et al. 2014). Despite these variations, four general categories of costs defined by Gray et al. (2015) are recognized:

- **Tenure-security establishment costs:** Costs associated with establishing or changing the institutional and legislative framework to secure indigenous forestlands tenure. Costs include investment and transaction costs associated with legislative or regulatory changes.

- **Indigenous-forestlands establishment costs:** Upfront or initial investment and transaction costs for identifying and securing lands as indigenous forestlands; including identification, demarcation, registration, titling, and management-plan establishment costs.

- **Indigenous-forestlands management, operating, and monitoring costs:** Annual or recurring costs associated with protecting indigenous forestlands tenure; monitoring and enforcement activities on these lands to ensure that rights are protected; transaction costs associated with handling disputes over indigenous forestlands; and recurring investments in programs or activities to support and strengthen indigenous rights and livelihoods on these lands.

- **Opportunity costs:** Foregone income from alternative land use that Indigenous Peoples and other parties would have received if the indigenous forestlands had been converted to another highest-value alternative land use, such as agriculture or cattle pastures.

Tenure-security establishment costs; indigenous-forestland establishment costs; and indigenous-forestland management, operating, and monitoring costs are actual expenses incurred at different stages of land-tenure reform and may be incurred by a variety of actors.

These actors include Indigenous Peoples, that is, those who directly experience the impacts of forest-tenure policy changes. In particular, Indigenous

Peoples incur investment and transaction costs associated with working with local and federal government agencies to establish and maintain tenure, as well as costs from monitoring and managing their land, and defending it from loggers, ranchers, and other intruders (Nepstad et al. 2006). Other actors include local and federal government agencies, natural-resource managers, and others who can make and shape decisions that provide financial and technical support to Indigenous Peoples to help secure and guarantee their rights (Borger et al. 2015). Finally, actors include people with the power to influence decisions, including the bilateral and multilateral development organizations that support government agencies, and nongovernmental organizations (NGOs) (Waite et al. 2014).

International organizations have played an essential role in financing and supporting the land-tenure regularization and titling process in many Amazon basin countries. Therefore, budgetary data published by these organizations have served as an important source of cost data for the benefit-cost analysis presented in this study. Moreover, detailed cost components vary depending on the status and size of the land, the efficiency of existing land administration systems, and the legal framework and institutional structures that facilitate the land regularization and titling process of the country.

Table 7 summarizes a list of cost components that have been observed in association with land-tenure security establishment in Amazon basin countries in general, and in Bolivia, Brazil, and Colombia in particular. Opportunity costs, which represent the highest values of alternative land uses, are an indicator of deforestation pressures (e.g., urban development, agriculture, and cattle pastures). Opportunity costs reflect threats to forest conservation in many developing countries, and these threats have led to land conversion and deforestation in the Amazon basin. However, in the present study, opportunity costs are excluded from the benefit-cost analysis. Indigenous land titles specify that the lands be used for traditional subsistence uses (see Section 3). Commercial use of forest products and conversion of forestlands to other uses would require government approval. Most Indigenous Peoples in Bolivia, Brazil, and Colombia have sought to maintain their forests and have not requested government approval to convert their land to other uses. Amazon basin governments have also expressed reluctance to authorize Indigenous Peoples to convert their forestlands to agriculture or other uses. Thus, if the land laws are adhered to, the opportunity costs of conversion are equal to zero.

Table 7 | **Costs Associated with Tenure Security of Indigenous Forestlands in the Amazon Basin**

| COST CATEGORY | COST COMPONENTS | STAKEHOLDERS WHO MAY INCUR COSTS |
|---|---|---|
| **Tenure-security establishment costs** | ■ Constitutional reforms<br>■ Governmental decrees<br>■ Law reforms and implementation | National government, international organizations |
| **Indigenous-forestland establishment costs** | ■ Establishment of supporting agencies and system upgrade<br>■ Delimitation and approval<br>■ Declaration of indigenous lands<br>■ Demarcation<br>■ Technical evaluation and registration | International organizations, national and local government agencies, Indigenous Peoples |
| **Indigenous forestland management, operating, and monitoring costs** | ■ Development of forest management plans<br>■ Ongoing management and monitoring of land titling process<br>■ Management and regulation for land regulation and cadaster<br>■ Consolidation and technical support for capacity building<br>■ Compensation for relocation | International organizations, national and local government agencies, NGOs, Indigenous Peoples |
| **Opportunity costs** | Foregone income from soybean production, cattle pastures, roads, commercial timber, and/or urban development | Landholders |

While this applies to titled indigenous land in the three countries studied for this report, it does not apply to other lands. Outside of protected indigenous lands, landowners may have incentives to convert forestlands at agricultural frontiers to maximize their land rents and financial returns, for example by converting to production of high-value agricultural commodities such as meat, vegetable oils, and sugar. Some of the observed driving forces of deforestation in these cases include government programs that provide incentives for frontier expansion, infrastructure improvement and expansion, land speculation in the absence of land titling and governance, logging, and increasing demand for biofuels and food (May et al. 2013). Studies show that, in the Amazon basin, average values of alternative land uses are often high and cannot be neglected (Table 8).

Table 8 | **Opportunity Costs Arising from Indigenous Forestlands in the Amazon Basin (US$/ha/yr)**

| | AVERAGE | LOWER BOUND | UPPER BOUND |
|---|---|---|---|
| Cropland (i.e. soy beans) | 450 | 300 | 600 |
| Pasture | 78 | 40 | 115 |
| Timber | 25 | 17 | 33 |

*Source:* van Beukering et al. (2015): Table 5.1

## 5.2 Costs of Indigenous-Forestland Tenure Security in Bolivia, Brazil, and Colombia

Cost data were collected primarily from government and other stakeholder websites, publicly available data on land regulatory programs financed by international organizations, peer-reviewed and grey literature, and solicitation of data from local researchers and country experts (where data were not available online) (see Appendix 3 for more budget data for all countries).

Most Indigenous Peoples in Bolivia, Brazil, and Colombia have sought to maintain their forests and have not requested government approval to convert their land to other uses. Amazon basin governments have also expressed reluctance to authorize Indigenous Peoples to convert their forestlands to agriculture or other uses. Thus, if the land laws are adhered to, the opportunity costs of conversion are equal to zero.

## BOLIVIA

At the time of this research, it was not possible to obtain budgetary data from the national agency in Bolivia that is responsible for land regularization and titling. Therefore, the costs were estimated using data from international funders. Data on the costs of tenure-security establishment were obtained mainly from international development agencies (e.g., World Bank (WB), Inter-American Development Bank (IDB), European Union, and International Fund for Agricultural Development (IFAD)), together with some national agencies (e.g., Danish International Development Agency (DANIDA), U.S. Agency for International Development (USAID), and Netherlands Development Cooperation). International financing to support indigenous lands has generally been concentrated in two periods: 1996–2002, and 2003–2012. Although Bolivia's reforms of indigenous land rights have occurred within the broader context of the nation's history of agrarian reform, the government only began to recognize indigenous land claims in a significant manner following enactment of the 1994 Constitution. In 1996, the National Agrarian Reform Institute law was passed, which recognized Indigenous Peoples' traditional lands and called for land titles to be issued. Since 1996, both the WB and IDB have provided loans to support constitutional and legal reforms, and help the government strengthen its capacity to process land registration, titling, and management systems, which are categorized as tenure-security establishment costs. Other organizations such as USAID and DANIDA have provided a significant amount of the financial and technical support to help with land titling and regularization through projects on the ground. These budgets are categorized under indigenous-forest-land establishment costs and other costs related to management, operations, and monitoring.

## BRAZIL

To estimate indigenous-forestland establishment costs and indigenous-forestland management, operating, and monitoring costs, researchers from the University of São Paulo collected federal and local government budgetary data. The researchers indicated that this estimate provides a general approximation of costs. As the Fundação Nacional do Índio (FUNAI) is the official indigenous agency of Brazil, costs are based on the average annual FUNAI budget for working with and managing indigenous lands from 2005 to 2014. These costs are broken out into three categories: ethnic identity/cultural heritage expenses, administrative expenses, and protection/land-management expenses. FUNAI's annual budget for working with and managing indigenous lands is available at the government online platform Transparência Pública (CGU/ Transparência Pública 2015). Additionally, local government expenditures for indigenous lands were included in indigenous-forestland establishment and indigenous-forestland management, operating, and monitoring costs, based on the average expenditure from 2005 to 2014 (FINBRA 2015). The costs do not include tenure-establishment costs such as constitutional reforms and government decrees.

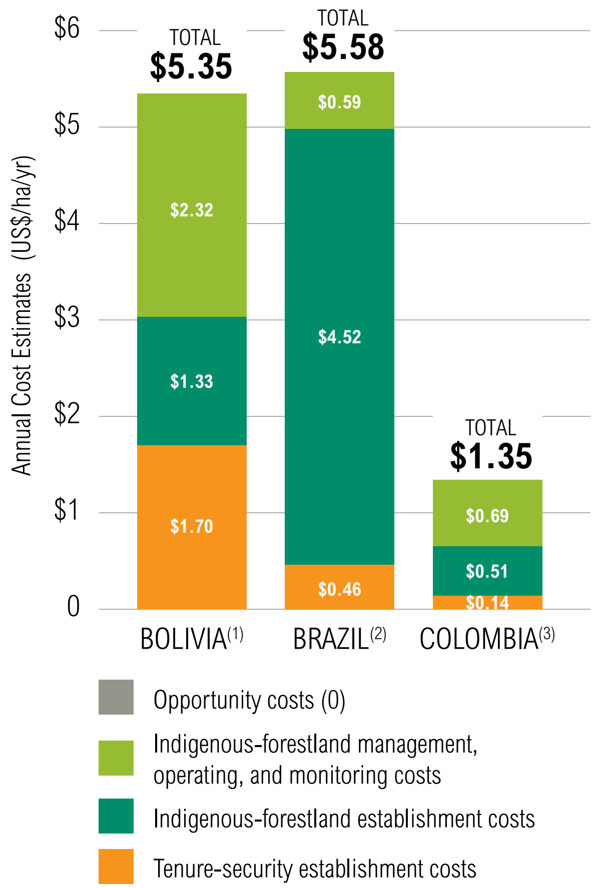
**COLOMBIA**

Two main sources of budgetary data were used for estimating the costs of establishing tenure security and indigenous forestlands in Colombia. The first is the Natural Resources Management Program (NRMP), which has been implemented by the Colombian Ministry of Environment and supported by the World Bank since 1994. As part of the Policy and Strategy Development aspect of NRMP, three components deal with: titling and demarcating indigenous reserves (*Resguardo Indigena*), titling Afro-Colombian community lands, and setting up a series of Regional Committees. These components ensure the active participation of Indigenous Peoples and Afro-Colombian communities and their organizations in the land titling, environmental monitoring, and natural resources management activities financed under the program. These data were used to assess the costs related to tenure-security establishment in Colombia. The second source of data is the average land titling costs of each *Resguardo Indigena* provided by the *Instituto Colombiano de Desarrollo Rural* (INCODER). These data were used to estimate the costs of indigenous-forestland establishment, management, operations, and monitoring.

Figure 4 presents the estimated annual costs related to tenure-security establishment of indigenous forestlands in Bolivia, Brazil, and Colombia. The costs estimated for Brazil, in particular the management, operating, and monitoring costs, may be lower than the costs in Bolivia and Colombia because many Indigenous Peoples in Brazil monitor and patrol their own lands. After initial and relatively high up-front costs, maintenance costs can be quite low for government due to the efforts of Indigenous Peoples, and their indigenous organizations (e.g., Xingu Indigenous Land Associations).

Some of the challenges presented by cost-data collection are outlined in Box 6.

Figure 4 | **Costs of Securing Indigenous Forestland Tenure in the Amazon Basin (2015 USD)**




*Sources:* Authors' estimate based on: (1) World Bank (2006); IDB (2003, 2012); USAID (2011); (2) CGU/Transparencia Publica (2015); FINBRA (2015); (3) INCODER (2015); World Bank (2001)

## BOX 6 | CHALLENGES OF COST-DATA COLLECTION

In the present economic analysis, it is not possible to capture all costs of tenure-secure indigenous forestlands because of the following data limitations and knowledge gaps:

### TENURE-SECURITY ESTABLISHMENT COSTS

Valuing the costs associated with establishing tenure security (via policy and institutional changes) necessitates an understanding of the transaction costs associated with these changes, including, for example, staff time spent drafting tenure reforms and working with Indigenous Peoples. For Bolivia and Colombia, tenure-security and indigenous-forestland establishment, management, and monitoring costs could be approximated based on estimates of foreign and domestic expenditures to support the land administration reform, and regularization and titling of indigenous lands. For Brazil, however, the available data are not clear on the financing that supported the constitutional reform of 1988 and other government decrees and policy changes.

### UNCERTAINTY REGARDING COST DATA

Cost data are often not disaggregated by stakeholders in ways that permit easy estimation of individual cost components associated with securing and maintaining tenure security. In Brazil, for example, government cost data were not available by cost component (e.g., demarcation vs. registration vs. titling) or by indigenous land. Rather, annual federal and local government budgetary data for indigenous lands were available for broad categories. In Bolivia and Colombia, it is clear that a significant amount of foreign aid, combined with domestic financial support and technical and financial assistance from NGOs went into promoting land and regularization reform and establishing the legal administration system and indigenous lands. However, a detailed registry of these costs is not available, making it difficult to discern the exact investment total and the percentage of costs that went to tenure-security establishment, and to indigenous-forestland establishment, management, operations, and monitoring.

