USAID
FROM THE AMERICAN PEOPLE

FINAL REPORT:

Climate Economic Analysis for Development, Investment, and Resilience Activity

This report was made possible by the support of the American People through the United States Agency for International Development (USAID). It was prepared by Crown Agents USA and Abt Associates.

Recommended Citation: Torres, Pablo; Eric Hyman; and Leah Quin. 2021. *Final Report: Climate Economic Analysis for Development, Investment, and Resilience (CEADIR) Activity*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Photo source: Kathryn L. Hoeflich. Unless otherwise specified, photos on this report are courtesy of Pixabay.

Crown Agents USA Ltd. | 1129 20th Street NW | Suite 500
Washington, DC 20036 | T. (202) 822-8052 | www.crownagentsusa.com

FINAL REPORT: CLIMATE ECONOMIC ANALYSIS FOR DEVELOPMENT, INVESTMENT, AND RESILIENCE (CEADIR) ACTIVITY

Contract No.: AID-OAA-I-12-00038
Task Order AID-OAA-TO-14-00007

Economic Policy Office and Global Climate Change Office
Bureau for Economic Growth, Education and Environment
U.S. Agency for International Development
1300 Pennsylvania Avenue NW
Washington, DC 20523

Prepared by

Pablo Torres (Crown Agents USA);
Eric Hyman (USAID);
and Leah Quin (Abt Associates),

July 13, 2021

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

ACEF	Asia Clean Energy Forum
AFOLU	Agriculture, forestry, and other land uses
AILEG	Analysis for Investments in Low-Emissions Growth (USAID-funded activity)
BESS	Battery energy storage systems
BNCCC	Bureau National de Coordination des Changements Climatiques
BTG	Beyond the Grid (Power Africa)
CBA	Cost-benefit analysis
CCAP	Coastal City Adaptation Project (USAID-funded activity in Mozambique)
CE	Clean energy (renewable energy and energy efficiency)
CEA	Cost-effectiveness analysis
CEADIR	Climate Economic Analysis for Development, Investment, and Resilience
CEIA	Clean Energy Investment Accelerator
CELT	Clean Energy Lending Toolkit
CIAT	International Center for Tropical Agriculture
CSA	Climate-smart agriculture
CSR	Corporote social responsibility
DCA	Development Credit Authority (USAID program, now part of the DFC)
DER	Distributed energy resources
DFC	U.S. International Development Finance Corporation
DRC	Democratic Republic of the Congo
DRR	Disaster risk reduction
ECAM	USAID Regional Mission for El Salvador, Central America, and Mexico
EE	Energy efficiency
E3	Economic Growth, Education, and Environment Bureau (USAID)
EP	Economic Policy Office (E3)
FAO	Food and Agriculture Organization of the United Nations
FI	Financial institution
FiTs	Feed-in-tariffs
GCC	Global Climate Change Office (E3)
GHG	Greenhouse gas
GoM	Government of Mexico
GoS	Government of Senegal
GVMC	Greater Visakhapatnam Municipal Corporation (India)
Ha	Hectare
IPCC	Intergovernmental Panel on Climate Change

ITA	International Trade Administration (United States)
kW	Kilowatt
kWh	Kilowatt-hour
LEDS	Low emission development strategies
MW	Megawatt
NAP	National adaptation plans
NAPGN	National Adaptation Plan Global Network
NCA	National Climate Assessment (United States)
NDCs	Nationally Determined Contributions
NGO	Nongovernmental organization
NPV	Net present value
NREL	National Renewable Energy Laboratory (United States)
OPIC	Overseas Private Investment Corporation (United States, now part of the DFC)
PATRP	Power Africa Transactions and Reforms Program
PayGo	Pay-as-you-go
PFAN	Private Financing Advisory Network
PPP	Public-private partnerships
PV	Photovoltaic
RE	Renewable energy
RFP	Request for proposals
SEEK	Sharing Environment and Energy Knowledge (USAID-funded Activity)
SL	Sustainable landscapes
TA	Technical assistance
TERI	The Energy and Resources Institute (India)
TNRE	Technology neutral renewable energy (auctions)
TOT	Training of trainers
UNDP	United Nations Development Program
USAID	United States Agency for International Development
USAID/WARM	USAID West Africa Regional Mission
USG	United States Government
USTDA	U.S. Trade and Development Agency
VMC	Vijayawada Municipal Corporation (India)
WCF	World Cocoa Foundation

