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What Works to Improve Lives?

by **Leonardo Corral**

What Works to

PROMOTE FOREST CONSERVATION, ENVIRONMENTAL SUSTAINABILITY, AND CLIMATE RESILIENCE

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PREFACE

This publication is one of a five-monograph series produced by the Inter-American Development Bank to take stock of the lessons learned from impact evaluations of investments supported by the IDB Group for over a decade across a wide range of economic and social development sectors. The aim of the evaluations and these five monographs is to identify policies and programs that work, enhance the use of rigorous evidence for decision-making, and ultimately improve the lives of the people of Latin America and the Caribbean.

The coverage of IDB Group impact evaluations discussed in the five monographs is not meant to be exhaustive of all evaluations supported by the Group, but rather to summarize lessons on topics with multiple completed evaluations on a common intervention or outcome.

This first monograph is authored by Leonardo Corral. Carola Álvarez, Leonardo Corral, Andrés Gómez-Peña, and Sebastián Martínez coordinated the production of the five monographs and provided strategic input and guidance throughout the process. Allen Blackman provided valuable comments on earlier drafts and Solis Winters provided outstanding research assistance. The monograph series was edited by David Einhorn. Gaston Cleiman led art direction and graphic design of this publication.

This monograph series would have not been possible without the valuable time and contributions of the many researchers, counterparts in governments, survey firms, partner organizations, and, above all, participants in the evaluations discussed in this volume.

What Works to Improve Lives?

INTRODUCTION

As regional interest in mitigating and adapting to climate change continues to increase, there is an ever-growing demand to identify effective policies to (1) stem deforestation, (2) promote growth with sustainability, and (3) enhance the climate resilience of affected populations.

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As regional interest in mitigating and adapting to climate change continues to increase, there is an ever-growing demand to identify effective policies to **(1)** stem deforestation, **(2)** promote growth with sustainability, and **(3)** enhance the climate resilience of affected populations. This chapter will summarize the evidence from impact evaluations carried out by the Inter-American Development Bank (IDB) over the last decade on each of these three themes.

Key lessons on "what works" in promoting forest conservation, environmental sustainability, and climate resilience:

- **Stemming deforestation**. The quickly growing body of evidence suggests that protected areas are effective in reducing deforestation, and that allowing some sustainable extractive activities is more effective than strict protection. Decentralized approaches, including granting titles or transferring management of forests to indigenous communities, have also been effective in combatting deforestation, forest degradation, and thus climate change, and provide a cheaper and less resource-intensive alternative to centralized approaches. However, effects on forest outcomes depend critically on local conditions. As far as certification and regulatory extraction schemes, there is little evidence to support their effect on deforestation, notwithstanding potential benefits associated with market access and small price premiums.

- **Promoting growth with sustainability**. Shoreline stabilization and beach amenity enhancement measures may not only help preserve fragile ecological conditions but can also lead to sustainable growth in the local economy, particularly in small island nations where a large share of economic activity focuses on tourism activities. Including strict environmental and social safeguards in the design and implementation of large infrastructure projects can prevent adverse environmental consequences of the project on the surrounding area while still promoting economic growth.

- **Enhancing the climate resilience of affected populations**. Climate-smart agriculture, including irrigation, agroforestry, and soil and water conservation practices, can be effectively promoted through the use of smart subsidies and technical assistance and can lead to increases in the productivity, income, and food security of small-scale producers who are highly affected by climate change.

What Works to Improve Lives?

Effective Policies to STEM DEFORESTATION

It is estimated that 17 percent of global CO_2 emissions are due to deforestation and forest degradation (van der Werf et al. 2009). At the same time, forests play a crucial role in mitigating climate change and maintaining ecosystem functions essential to human survival and well-being (Seymour and Busch 2016).

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It is estimated that 17 percent of global CO2 emissions are due to deforestation and forest degradation (van der Werf et al. 2009).[1] At the same time, forests play a crucial role in mitigating climate change and maintaining ecosystem functions essential to human survival and well-being (Seymour and Busch 2016). Thus, ever-growing attention is being devoted to preserving tropical forests and increasing the funding available to support such initiatives. For instance, Norway is investing approximately US$500 million in tropical forest conservation each year. Similarly, with the aim of reducing tropical deforestation by 50 percent by 2020 and completely by 2030, some 190 entities signed the New York Declaration on Forests in 2014. The signees include governments, companies, and nongovernmental organizations. This broad participation points to the importance being placed on forests as part of an international solution to climate change. Stemming tropical forest loss and strengthening the recuperation of these forests could provide more than a quarter of the reduction in emissions needed by 2030 to avoid the catastrophic impacts of climate change (Griscom et al. 2017).

Close to 35 percent of all forests on the planet are in Latin America and the Caribbean (Hansen et al. 2013). Forest carbon stocks in the region account for just shy of 50 percent of total carbon above ground in the tropics worldwide (Saatchi et al. 2011). Unfortunately, the region witnessed a rapid process of forest loss between 2000 and 2017 that represents about 22 percent of the global forest loss (Hansen et al. 2013).

This section reviews evaluations that aim to identify effective policies to stem the loss of forests and changes in land use. These policies can be broadly classified as centralized (through the establishment of protected areas); decentralized (by granting indigenous groups and local communities formal title to land); and market-based (through certification schemes). Even with the accelerating pace of investment in reducing emissions from deforestation and forest degradation, forest conservation policymakers in the region still have limited resources. Therefore, it is more important than ever to have effective initiatives, which in turn requires objective, rigorous

1_ When agriculture, mining, urban development, or other land uses replace forest, the land is said to have experienced deforestation. By contrast, degradation is a gradual process through which a forest's biomass declines and its species composition changes.

evaluations that analyze the extent to which forest conservation policies achieve their aims.

Until fairly recently, such rigorous evaluations were uncommon due primarily to two factors.[2] First, conservation scientists and practitioners historically depended on intuition and anecdotes to guide the design of conservation investments, so the demand for rigorous evaluations of forest conservation policy was limited (Ferraro and Pattanayak 2006). Second, collecting and analyzing the requisite data proved to be prohibitively expensive, as evaluations of forest conservation policies had to rely on costly field measurements. Over the past two decades, however, evaluation costs have been dramatically reduced as high-resolution remotely sensed (satellite) data on deforestation and degradation has become publicly available, geographic information system (GIS) software has been developed, and the capacity needed to analyze the data has increased. These advances have created significant new opportunities to enhance our understanding of the effectiveness of forest conservation policy (Blackman 2012).

EVIDENCE FROM IMPACT EVALUATIONS SUPPORTED BY THE IDB GROUP

Centralized Approaches

Protected areas are a cornerstone of forest conservation policy in developing countries (Duraiappah et al. 2005; UNEP 2010). Today, approximately 13 percent of the land area of developing countries is protected (IUCN and UNEP-WCMC 2011). The chief aim of policymakers in establishing

2_ Some recent reviews of rigorous evidence on effectiveness of forest conservation policies include Baylis et al. (2016), Börner et al. (2020), and Burivalova et al. (2019).

protected areas is typically to conserve forests and the ecological benefits they provide, including carbon sequestration, biodiversity habitat, and hydrological services. The hope is that these goals can be achieved without imposing significant costs on local communities. However, the direction and magnitude of the effects of protected areas on local communities and on the environment are uncertain. In theory, protected areas could impose economic costs on local communities by limiting their ability to use forests for agriculture, logging, and hunting. But they could also provide economic benefits by promoting tourism, attracting infrastructure investments, and ensuring the continued provision of valuable forest ecosystem services (Ferraro 2008; Ferraro, Hanauer, and Sims 2011; Robalino et al. 2008).