SECTION VI

# COMPARING THE BENEFITS AND COSTS OF TENURE-SECURE INDIGENOUS FORESTLANDS

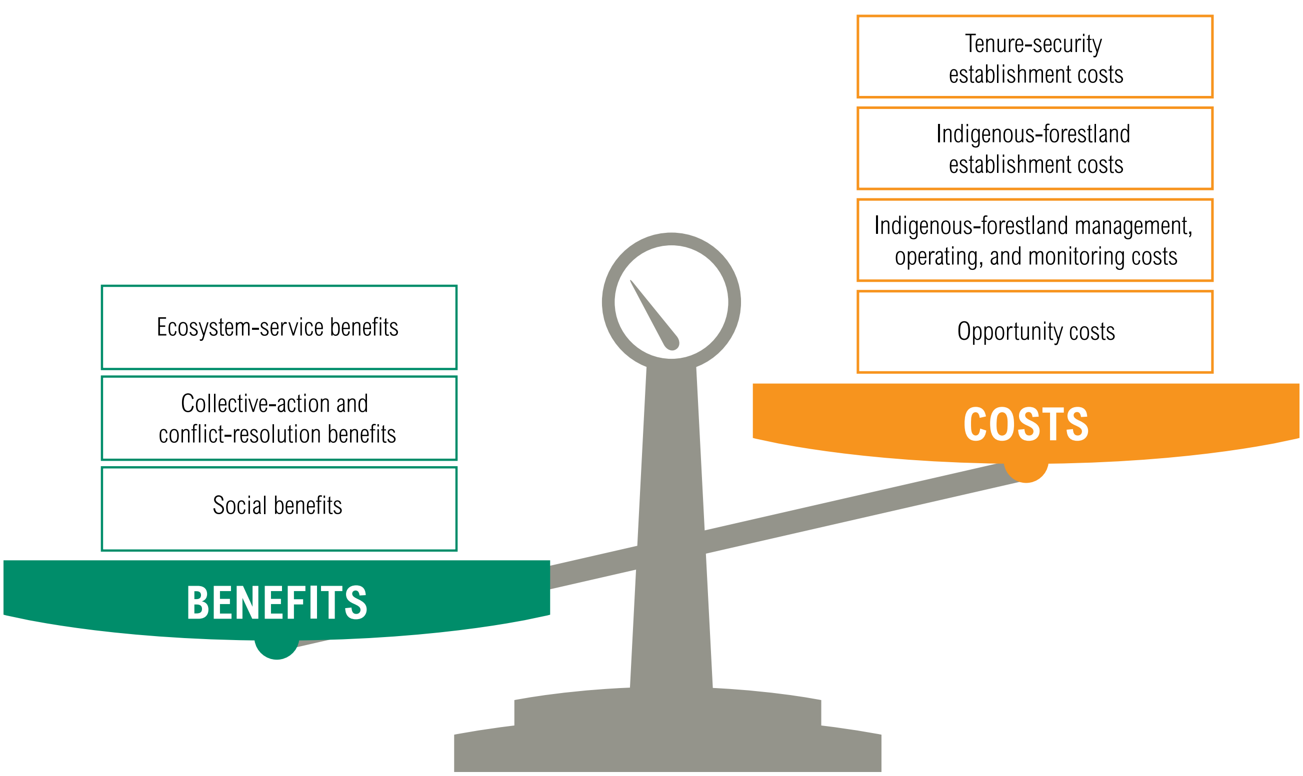
If the indigenous forestlands in Bolivia, Brazil, and Colombia were to be held in a secure manner for the next 20 years, they would generate significant local and global ecosystem-service benefits, including $21–30 billion in carbon benefits through the avoided annual release of 42.8–59.7Mt CO2 emissions. The costs of securing the indigenous forestlands are low, accounting to at most 1 percent of the total benefits derived.

## 6.1 Understanding Benefit-Cost Analysis

Benefit-cost analysis is an economic decision-making approach, consisting of a set of procedures for defining and comparing the full benefits and costs of a given action (Zerbe and Dively 1994). In this report, benefit-cost analysis (Figure 5) is used to assess whether the continuous effort of securing indigenous forestland tenure in the Amazon basin is worth pursuing from an economic perspective. It involves comparing the total expected costs of establishing and maintaining indigenous-forestland security (Section 5) against the total expected benefits (Section 4), to see whether the benefits outweigh the costs. Both benefits and costs are expressed in monetary terms, and are adjusted for the time value of money (2015 US$) so that all flows of benefits and costs over time (which tend to occur at different points in time) are expressed on a common basis in terms of their "present value" (see Appendix 4 for technical discussions of benefit-cost analysis).

In this study, annual benefits and costs are calculated over a 20-year period and discounted to their present value in 2015 using a 6 percent real discount rate, which is the average discount rate between 2 percent and 10 percent—the rates that are most commonly used in forestry studies (Cubbage et al. 2013). Box 7 provides the detailed justifications for these choices. The discounted benefits and costs are then compared to calculate the net present value (NPV). NPV is a common metric for comparing benefits and costs because it converts benefits and costs into a single value by discounting so that they can be compared in present value terms. The results of the NPV can be used to assist policy decision-making (Cubbage et al. 2013); a positive NPV indicates a gain from investing in indigenous-forestland tenure security in the Amazon basin whereas a negative NPV indicates a loss. In our analysis, NPV results are presented at both per-hectare and aggregated-indigenous-forestland scales. Finally, results for 2 and 10 percent discount rates are also presented, as part of a sensitivity analysis to understand the robustness of the results.

Figure 5 | **Benefits and Costs of Securing Indigenous Forestlands Tenure in the Amazon Basin**



## 6.2 Results of the Benefit-Cost Analysis

The economic analysis results are presented in the form of estimates of the following:

- the present value of global carbon-mitigation benefits;
- the present value of local and regional ecosystem-service benefits (including regulation of regional climate dynamics, hydrological services, pollination, nutrient retention, and other non-use values);
- the present value of tenure-security establishment and maintenance costs; and
- the NPV (i.e., the difference between discounted benefits and costs) of the investments in securing indigenous forestland tenure in Bolivia, Brazil, and Colombia for a timeframe of 20 years at a 6 percent discount rate.

### BOX 7 | THE CHOICE OF TIMEFRAME AND DISCOUNT RATE IN THE PRESENT ANALYSIS

#### TIMEFRAME

Land tenure impacts investment, credit availability, poverty rates, land values, and agricultural productivity, are all linked to economic performance. Securing indigenous forestland tenure is considered a long-term investment (greater than 10 years) by national governments to meet one or more goals; therefore a timeframe that is long enough for calculating the associated benefits and costs must be considered. However, despite the constitutional reforms that have taken place in several Amazon basin countries, in particular since the 1990s, tenure-security risks still exist. For instance, a large political faction in Brazil opposes the expansion of indigenous lands (Vianna 2015), and Brazil's policy for Indigenous Peoples still has extensive legal, institutional, and methodological deficits in terms of how it handles the protection and management of indigenous lands (GIZ 2015). As a consequence, a 20-year analysis period is used to cover the uncertainty and risks associated with maintaining tenure security over the long term.

#### DISCOUNT RATE

In order to compare economic effects that occur at different points in time, the practice of applying a discount rate to future effects is essential, as the selection of the discount rate (or rates) may greatly alter the NPV and, ultimately, influence decision-making. For natural assets such as fisheries and forest, the rate commonly used for most calculations is 4 percent, based on an estimate of the social discount rate made in earlier work by Pearce and Ulph (1999). In a more recent study, Cubbage et al. (2013), argue that "the appropriate discount rate is a controversial subject, but in principle it should represent an individual's, organization's, or government's opportunity cost of capital for an investment. Discount rates commonly vary from as little as 2 percent up to 10 percent in forestry literature, but are often as much as 6 percent to 15 percent or more in practice."

Discount rates measure social or individual preferences for the value attached to future resources. The higher the discount rate, the lower will be the discounted present value of the resources in a future point of time. Therefore, low discount rates may be considered appropriate for public goods and investments because they place relatively more value on returns for future generations. However, obtaining market loans at such low discount rates is often not possible, and many poor people, Indigenous Peoples, and other communities may have very high discount rates—they place a much higher premium on funds and income in the present than in the future. Thus, the higher discount rates common in the market reflect the cost of capital for private goods and services. Because indigenous forestlands secure the collective rights of Indigenous Peoples in the Amazon basin, these forests resources are not pure public goods in nature. In the present study, a 6 percent discount rate is used to reflect the fact that Indigenous Peoples may expect to gain economic returns from their commonly owned forest resources sooner rather than later. The results for a 2 and 10 percent discount rate are also examined.

The NPVs for Bolivia, Brazil, and Colombia are positive (Table 9), indicating that the economic benefits of the ecosystem services provided by tenure-secure indigenous forestlands in these countries significantly outweigh the annual per-hectare costs of securing indigenous-forestland tenure. Comparing the total benefits (i.e., the local and global benefits combined) against the costs, securing indigenous forestland tenure can generate a net total benefit in Bolivia ranging between $4,888/ha and $10,784/ha, a net benefit in Brazil ranging between $4,636/ha and $10,402/ha, and a net benefit in Colombia ranging between $4,610/ha and $10,344/ha, respectively.

It should be noted that the per-hectare benefits of local and regional ecosystem services are estimated regional averages from the literature, whereas the marginal per-hectare carbon-mitigation benefits are estimated differently across countries due to the significant variations in deforestation rates inside and outside indigenous forestlands. This difference may provide additional insights into the efficiency of investing in tenure security in different regions. For instance, the results indicate that securing land tenure on each hectare of

The analysis suggests that securing each hectare of indigenous-forestland tenure can generate global carbon-mitigation benefits and local and regional ecosystem service benefits that are higher than the costs of tenure-security establishment and maintenance costs.

Table 9 | **Benefit-Cost Analysis Results—The Net Present Value (Period = 20 years, Discount rate = 6%, 2015 USD)**

| BENEFITS/COSTS/NPV | BOLIVIA | BRAZIL | COLOMBIA |
|---|---|---|---|
| **Global Carbon-Mitigation Benefits** | | **US$/ha** | |
| Lower-bound estimate | 373 | 144 | 57 |
| Upper-bound estimate | 555 | 196 | 87 |
| **Local and Regional Ecosystem-Service Benefits** | | **US$/ha** | |
| Lower-bound estimate | | 4,559 | |
| Upper-bound estimate | | 10,274 | |
| **Total Benefits (= Global Carbon-Mitigation Benefits + Local and Regional Ecosystem-Service Benefits)** | | **US$/ha** | |
| Lower-bound estimate | 4,933 | 4,704 | 4,616 |
| Upper-bound estimate | 10,829 | 10,470 | 10,360 |
| Tenure-security Establishment and Maintenance Costs (US$/ha) | 45 | 68 | 6 |
| **The Net Present Value (= Total Benefits – Tenure-security Establishment and Maintenance Costs)** | | **US$/ha** | |
| Lower-bound estimate | 4,888 | 4,636 | 4,610 |
| Upper-bound estimate | 10,784 | 10,402 | 10,344 |

*Note:* Costs are likely underestimated due to data constraints regarding tenure-security establishment. Likewise, benefits are also likely underestimated due to data constraints.

indigenous forestlands for a period of 20 years could generate carbon-mitigation benefits of up to $555/ha in Bolivia. In Brazil and Colombia, the benefits could be lower, amounting to $196/ha and $87/ha, respectively. The carbon-mitigation benefits in Bolivia are estimated to be higher than in the other study countries because deforestation rates in the unsecured forestlands are much higher than in the secured forestlands (see Table 3), suggesting that if all other conditions held constant, investing in tenure security on each hectare of indigenous forestlands in Bolivia would result in greater reductions in deforestation and hence higher carbon benefits in terms of reduced carbon emissions.

If the existing indigenous lands in Bolivia (10,964,600 ha), Brazil (111,238,600 ha), and Colombia (26,752,500 ha) were to be held in a secure manner for the next 20 years, they would generate positive carbon benefits amounting to $21–30 billion, by avoiding the release of 42.8–59.7 $MtCO_2$ emissions annually from deforestation (Table 10). These avoided $CO_2$ emissions are equivalent to about 9 percent of Bolivia's total greenhouse gas (GHG) emissions (i.e. $CO_2e$ including land-use change and forestry) in 2012, and up to 3 percent of total $CO_2e$ emissions from Brazil as well as from Colombia in 2012. Overall, avoided $CO_2$ emissions achieved by avoided deforestation through tenure-secure indigenous forestlands in the Amazon basin can contribute to the objectives of the three study countries' Nationally Determined Contributions (NDCs).

Regarding the per-unit carbon-mitigation cost ($/$tCO_2$) of securing indigenous forestland tenure in Bolivia, Brazil, and Colombia, the results suggest that securing tenure in these countries as a climate-mitigation strategy may be more cost-effective than other carbon capture and storage measures. A recent report (IEA 2011) estimated the average cost of avoided $CO_2$ through carbon capture and storage to be about $58/$tCO_2$ (adjusted in 2015 US$) for coal-fired power plants, and $85/$tCO_2$ for natural gas-fired power plants.[25] In contrast, the per-unit costs of carbon mitigation ($/$tCO_2$) through avoiding deforestation by securing tenure in indigenous forestland are significantly cheaper, with an estimated range of $2.04 to $3.66/$tCO_2$ in Bolivia, $8.74 to $11.88/$tCO_2$ in Brazil, and $4.75 to $7.26/$tCO_2$ in Colombia (Table 10).

It is important to distinguish between carbon-mitigation costs incurred through securing indigenous forestland tenure, and the carbon price paid per unit of carbon stocks saved via the Reduction of Emissions from Deforestation and Forest Degradation (REDD+) program. The former shows only that investing in securing indigenous forestland tenure is a low-cost option that helps governments to create enabling conditions, remove institutional barriers, and incentivize forest conservation and sustainable management. The latter indicates the appropriate level of market incentives required to compensate large private owners for the financial costs of forest conservation (including avoided forestland conversion), taking into account the opportunity costs that drive deforestation in the area (see discussion in Section 5).