ACKNOWLEDGEMENTS

CEADIR received core funding from the USAID Global Climate Change Office (GCC) in the Economic Growth, Education, and Environment (E3) Bureau, with buy-ins from USAID country and regional missions and Power Africa. The USAID Energy and Infrastructure Office (E&I) also provided some core fund support. CEADIR was managed by the E3 Economic Policy (EP) and GCC Offices. CEADIR was led by Dr. Marcia Trump (05/14/14 – 05/15/19) and Pablo Torres (05/15/19 – 3/29/2021). CEADIR would like to dedicate this report to the late Dr. Marcia Trump for her leadership, dedication, and kindness.

CEADIR's core team members and lead field consultants included Gwen Andersen, José Córdova, Patrick Doyle, Santiago Enriquez, Antoine Faye, Edward Hoyt, Walter Jokisch, Martin Lyambai, Luiz Maurer, Javier Molina, Crystal Mugimba, Khadija Mussa, Raouf Saidi, Nadia Scharen-Guivel, and Abdoulaye Seck (Clean Energy); Benjamin Brown, Dr. Rodolfo Camacho, Michelle Manion, Stanley Ng'ang'a, Dr. Gordon Smith, and Lawrence Szott, (Sustainable Landscapes); Glen Anderson, Lorine Giangola, Charlotte Mack-Heller, Joel Smith, and Jason Vogel (Climate Adaptation); Sandra Khananusit, Michele Laird, Alan Miller, Mikell O'Mealy, Tanat Sangarasri, and Natcha Tulyasuwan (Climate Financing and Private Investment); and David Cooley, Santiago Enriquez, Lindsay Foley, Benjamin Matek, Dr. Tulika Narayan, Suzanne Shaw, and Kait Siegel (Cost-Benefit Analysis and LEDS Modeling). Core communication staff included Leah Quin, Alexa Smith-Rommel, and Joan Steiger.

Initially, Dr. Yoon Lee (E3/EP) was the Contracting Officer's Representative (COR) and Dr. Eric Hyman (E3/EP) was the Alternate Contracting Officer's Representative (ACOR). Dr. Eric Hyman was the COR for most of the activity and Matthew Ognonowski (GCC) was the subsequent ACOR. The USAID/Washington Activity Managers varied over the course of the activity: Economic Analysis and Policy (Eric Hyman); Clean Energy (Zephyr Taylor [GCC], Matthew Ogonowski, and Eric Hyman); Sustainable Landscapes (Matthew Ogonowski and Eric Hyman); Climate Adaptation (Jonathan Cook [GCC] and Eric Hyman); and Financing (Matt Austin [E3/Private Capital and Microenterprise Office {PCM}] and Eric Hyman). CEADIR would like to thank the USAID Contract Officers: Michael Douglas, Robert Johnson, Ryland Marbray, Albert Rexhepi, Arthur Muchajer, Patrice Lee, Matthew Courtad, Ayla-Rebeka Brooks, and Shannon White-Benson.

CEADIR is grateful for the support of the GCC Office Directors and Deputy Office Directors during the activity -- Rolf Anderson, William Breed, Dr. Allen Eisendrath, Michelle Jennings, and Kathryn Stratos. Other current and former GCC staff who provided guidance included Collin Green and Jennifer Leisch (Clean Energy); Dr. Juliann Aukema, Dr. Geoffrey Blate, Dr. Cleo Chou, Katherine Faulhaber, Dr. Noel Gurwick, Dr. Lexine Hansen, Eric Haxthausen, Colin Holmes, Evan Notman, and Geeta Uhl (Sustainable Landscapes); Rebecca Chacko, Pete Epanchin, Jenny Frankel-Reed, John Furlow, Danielle Miley, and Rebecca Nicodemus (Climate Adaptation and Risk Management); and Andrea Welsh (Communications Officer).