In principle, protected areas stem forest clearing and degradation within their borders by restricting land-use change and extractive activities. Yet these restrictions may not be enforced because of insufficient human, financial, and political resources, uncertainty about land tenure, and conflicts with local communities (Balmford et al. 2003; Bruner, Gullison, and Bramford 2004; Naughton-Treves, Holland, and Bramford 2005). When regulatory control is particularly weak, protected areas can even exacerbate forest cover change by creating de facto open-access regimes (Blackman, Pfaff, and Robalino 2015; Liu et al. 2001; Wittemyer et al. 2008). Hence, empirical research is needed to measure the net effects of protected areas on both forest cover change and socioeconomic outcomes.

Unfortunately, accurately measuring these effects is challenging because protected areas are not randomly located. Rather, policymakers tend to establish them in remote regions with relatively low deforestation pressure and high levels of poverty (Andam et al. 2010; Ferraro, Hanauer, and Sims 2011; Sachs et al. 2009). As a result, the most common strategy for measuring protected environmental and socioeconomic effects – simply comparing outcomes of interest (e.g., deforestation rates and poverty rates) inside protected area boundaries with outcomes outside – may generate biased results. Such analyses tend to conflate the environmental and socioeconomic effects of restrictions on land-use change and extractive activity with the effects of the preexisting characteristics of the land on which protected areas are established. To address these challenges, quasi-experimental program evaluation techniques (such as matching, difference-in-differences, and instrumental variables) along with remote sensing data to measure forest cover change have been increasingly used to measure the effect of protected areas on deforestation.

Miranda et al. (2016) used quasi-experimental matching techniques to assess the environmental and socioeconomic effects of protected areas in the Peruvian Amazon. Accurately measuring these effects in a country like Peru that is considered megadiverse because of the richness of its species is particularly important because half the population lives in poverty, and protected areas account for 27 percent of the total land surface in the country's Amazon region. The authors used high-resolution remote sensing data from 2000–2005 to measure forest cover change, including both deforestation and degradation. To measure socioeconomic outcomes, they primarily used contemporaneous 2001–2006 household survey data. The study found that protected areas reduced forest cover change by 1.3 percent per year between 2000 and 2006. This effect was an order of magnitude smaller than those generated by a naïve estimator that simply compared forest cover change inside and outside protected areas. The study also found that protected areas established before 1990 and those that were not strictly protected (where some extractive uses are allowed) were more effective in reducing deforestation. This result is consistent with the results found by Blackman (2015) for Guatemala's Maya Biosphere Reserve, a mixed-use protected area, and by Pfaff et al. (2014) for protected areas in Acre, a state in the Brazilian Amazon. Finally, Miranda et al. (2016) did not find conclusive evidence that protected areas in Peru affected socioeconomic conditions in local communities during the same period. That is, they did not find a "win-win" scenario, such as those found in the case of Costa Rica and Thailand (Ferraro, Hanauer, and Sims 2011). A plausible explanation provided by the authors was the remoteness of the protected areas studied, which consequently attracted few tourists. The percentage of national and international tourists traveling to the protected areas included in the study is at best 5 percent of total visitors to Peruvian national parks. An additional reason for this finding, which has gained attention of late, might simply be the limited attention given to environmental incomes in national income surveys due to cumbersome accounting for all extractive products that communities close to protected areas most value (Wunder, Angelsen, and Belcher 2014). This may lead to the underestimation of total household incomes by understating the value of the environment to households in proximity to protected areas. This might be exacerbated in the cases that allow extraction or mixed-use parks.

The questions of how mixed-use parks that allow sustainable extractive activities perform relative to strictly protected parks, as well as what types of mixed-use management perform best, are addressed by Blackman (2015) in the context of Guatemala's Maya Biosphere Reserve. The author used high-resolution land cover data for 2001–2006 derived from satellite images, along with statistical techniques that control for nonrandom location, to examine the relative effectiveness of strict and various mixed-use protection strategies in the 2 million-hectare Maya Biosphere Reserve. The results showed that mixed-use protection in this park was more effective in stemming deforestation than strict protection because of the performance of forest concessions within the multiple-use zone.

For protected areas in Acre in the Brazilian Amazon, Pfaff et al. (2014) also found that sustainable-use protection prevented more deforestation than did strict protection, where all extractive activities are banned. However, the authors attributed this to the placement of sustainable-use protected areas on sites with a high threat of clearing. The authors concluded that strict protected areas, which ban forest clearing, seem politically feasible only if they are further away from deforestation threats, which gives them less additionality.

These results in Guatemala and Brazil, together with those reported by Miranda et al. (2016) for Peru, are in line with the emerging consensus that, on the whole, parks that allow some sustainable extractive activities are more effective in stemming deforestation.[3]

3_ However, it needs to be acknowledged that it is generally hard to disentangle the effects of (i) mixed-use (vs. strictly protected) parks, and (ii) deforestation risk ("threat of clearing), which Pfaff et al. (2014) highlight. The reason is that protected areas are generally found to not be very effective at stemming deforestation in places where deforestation risk is low, precisely because there is not much deforestation to avoid. But these are the same places where it is politically feasible to establish strictly protected areas. By contrast, in places where deforestation risk is high, it is less feasible to establish strictly protected areas, and more feasible to establish mixed-use protected areas. Therefore, with the available evidence to date, it is not clear whether (i) mixed-use protected areas are more effective than strictly protected ones, or (ii) the only types of protected areas used in places where they can have a big effect are mixed-use protected areas.

Reboredo et al. (2018) assessed whether a project in Guatemala's Peten region (IDB Project #GU-L1014) to enhance tenure security of protected areas through delimitation, demarcation, and cadaster helped to reduce deforestation and forest degradation. Insecure land tenure has hampered effective land management in Guatemala for decades. Uncertainty about protected area boundaries, property boundaries within protected areas, and land use permitted within those areas contribute to deforestation and forest degradation. By clarifying park boundaries and people's land-use rights within the parks, and by giving more legitimacy to boundary enforcement, the hope was to reduce encroachment into protected areas, deforestation, and degradation. To determine the project's impacts on deforestation and forest degradation, the authors developed a novel dataset on deforestation and degradation generated by the Continuous Degradation Detection (CODED) algorithm. The results, estimated through fixed-effects models and matching analyses, indicate that the tenure intervention has done little so far to reduce deforestation and forest degradation overall. However, for protected areas where enforcement is stronger and where local communities are deemed to accrue more conservation benefits, results showed slight increases in avoided deforestation and forest degradation. It should be noted that the evaluation was carried out shortly after the project closed, so impacts might be understated.