Table 10 | **Estimated Costs of Carbon Mitigation through Avoided Deforestation on Indigenous Lands (2015 US$)**

| COUNTRY | COST OF CARBON MITIGATION ($/$tCO_2$) | | AVOIDED ANNUAL $CO_2$ EMISSIONS (Mt/yr) | | PERCENTAGE OF TOTAL GHG EMISSIONS INCLUDING LAND-USE CHANGE AND FORESTRY (%)* | |
|---|---|---|---|---|---|---|
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| **Bolivia** | 2.04 | 3.66 | 8.0 | 12.0 | 6 | 9 |
| **Brazil** | 8.74 | 11.88 | 31.8 | 43.2 | 1.7 | 2.4 |
| **Colombia** | 4.75 | 7.26 | 3.0 | 4.6 | 1.5 | 2.3 |

*Data on $CO_2e$ emissions including land-use change and forests were taken from http://cait.wri.org/ for year 2012.

The variations among mitigation costs across countries (Table 10) may indicate where investment in indigenous forestland-tenure security is most cost-efficient. Economic theory suggests that investing in the country with the lowest cost of carbon mitigation through avoided deforestation is more efficient in terms of generating marginal economic returns. In this case, investing in a country like Bolivia, where land regularization has faced more institutional challenges (Stevens et al. 2014) will provide more significant returns at the margin, followed by Colombia and Brazil. As pressures on land increase, securing indigenous forestland tenure will likely become politically more difficult and financially more costly.

In addition to carbon benefits, securing indigenous forestland tenure in the Amazon basin will also safeguard a multitude of regional and local ecosystem services that benefit Indigenous Peoples, both directly and indirectly. Among the total ecosystem-service benefits valued (including the carbon benefits), a significant portion (about 90 percent on average) of these benefits are primarily local or regional benefits (e.g., hydrological services, nutrient retention, local climate regulation, and pollination) and often unpriced in the market.

In sum, the total economic benefits associated with securing indigenous forestland tenure for the analysis period could reach between $54.1 and $118.7 billion in Bolivia, $523.2 billion and $1.2 trillion in Brazil, and $123.4 and $277 billion in Colombia. These results are likely to be underestimates due to the omitted social benefits (Section 4), including job creation and avoided social conflicts associated with tenure-secure indigenous forestlands.

## 6.3 Uncertainty and Sensitivity Analysis

Given uncertainty and data-collection constraints, this study includes lower- and upper-bound value estimates of all ecosystem-service benefits (Section 4). In addition, a two-step sensitivity analysis is performed by varying the discount rates and carbon prices to test the robustness of the research results:

- First, 2 percent and 10 percent discount rates are applied in addition to the 6 percent discount rate used in the study to calculate the NPV.
- Second, a lower and higher carbon price is used to assess the robustness of the results:
  - The lower carbon price of $6/tCO_2$ used in the sensitivity analysis is the average historical carbon-market price from the 2014 State of the Voluntary Carbon Markets Report from Forest Trends (Goldstein and Gonzalez 2014).
  - The higher carbon price of $119/tCO_2$ used in the sensitivity analysis is an estimate of the 95th percentile upper-bound SCC value recommended by the U.S. Interagency study.

The results are presented in Table 11.

Economic theory suggests that investing in the country with the lowest cost of carbon mitigation through avoided deforestation is more efficient in terms of generating marginal economic returns.


Table 11 | **Sensitivity Analysis of the Benefit-Cost Analysis**

| COUNTRY | NET PRESENT VALUE ($/HA, 2015 US$) | | | | | | COST OF CARBON MITIGATION ($/tCO$_2$) | |
|---|---|---|---|---|---|---|---|---|
| | At carbon price of $41/tCO$_2$ | | At carbon price of $6/tCO$_2$ | | At carbon price of $121/tCO$_2$ | | | |
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| **CALCULATED AT DISCOUNT RATE OF 6 PERCENT** | | | | | | | | |
| Bolivia | 4,888 | 10,784 | 4,568 | 10,308 | 5,603 | 11,848 | 2.04 | 3.66 |
| Brazil | 4,636 | 10,402 | 4,519 | 10,234 | 5,063 | 10,778 | 8.74 | 11.88 |
| Colombia | 4,610 | 10,344 | 4,551 | 10,270 | 4,709 | 10,510 | 4.75 | 7.26 |
| **CALCULATED AT DISCOUNT RATE OF 2 PERCENT** | | | | | | | | |
| Bolivia | 6,699 | 14,786 | 6,264 | 14,138 | 7,674 | 16,235 | 2.90 | 4.32 |
| Brazil | 6,359 | 14,269 | 6,200 | 14,038 | 6,944 | 14,783 | 11.99 | 16.30 |
| Colombia | 6,310 | 14,190 | 6,243 | 14,088 | 6,243 | 14,088 | 6.52 | 9.95 |
| **CALCULATED AT DISCOUNT RATE OF 10 PERCENT** | | | | | | | | |
| Bolivia | 3,768 | 8,310 | 3,520 | 7,941 | 4,322 | 9,135 | 1.52 | 2.88 |
| Brazil | 3,571 | 8,012 | 3,481 | 7,883 | 7,883 | 8,303 | 6.73 | 9.15 |
| Colombia | 3,543 | 7,968 | 3,505 | 7,910 | 3,505 | 7,910 | 3.66 | 5.59 |

The results are robust to these variations and all NPVs remain positive and large regardless of the discount rates and carbon prices used. It should be noted, however, that whereas the estimated NPV results are not sensitive to the changes of carbon prices from $41/tCO$_2$ to $6/tCO$_2$, the choice of discount rate has a significant impact on the estimated NPVs for all countries. In particular, NPVs estimated at a 2 percent discount rate are nearly double those estimated at a 10 percent discount rate. This suggests that policies designed to secure indigenous forestland tenure for long-term benefits—reflected in the choice of a lower discount rate—can generate a positive and higher NPV.

## 6.4 Key Findings and Conclusions of the Benefit-Cost Analysis

1. **SECURING INDIGENOUS FORESTLAND TENURE IS A LOW-COST, HIGH-BENEFIT INVESTMENT.**

   If the existing indigenous forestlands in Bolivia, Brazil, and Colombia were to be secure for the next 20 years, these forests would provide significant local and global ecosystem-service benefits. More specifically:

   - Tenure-secure indigenous forestlands provide significant global carbon benefits in Bolivia, Brazil, and Colombia, amounting to $21–30 billion, through the avoided annual release of 42.8–59.7Mt CO$_2$ emissions. According to the U.S. Environmental Protection Agency's greenhouse gas (GHG) equivalencies calculator,[26] this amount of avoided CO$_2$ emissions is equivalent to taking 9–12.6 million passenger vehicles off the roads for one year (Figure 6 presents a lower bound of the estimate). This suggests that securing indigenous forestland tenure represents significant potential in terms of helping the governments of Bolivia, Brazil, and Colombia to meet the climate change mitigation objectives stated in their NDCs.

Figure 6 | **Annually Avoided $CO_2$ Emissions through Indigenous Forestland-Tenure Security in Bolivia, Brazil, and Colombia**

**Bolivia**
has the potential to avoid:

**8.04**
Mt $CO_2$ per year

WHICH IS EQUIVALENT TO:

**1,698,318**
Passenger vehicles taken off the roads for one year

**Brazil**
has the potential to avoid:

**31.76**
Mt $CO_2$ per year

WHICH IS EQUIVALENT TO:

**6,708,778**
Passenger vehicles taken off the roads for one year

**Colombia**
has the potential to avoid:

**3.01**
Mt $CO_2$ per year

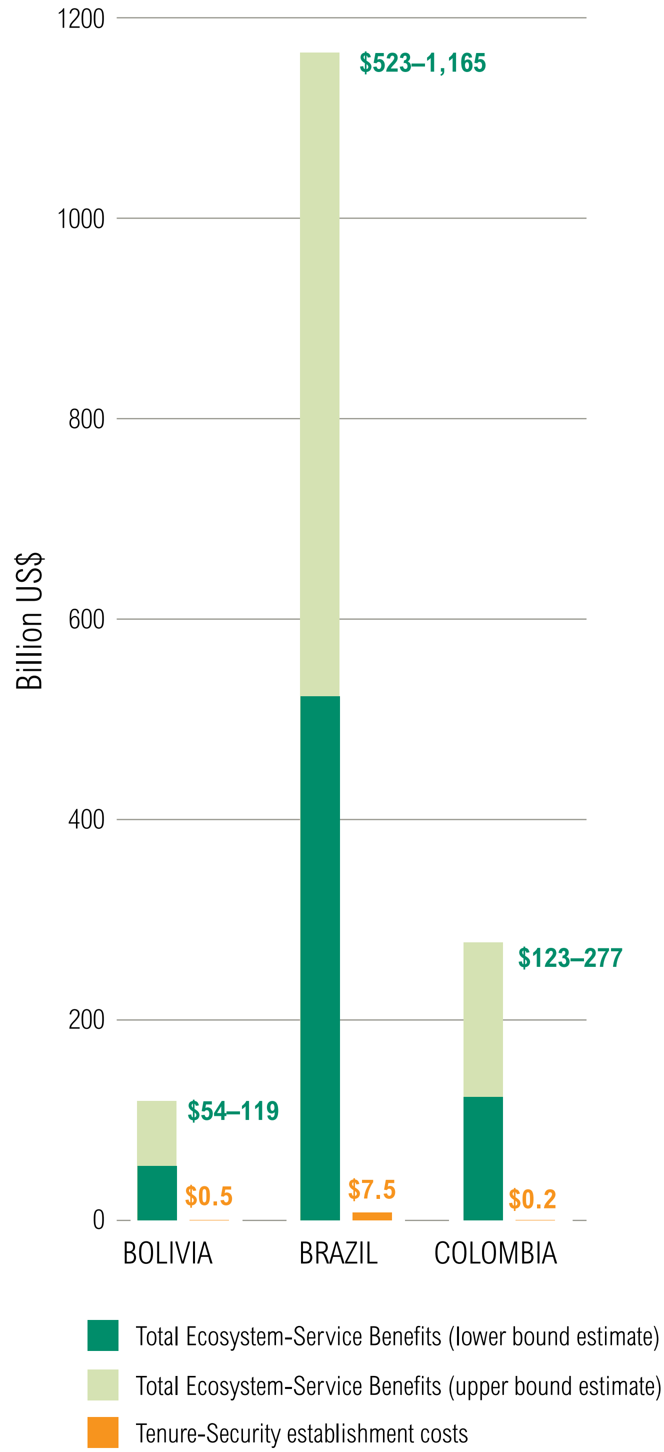
WHICH IS EQUIVALENT TO:

**635,813**
Passenger vehicles taken off the roads for one year

- Tenure-secure indigenous forestlands provide significant local and regional ecosystem-service benefits to the local community, including regulation of local climate dynamics and water cycling, hydrological services, pollination, nutrient retention, existence values, and recreation and tourism values. This study estimates that benefits ranging between $679 billion and 1,530 billion would result from a 20-year indigenous forestland tenure-security investment (Figure 7). This translates to per-hectare estimated net benefits in the order of $4,559–10,274/ha). Challenged by the "free good" characteristics of ecosystem service, many ecosystem benefits are not (directly) valued in the market place, adding ambiguity to the expected returns on investment in forest conservation. Identifying, measuring, and demonstrating non-market ecosystem-service benefits is essential if governments and business are to make informed decisions about land management and natural resource conservation.

- Tenure-secure indigenous forestlands represent low-cost forest conservation investments for governments (and therefore the public). Secure tenure (coupled with other incentives), encourages Indigenous Peoples to manage their forests sustainably and reduces deforestation at low cost to government (and therefore the public)—costs estimated at $45/ha in Bolivia, $68/ha in Brazil, and $6/ha in Colombia—the calculated sum of discounted total costs for a 20-year period. This accounts to at most 1 percent of the total benefits derived from tenure-secure indigenous forestlands in the three countries. When total benefits (i.e., local and global benefits combined) are compared with total costs, securing indigenous forestland tenure can generate a positive net per-hectare benefit in Bolivia ranging between $4,888/ha and $10,784/ha, a net benefit in Brazil ranging between $4,636/ha and $10,402/ha, and a net benefit in Colombia ranging between $4,610/ha and $10,344/ha. A good understanding of the benefits and costs of tenure-secure indigenous forestlands will allow policymakers to better target their investments.