CEADIR is grateful for the support of the EP Office Directors during the activity – Robyn Broughton, Dr. John Crihfield, Dr. Gary Linden, Melissa Rosser, and Robert Wuertz. Other EP managers who provided guidance and support included Dr. Juan Belt, Lawrence Daum, Alex Gainer, Sarah Lane, Nathan Martinez, Jerrod Mason, Lisa Ortiz, Ryder Rogers, Kristen Schubert, Caroline Smith, and Dr. William Ward. CEADIR would like to thank the GCC and EP Program Officers, Todd Harding and Erin Shutty, and the EP Communications Officers James Carey and Margot Kitonis.

Other current and former USAID/W staff who provided important technical input included: Raul Flores, Maria Hilda Rivera,and Ryan Tramonte (Power Africa); Felizia Bacall, Jason Fleming, J.P. Gibbons, and Stephen Matzie (E3 Development Credit Authority); Monica Bansal, Jeff Haeni,

Alexander Lane, Sarah Lawson, and Kristen Madler (E3 Energy and Infrastructure Office); Cynthia Gill, Alicia Grimes, Hadas Kushnir, Jenny Kane, Scott Lampman, Mary Rowen, and Olaf Zerblock (E3 Forests and Biodiversity); Stephen Brooks and Caleb Stevens (E3 Land Tenure and Resource Management); Lawrence Camp, Lalarukh Faiz, and Autumn Gorman (PCM); Jennifer Chow, Moffat Ngugi, Curt Reintsma, Mark Visocky, and Emily Weeks (Bureau for Food Security); Tegan Blaine, Julia Bradley-Cook, Roopa Karia, and Lucy Gibbon (Africa Bureau); Mary Melnyk, Jayne Somers, and Todd Johnson (Asia Bureau); Jamila Amodeo (Europe and Eurasia Bureau); and Eliza Cushion, Christine Pendzich, Jessica Rosen, and Benjamin Schapiro (Latin America/Caribbean Bureau).

CEADIR would like to thank the following current and former USAID country and regional mission staff: Christopher Abrams, Pearl Ackah, Kevin Adkin, Dubale Admasu, Brad Arsenault, Sithisakdi Apichatthanapath, Thomas Black, Matthew Burton, Robert Buzzard, Gina Cady, Mohamed Cama, Manuel Cerrato, Richard Chen, Jeff deGraffenried, Theodora Dell, Balaka Dey, Peter du Pont, Dan Evans, Alvaro Gaillour, Conrado Garcia, Farhad Ghaussy, Sharon Gulick, Shawna Hirsch, Angela Hogg, Madalitso Kaferawanthu, Christopher La Fargue, Oumou Ly, David Mann, Don McCubbin, Robert Matengula, Azharul Mazumder, Melody McNeil, Aurelia Micko, Victor Mombu, Emmanuel Moteng, David Mpundu, Eric Naranjo, Claire Nelson, Mark Newton, Adam Norikane, Kofi Owusu-Boakye, Suphasuk Pradubsuk, Serge Ramanantsoa, Nathan Sage, Fenton Sands, Agathe Sector, Sothira Seng, Paul Seong, Jason Seuc, Shahadat Shakil, Jessie Snaza, Bruce Sosola, Danielle Tedesco; Catherine Tembo, Dan Whyner, Karl Wurster, and Esther Zeledon.

Other U.S. Government agency staff who made important contributions to CEADIR's work included Paul Bergman (U.S. International Trade Administration [ITA]), Danielle Caltabianon (U.S. Commercial Service), Kristin Clary (National Renewable Energy Laboratory [NREL]), J.A. Colantonia (NREL), Victoria Gunderson (ITA), Craig O'Connor (U.S. EXIM Bank), Adam O'Malley (ITA), David Riposo (U.S. Trade and Development Agency [USTDA]), Robert Sandoli (U.S. Department of Energy), Clare Sierawski (USTDA), Bethany Speer (NREL), and Jason Whitney (Overseas Private Investment Corporation). Special thanks also to Alison Decarlo and Ethan Zindler (Bloomberg NEF).