The ultimate goal of the tenure clarification project in Guatemala was to deter encroachment and illegal land-use change inside protected areas, a common problem in the region. For example, Leisher et al. (2013) found that 45 percent of the protected areas in 19 Latin American countries experienced forest and land degradation between 2004 and 2009 and that this degradation affected more than 1 million hectares. However, even when only minimally funded or managed, protected areas might create sufficient tenure insecurity for those who encroach on their boundaries to deter investments, particularly long-term capital-intensive investment. The risk that investments on cleared land will be appropriated by state authorities can impinge on land-use change. Blackman and Villalobos (2019) used quasi-experimental methods to assess whether protected areas in Honduras – where deforestation rates both inside and outside protected areas are among the highest in the world, and where funding and management of protected areas are generally inadequate –

disproportionately discouraged conversion of forests to capital-intensive land use such as coffee and oil palm plantations. The authors found that to be the case: on average, protected areas reduced the probability that forestland was converted to capital-intensive land uses by more than two-thirds compared to traditional agriculture or pasture. The authors also found that protected areas that were located farther from cities, at higher elevation, flatter, and that had relatively sparse baseline tree cover were less effective in deterring conversion of forests to capital-intensive land use. Thus, greater monitoring and control efforts should be directed towards protected areas with these characteristics.

To sum up, protected areas remain the foundation of regional efforts to stem tropical deforestation. The quickly growing body of evidence suggests that, even after controlling for nonrandom siting, protected areas are effective in reducing deforestation, although substantially less effective than indicated by a simple inside-outside comparison. However, it should be noted that protected areas without some funding and management have no discernible effect.

Protected areas that allow some sustainable extractive activities are more effective in stemming deforestation. This might be due at least in part to the siting of these types of protected areas vis-à-vis strict-protection protected areas. Even when protected areas are poorly managed, their status might create enough risk of appropriation by administrators for encroachers to limit capital-intensive plantation investments, such as palm or coffee.

Finally, in Guatemala, efforts to clarify protected area boundaries and tenure in and by themselves seem to have negligible short-term effects on deforestation and degradation. These efforts might prove more effective in protected areas with some enforcement and where local communities are deemed to accrue more conservation benefits.

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Close to 35 percent of all forests on the planet are in Latin America and the Caribbean.

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Decentralized Approaches

Cognizant of the political costs, shortages of funding, and lack of institutional support that affect the creation and efficacy of protected areas, developing countries are increasingly decentralizing forest governance by granting indigenous communities formal legal title to land. Almost one-third of forests in the developing world are now managed by local communities, more than twice the share of forests currently located in protected areas. However, little is known about the effects of titling on forest clearing and disturbance, both of which remain urgent problems. Rigorous analyses of titling efforts are rare, and related theoretical and empirical research suggests that they could either stem or spur forest damage (Liscow 2013). Blackman et al. (2017) used fixed effects models to analyze the effect of titling campaigns in the Peruvian Amazon, where more than 1,200 indigenous communities covering about 11 million hectares have been titled since the mid-1970s. The authors used community-level longitudinal data derived from high-resolution satellite images to estimate the effect of titling between 2002 and 2005 on contemporaneous forest clearing and disturbance. Results from their study showed that titling reduced deforestation by more than three-quarters and forest degradation by roughly two-thirds in a two-year window spanning the year the title was awarded and the year afterward. These results suggest that awarding formal land titles to local communities can advance forest conservation.

Similar results were found in a study by Blackman and Veit (2018) that looked at the role titled indigenous communities play in reducing carbon emissions in several countries in South America. The authors used propensity score matching and regression models to analyze the effects of indigenous community management on deforestation and forest carbon emissions in the Amazon regions of Bolivia, Brazil, Ecuador, and Colombia between 2001 and 2013 They found that such management reduced both deforestation and forest carbon emissions in Bolivia, Brazil, and Colombia, but found no statistically significant effect for Ecuador.

These findings suggest that decentralized approaches, including granting titles or transferring the management of forests to indigenous communities, can help combat deforestation, degradation, and climate change. However, the effect of decentralized forest management in general, and titling local communities in particular, depends on local conditions.

Market-based and Regulatory Approaches

In principle, market-based approaches, such as forest certification, can generate nonregulatory incentives for sustainable forest management, thereby sidestepping the problems of weak institutions and limited political will that often undermine conventional environmental policy initiatives in developing countries (Blackman, Goff, and Rivera 2018; Cashore et al. 2006). According to advocates, the principal nonregulatory motivations are economic. Certification allows consumers and creditors to select "green" producers and boycott others. That selection, in turn, can lead to a price premium and/or improved access to output and credit markets.

Sustainable forest certification involves working with one of the major worldwide certification groups to develop management plans for forests that reduce the impact of harvesting on ecosystems. These initiatives are largely consumer-driven and voluntary. According to the Food and Agriculture Organization (FAO), such initiatives have expanded globally to over 415 million hectares. Within Latin America, the FAO (2018) reports that there are 15 million hectares under sustainable forest management. Participants generally find two main benefits of certification: market access and price premiums. The evidence suggests that market access is the most critical benefit. Empirical evidence from markets shows that the actual price premium is nil or small, in the 1 to 4 percent range (Yamamoto, Takeuchi, and Shinkuma 2014)

Forest certification has proliferated rapidly in developing countries, yet little is known about whether and under what conditions it affects deforestation. Blackman, Goff, and Rivera (2018) used rich forest management unit-level panel data – which included information on deforestation, certification, regulatory permits, and geophysical and socioeconomic land characteristics – along with matched difference-in-differences models to identify the effect of Forest Stewardship Council (FSC) certification on deforestation in Mexico, the country with the third-highest number of FSC certifications in the developing world. The results of the analysis showed no evidence that FSC certification affected deforestation. These findings are in line with several studies that were also unable to discern effects of certification on environmental outcomes (Norden, Coria, and Villalobos 2015; Panlasigui et al. 2015; Barbosa de Lima et al. 2009).

Regulated timber extraction is also touted as an effective approach to discourage illegal logging and land-use change, which are major drivers of forest loss. However, rigorous evidence testing the effect of regulated timber extraction on forest loss is quite limited. Blackman and Villalobos (2021) used remotely sensed forest-loss panel data, detailed information on more than 650 communal forest management units awarded timber extraction permits, and matched difference-in-differences models to measure the net effect of permits issued after 2001 on forest loss in Mexico between 2001 and 2012. Their findings do not support the assertion that, in general, regulated timber extraction stems forest loss. However, they found that permits exacerbate forest loss in certain subgroups, specifically, forest management units with weak governance and where returns to agriculture and pasture are relatively high.

Although the body of evidence is still relatively small, there appears to be little effect of certification and regulatory extraction schemes on deforestation, despite potential benefits associated with market access and small price premiums. However, the effectiveness of these forest conservation policies is highly context-dependent.