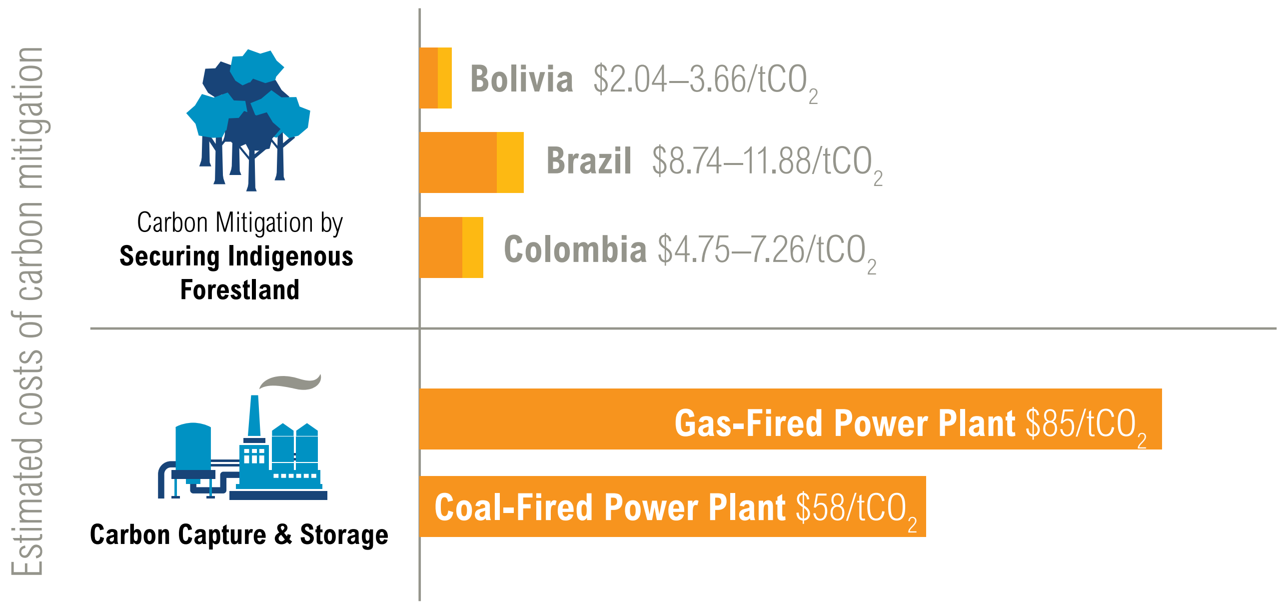
Figure 7 | **Benefit-Cost Analysis Results–Net Present Values (2015 USD)**



**2. SECURING INDIGENOUS FORESTLAND TENURE HAS SIGNIFICANT POTENTIAL FOR COST-EFFECTIVE CARBON MITIGATION.**

From a financial perspective, investing in securing indigenous forestland tenure represents a relatively cost-effective measure for climate change mitigation when compared with other carbon capture and storage measures. The estimated costs of carbon mitigation through indigenous forestland tenure-security programs in Bolivia, Brazil, and Colombia range from \$2.04–3.66/t$CO_2$, \$8.74–11.88/t$CO_2$, and \$4.75–7.26/t$CO_2$, respectively (Figure 8). These costs are significantly lower than the average costs of avoided $CO_2$ through carbon capture and storage, which are estimated to be about \$58/t$CO_2$ for coal-fired power plants (5 to 29 times more expensive than securing indigenous forestland tenure) and \$85/t$CO_2$ for natural gas-fired power plants (7 to 42 times more expensive) (IEA 2011). Although conducting a cost-competitiveness analysis of different climate change mitigation measures is beyond the scope of this study, the mitigation-cost estimates presented here demonstrate the cost-effectiveness of tenure-secure indigenous forestlands as a carbon-mitigation measure.

Figure 8 | **Estimated Costs of Carbon Mitigation through Indigenous Forestland-Tenure Security and Other Carbon Capture and Storage**



SECTION VII

# CHALLENGES AND RECOMMENDATIONS

Indigenous lands in the Amazon basin are under increasing threat from infrastructure development, extractive resource operations, industrial agriculture, and other investments. There is an urgent need for governments—with help from their partners—to enact laws that provide Indigenous Peoples with sufficient legal protections over their land; to map, demarcated, and formally register all undocumented indigenous lands; and to make tenure-secure indigenous forestlands a central component of their national climate change mitigation strategy.

## 7.1 Challenges to Indigenous Land Rights in the Amazon Basin

These research findings make a strong economic case for securing indigenous and, more broadly, community forestland tenure. It is, therefore, troubling that recent developments in Bolivia, Brazil, Colombia, and other Amazon basin countries threaten the tenure security of indigenous and other community lands. While the specific challenges vary across the Amazon basin, several common developments are noteworthy.

## 7.2 Slowdown in the Legal Recognition of Indigenous Land Rights

In the last few years, there has been a systematic slowdown in the formal recognition of indigenous lands, including the mapping, demarcation, and titling of indigenous lands, in Bolivia, Brazil, Colombia, and other Amazon basin countries. Several actions have contributed to this slowdown including new administrative procedures that do not favor indigenous lands and reduced government capacity (e.g., limited human and financial resources) that prevent administrative procedures from being undertaken in a timely manner. Where legal advances had been made, there is now strong pushback from political and commercial interests. In Brazil, a powerful bloc of anti-indigenous politicians with links to the large agri-business, mining, and hydro-electric sectors is pushing forward a series of proposals that could open up indigenous lands to industrial projects. For example, the proposed Constitutional Amendment 215 (PEC 215) would roll back the demarcation of new indigenous lands by passing the authority from the Fundação Nacional do Índio (FUNAI), the government's indigenous affairs department, to the legislature. If approved, the shift would likely cause significant delays in the recognition of indigenous lands and many indigenous lands could be reduced in size (Quadros 2015; Vianna 2015; RRI and ISA 2014).

In Bolivia, more than 90 percent of the land titles held by Indigenous Peoples have been issued since President Evo Morales took office in 2005 but, still, the pace of land titling has fallen short of legal requirements and popular expectation. In recent years, the government has repeatedly

stalled on efforts to redistribute land and title indigenous lands, rolled back procedural rights and environmental obligations, created bureaucratic obstacles to the implementation of promised—and constitutionally mandated—self-determination on indigenous lands, and continued to allocate oil concessions on indigenous lands (Achtenberg 2013; Sturtevant 2015). While Indigenous Peoples have the right of Free, Prior, and Informed Consent (FPIC), implementation does not always reflect their interests or concerns.

In Colombia, there has been progress in titling indigenous (and Afro-Colombian community) lands, although the process is far from complete. In a significant number of cases, the necessary technical studies and demarcation have yet to be carried out. The country's five-decade-long conflict (Box 8) hampered field efforts and resulted in the formal recognition process being understaffed and underfunded. Laws that favor indigenous lands have not been effectively implemented. Many Indigenous Peoples feel abandoned by the government, which has not provided them with even basic social services, leaving them isolated and at the mercy of armed groups and extractive industries operating in the region (WOLA 2013).

## 7.3 Threats to Indigenous Land Rights

The slowdown in the formal documentation of indigenous lands is coupled with government efforts to establish the Amazon basin as the new economic frontier for Latin America. Indigenous lands are threatened by infrastructure development, extractive resource operations, industrial agriculture, and other investments.

**INFRASTRUCTURE DEVELOPMENT.** Governments and companies are making significant investments in infrastructure in the Amazon basin, which will have significant and adverse effects on Indigenous Peoples and their forestlands. The Iniciativa para la Integracíon de la Infraestructura Regional Sudamericana (Initiative for Integration of Regional Infrastructure in South America, or IIRSA) is the signature initiative, with proposals for more than 500 mega-projects, including hydroelectric dams (e.g., Belo Monte and Balbina dams on the Xingu River), highways, waterways, ports, and pipelines stretching across the Amazon basin. IIRSA will link Brazil, the regional powerhouse, to the Pacific Ocean and branch out through the Amazon basin to connect mines, oil operations, and industrial agriculture to power supplies and trade routes (Guest 2013). If the Colombian peace holds (Box 8), IIRSA could extend to the whole of the western Amazon basin. Brazil is the key convener of many IIRSA projects and its investments have grown exponentially in the last five to seven years. The Brazilian Development Bank (BNDES), which operates much like a development bank and trade finance organization, has participated in the expansion of the Brazilian mining industry, as have companies from the country's powerful agro-industrial lobby (Guest 2013).

**EXTRACTIVE RESOURCE OPERATIONS.** The Amazon basin has vast reserves of hard minerals, oil, and natural gas, many yet untapped, which governments are increasingly interested in exploiting to generate much-needed public revenues. The implications for Indigenous Peoples are significant. Many governments are overhauling their laws to enable extractive resources extraction. For example, in Bolivia in May 2015, Supreme Decree 2366 opened up several protected areas and national parks for oil and gas extraction, many of which coincide with indigenous lands (Hill D. 2015; Hill T.S. 2015).[27] The recent decline in oil prices has encouraged governments to expand their oil frontiers, especially in the western Amazon basin that includes parts of Bolivia, Colombia, Ecuador, Peru, and western Brazil. In Ecuador and Peru, oil

### BOX 8 | CONFLICT, PEACE, AND INDIGENOUS PEOPLES IN COLOMBIA

The Colombian conflict began in the mid-1960s and has involved the government, paramilitary groups, crime syndicates, and guerrillas such as the Revolutionary Armed Forces of Colombia—People's Army (FARC–EP) and National Liberation Army (ELN). The Indigenous Peoples of western Colombia (highlands) have been most affected, but fighting has also taken place in the Amazon basin. Large areas of the Colombian Amazon basin were occupied by armed groups, especially in the 1980s and 1990s, endangering and displacing entire communities. Many indigenous people have been arrested and killed, and several Indigenous Peoples are at risk of extinction as a result of the five-decade-long conflict (Belazelkoska 2013; Bryan 2011; Garcia and Slunge 2015; IWGIA 2015; AI 2015; WOLA 2013).

Since 2013, the government and FARC had been negotiating (with Norway and Cuba sponsorship) a peace deal with a self-imposed 23 March 2016 deadline to reach a comprehensive pact (Acosta 2016). Although this date was missed, a ceasefire and disarmament accord was reached on 23 June (WOLA 2016) and a final peace deal was reached on 24 August. The accord sets out a roadmap for disarming and demobilizing the FARC and foresees a swift process - a full turnover of guerrilla weapons. A plebiscite is scheduled for 2 October 2016 in which voters would vote "yes" or "no."

Even before the accord was reached, conflict had subsided in some areas, including a number of indigenous lands. The peace brought much-needed relief, new social services, and other benefits, but it also brought new challenges to Indigenous Peoples and their lands. With stability and security, the government is moving ahead with its plans to open the Colombian Amazon basin to economic development. New investments are being made in infrastructure and extractive resource operations, including on indigenous lands. The peace has coincided with increased deforestation on indigenous lands in post-conflict areas.

and gas blocks alone cover more than two-thirds of their portion of the Amazon basin, and in Bolivia, Colombia, and western Brazil, major exploration activities are rapidly increasing (Cregan 2015; Finer et al. 2008). Many blocks overlap indigenous lands. Unlike the eastern Brazilian Amazon basin, the western Amazon forest is still a largely intact area where Indigenous Peoples have effectively protected and sustainably managed their lands (and where many still reside in voluntary isolation).

**AGRICULTURE.** Agricultural practices (farming and ranching) undertaken by settler families and agribusiness also threaten indigenous lands in the Amazon basin. Cattle ranching has been the leading cause of deforestation in the Brazilian Amazon basin since the mid-1960s, and has resulted in Indigenous Peoples losing their lands. Since 1970, 91 percent of land deforested in the Brazilian Amazon basin has been used for livestock pasture (Steinfeld et al. 2006). In many cases, it is less expensive for ranchers to clear forest for new pasture than to adopt a pasture management system, resulting in a constant push into the forest. Many ranchers (along with colonists and other developers) clear forest for pasture that is unprofitable or only marginally profitable as part of a process of land speculation (Butler 2012). Clearing the forest allows the private landholder to claim the land, in the hope that it will be more valuable in the future. Today, Brazil is the world's top exporter of beef, and demand is growing rapidly. In August 2014, Russia announced a suspension of beef imports from the United States, Australia, and the European Union, further encouraging production in Brazil (Datu 2014). Brazil is also a major producer of soybeans—the second-largest global producer after the United States—mostly for livestock feed (Kirby et al. 2006). As production expands, farmers are pushing northward into the Amazon basin.[28] And industrial-scale oil palm operations, especially for biofuel production, may soon take over from cattle ranching as the biggest threat to the Brazilian Amazon forest and indigenous lands (Frayssinet 2013). Agriculture is also expanding in other Amazon basin countries. In 2013, President Morales of Bolivia presented the "2025 Patriotic Agenda," a national development blueprint. It calls for nearly quadrupling the area of agricultural production over the next 10 years, from 3.5 million to 13 million hectares (Sturtevant 2015), an expansion that will threaten indigenous lands and forests (Boone 2013).

## 7.4 Recommendations

The research findings provide a strong economic case for governments, climate change funding agencies, civil society organizations, and other parties to invest in securing indigenous and community land rights in Latin America and around the world. While significant progress has been made in some countries over the last 10 to 30 years to formally recognize community lands, more efforts are needed to secure the community lands that are not documented or protected by government. The recently launched Sustainable Development Goals (SDGs) and new international agreement to curb climate change present opportunities for the world to secure indigenous and other community lands and achieve positive development and environment outcomes.

There is an urgency to securing indigenous and other community land rights now. As the threats grow, pressures increase and the opportunity costs of alternative community land uses rise. Opposition to securing indigenous lands, especially from some senior lawmakers in local and national government, business leaders, large investors, and other influential parties is growing in all Amazon basin countries and in many other regions of the world. As a consequence, it becomes more challenging and financially more costly to recognize and protect indigenous and community lands.

Based on the findings of the benefit-cost analysis and the challenges confronting Indigenous Peoples in the Amazon basin, a set of policy recommendations is proposed to secure indigenous land rights in Bolivia, Brazil, and Colombia. Given that many indigenous and community lands around the world are not secure, these recommendations may also apply to other countries.

1. **SECURE COMMUNITY LAND RIGHTS.** Given the significant economic benefits of tenure-secure indigenous forestlands at the local, national, and global levels, governments and their partners should reform their laws and take other actions to secure community lands. While many actions can help secure community lands, three are of particular importance.

- *Enact Supportive Laws*. The laws in Bolivia, Brazil, and Colombia recognize indigenous land rights, but do not provide Indigenous Peoples with sufficient legal protections. Statutory laws that undermine community land rights should be repealed and replaced by supportive legislation. Among other provisions, supportive laws recognize customary tenure arrangements, establish community authority over land matters, and provide communities with the right of FPIC over all developments that affect their land (e.g., natural resource concessions). The laws, enabling regulations, and guidelines should also provide for simple, streamlined land-registration procedures that are not costly or time-consuming and, therefore, available to Indigenous Peoples and communities.

- *Formally Recognize Community Land*. While important strides have been taken, there remains considerable indigenous land in Bolivia, Brazil, and Colombia that is not mapped,[29] demarcated, and formally registered. Globally, most of the world's community land has not been formally recognized and documented. In the study countries, there has been a significant slowdown in legal recognition brought on by recent regulatory reforms and other government actions that have resulted in administrative hurdles and other obstacles. Governments should remove these barriers and provide responsible agencies with the human and financial resources needed to document all indigenous and community lands.

The recently launched Sustainable Development Goals (SDGs) and new international agreement to curb climate change present opportunities for the world to secure indigenous and other community lands and achieve positive development and environment outcomes.