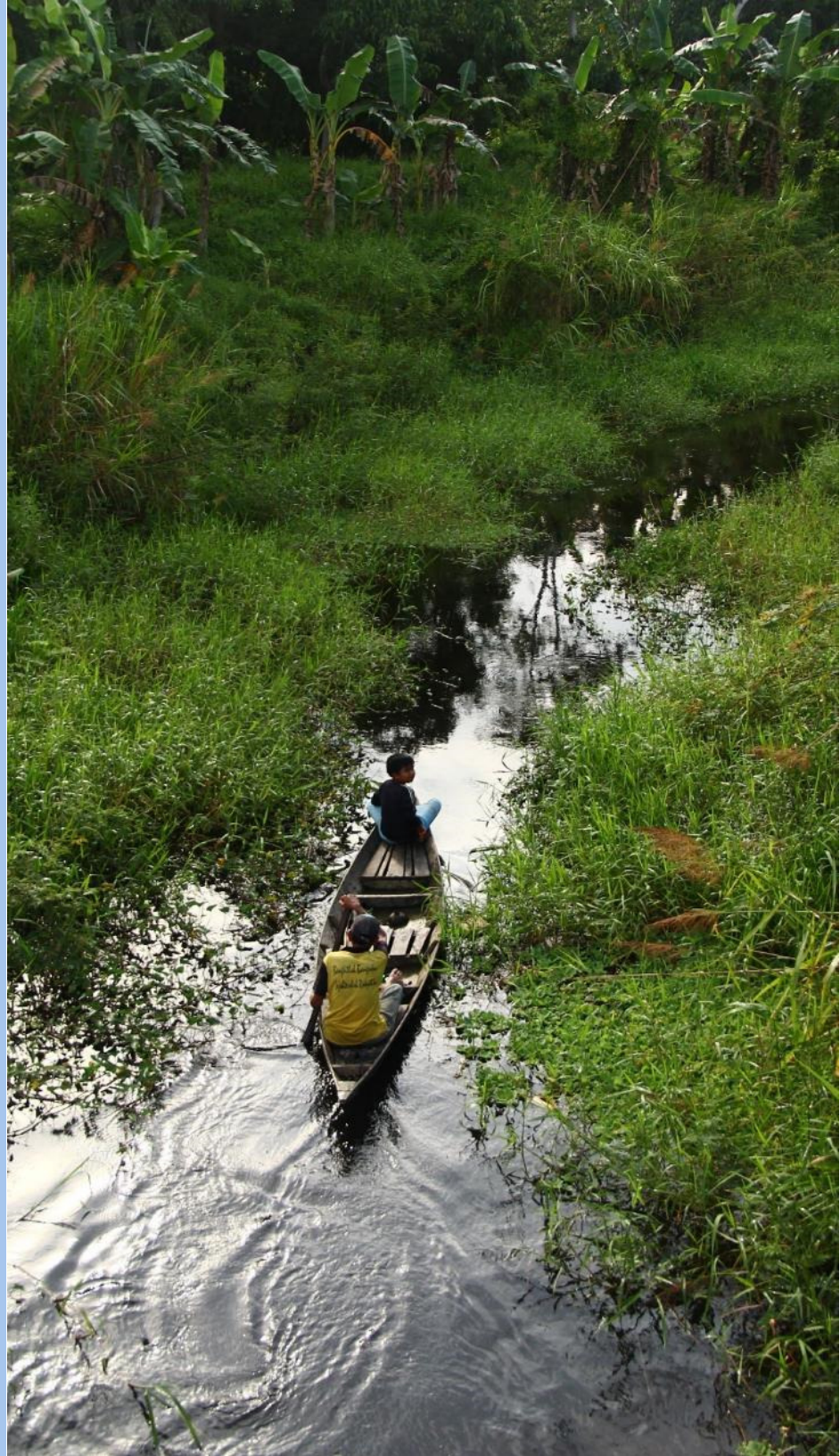
CEADIR is grateful to the many presenters and panelists at the conferences, workshops, webinars, and trainings that it organized (acknowledged in the various reports and presentation recordings and blogs). CEADIR would also like to thank Isabela Barriga, Kaitlin Conway, Meredith Ferris, Stephen Hardeman, Katie McElhinny, and Clair Schleiffer (the USAID-funded Sharing Environment and Energy Knowledge (SEEK) Activity for publicizing CEADIR's work through ClimateLinks and in co-organizing several major workshops and webinars.