Compensatory schemes, such as payments for environmental services, have also been applied by policymakers in the region. Perhaps the most well-known and most studied scheme is Costa Rica's Payments for Economic Services (PES) program. Overall, the evidence from available evaluations of the PES program indicates that effects on deforestation are small. Impact evaluations on the early years of the program found that 83 to 99 percent of the area covered by the program would not have been deforested in the absence of the PES program, suggesting that the program had low additionality (Arriagada et al. 2010; Pfaff, Robaldino, and Sanchez-Azofeifa 2008; Robalino et al. 2008).

Jurisdictional results-based payments are of growing interest in the region. The most prominent example for tropical forests is the Reducing Emissions from Deforestation and Forest Degradation (REDD+) initiative, with the "+" referring to forest carbon enhancement. The programs and projects under this initiative vary widely in terms of complexity and scale. They include Norway's performance-based commitment to the Brazilian Amazon Fund and to Guyana; the REDD for Early Movers programs of Germany and the United Kingdom; and the Green Climate Fund's results-based-payments. These agreements tie the disbursement of funds to low or declining emissions from deforestation across entire areas such as states and nations. The national coverage of these programs complicates the identification of a credible counterfactual path needed for robust impact assessment.

IDEAS FOR FUTURE WORK

The effectiveness of forest conservation policies is context-dependent, thus it is important to foster the evaluation of policies in different countries and contexts. Also, evaluation of conservation policies should attempt to shed light on the mechanisms that drive forest outcomes, including the use of administrative data or purpose-specific surveys. The unintended or indirect impacts on deforestation of infrastructure projects, or even of poverty alleviation programs (as evaluated by Alix-Garcia et al., 2010, for Mexico's conditional cash transfer program), are another key area for future work. Finally, understanding which forest conservation policy can yield the most cost-effective outcome by assessing across policies can provide policymakers strapped for resources with valuable information, particularly in the context of international REDD agreements. Sims and Alix-Garcia (2017) carried out this type of analysis in comparing protected parks in Mexico to a payment for ecosystem services scheme.

What Works to Improve Lives?

What Works to PROMOTE GROWTH WITH SUSTAINABILITY

Two defining challenges facing Latin America and the Caribbean are to promote growth and to reverse, or at the very least not exacerbate, environmental degradation. Understanding how progress on one of these challenges affects the other is key to identify measures that can lead to win-win outcomes.

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Two defining challenges facing Latin America and the Caribbean are to promote growth and to reverse, or at the very least not exacerbate, environmental degradation. Understanding how progress on one of these challenges affects the other is key to identify measures that can lead to win-win outcomes. Yet despite the importance of recognizing this interplay, little is known about either the environmental impact of actions designed to promote growth or the growth impact of actions designed to protect the environment. Policymakers would benefit from more reliable evidence about pathways to meet the simultaneous challenges of promoting growth and reversing environmental change. This section presents two impact evaluations that aimed to assess effective means to meet the twin challenges of fostering growth and reversing or not exacerbating environmental degradation.

EVIDENCE FROM IMPACT EVALUATIONS SUPPORTED BY THE IDB GROUP

Impact of Shoreline Stabilization on Economic Growth

The plight of small island developing states in the face of climate change is particularly serious, as there is a crucial interdependence between an island's local environment and natural resources and sustainable growth of the economy. In this context, sustainability implies that natural resources that are the cornerstone of economic development be managed wisely and protected from overuse and degradation (Briassoulis 2002). Importantly, in most small island countries, a large share of economic activity focuses on tourism services. Among the Caribbean islands in 2011, tourism generated an average of 14.2 percent of GDP and employed 2.2 million people – which represents 1 in every 8 jobs (Mahon, Becken, and Renni. 2013). Given that tourism in this context represents a narrow economic base that strongly relies on environmental features, the economic vulnerability of many small island developing states to ecological fragility and climate change has received increasing attention from local agents and governments, as well as the international community.

Beginning with the United Nations Conference on Environment and Development in the early 1990s, the environmental effects of climate change, particularly the rise of sea levels, were identified as a major environmental challenge to the sustainable development of small island developing states (Wong et al. 2014). Due to the low altitudes above sea level of these states, the steady rise of sea levels due to climate change and excessive coastal development are resulting in continuous coastal degradation and beach reduction (Ghina 2003). Currently, up to 70 percent of all beaches worldwide are experiencing some erosion, and this is expected to further increase with the global rise of sea levels (Johnston and Ellison 2014). This projected loss of beaches may result in severe impacts on the tourism industry and the economies that depend on it. In many small island countries whose local businesses, employment, and real estate markets rely crucially on tourist demand, this would prove detrimental to economic growth.

Recognizing the economic importance of maintaining shorelines and beaches in order to protect the livelihoods of local inhabitants, small island developing states and other countries facing coastal degradation have taken measures to protect and rehabilitate shorelines. Barbados has been a regional leader in coastal zone management over the past 25 years. Barbados implemented the Coastal Infrastructure Program (CIP) (IDB Project #BA0019) with support from the IDB between 2002 and 2009 to reverse coastal erosion of targeted beaches along the touristic west and south coasts. Specifically, shoreline stabilization works focused on coastal infrastructure to create and enhance the amenity value of beaches for local and tourist use and to protect three popular beaches on the southern and western coasts of Barbados from erosion.

Corral and Schling (2017) assessed the ex-post economic growth impact of shoreline stabilization policy in the Barbadian context by exploring whether stabilization and beach amenity enhancement investments at

Rockley Beach had beneficial effects on medium-term economic growth. Under the hypothesis that shoreline stabilization can enhance overall access to and the quality of public beaches on Barbados' popular south and west coast, the CIP was expected to support local economic growth in the country. Specifically, there would be several distinct benefits and beneficiaries of program efforts. First, tourists would be more likely to return to the island if the quality of beaches remained high (Bell and Leeworthy 1990; Kragt, Roebeling, and Rujis 2009). Second, landowners would benefit from higher property values due to the improvement of beach and shoreline amenities as well as better protection from erosion and storm damage (Brown and Pollakowski 1977; Cordes and Yezer 1998; Bin et al. 2008). Finally, if tourists and landowners were to find the area close to improved beaches more attractive, this would boost the local economy, as local businesses, including hotels and restaurants, would enjoy increased revenues. Residents would then also benefit from an increase in employment opportunities. As a result, one would expect an increase in local economic activity near the beach sites that received investments.

In order to assess the effect of the CIP on economic activity near Rockley Beach, Corral and Schling (2017) had to overcome three main challenges. First, economic activity had to be measured at a sufficiently small geographic level to capture the localized impact of the program. Second, an identification strategy for comparison beach sites needed to be proposed to address the nonrandom siting of the CIP investments at Rockley Beach in a way that was systematic and transparent. Lastly, given the limited number of treated units, a method was required that did not rely on large samples for credible estimates of counterfactual baselines.

Beach-level disaggregated data for Barbados with traditional measures of economic activity do not exist. To overcome this, Corral and Schling (2017) used remotely sensed nightlight density, or luminosity, since these data capture human economic activity carried out during nighttime at considerably low levels of spatial disaggregation (Henderson, Storeygard, and Weil 2012).

Given that the expected impacts from the CIP discussed above are linked to the location of the beaches where shoreline stabilization measures were implemented, the analysis used GIS mapping to create a multilayer visual map of the island. The map combined georeferenced panel data for luminosity with relevant beach characteristics, such as beach size and topography, as well as information on local real estate activity, infrastructure, and demographic data. The final dataset included this information for 23 beaches within a 40-kilometer stretch along the south and west coast of Barbados.