- *Protect Community Lands.* For Indigenous Peoples and other communities to realize their legal rights, laws that support their lands must be implemented. The governments in Bolivia, Brazil, and Colombia and their partners—civil society organizations, companies and investors, and development assistance agencies—can help protect community lands in various ways. Governments can use their police powers to monitor indigenous and community lands, and remove illegal occupants (e.g., settlers and loggers). This may involve investing in new technologies (e.g., computerized land-record management information systems and unmanned aerial vehicles/drones); supporting community organizations to better monitor and protect their land; building local capacity to effectively manage forests; and refraining from allocating extractive resource and agricultural concessions on community lands.

2. **MAKE TENURE-SECURE COMMUNITY FOREST-LANDS A CENTRAL CLIMATE CHANGE MITIGATION STRATEGY.** The governments of Bolivia, Brazil, and Colombia recognize the role of forests in carbon sequestration and committed in their NDCs to protect forests, reduce deforestation rates, and restore forestlands. The research results suggest that avoided $CO_2$ emissions from avoided deforestation on tenure-secure indigenous forestlands in the Amazon basin can significantly contribute to country NDC objectives. The NDCs of Bolivia, Brazil, and Colombia do not make any specific commitments to securing indigenous land rights, but the research findings show that indigenous lands have helped reduce deforestation rates in all three countries. Had the Indigenous Peoples not had secure tenure over their lands and forests, the $CO_2$ emissions of each country would have been higher—by up to 9 percent in Bolivia, and 3 percent in Brazil and Colombia.[30] For Brazil, this emission difference is equivalent to 25–35 percent of Belgium's total national $CO_2e$ emissions in 2012. These figures are non-negligible and represent an important contribution to the avoided emissions (or emissions reductions) of each country and the Amazon forest.

   Given these climate benefits, investing in securing indigenous forestland tenure would be a relatively inexpensive action for governments to take to help meet the emissions reduction objectives put forward in their NDCs. For instance, the government of Colombia committed to reducing emissions by an estimated 67Mt$CO_2e$ by 2030 and, with international support, by an estimated 100Mt$CO_2e$. Securing indigenous forestland tenure in its region of the Amazon basin could avoid the release of about 3–4.6Mt$CO_2$ emissions into the atmosphere per year (over 20 years), an amount that represents over 69 percent of the amount the government proposed to reduce. If the rights of currently unregistered indigenous forestlands in Bolivia, Brazil, and Colombia were to be formally documented and protected, the $CO_2e$ emissions in these countries would be further reduced through avoided deforestation. For many governments, the preparation of their NDC catalyzed and kick-started national-level climate mitigation processes. With the NDCs now in place, governments around the world have an opportunity to develop and implement national action plans that call for documenting and protecting all community lands in their countries.

3. **UTILIZE INTERNATIONAL DEVELOPMENT FUNDS TO SUPPORT SECURING COMMUNITY FORESTLAND TENURE.** Many studies show that tenure-secure community forestlands experience low deforestation rates. Consistent with the findings in *The Economic Costs and Benefits of Securing Community Forest Tenure* (Gray et al. 2015), this research shows that tenure-secure indigenous forestlands are low-cost, high-benefit investments from an economic perspective, and are a cost-effective climate change mitigation measure. The findings provide the evidence needed for governments and their partners to increasingly direct their resources to securing indigenous and community land rights. The funds could support government agencies to formally document community lands as well as the Indigenous Peoples and communities which invest in protecting their forests.

   In addition to traditional bilateral and multilateral support for securing indigenous and community land rights, governments should also look to the global climate finance architecture. This finance is channeled through various multilateral funds, such as the Global Environment Facility, Green Climate Fund, Africa Climate Change Fund, Climate Investment Funds, Special Climate Change Fund, and Strategic Climate Fund (Nakhooda et al. 2015b). Climate finance is also increasingly available through bilateral channels such as the Global Climate Change Initiative (United States), Global Climate Partnership Fund (Germany, UK, and Denmark), International Climate Fund (UK), International Climate Forest Initiative (Norway), and International Climate Initiative (Germany). And a growing number of recipient countries (e.g., Brazil and Indonesia) have set up national climate funds that receive and disburse funding for mitigation and adaptation.

   Some analysts have argued that progress in reducing deforestation through these climate funds has been limited and has contributed to the shuttering of the Congo Basin Forest Fund, the Australian International Forest Carbon Initiative, and other initiatives (Nakhooda et al. 2015a). This research suggests that climate funds could, in some cases, meet their climate change mitigation and avoided deforestation objectives by supporting efforts to secure community forestland tenures.

Finally, there is need for further analysis on the benefits and costs of securing community forestland tenures. For example, additional analysis is needed to:

- *Address Data Constraints for More Comprehensive Benefit-Cost Analysis*. Addressing the data constraints identified in this report could improve our understanding of the net economic gains from tenure-secure community forestlands. Investing in improved monitoring and evaluation of community forestlands would be an important first step. Improved methods for valuing ecosystem services and social benefits coupled with disaggregated and transparent stakeholder budgetary data would help to fill some of the data gaps.

- *Conduct Benefit-Cost Analysis of other Community Lands*. Research attention has focused on indigenous forestlands in Central America and the Amazon basin countries. It is important to assess the economic benefits and costs for other community lands in these regions (e.g., Quilimbola communities in Brazil) as well as community forestlands in other parts of the world, especially Africa.

- *Complementary Economic Analysis on Tenure-Secure Community Land*. The benefit-cost analysis for this report identified several questions that need further study. For example, additional research is needed on the opportunity costs of indigenous lands and the cost-effectiveness of community forestlands as a climate change mitigation strategy.

# APPENDIX 1: ROLE OF FORESTS IN NEW CLIMATE COMMITMENTS IN BOLIVIA, BRAZIL, AND COLOMBIA

Several commitments in the NDCs of Bolivia, Brazil, and Colombia are relevant to tenure-secure community forestlands and are summarized below.

**BOLIVIA.** Bolivia's NDC (Government of Bolivia 2015) promotes the concept of "Living Well," which includes a vision of holistic development and people living in harmony with nature. It notes that Bolivia has large forest areas (52.5 million ha in 2015) and recognizes that forests contribute both to mitigation and adaptation to climate change. As such, the government makes a number of forestry commitments, including the following:

- increase forest areas with integrated and sustainable community management approaches to 16.9 million hectares by 2030, from 3.1 million hectares in 2010;
- reduce extreme poverty within the population that depends on forests to zero by 2030, from approximately 350,000 people in 2010;
- increase net forest coverage to more than 54 million hectares by 2030, from 52.5 million in 2010; and
- achieve zero illegal deforestation by 2020 and establish systems of control and monitoring of deforestation, fires, and forest fires.

Bolivia's NDC does not specifically mention securing indigenous land rights, but it does call for strengthening community-based stewardship in forest management and farming systems, and increasing community-forestland management sevenfold by 2030. However, Bolivia's NDC also calls for actions that could threaten indigenous lands. It proposes expanding investments in hydro-projects to generate power and increase water storage capacity; increasing agricultural production with the participation of smallholders and communities; increasing the area of irrigated agricultural land; boosting the oil and mining sectors; and developing the road, rail, and river integration of the country to connect populations and the flow of goods between the Atlantic and Pacific Oceans.

**BRAZIL.** Brazil commits in its NDC (Government of Brazil 2015) to reduce $CO_2e$ in 2025 by 37 percent below 2005 levels, and by 43 percent below 2005 levels in 2030. According to the government, Brazil's current actions against climate change represent one of the largest undertakings by any country, having reduced its emissions by 41 percent in 2012 in relation to 2005 levels. It states that in the period 2004–2012, Brazil's GDP increased by 32 percent, while emissions dropped more than 50 percent, delinking economic growth from emissions over the period, while at the same time lifting more than 23 million people out of poverty.

The NDC states that Brazil has also reduced its emissions from deforestation, mainly by reducing deforestation rates in the Brazilian Amazon basin by 82 percent between 2004 and 2014. This takes into account the role of conservation units and indigenous lands as forest managed areas. To further reduce the rate of deforestation, the NDC includes several forestry commitments, including the following:

- strengthen and enforce the implementation of the Forest Code, at federal, state, and municipal levels;
- strengthen policies and measures with a view to achieving zero illegal deforestation in the Brazilian Amazon basin by 2030, and compensating for $CO_2e$ emissions from legal suppression of vegetation by 2030;
- restore and reforest 12 million hectares of forests by 2030; and
- enhance sustainable native forest management systems with a view to curbing illegal and unsustainable practices.

Brazil's NDC does not commit the country to titling additional indigenous lands (or quilombos i.e., Afro-descendant communities). As in the case of Bolivia, Brazil's NDC calls for developments that could threaten indigenous lands. They include a commitment to increase the share of sustainable biofuels in the Brazilian energy mix to approximately 18 percent by 2030. Notably, Brazil's NDC does not call for expanding hydropower, which has threatened indigenous lands.

**COLOMBIA.** In 2010, Colombia produced estimated GHG emissions of 224 $MtCO_2e$, which represents just 0.46 percent of total global emissions in 2010. Of this total, 130.36 $MtCO_2e$ came from agriculture, forestry, and other land uses (about 58 percent of the total emissions). In its NDC (Government of Colombia 2015), the government commits to reducing its $CO_2e$ emissions by 20 percent by 2030 with respect to the projected Business-as-Usual (BAU) scenario. This translates to a reduction from 335 $MtCO_2e$ (BAU) to 268 $MtCO_2e$, a reduction of 67$MtCO_2e$. With international support, the government would increase its ambition from a 20 percent to a 30 percent reduction with respect to BAU by 2030—a reduction of 100.5 $MtCO_2e$.

Colombia's NDC reaffirms its commitment to reduce deforestation and to preserve important ecosystems, including the Amazon basin, given its huge potential to contribute to the stabilization of $CO_2e$ in the atmosphere. Specifically, the government commits to protecting 3 million ha of the high mountain Andean ecosystems and to expanding protected areas by 2.5 million ha. There is no specific mention in the NDC of Indigenous Peoples or of securing indigenous land rights, although it does mention building peace and reducing conflicts, which have threatened indigenous lands. As with Bolivia, Colombia's NDC also commits to expanding agriculture, which could threaten indigenous lands.

# APPENDIX 2: MATCHING ANALYSIS DETAILS

## Overview

In this report, we conducted a primary matching analysis to examine the link between providing formal land title to Indigenous Peoples and 2000–2012 deforestation in the Amazon basin in three countries: Bolivia, Brazil, and Colombia. The analysis uses fine-scale data derived from satellite images to measure deforestation along with statistical techniques that aim to disentangle the effects of land-titling from those of pre-existing characteristics of the indigenous lands that affect deforestation, including population density and proximity to population centers. We find that, even after controlling for such factors, titling of indigenous land is correlated with substantially lower rates of deforestation in Bolivia, Brazil, and Colombia. However, as discussed below, the data and analysis have limitations and therefore caution must be used in interpreting our results. Although our results suggest that titling indigenous land reduces deforestation, they do not amount to proof.

This appendix details the methods and data used to derive the results summarized in Section 4.2.1 Matching Analysis for Estimating the Impacts of Tenure-Secure Indigenous Forestlands on Deforestation.

### 1. Sample

Our matching analysis uses a quasi-random sample of dimensionless points defined by latitude and longitude coordinates. For each country included in our analysis—Bolivia, Brazil, and Colombia—we select a sample by overlaying onto a map of the country a rectangular 1 km sampling grid, that is, a grid with points spaced 1 km apart vertically and horizontally. We include in the sample all points where gridlines cross.

From the sample, we drop a number of subsamples. First, we drop all points outside of the Amazon basin of each country. For Brazil, the definition of the Amazon basin has a legal foundation (IBGE, 2010). For Bolivia and Colombia, it is defined by a map of Amazon basin watersheds (Mayorga et al. 2012). Second, from the Bolivia and Colombia data sets, we drop all points inside protected areas. That ensures that all sample points in indigenous lands are matched to points outside that are not in protected areas. The purpose is to avoid conflating the effects of titling indigenous lands and of protected areas. For Brazil, as discussed below, we treat this issue differently. Finally, we drop from each sample a small number of points for which data from the various GIS layers are missing.

### 2. Estimators

We use the following three matching estimators to generate treatment effect estimates.

- **Nearest neighbor one-to-one propensity score matching.** The first estimator uses propensity scores—the probability that a point is inside a titled community as predicted by a probit regression—as a measure of similarity between titled and untitled points. A propensity score can be interpreted as a weighted index of point characteristics, where the weights reflect the importance of each characteristic in explaining whether observations were included in the titled group (Rosenbaum and Rubin 1983). Each titled point is matched to the one untitled point with the closest propensity score. Matching is with replacement and we enforce a common support.
- **Nearest neighbor one-to-eight propensity score matching.** The second estimator uses propensity scores to match each titled point to the eight untitled points, with the average outcome for these eight points serving as the counterfactual.
- **Probit with matched controls.** The third estimator combines nearest neighbor one-to-eight covariate matching with regression, a hybrid approach that typically generates treatment effects estimates that are more accurate and more robust to misspecification than does either matching or regression alone (Imbens and Wooldridge 2009; Ho et al. 2007). Specifically, we estimate a point-level probit regression in which the sample is limited to points inside titled communities and matched points outside, the dependent variable is a dummy variable that indicates whether a point was cleared between 2001 and 2013, the key independent variable is a dummy variable indicating whether the point was in a titled community, and control variables are those listed in Table 1. Because matching is with replacement, we weight untitled observations that constitute the control group based on the number of times they were included as matches (Abadie and Imbens 2006). ATT (Average Treatment effect for the Treated) is given by the marginal effect of the treatment dummy variable.

For each of these estimators, we require matched points outside indigenous land to be in the same biome as points inside. This "exact" matching helps ensure that the two sets of points are similar in terms of unobserved features that affect deforestation.