1. INTRODUCTION

1.1 OVERVIEW

The USAID-funded Climate Economic Analysis for Development, Investment, and Resilience (CEADIR) Activity helped governments, the private sector, and civil society make the business and economic case for investing in climate change mitigation and adaptation through analysis, planning, and capacity development. CEADIR also helped to identify and mobilize financing for clean energy, sustainable landscapes (natural climate solutions), and climate adaptation opportunities.

This activity was implemented from May 16, 2014 to March 29, 2021. The Activity was led by Crown Agents USA with principal technical subcontractor Abt Associates. Other consortium members included Bloomberg New Energy Finance, Connexus, and Enclude Solutions, Ltd.



This final report describes CEADIR's activities, approaches, and results of its technical, analytical, and financial mobilization assistance in 32 countries in Africa, Asia, and Latin America and the Caribbean. It presents lessons learned and recommends next steps for USAID, partner organizations, and the private sector for scaling up climate finance sustainably. This report includes links for USAID and other development partners to access CEADIR resources, including webinars, technical reports, trainings, tools, and guidance documents.

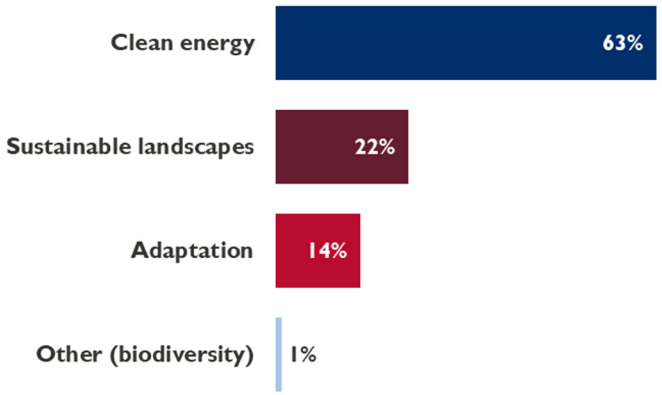
The rest of chapter 1 summarizes CEADIR approaches, outputs, and overall results. Chapters 2-4 discuss the work and results in clean energy, sustainable landscapes, and climate adaptation in greater detail. Chapter 5 presents the climate finance work and results. Chapter 6 describes the webinars, workshops, and conferences that CEADIR organized or led. Chapter 7 summarizes lessons learned across the subtaks and recommendations for additional USAID assistance for climate finance and private sector engagement in low-emission, climate-resilient activities. Finally, Annex A contains reporting results for relevant USAID and Power Africa standard indicators. Annex B summarizes CEADIR's custom indicator reporting.

1.2 OVERALL RESULTS

CEADIR services included sector studies; cost-benefit and cost-effectiveness analyses through economic modeling and co-benefit estimation; vulnerability and impact analyses; PPP development; clean energy lending market assessments, readiness diagnostics, and transaction advisory; low-emission development strategies; adaptation planning and financing; identification and leveraging of climate finance and risk mitigantss; private sector engagement; and training on the economics and planning of climate change mitigation and adaptation.

CEADIR's ceiling was $20,106,481 and total obligations and expenditures were $20,106,466. Figure 1 shows CEADIR's obligations by source. The obligations included $11,978,663 from core funds and $8,127,803 from buy-ins from USAID country and regional missions and Power Africa. Expenditures were $12,591,477 from clean energy funds, $4,491,253 from sustainable landscapes funds, $2,886,785 from adaptation funds, and $136,951 from biodiversity funds.