In order to identify the true causal impact of the CIP investments on local economic growth, the empirical approach needed to identify a valid comparison unit for Rockley Beach from the available pool of potential control beaches. The authors addressed this challenge by using the synthetic control method introduced by Abadie and Gardeazabal (2003), and touted by Athey and Imbens (2017, 9) as "arguably the most important innovation in the policy evaluation literature in the last 15 years." The method uses a weighted average of all potential control units (untreated beaches, in this case) to construct a synthetic control group that can mirror the trajectory of the aggregate outcome (growth) in the absence of treatment (CIP investments). Due to the relatively small number of possible control beaches in the donor pool, standard errors that rely on large-sample properties are not reliable. In their place, the authors employed a bootstrapping method to create confidence bounds around the estimated synthetic counterfactual that could help evaluate the significance of the treatment effect (Kirkpatrick and Bennear 2014; Sills et al. 2015).

The results of the analysis indicate that the CIP program had a positive impact on local economic growth, as measured by an average annual gap of 22.1 percent in luminosity, or approximately 11.7 percent in local GDP between Rockley Beach and its synthetic counterfactual.[4] Overall, these results suggest that shoreline stabilization and beach amenity enhancement measures have had a positive effect on local economic activity in Barbados. Shoreline stabilization works may therefore not only help preserve fragile ecological conditions, but also lead to sustainable growth in local economies.

4_The elasticity between luminosity and GDP is approximate and might be stable only under certain circumstances (Bickenbach et al. 2016).

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Sustainability implies that natural resources that are the cornerstone of economic development be managed wisely and protected from overuse and degradation.

Infrastructure Projects Leading to Sustainable Development

The economic impact of natural resource endowments has received widespread attention in the literature. Some studies highlight the positive effects of natural resource endowments (i.e., oil, gas, fisheries, mining, forestry) – for example, that backward linkages to local input markets and strengthened local institutions may benefit economic development (Collier and Hoeffler 2004; Aragón and Rud 2013; Lippert 2014; Corral, Henderson, and Miranda 2019). Other studies note the perils of a "resource curse" that associates resource wealth with a number of economic and political woes (Robinson, Torvik, and Verdier 2006; Dalgaard and Olsson 2008; van der Ploeg 2011). What has received significantly less attention, however, is the environmental consequences of the large infrastructure projects usually required to exploit natural resources. Research shows that infrastructure extension is among the leading global causes of deforestation (Barbier and Burgess 1996; Mayaux et al. 2013). Given that carbon emissions caused by forest clearing contribute approximately 17 percent of global CO2 emissions to the global total of greenhouse gases, the long-term consequences of climate change, in addition to the significant loss of biodiversity, are of major concern (van der Werf et al. 2009).

A well-rounded approach to assessing the sustainability of large hydrocarbon and other infrastructure projects should therefore consider both their economic and environmental impacts. Such evidence is mostly absent from the literature.

Corral, Schling, and Montilel (2018) studied the effects of the Camisea Gas Project, Peru's biggest energy project, on economic development and forest cover change in the department of Cusco. The Camisea fields are deep in one of the more pristine parts of the Peruvian jungle, and have proven reserves of 9 trillion cubic feet of natural gas. In 2000, Peru's government awarded licenses to develop the Camisea fields and to build and operate a 700-kilometer pipeline to the Peruvian coast (IDB 2002). Opponents at the time claimed that the project threatened isolated tribes of Amazon Indians, rare species, and the rainforest (The Economist 2003). This led the IDB, which provided a US$75 million loan (PE0222) for construction of the pipeline, to carry out detailed environmental and social impact studies and propose a series of design modifications and actions to mitigate the potential negative impacts. As a result, the extraction firm used "offshore" technology at Camisea: drilling sites were operated as if they were islands in the jungle (IDB 2003). Workers and supplies traveled to the site by helicopter, and no access roads were built. These efforts were meant to minimize risks of colonization from the highlands and illegal extraction activities in the pristine rainforest. In parallel, the IDB also provided a US$5 million institution-building loan (**IDB Project #PE0233**) to the government to help it police the Camisea project and support sustainable development planning in affected areas. This led to the creation of four new protected areas covering close to 1 million hectares (12.8 percent of the total territory of the Department of Cusco), the titling of 28 native communities, and the issuance of over 10,000 property titles (IDB 2008)[5]. Since the project's operational inception in 2004, the Department of Cusco has enjoyed significant windfalls, receiving approximately US$300 million annually in transfers from the central government earmarked for capital investments, including roads.[6]

To assess the economic and environmental impacts of the Camisea Gas Project at the department level, Corral, Schling, and Montiel (2018) used two sources of remote-sensing data. They relied on remotely sensed nightlight density, or luminosity, which is correlated with human economic activity during the night at considerably low levels of spatial disaggregation. The environmental effect of the program was measured in terms of deforestation rates, as captured by the Normalized Difference Vegetation Index processed from NASA's Land Long Term Data Record satellite imagery, which provides both sufficient spatial resolution to

5_ The effectiveness of these interventions on stemming deforestation was discussed in the previous section.

6_ The Canon Law of 2001 allocates royalties associated with the extraction of a number of different natural resources (e.g., gas, mining, oil, energy, fisheries, and forestry). "Canon" is a Spanish word commonly used in Peru to describe a rule by which a portion of natural resource revenues collected by the central government is allocated to subnational governments in locations where the resources are found. The Canon Law thus regulates the distribution of resources in favor of municipalities and regional governments where the resources are located. Thus, Cusco, as the region where the Camisea Gas Project's natural gas is located, receives revenues through the Canon Law.

measure deforestation at the departmental level as well as a continuous time series dating back more than 20 years. The final dataset included this information for a total of 25 departments for the period between 1992 and 2012.

Using these data and the synthetic control method, the authors created a valid comparison group that represented a weighted average of all Peruvian departments and mirrored the trajectory of luminosity and forest cover that would have occurred in the Department of Cusco in the absence of the project. The analysis provided a positive image of the medium-term effects of this large-scale infrastructure investment. The results indicated that the Camisea Gas Project had a positive impact on local economic growth as measured by an annual gap of 27.9 percent in luminosity, or approximately 7.5 percent in local GDP, between Cusco and its synthetic counterpart. This suggests that royalty payments that targeted the department's economic development may have helped Cusco avoid to a certain extent the trap of the natural resource curse. Results related to the environmental impact of the project were also encouraging. Despite the feared adverse effect on Cusco's pristine rainforest, the analysis did not detect significant negative effects, with the annual post-treatment gap between actual and synthetic Cusco remaining close to zero. This neutral result suggests that strict environmental and social safeguards may have played a significant role in preventing adverse ecological effects of the project on the surrounding area, and that encouraging economic growth without negative environmental consequences might be possible if a project is strictly monitored and regulated.