For all three matching estimators we cluster standard errors at the level of the second-level administrative units (roughly the equivalent of counties in the United States). Clustering helps to control for spatial correlation of errors.

In addition to the three matching estimators discussed above, we also use a naïve estimator that does not control for selection bias—the simple difference between the average rates of deforestation on all titled and untitled points in our sample. The purpose is to shed light on the value of our matching approach.

## 3. Data

Table 2 lists the data used in our matching analysis, including the sources and units. Note that the population density variable is not used in the matching analysis in the cases of Bolivia and Colombia. The reason is that the probit regressions used to estimate propensity scores do not converge when it was included.

## 4. Matching Quality

Following Rosenbaum and Rubin (1983), we use mean standardized bias (MSB) to assess matching quality—the extent to which our estimators succeeded in identifying a set of matched untitled points with average characteristics that are similar to titled points. MSB is the mean across our control variables of the (variance-adjusted) percentage difference between the mean for the titled subsample and the matched untitled sample. A univariate summary statistic, MSB provides a concise means of assessing matching quality for multiple estimators. Although a clear threshold for acceptable MSB does not exist, a statistic below 3–5 percent is generally viewed as sufficient (Caliendo and Kopeinig 2008).

## 5. Unobserved Heterogeneity

The key identifying assumption for matching estimators, typically referred to as "ignorability" or "conditional independence," is that, conditional only on observed characteristics, non-random selection into the treatment is ignorable for purposes of measuring treatment effects (Caliendo and Kopeinig 2008; Stuart 2010). In terms of our application, the assumption is that we are able to observe and control for all important confounding factors, that is, variables that affect both the probabilities that points were included in indigenous lands and that they were deforested between 2001 and 2012. This assumption is untestable. In practice, we recognize that it may not hold. For example, stumpage values, which we do not observe, may be negatively correlated with location in indigenous lands (if policy-makers tend to shy away from titling communities in forests where logging earns particularly high profits) and positively correlated with deforestation (if loggers tend to target such forests). In principle, an inability to control for stumpage values could bias our treatment effects estimates upwards.

We use Rosenbaum bounds to check for the sensitivity of our results to this type of unobserved heterogeneity (Aakvik 2001; Rosenbaum 2002). Rosenbaum bounds indicate how strong unobserved confounding factors would need be to influence selection into the treatment in order to undermine a statistically significant ATT. To be more specific, the Rosenbaum procedure adapted to a binary outcome generates a probability value for Mantel and Haenszel (1959) test statistic for a series of values of G, an index of the strength of the influence that unobserved confounding factors have on the selection process. G = 1 implies that unobserved confounding factors have no influence, such that pairs of plots matched on observables do not differ in their odds of being treated; G = 2 implies that matched pairs could differ in their odds of treatment by as much as a factor of two because of unobserved confounding factors; and so forth. The probability value on the Mantel and Haenszel statistic is a test of the null hypothesis of a zero ATT given unobserved confounding variables that have an effect given by G. So, for example, a probability value of 0.01 and a G of 1.2 indicate that ATT would still be significant at the 1 percent level even if matched pairs differed in their odds of protection by a factor of 1.2 because of unobserved confounding factors. We calculate G*, the critical value of G at which ATT is no longer significant at the 10 percent level in each case where ATT is significant. An ATT estimate can be considered highly sensitive to unobserved heterogeneity when G* is close to unity.

## 6. Results

Overall, our analysis suggests that:

- The geophysical and socioeconomic characteristics of titled indigenous land are significantly different from those of land outside. As a result, it is, in fact, important to control for these differences in estimating the deforestation effect of the titling of these communities.
- After controlling for observable differences between titled and untitled land, titling is correlated with reduced deforestation in Bolivia, Brazil, and Colombia.

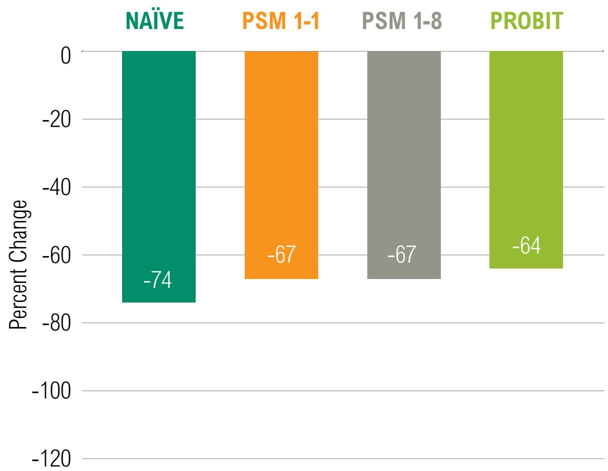
**BOLIVIA**

In Bolivia, indigenous lands comprise 15 percent of the total land area of the country's Amazon basin outside of protected areas. The 2001–2012 rate of deforestation on land inside indigenous land was 2 percent and that on unprotected land outside was 5 percent (Table A1). Indigenous land has different average characteristics than land outside: it tends to be at lower altitude, flatter, more carbon dense, farther from large population centers, less populated, and, in areas with relatively low opportunity costs, to have more rain, and higher temperatures.

Table A1 | **Bolivia: Variable Means and Difference in Means Tests for Two Subsamples (Titled, Untitled)**

| VARIABLE | MEAN TILLE=1 (N=90,782) | MEAN TILLE=0 (N=513,432) | T-TEST |
|---|---|---|---|
| **Outcome** | | | |
| CLEAR | 0.018 | 0.053 | *** |
| **Treatment** | | | |
| TILLE | 1.000 | 0.000 | *** |
| **Controls** | | | |
| ALTITUDE | 495.524 | 683.875 | *** |
| SLOPE | 3.639 | 5.432 | *** |
| NORTHFACE | 0.387 | 0.383 | *** |
| CARBON | 174.988 | 116.612 | *** |
| TRAVEL TIME | 815.813 | 636.678 | *** |
| POPULATION | 3.401 | 10.238 | *** |
| OPP. COST | 6.247 | 14.934 | *** |
| RAIN | 123.953 | 118.700 | *** |
| TEMP | 242.511 | 234.947 | *** |

Figure A1 | **Effect of Bolivian Indigenous Lands on 2001–2012 Deforestation, by Estimator**




After controlling for these differences, we find that indigenous lands are correlated with reductions in deforestation ranging from 64–67 percent (Figure A1; Table A2). These estimated effects are somewhat smaller than the 74 percent reduction implied by a naïve comparison of deforestation rates inside and outside indigenous lands, that is, a comparison that does not control for pre-existing land characteristics.

As noted above, we use matching to control for these observable differences. MSB before matching is 26.8 percent (Table A2). MSB after matching for the nearest neighbor 1-1 estimator is 4.2 percent and for the nearest neighbor 1-8 estimator is 4.3 percent. In both cases, these statistics meet the conventional acceptability standard.

Table A2 | **Bolivia: Effect of Titling on 2001–2013 Deforestation Inside Indigenous Lands: Average Treatment Effect on Treated in Percentage Points, by Estimator (standard error[a]) [mean standardized bias[b]] {critical value of Rosenbaum's G[c]}**

| ESTIMATOR | STATISTIC |
|---|---|
| **Naïve** | |
| Unmatched controls | -73.8***<br>[26.8] |
| **Propensity score matching** | |
| Nearest neighbor 1-1 | -67.5***<br>[4.2]<br>{3.0} |
| Nearest neighbor 1-8 | -67.3***<br>[4.3]<br>{3.0} |
| Probit w/matched controls | -63.7***<br>[4.3] |
| | |
| **Outcome treatment points** | 0.018 |
| **No. points** | 604,214 |
| **No. points treatment** | 90,782 |

*** p<1 percent, ** p<5 percent, * p<10 percent.
[a] Standard errors for propensity score matching estimators clustered at the county (municipio) level.
[b] For a given covariate, the standardized bias (SB) is the absolute value of the difference of means in the treated and matched untreated subsamples as a percentage of the square root of the average sample variance in both groups. We report the mean SB for all covariates.
[c] Critical value of odds of differential assignment to indigenous land due to unobserved factors (i.e., value above which ATT is no longer statistically significant at 10 percent level).

ATT from all three of our estimators are statistically significant at the 1 percent level. They range from 64–68 percent (Table A2). Sensitivity analysis indicates that these results are robust to moderate levels of unobserved heterogeneity (Table A2). For both our 1-1 and 1-8 propensity score estimators, G* is 3.0. Note that a gamma value of 3 (or whatever other number) means that the average treatment effect on the treated (ATT) would still be significantly different from zero even if the titled areas had a three times larger probability of being titled due to unobserved factors.

The naïve estimator generates a slightly larger ATT than our matching estimators (74 percent). The implication is that in Bolivia, indigenous lands tend to be located in places with observable characteristics associated with relatively low rates of deforestation and that a failure to control for that fact biases ATT upwards.

## BRAZIL

In Brazil, indigenous lands comprise 28 percent of the total land area of the country's legal Amazon basin outside of protected areas. Here, our analysis of the deforestation effect of indigenous land is more complicated than that for the other study countries. In our other study countries, we eliminate from our sample all points inside protected areas. The purpose is to avoid conflating the effects of indigenous lands and protected areas. We compare average outcomes on (i) points inside indigenous lands, which are also outside protected areas, and (ii) points outside both indigenous lands and protected areas.

However, in Brazil, that strategy is not feasible. The reason is that today, 99 percent of indigenous lands have been legally designated as protected areas subject to the same land-use and land-cover change restrictions that apply to nonindigenous protected areas. Moreover, in some cases, protected area status was conferred upon indigenous lands after the start of the 2001–2012 period over which we measure deforestation. Given the complex dual status of indigenous lands as protected areas, the proper definition of our unmatched control group of points is unclear. Obviously, they must be outside indigenous lands. But an argument could be made for using points either inside or outside of protected areas. Therefore, we report results from both specifications.

*Unmatched control group comprised of points outside of both indigenous lands and protected areas*

When we use as unmatched control points those that are outside of both indigenous lands and protected areas, the 2001–2012 rate of deforestation inside indigenous lands was 1 percent and outside was 9 percent (Table A3). In this sample, indigenous land has different average characteristics than land outside: it tends to be at higher altitude, more steeply sloped, more carbon dense, farther from large population centers, less populated, and in areas with relatively low opportunity costs, to have more rain, and lower temperatures.

Table A3 | **Brazil: Variable Means and Difference in Means Tests for Two Subsamples (Titled, Untitled)**

| VARIABLE | MEAN TILLE=1 (N=1,105,080) | MEAN TILLE=0 (N=2,873,689) | T-TEST |
|---|---|---|---|
| **Outcome** | | | |
| CLEAR | 0.007 | 0.086 | *** |
| **Treatment** | | | |
| TILLE | 1.000 | 0.000 | *** |
| **Controls** | | | |
| ALTITUDE | 233.021 | 209.3467 | *** |
| SLOPE | 3.560 | 2.822 | *** |
| NORTHFACE | 0.380 | 0.381 | ** |
| CARBON | 226.749 | 146.229 | *** |
| TRAVEL TIME | 2255.391 | 1014.377 | *** |
| POPULATION | 1.050 | 4.828 | *** |
| OPP. COST | 13.824 | 32.319 | *** |
| RAIN | 187.916 | 167.152 | *** |
| TEMP | 255.186 | 257.550 | *** |

After controlling for these characteristics, we find that indigenous lands are correlated with reductions in deforestation ranging from 53–91 percent (Figure A2; Table A4). Two of our three estimated effects are fairly close to the 92 percent effect implied by a naïve comparison of deforestation inside and outside indigenous lands.

Figure A2 | **Effect of Brazilian Indigenous Lands on 2001–2012 Deforestation, by Estimator**

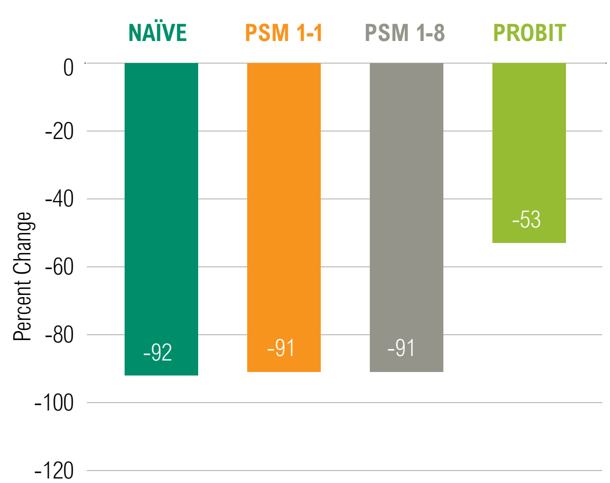


Table A4 | **Brazil: Effect of Titling on 2001–2012 Deforestation Inside Indigenous Lands: Average Treatment Effect on Treated in Percentage Points, by Estimator (standard error[a]) [mean standardized bias[b]] {critical value of Rosenbaum's G[c]}**

| ESTIMATOR | STATISTIC |
|---|---|
| **Naïve** | |
| Unmatched controls | -92.3***<br>[41.2] |
| **Propensity score matching** | |
| Nearest neighbor 1–1 | -90.6***<br>[5.3]<br>{12.6} |
| Nearest neighbor 1–8 | -90.6***<br>[5.4]<br>{14.4} |
| Probit w/matched controls | -53.3***<br>[5.4] |
| | |
| Outcome treatment points | 0.007 |
| No. points | 3,978,769 |
| No. points treatment | 1,105,080 |

*** p<1 percent, ** p<5 percent, * p<10 percent.
[a] Standard errors for propensity score matching estimators clustered at the county (municipio) level.
[b] For a given covariate, the standardized bias (SB) is the absolute value of the difference of means in the treated and matched untreated subsamples as a percentage of the square root of the average sample variance in both groups. We report the mean SB for all covariates.
[c] Critical value of odds of differential assignment to indigenous land due to unobserved factors (i.e., value above which ATT is no longer statistically significant at 10 percent level).