IDEAS FOR FUTURE WORK

Understanding which strategies are most effective to meet the simultaneous challenges of fostering growth and reversing or at the very least not exacerbating environmental degradation is of the utmost importance in the face of a changing climate. Yet too few evaluations focused on assessing growth measure environmental outcomes. Multilateral funders aim to both promote growth and mitigate environmental change, so in contexts where environmental issues are salient, such as in tropical forest areas, these funders should provide incentives for project evaluation teams to examine relevant environmental indicators. Ideally, such projects should also provide incentives to identify the mechanisms through which the intervention has an environmental impact.

What Works to Improve Lives?

What Works to ENHANCE THE CLIMATE RESILIENCE OF AGRICULTURAL PRODUCERS

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change released in 2014 found that climate change effects are already being felt on agriculture and food security.

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The Fifth Assessment Report of the Intergovernmental Panel on Climate Change released in 2014 found that climate change effects are already being felt on agriculture and food security, and that the negative impacts are most likely in tropical zones where most of the world's poor and agriculturally dependent populations are located (IPCC 2014). More recent assessment reports from the IPCC have stated with increasing confidence that the stability of food supply will decrease as the magnitude and frequency of extreme weather events that disrupt food chains increase (IPCC 2019). Climate change is expected to have a range of consequences on agriculture, chief among them yield declines and higher yield variability (McCarthy 2014). The impacts of climate change, and the effectiveness of adaptation and mitigation efforts in agriculture, are critical to the future of large segments of the population in Latin America and the Caribbean. Developing technologies and policy measures to reduce vulnerability and increase the capacity of producers (and particularly smallholders) to effectively adapt is a major challenge. At the same time, given agriculture's role as a major source of greenhouse gas emissions, it becomes necessary to seek and incentivize low-emission growth paths (IDB 2019). The dual challenge for policymakers is thus to ensure that agriculture contributes to addressing both food security and climate change.

EVIDENCE FROM IMPACT EVALUATIONS SUPPORTED BY THE IDB GROUP

Irrigation to Promote Climate Resilience

Access to water and irrigation is considered a major determinant of land productivity and is becoming crucially important in the presence of climate risk and irregular rainfall (IDB 2019). Irrigation can play a key role in reducing the risk of crop failure and allowing farmers to cultivate year-round without having to rely on rain patterns. Recent estimates show that Latin America and the Caribbean has 16 percent of the world's agricultural land but only 6 percent of the irrigated land (Meier, Zabel, and Mauser 2018).

Given the key role of irrigation in reducing vulnerability to climate extremes and fostering the stability of agricultural productivity, investment in irrigation systems is of keen interest (IDB 2019). However, irrigation systems require both a large initial investment as well as continued maintenance and occasional rehabilitation and improvements to keep operating efficiently. Most evaluations in the literature study only the effect of irrigation itself (i.e., comparing a situation with irrigation with a situation without irrigation),[7] while little is known about the benefits of irrigation rehabilitation works, which might require a substantial investment but potentially have a lower return.

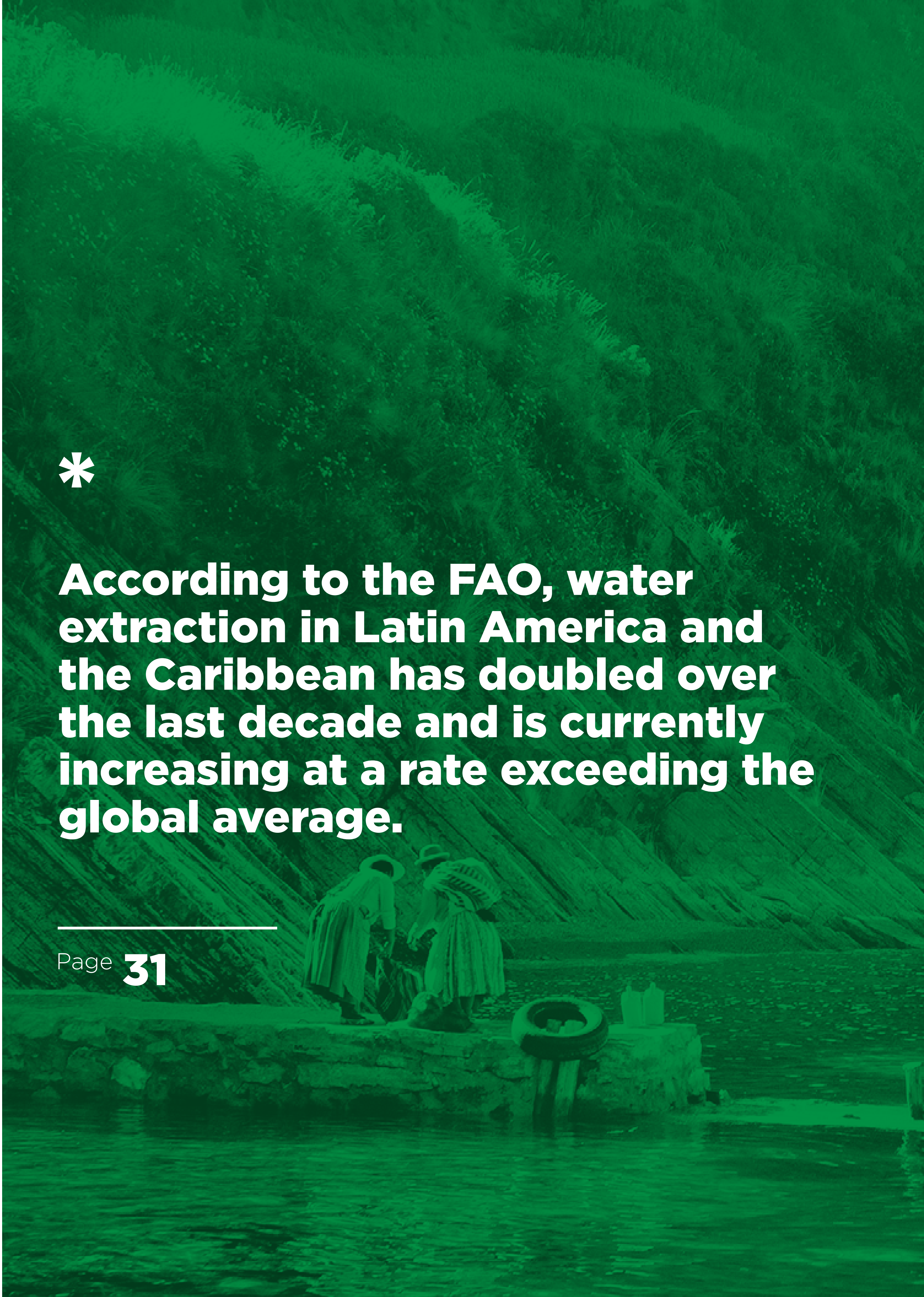
According to the FAO, water extraction in Latin America and the Caribbean has doubled over the last decade and is currently increasing at a rate exceeding the global average. Consequently, per capita measures of water availability and overall water quality are falling throughout the region (IPBES 2018). At the same time, projections suggest that by 2050 regional demand for water will increase by 55 percent, and that demand for water for agricultural purposes will rise by 59 percent to 127 percent (de Fraiture and Wichelns 2010). As a result, 40 percent of the Latin American and Caribbean population will live in watersheds under severe water stress (OECD 2012), and conflicts between different sectors stemming from water use will be exacerbated (Mahlknect and Pastén Zapata 2013). A response to these water management challenges needs to be taken at the watershed level, so irrigation programs are increasingly advocating for a watershed approach.

Using a difference-in-differences methodology, Corral and Zane (2020) evaluate the extent to which irrigation improvement works (**IDB Project #EC-L1121**) benefited indigenous communities in the highlands of Chimborazo Province, Ecuador that are largely dependent on agriculture for their livelihoods. The findings suggest that the program increased

7_ A large body of literature, summarized by Giordano, Namara, and Bassini (2019), found that irrigation is clearly associated with increased agricultural output, both directly and by increasing the productivity or agricultural inputs (improved seeds, fertilizers, etc.).

access to irrigation, investment in productivity-enhancing agricultural inputs, and cultivation of crops that required irrigation. The project increased the adoption of aspersion sprinkles, a more efficient irrigation technology, by 18 percentage points. Importantly, the authors found that the program significantly increased food security by reducing the number and frequency of "food insecurity" events. The authors found insignificant effects on agricultural productivity, sales, and household income. However, they posit that the results of the study may have been underestimating the overall impact of the program because, at the time of data collection, beneficiaries were still receiving training on good agricultural practices that were expected to further increase their productivity. Similarly, some of the irrigation works were completed in the few months prior to data collection, and some benefits therefore might not have been captured in the analysis. Robustness checks confirmed the validity of the main results.

Similar results were reported by Salazar and Lopez (2017) for community-based irrigation systems implemented under the National Irrigation Program with a Watershed Approach (*Programa Nacional de Riego con Enfoque en Cuenca* - PRONAREC) in Bolivia (IDB Project #BO-L1084). The authors used a cross-sectional dataset collected from a sample of 1,682 farmers (583 beneficiaries and 1,099 controls) for the 2014–2015 agricultural cycle, and used propensity score matching to estimate the program's effects. The results showed that participation in the program improved the value of agricultural production, and that, like the result for Chimborazo discussed above, the program triggered technological change that led to investments in complementary inputs, such as improved seeds. The authors also reported evidence that PRONAREC strengthened farmers' access to markets and increased household incomes. However, similar to the finding in Chimborazo, no effect on agricultural productivity was found, leaving the authors to conclude that the program beneficiaries were in the upward sloping curve of the learning process. The authors also found evidence related to the management of the systems showing that the program promoted the formalization of water user associations and improved the organization and management of irrigation systems.



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According to the FAO, water extraction in Latin America and the Caribbean has doubled over the last decade and is currently increasing at a rate exceeding the global average.

Smart Subsidies to Promote Technology Adoption

The promotion of technology adoption through the provision of incentives by way of smart subsidies and technical assistance has gained wide appeal in recent years. The subsidies are deemed “smart” because, unlike regular subsidies that seek to keep the price of a good or service (such as inputs or machinery) artificially low, smart subsidies do not distort prices and therefore do not distort investment decisions in markets. Such instruments tend to be based on the delivery of vouchers or coupons that beneficiaries can use in the marketplace to purchase inputs, machinery, technical assistance, and insurance (IDB 2019). Thus, for producers who face multiple development restrictions – such as liquidity constraints, insufficient credit access, limited access to markets and information, and high transaction costs, among others (Feder, Just, and Zilberman 1985) – smart subsidies can serve as a mechanism to incentivize technological adoption. Smart subsidy schemes might also prove to be an effective mechanism to allow farmers to adopt climate-resilient practices and technologies.

For instance, using an instrumental variable model, Salazar et al. (2015) assessed the impact of the Creation of Rural Agri-food Initiatives (*Creación de Iniciativas Agroalimentarias Rurales* - CRIAR) program in Bolivia (**IDB Project #BO-L1040**). The program was implemented in rural areas to increase smallholders’ agricultural income and food security through productivity improvements fostered by technological adoption. It provided non-reimbursable vouchers to finance 90 percent of the purchase of a technology chosen by the farmer from a menu. Modern irrigation equipment that would allow for more efficient water use, a key adaptation to irregular precipitation, was among the technologies most highly demanded by beneficiary farmers. The authors found that the program increased participants’ annual value of production per hectare by 92 percent, the value of their production sold by 360 percent, net annual agricultural household income by 36 percent, and per capita household income by 19 percent. It also found that CRIAR participation increased the probability of a household being food secure by 32 percent. Reduction of vulnerability to food insecurity was entirely driven by an increase in income rather than by higher levels of home consumption. For the case of

Chimborazo, Ecuador, discussed above, the reduction in food insecurity was most likely due to increased levels of home consumption.

Aramburu et. al (2019) used an experimental approach to estimate the impact of an agricultural technology adoption program on agricultural production and income in the Dominican Republic. The program (IDB Project #DR-L1031) aimed to increase agricultural productivity and incomes among smallholder farmers by encouraging technological adoption. It provided nonreimbursable vouchers to finance a percentage (between 33 and 59 percent) of the total cost of a technology chosen by the farmer from a fixed menu of agricultural technologies. The authors focused on evaluating the impact of pasture and grassland conservation and rehabilitation and irrigation technologies, which together comprised over 80 percent of the program's total demand. The maximum amount financed by the program was US$3,650 for pasture and grassland conservation and rehabilitation, and US$3,500 for irrigation. Estimates indicate the program had a significant positive effect on adoption. Farmers who enrolled for the improved pastures and irrigation technologies were, respectively, 68 and 62 percentage points more likely to use the technology. The results for the improved pasture technology show that participating farmers were better equipped to benefit from the advantages of rotational grazing.[8] The authors noted that the program not only had positive effects on the number and size of paddocks but also fostered a switch from natural to improved pasture.

Nonetheless, even though significant effects on agricultural income were reported, Aramburu et. al (2019) found no impact on the production of meat or milk. The adoption of irrigation technologies (drip, sprinkler, and micro-sprinkler) had unexpected effects on production. Beneficiary farmers experienced significantly lower agricultural expenditures (i.e., labor) and a lower value of production, and were less likely to harvest and sell crops from the 2014 agricultural cycle. When analyzing the impact of the intervention based on the number of months of exposure to irrigation, the authors found evidence of changes to farmers' crop portfolios – switching from the production of temporary to permanent crops, such

8_ Pasture rotation systems lower soil erosion and promote the accumulation of soil organic matter (Garcia-Préchac et al. 2004) as fruit trees. The authors concluded that since program implementation began in December 2012, it is plausible that the permanent crops had not yet reached the optimum stage of harvesting, which might explain the negative effects on output and income.