ATT from all three of our estimators are statistically significant at the 1 percent level. They range 54–91 percent (Table A4). Sensitivity analysis indicates that these results are quite robust to unobserved heterogeneity (Table A4). For our 1-1 propensity score estimator, G* is 12.6 and for our 1-8 propensity score estimator it is 14.4.

Unmatched control group comprised of points outside indigenous lands and inside protected areas

When we use as unmatched control points those that are outside of indigenous lands and inside of protected areas, the 2001–2012 rate of deforestation inside indigenous lands was 1 percent and that outside was 2 percent (Table A5). Here too, land inside indigenous lands has different average characteristics than land outside: it tends to be at higher altitude, less steeply sloped, more carbon dense, farther from large population centers, less populated, and in areas with relatively low opportunity costs, to have more rain and lower temperatures.

Table A5 | **Brazil: Variable Means and Difference in Means Tests for Two Subsamples (Titled, Untitled)**

| VARIABLE | MEAN TILLE=1 (N=1,105,080) | MEAN TILLE=0 (N=1,045,095) | T-TEST |
|---|---|---|---|
| **Outcome** | | | |
| CLEAR | 0.007 | 0.016 | *** |
| **Treatment** | | | |
| TILLE | 1.000 | 0.000 | *** |
| **Controls** | | | |
| ALTITUDE | 233.021 | 170.783 | *** |
| SLOPE | 3.560 | 3.721 | *** |
| NORTHFACE | 0.380 | 0.380 | |
| CARBON | 226.749 | 223.110 | *** |
| TRAVEL TIME | 2255.391 | 1967.204 | *** |
| POPULATION | 1.050 | 3.278 | *** |
| OPP. COST | 13.824 | 17.522 | *** |
| RAIN | 187.916 | 187.246 | *** |
| TEMP | 255.186 | 260.179 | *** |

Our matching estimators do a good job of controlling for these characteristics. MSB before matching is 16.9 percent (Table A6). MSB after matching for both the nearest neighbor 1-1 estimator and the nearest neighbor 1-8 estimator is 4.1 percent.

After controlling for these characteristics, we find that indigenous lands are correlated with reductions in deforestation ranging from 57–65 percent (Figure A3; Table A6). These estimated effects are fairly close to the 57 percent effect implied by a naïve comparison of deforestation inside and outside indigenous lands.

Figure A3 | **Effect of Brazilian Indigenous Lands on 2001–2012 Deforestation, by Estimator**

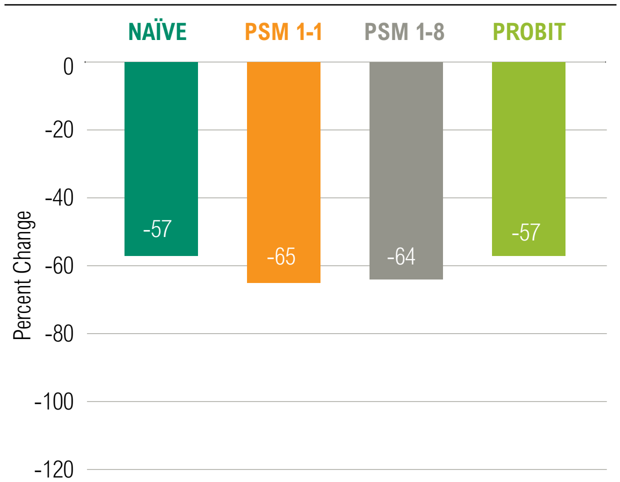


Table A6 | **Brazil: Effect of Titling on 2001–2012 Deforestation Inside Indigenous Lands: Average Treatment Effect on Treated in Percentage Points, by Estimator (standard error[a]) [mean standardized bias[b]] {critical value of Rosenbaum's G[c]}**

| ESTIMATOR | STATISTIC |
|---|---|
| **Naïve** | |
| Unmatched controls | -57.4***<br>[16.9] |
| **Propensity score matching** | |
| Nearest neighbor 1-1 | -64.6***<br>[4.1]<br>{2.7} |
| Nearest neighbor 1-8 | -64.4***<br>[4.1]<br>{2.5} |
| Probit w/matched controls | -57.3***<br>[4.1] |
| | |
| Outcome treatment points | 0.007 |
| No. points | 2,150,175 |
| No. points treatment | 1,105,080 |

*** p<1 percent, ** p<5 percent, * p<10 percent.
a Standard errors for propensity score matching estimators clustered at the county (municipio) level.
b For a given covariate, the standardized bias (SB) is the absolute value of the difference of means in the treated and matched untreated subsamples as a percentage of the square root of the average sample variance in both groups. We report the mean SB for all covariates.
c Critical value of odds of differential assignment to indigenous land due to unobserved factors (i.e., value above which ATT is no longer statistically significant at 10 percent level).

ATT from all three of our estimators are statistically significant at the 1 percent level. They range from 57–65 percent (Table A6). Sensitivity analysis indicates that these results are moderately robust to unobserved heterogeneity (Table A6). For our 1-1 propensity score estimator, G* is 2.7 and for our 1-8 propensity score estimator it is 2.5.

### COLOMBIA

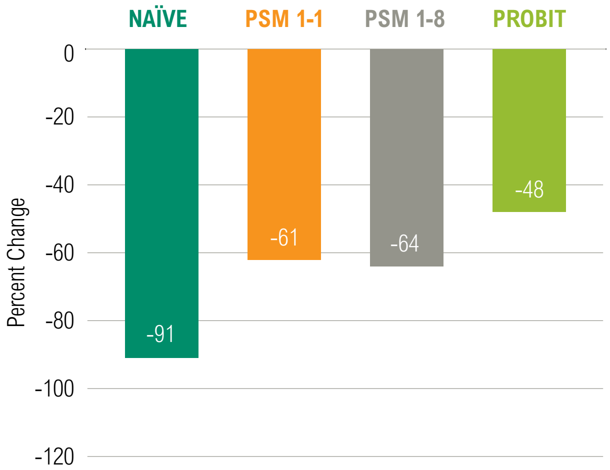
In Colombia, indigenous lands comprise 56 percent of the total land area of the country's Amazon basin outside of protected areas. The 2001–2012 rate of deforestation on indigenous lands was less than 1 percent and that on unprotected land outside was 5 percent (Table A7). Again, indigenous land has different average characteristics than land outside: it tends to be at lower altitude, flatter, more carbon dense, farther from large population centers, less populated, and in areas with relatively low opportunity costs, and higher temperatures.

Table A7 | **Colombia: Variable Means and Difference in Means Tests for Two Subsamples (Titled, Untitled)**

| VARIABLE | MEAN TILLE=1 (N=224,450) | MEAN TILLE=0 (N=174,669) | T-TEST |
|---|---|---|---|
| **Outcome** | | | |
| CLEAR | 0.004 | 0.050 | *** |
| **Treatment** | | | |
| TILLE | 1.000 | 0.000 | *** |
| **Controls** | | | |
| ALTITUDE | 173.287 | 402.412 | *** |
| SLOPE | 2.268 | 4.445 | *** |
| NORTHFACE | 0.364 | 0.346 | *** |
| CARBON | 229.772 | 192.314 | *** |
| TRAVEL TIME | 3384.241 | 1525.130 | *** |
| POPULATION | 0.747 | 6.829 | *** |
| OPP. COST | 3.264 | 8.578 | *** |
| RAIN | 248.533 | 228.742 | *** |
| TEMP | 263.688 | 253.666 | *** |

After controlling for these characteristics, we find that indigenous lands are correlated with reductions in deforestation ranging from 48–64 percent (Figure A4; Table A8). These estimated effects are somewhat smaller than the 91 percent reduction implied by a naïve comparison of deforestation inside and outside indigenous lands.

Figure A4 | **Effect of Colombian Indigenous Lands on 2001–2012 Deforestation, by Estimator**




Our matching estimators do a reasonably good job of controlling for these characteristics. MSB before matching is 56 percent (Table A8). MSB after matching for both the nearest neighbor 1-1 estimator and the nearest neighbor 1-8 estimator is 4.4 percent.

Table A8 | **Colombia: Effect of Titling on 2001–2012 Deforestation Inside Indigenous Lands: Average Treatment Effect on Treated in Percentage Points, by Estimator (standard error[a]) [mean standardized bias[b]] {critical value of Rosenbaum's G[c]}**

| ESTIMATOR | STATISTIC |
|---|---|
| Naïve | |
| Unmatched controls | -91.3***<br>[56.0] |
| Propensity score matching | |
| Nearest neighbor 1-1 | -60.8**<br>[4.4]<br>{5.2} |
| Nearest neighbor 1-8 | -63.8**<br>[4.4]<br>{8.8} |
| Probit w/matched controls | -48.2**<br>[4.4] |
| | |
| Outcome treatment points | 0.004 |
| No. points | 399,119 |
| No. points treatment | 224,450 |

*** p<1 percent, ** p<5 percent, * p<10 percent.
[a] Standard errors for propensity score matching estimators clustered at the county (municipio) level.
[b] For a given covariate, the standardized bias (SB) is the absolute value of the difference of means in the treated and matched untreated subsamples as a percentage of the square root of the average sample variance in both groups. We report the mean SB for all covariates.
[c] Critical value of odds of differential assignment to indigenous land due to unobserved factors (i.e., value above which ATT is no longer statistically significant at 10 percent level).

ATT from all three of our estimators are statistically significant at the 5 percent level. They range from 48–61 percent (Table A8). Sensitivity analysis indicates that these results are robust to unobserved heterogeneity (Table A8). For our 1-1 propensity score estimator, G* is 5.2 and for our 1-8 propensity score estimator it is 8.8.

As in Bolivia, the naïve estimator generates a larger ATT than our matching estimators (91 percent). Here too, the implication is that indigenous lands tend to be located in places with observable characteristics associated with relatively low rates of deforestation, and that a failure to control for that fact biases ATT upwards.

# APPENDIX 3: COST DATA DETAILS

**BOLIVIA**

Data presented for Bolivia were taken from World Bank—National Land Administration Project—Implementation Completion Report 2006, International cooperation support for land regularization projects between 1995 and 2004, IDB project no. BO0221, and USAID financing support for land titling between 2003 and 2008. Data sources used for computing the per-hectare cost related to land-tenure security in Bolivia are presented in Table A9 and A10. However, since most of the land titling support from international organizations had been withdrawn from the country by 2012 (e.g., USAID had removed its country office by 2012), it was difficult to verify the detailed expenditures for the different land regularization and titling processes.

Table A9 | **Sources of Cost Data Collected from International Organizations**

| COSTS INCURRED BETWEEN 1996 AND 2002 | | | |
|---|---|---|---|
| **Variable** | **Unit** | **Value ($)** | **Source** |
| **World Bank—National Land Administration Project—Implementation Completion Report 2006** | | | |
| INRA expenditures for land regularization component | 2006$ | 25,607,000 | WB 2006 |
| Property registry expenditures | 2006$ | 2,963,000 | WB 2006 |
| Agrarian tribunal expenditures | 2006$ | 308,000 | WB 2006 |
| Total | 2006$ | 28,878,000 | WB 2006 |
| **International Cooperation Support for Land Regularization (Projects) ICL=Indigenous Community Lands** | | | |
| Regularization and titling of Monteverde, Guarayos, and Lupaguasu ICLs-pilot | 2003$ | 743,553 | IDB 2003 |
| Regularization and titling of ICLs in Oriente, Chaco, and Bolivian Amazon basin | 2003$ | 3,799,740 | IDB 2003 |
| Regularization and titling of Uru Chipayas and Uru Muratos ICLs | 2003$ | 110,682 | IDB 2003 |
| Regularization of the Ayllu Sicuya ICL | 2003$ | 70,243 | IDB 2003 |
| Regularization project in 17 Communities in Beni | 2003$ | 31,134 | IDB 2003 |
| Regularization of ICLs in highland and lowland areas | 2003$ | 3,805,662 | IDB 2003 |
| Program to support alternative development in Chapare | 2003$ | 6,577,200 | IDB 2003 |
| Project for regularization and titling in the TIPNIS, TICH, and CIRABO areas | 2003$ | 954,000 | IDB 2003 |
| Regularization and titling of ICLs in the TIPNIS and TICH areas | 2003$ | 545,000 | IDB 2003 |
| Rural legal cadastre project in Chuquisaca | 2003$ | 10,229,523 | IDB 2003 |
| Land titling project in the Tropic of Cochabamba | 2003$ | 3,500,000 | IDB 2003 |
| Total | 2003$ | 30,366,737 | IDB 2003 |

Table A10 | **Sources of Cost Data Collected from International Organizations (cont.)**

| TOTAL COSTS INCURRED BETWEEN 2003 AND 2012 | | | |
|---|---|---|---|
| **Variable** | **Unit** | **Value ($)** | **Source** |
| **Inter-American Development Bank—Land Regularization and Legal Cadastre Program (Project No. BO0221)** | | | |
| I. Management and supervision | 2006$ | 575,626 | IDB 2012 (ES doc) |
| II. Direct costs | 2006$ | 17,402,997 | IDB 2012 |
| Regularization and enhancement of agricultural property rights | 2006$ | 10,628,295 | IDB 2012 |
| Consolidation and technical bases for maintenance of the legal cadastre | 2006$ | 6,774,702 | IDB 2012 |
| III. Concurrent Costs | 2006$ | 282,341 | IDB 2012 |
| Audits | 2006$ | 282,341 | IDB 2012 |
| Total | 2006$ | 18,260,964 | IDB 2012 |
| USAID Financing Support for Land Titling, 2003–2008 | 2008$ | 8,968,846 | USAID country profile |

Table A11 | **Estimated Expenditure Data for Indigenous Lands in Bolivia (1999–2013, US$/ha)**

| COST COMPONENTS | ANNUAL VALUE $/HA | NOTES | YEARS |
|---|---|---|---|
| Cost of implementation of the INRA law through the land administration Project (WB land administration project) | 1.68 | one-off cost | 1996–2002 |
| Agrarian tribunal expenditures (WB land administration project) | 0.02 | one-off cost | 1996–2002 |
| Property registry expenditures (WB land administration project) | 0.19 | one-off cost | 1996–2002 |
| International cooperation support for land regularization (projects) ICL=Indigenous Community Lands | 1.14 | one-off cost | 1996–2002 |
| USAID financing support for land titling 2003–2008 | 2.10 | one-off and recurring cost | 2003–2008 |
| Consolidation and technical bases for maintenance of the legal cadastre | 0.08 | recurring cost | 2003–2008 |
| Management and supervision costs for land regulation and cadastre | 0.01 | recurring cost | 2003–2008 |
| Regularization and enhancement of agricultural property rights | 0.13 | recurring cost | 2003–2008 |
| Other operating and monitoring costs | 2.10 | recurring cost | 2003–2008 |

## BRAZIL

Table A12 provides an overview of national and local government expenses from 2005 to 2014. Local government expenses include support to Indigenous Peoples in order to guarantee their rights. This expense is included in a subgroup called "right of citizenship." Expenses in this subgroup aim to guarantee the rights of minorities and to assist them inside the municipalities. These expenses are assumed to be indicative of local support for all the initiatives regarding Indigenous Peoples' rights.