Agroforestry can play a significant role in adaptation to climate change: deep roots enable trees to access more water, increase soil porosity, reduce run-off, increase soil cover (which increases infiltration and thus water-use efficiency), have higher evapotranspiration rates (and thus help to aerate the soil), contribute organic matter to the soil via leaf litter, lower the temperature under the canopy (thus creating a buffer against temperature increases), and produce higher-value products that can strengthen farmers' income levels (McCarthy 2014). Macours et al. (2018) used quasi-experimental methods to evaluate the effectiveness of smart subsidies on the adoption of agroforestry by small farmers in Haiti (IDB Project #HA-L1059). Agroforestry incentives made up the bulk of the program's budget. The study found that agroforestry subsidies were effective in increasing the total value of production of crops and the agricultural income derived from the sales of these crops. The authors concluded that the findings provide a strong justification for further iterations of similar programs geared towards agroforestry.

In the context of the Environmental Program for the Management of Disaster Risks and Climate Change (*Programa Ambiental de Gestión de Riesgos de Desastres y Cambio Climático* - PAGRIC) in Nicaragua (IDB Project #NI-L1048), smart subsidies were used with the explicit objective of reducing vulnerability and enhancing the resilience of farmers. Using difference-in-differences methods, González and Le Pommellec (2019) assessed the effects of the smart subsidies to promote the adoption of environmental restoration systems. The program promoted the adoption of such systems by eligible farmers through the *Bono Ambiental* (Environmental Bond), which had an approximate average value of US$1,230. Seventy percent of the bond was transferred for the establishment of the chosen environmental restoration system, while the remaining 30 percent was used for technical assistance to assure proper implementation of the chosen system. The program promoted seven environmental restoration systems, ranging from eco-coffee to forest management. The authors found that program participants adopted improved productive practices and experienced an average increase in the value of production per hectare of close to US$200 per year. Thanks to the adoption of the environmental restoration systems, participating farmers had an increase in tree cover, eco-forest management plants, and the volume of water captured through increased use of water harvesters. The authors concluded that the results were especially reassuring, given that the project area suffered from a prolonged drought during project implementation, suggesting that the adoption of the environmental restoration systems strengthened participating farmers' resilience to drought.

Using quasi-experimental methods, Mullally and Maffioli (2015) assessed the impact of smart subsidies and extension services on the adoption of intensive management practices (IDB Project #UR0141), including improved pasture management, by small and medium-sized cattle producers in Uruguay. The authors found that the program had a large impact on net sales and production of calves, but that program effects on production and sales translated into modest net economic impacts overall. The authors examined the mechanisms that may have driven impacts by analyzing their variation by producer size and concluded that program impacts were likely caused by improved management practices rather than by alleviating liquidity constraints on producers.

Income and consumption shocks are expected to increase with climate change. Diversification can be thought of as an ex-ante strategy for adapting to climate variability (Cooper et al. 2008). In a survey of 2,000 farmers in seven South American countries, Seo (2010) found that 42 percent of them operated mixed systems of both livestock and crops to mitigate risks. Using difference-in-difference methods combined with propensity score matching, Salazar, Fahsbender, and Kim (2018) evaluated the impact of a livestock transfer program in Nicaragua (IDB Project #NI-L1020). They found that the program increased on-farm income diversification by increasing the share of agricultural production obtained from livestock. In principle, these households may be less vulnerable to income and consumption shocks, as livestock production is less risky and more stable than crop production because it is less dependent on weather patterns. The program targeted smallholder female farmers with high levels of food insecurity in Nicaragua. The authors reported that program participation improved households' food security through higher income from livestock sales and home consumption from own production (i.e., access and availability). In addition, some evidence was found that food use was improved by greater protein intake. Moreover, the evaluation found a positive impact on women's empowerment and gender parity within the household, mainly driven by a higher level of associativity.

Finally, climate change is expected to facilitate the propagation of pests and diseases that affect plant and animal species used in agricultural production and thus affect yields (IDB 2019). Among practices recognized to decrease yield variability in the face of climate change is integrated pest management (McCarthy 2014). Salazar et al. (2016) used a geographical regression discontinuity approach to evaluate the short-term impact of a fruit fly eradication program (IDB Project #PE-L1023) in the coastal areas of Peru. The results show that farmers in treated areas improved their pest knowledge and were more likely to implement best practices for plague prevention and control. Beneficiary farmers also had increased fruit crop productivity and sales.

IDEAS FOR FUTURE WORK

In what has broadly come to be known as "climate-smart agriculture," irrigation, agroforestry, and soil and water conservation practices have been endorsed to reduce vulnerability to climatic variations (McCarthy 2014). Irrigation reduces farmers' reliance on natural rainfall patterns, which in general reduces vulnerability to climatic variation. Agroforestry is a broad term that encompasses a number of different practices but essentially amounts to incorporating trees into agricultural systems to increase sustainability. In terms of greenhouse gas emissions, agroforestry is generally recognized as the climate-smart agricultural practice with the greatest potential for contributing to climate change mitigation via carbon sequestration in tree species and in the soil (Verchot et al. 2007). Soil conservation practices aim to reduce run-off and soil erosion, which can help increase yields. Effective pest management will become increasingly critical on a warming planet. As the review of impact evaluations presented in this section shows, adoption of these climate-smart practices by farmers can lead to increases in the productivity, income, and food security of small-scale producers, and can be effectively promoted through the use of smart subsidies, technical assistance, and training.

Future work on technology adoption should aim to identify the mechanisms that best facilitate adoption and impact on productivity. Specifically, it should assess the role of easing liquidity constraints and technical assistance, as done in the study by Mullally and Maffioli (2015). Future work should also aim to identify more efficient ways to target potential recipients and establish the amount of the smart subsidy to be granted. For example, more efficient targeting of public programs when the cost or benefit to potential recipients is private information might be achieved through an auction scheme (Jack 2013). This mechanism might also allow for more efficient sizing of the subsidy and, therefore, an increase in the number of beneficiaries (van Soest et al. 2018). Finally, most of the reviewed studies discussed estimate short-term impacts, usually coinciding with the end of the project. In some instances, the timing of these evaluations does not allow for a full expression of impacts, or for the assessment of the mid- to longer-term sustainability of results. Thus, the research agenda should consider doing follow-up evaluations that allow for this, or plan the endline of the evaluation taking into account the time needed for sufficient maturation of key impacts.

CONCLUSION

This monograph has summarized the evidence from impact evaluations carried out by the IDB Group over the last decade on policies to **(1)** stem deforestation, **(2)** promote growth with sustainability, and **(3)** enhance the climate resilience of affected populations. The various evaluations discussed assess different forest conservation policies, spanning from protected areas to the titling of native communities. The evidence reviewed suggests that not all protected areas are created equally, and that location and restriction on use matter. Decentralized approaches, including granting titles or transferring management of forests to indigenous communities, can help combat deforestation, degradation, and climate change.

In the face of a changing climate, understanding which strategies are most effective to meet the simultaneous challenges of fostering growth and reversing or at the very least not exacerbating environmental degradation is of the utmost importance. This monograph has discussed evidence about pathways to promote growth and reverse environmental change in the context of two impact evaluations of projects: one for coastal rehabilitation in Barbados and another for resource extraction in Peru. The emphasis has been on demonstrating methods and data that allow for the dual assessment of growth and environment.

Finally, this monograph has discussed several evaluations of interventions that can strengthen the resilience of small farmers in the face of a changing climate. The key finding is that the use of smart subsidies can be an effective tool to promote technology adoption.

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