Finally, the cost estimation also includes the cost of establishing a management plan. The calculation is based on a grant received by The Nature Conservancy (TNC) of $5.2 million for six indigenous lands. The total grant amount was divided by the area of six indigenous lands (1,248,948 hectares) in order to estimate a per-hectare value. The analysis assumes that only about 60 percent of the grant is applicable because the grant may also cover overhead and other general expenses for TNC. It is further assumed that management plans are established in year one, and are a one-time, upfront, expense. The management-plan cost is estimated at $2.61/ha/yr.

Average annual cost estimates are assumed to remain constant for the 20-year analysis period. However, it is possible that this approach may over- or under-estimate costs because it appears likely that the budget for national programs will be reduced in coming years (Borger et al. 2015). Lower- and upper-bound values shown in Table A12 are used for the sensitivity analysis (lower bound assumes maximum costs; upper bound assumes minimum costs).

Table A12 | **National and Local Government Expenditure Data for Indigenous Lands in Brazil (2015 US$/ha)**

| YEAR | FUNAI EXPENDITURES ($) | | | | LOCAL GOVERNMENT EXPENDITURES ($) | TOTAL ($) |
|---|---|---|---|---|---|---|
| | Ethnic Identity/ Cultural Heritage | Administrative Expenses | Protection/ Management Lands | Total | | |
| 2005 | 0.11 | 0.20 | 0.26 | 0.57 | 0.03 | 0.60 |
| 2006 | 0.10 | 0.17 | 0.21 | 0.48 | 0.03 | 0.50 |
| 2007 | 0.22 | 0.38 | 0.49 | 1.09 | 0.03 | 1.12 |
| 2008 | 0.24 | 0.42 | 0.54 | 1.19 | 0.02 | 1.21 |
| 2009 | 0.28 | 0.49 | 0.63 | 1.41 | 0.03 | 1.44 |
| 2010 | 0.33 | 0.57 | 0.73 | 1.63 | 0.12 | 1.74 |
| 2011 | 0.34 | 0.59 | 0.76 | 1.69 | 0.02 | 1.71 |
| 2012 | 0.33 | 0.58 | 0.75 | 1.66 | 0.01 | 1.67 |
| 2013 | 0.35 | 0.62 | 0.80 | 1.77 | -- | 1.77 |
| 2014 | 0.32 | 0.56 | 0.72 | 1.59 | -- | 1.59 |

*Source:* CGU/Transparencia Pública 2015; FINBRA 2015.

**COLOMBIA**

The World Bank NRMP loan 3692-CO for US$39 million with a maturity of 17 years including a four-year grace period, draws to a close at the end of the year 2000. By June 2000, the program had achieved 72 percent of its land titling goals, benefitting 19,860 families (over 100,000 people). The project spent US$3.25 million of the US$4.09 million allotted to these three components, leaving a balance of US$0.81 to terminate. The NRMP is responsible for 17 percent of land collectively titled to Indigenous Peoples on the Pacific coast and 100 percent of land collectively titled to black communities in Colombia in general. In addition, our contact in INCODER confirmed that the average land titling cost per *resguardo Indigena* is about COL$70million, of which 50 percent is used for direct field costs. Based on these two sources of information, we then computed the land tenure security costs in Colombia.

# APPENDIX 4: BENEFIT-COST MODEL, ASSUMPTIONS

## Benefit-Cost Analysis Model

The benefit-cost analysis for Bolivia, Brazil, and Colombia compares a policy scenario to a no-policy scenario. As a result, the paper calculates the net present value (NPV), that is, the difference between the benefit and cost streams for the analysis period of 20 years by:

$$NPV = \sum_{i=1}^{20} \frac{B_i - C_i}{(1 + r)^i}$$

**Where:**

$B_i$ = Benefits in year i
$C_i$= Costs in year i
r= discount rate

Annual costs (Ci) were calculated in US$/ha/yr using the equation:

$$C_i = TE_i + CFE_i + M_i$$

**Where:**

$TE_i$ = tenure-security establishment costs in year i
$CFE_i$= community-forestland establishment costs in year i
$M_i$ = management, operating, and monitoring costs in year i

Benefits (Bi) were calculated in US$/ha/yr using the equation:

$$B_i= CM_i + OEB_i$$

**Where:**

CM = carbon-mitigation benefits in year i ($/ha/yr)
OEB = other ecosystem-service benefits in year i ($/ha/yr)

# ENDNOTES

1. Some studies find little difference in the deforestation rates of indigenous forestlands and forests under other tenure types, and show that land titling (or forest management plans) alone have little effect on deforestation rates of indigenous forestlands (BenYishay et al. 2016; Buntaine et al. 2015; Rasolofoson et al. 2015). In many cases, the deforestation rates are uniformly low across all tenure types and on indigenous forestlands that are formally titled and not. This work underscores the many factors that can affect tenure security and forest outcomes (Baland and Platteau 1996; Pacheco and Benatti 2015; Ferretti-Gallon and Busch 2014; Larson and Lewis-Mendoza 2012).

2. This research does not examine indigenous lands outside the Amazon basin or non-indigenous community lands in the Amazon basin.

3. Despite the existence of increasing pressures on indigenous and community forestlands, it was not possible to examine the opportunity costs of these alternative land uses for this report.

4. According to the Rights and Resources Initiative (RRI 2015), land that is designated for Indigenous Peoples and local communities is land that is "governed under tenure regimes that recognize some rights on a conditional basis for Indigenous Peoples and local communities. While rights-holders have some level of 'control' exercised through use, management, and/or exclusion rights over land, they lack the full legal means to secure their claims to those lands (i.e., they do not have all rights required under the 'ownership' designation: the right to exclude, to due process and compensation, and to retain rights for an unlimited duration)."

5. UN Habitat estimates that 70 percent of lands in the developing world lack documented, recorded, or mapped land rights, but the percentage varies considerably by country and continent. For example, in 2013, the World Bank reported that, "90 per cent of Africa's rural land is undocumented" (Byamugisha 2013).

6. This figure recognizes 52 countries containing nearly 90 percent of the global forest cover. It includes forestland legally recognized as community land, as well as state land to which communities have some formal, conditional rights.

7. Various methods exist for defining the boundaries of the Amazon basin and there is no one definition of what constitutes the Amazon basin. The region is most commonly delimited using biophysical features (e.g., hydrography, relief, vegetation) or administrative boundaries. Legal, economic, and social criteria, however, can also be used to define the Amazon basin. For this research report, the Amazon basin is delimited using a hybrid of biophysical and administrative criteria. In Bolivia and Colombia, the boundary constitutes the hydrographic (i.e., watershed) limits of the Amazon, whereas in Brazil the boundary representing the "Legal Amazon" is defined by the state using administrative criteria. These boundaries of the Amazon basin are consistent with how RAISG defines the Amazon basin. In addition to Brazil, Ecuador also uses legal-administrative criteria for the boundary of the Amazon basin in its borders.

8. The government of Bolivia issues other titles to Indigenous Peoples and communities, which also provide tenure security, such as Asociaciones Sociales de Lugar (ASLs) (Cano et al. 2015).

9. FPIC is the right of communities to give or withhold their consent to proposed projects that may affect the lands they customarily own, occupy, or otherwise use.

10. With the exception of indigenous lands in Pando, Bolivia's most northern province, located entirely in the Amazon basin. In Pando, individual exploitation of forests on indigenous (and non-indigenous) lands has been allowed since 2008 and the harvestable amount per individual has increased from an initial 3 cubic meters to 43 cubic meters. Since law SF IDF N004/2008 and all following adjustments, members of Indigenous Peoples and other communities can obtain legal permits to harvest timber individually (CITE).

11. In Brazil, some collective forestlands are also held by Afro-descendant (non-indigenous) communities and a number of collectively managed community forests are located in sustainable development reserves and extractive reserves.

12. As in Brazil, some collective forestlands in Colombia are also held by Afro-descendant communities.

13. Ecosystem services valued included food, water, raw materials, genetic resources, medicinal resources, improvement of air quality, climate regulation, regulation of water flows, waste treatment/water purification, erosion prevention, and recreation and tourism.

14. Ecosystem services valued include carbon benefits and 17 other services, such as food, water, raw materials, and genetic resources.

15. Ecosystem services include carbon benefits and 15 other services including water regulation, pollination, and food production.

16. OECD (2013) defines collective action as "action taken by a group to achieve common interests."

17. It can be argued that protection of tenure-secured forestlands may stimulate forest regeneration and hence contribute to higher economic benefits. However, quantifying the benefits of ecosystem regeneration would rely on a sophisticated biophysical modeling process that is able to model the relationship between forest regeneration and the provision of ecosystem services by biomes under changing climate conditions in the future. This goes beyond the scope of the present research.

18. In the statistical analysis of observational data, propensity score matching is a statistical matching technique that attempts to estimate the effect of a treatment, policy, or other intervention by accounting for the covariates that predict receiving the treatment.

19. Probit regression, also called a probit model, is used to model dichotomous or binary outcome variables, such as success or failure in an exam.

20. Note that in Brazil, 99 percent of indigenous lands have been legally designated as protected areas subject to the same land-use and land-cover change restrictions that apply to nonindigenous protected areas. Moreover, in some cases, protected-area status was conferred upon indigenous lands after the start of the 2001–2012 period over which we measured deforestation. Given the complex dual status of indigenous lands as protected areas, the proper definition of our unmatched control group of points is unclear. Obviously, they must be outside indigenous lands. But an argument could be made for using points either inside or outside of protected areas. Therefore, we report results from both specifications in Appendix 2. However, in this table and in this report, we used only the annual deforestation rate resulting from the unmatched control group—comprising points outside indigenous lands and inside protected areas—to estimate the total carbon benefits from deforestation reduction due to community forestland-tenure security. We do that because this specification is more conservative, that is, it generates a lower estimates of carbon benefits.

21. This difference in estimated deforestation rates has, in part, led to different estimates of avoided deforestation and carbon sequestration benefits in the present study, compared to those of Gray et al. (2015).

22. The atomic weight of carbon is 12 atomic mass units, while the weight of carbon dioxide is 44, because it includes two oxygen atoms that each weigh 16. So, to switch from one to the other, use the formula: One tonne of carbon equals 44/12 = 11/3 = 3.67 tonnes of carbon dioxide.

23. Social cost of carbon is different from other forms of carbon-pricing mechanisms, such as the payments for forest communities to reduce emissions from REDD (Reduction of Emissions from Deforestation and Forest Degradation). Although the payment per tonne of $CO_2$ emissions reduction through the REDD program reflects the actual benefits that Indigenous Peoples can receive, the determination of the "right" market prices is based on a cost-based approach, which accounts for site-specific factors (i.e., the opportunity costs of deforestation, which will be discussed in the cost section of this report) and the implementation and transaction costs associated with REDD (the REDD mechanism is more complex, involving the demand and supply side analysis), which go beyond the scope of the current report.

24. To better understand the ecosystem-service benefits provided by Indigenous forestlands located in different Amazon biomes, a significant amount of effort (time and resources) will be required to design original studies using market and/or non-market valuation methods, as appropriate, to assess each benefit using site-specific and country-specific data. This analysis is outside the scope of the present study.

25. The carbon-mitigation cost reported in the OECD/IEA report assumes new-build power plants with integrated $CO_2$ capture installation that would be located in the United States, Europe, and China.

26. Based on U.S. Environmental Protection Agency GHG equivalencies calculator: http://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

27. Further, in 2014, a new mining law (Law 535/14) was enacted in Bolivia, which declares all state lands open to mining (including protected areas), gives water and other natural resource rights to mining companies even on indigenous lands, and has no consultation or FPIC provisions (IWGIA 2015). The government also amended the legal process regarding FPIC—the consultation process now lasts no more than 45 days (Cregan 2015). Such laws weaken the ability of Indigenous Peoples to bargain with government and companies, weaken their ability to protect their lands, and as a consequence, weaken land tenure.

28. In 2006, a pact between businesses, NGOs, and government known as the Amazon Soy Moratorium (SoyM) was the first voluntary zero-deforestation agreement implemented in the tropics (SoyM was recently extended to May 2016). Since then, soya production on Amazon forestland has fallen dramatically (Butler 2015, Gibbs et al. 2015). Many producers are buying up converted pasture from cattle ranchers, however, which pushes ranchers to clear pristine habitats, including indigenous forestlands (Gibbs et al. 2015).

29. Maps and land-use plans are common requirements of the formal documentation process.

30. Estimates based on CAIT data (http://cait.wri.org/) indicating that the 2012 national GHG emissions of Bolivia, Brazil, and Colombia are 136.47Mt$CO_2$e, 1,823.15 Mt$CO_2$e and 199.68 Mt$CO_2$e, respectively.

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**Our Challenge**
Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

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We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

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