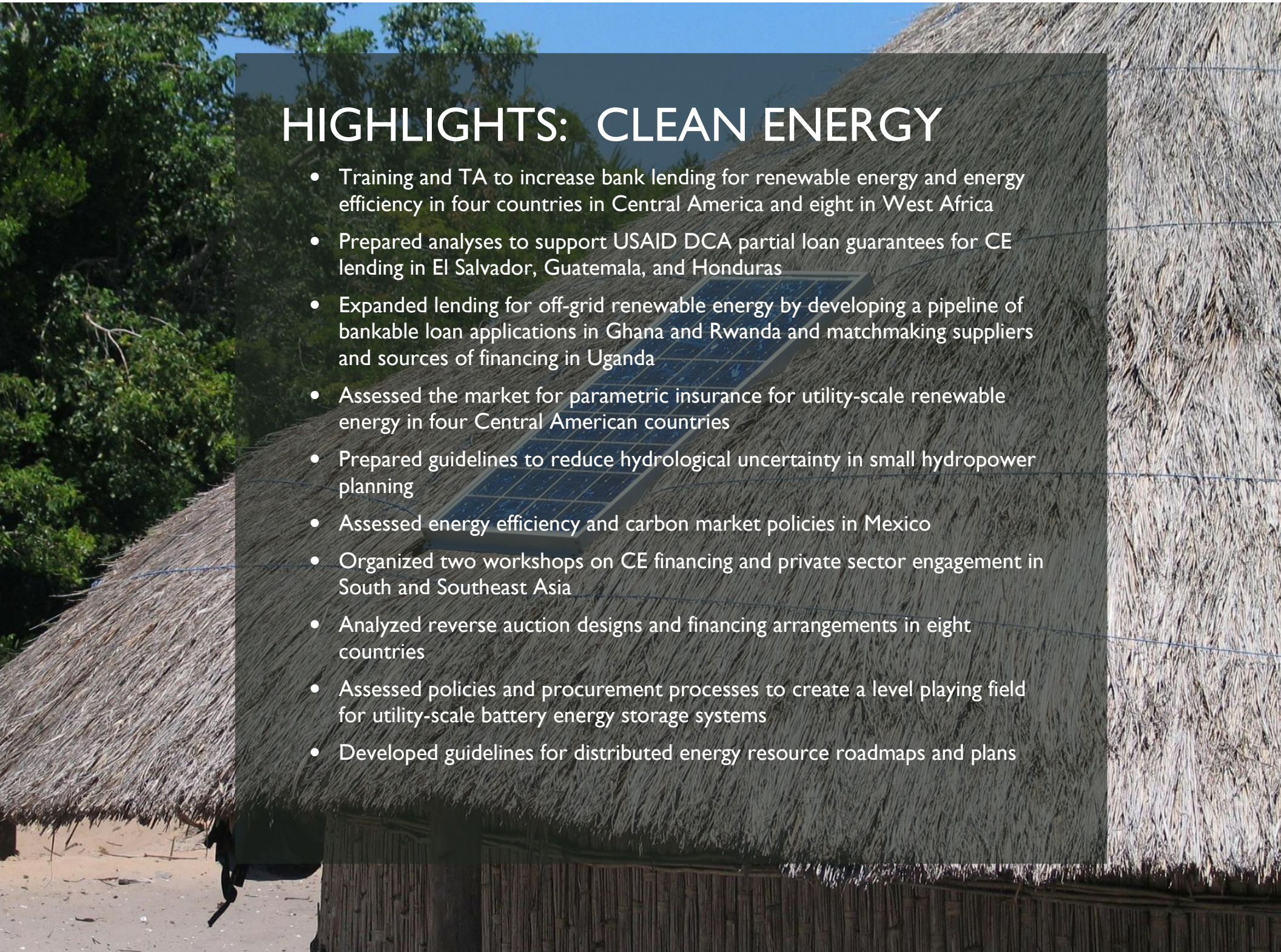
FIGURE 1: CEADIR Funding Obligations



CEADIR developed new tools and methods in clean energy, sustainable landscapes, and adaptation, including survey instruments for quantifying the economic value of mangroves, climate-smart cacao practices, and livestock management improvements. CEADIR provided technical assistance to 89 financial institutions. CEADIR's work contributed to development of 1,467 on- or off-grid power connections and $6.7 million in loans in Ghana and Rwanda for 6.84 megawatts (MW) of renewable energy. CEADIR helped mobilize $17.7 million in clean energy lending, including a $10.8 million loan guarantee through the USAID DCA in El Salvador and Guatemala, and. CEADIR developed 10 public-private partnerships for urban disaster risk reduction in India. CEADIR assessed the potential of the private sector and impact investors in Madagascar and provided training to USAID partners on climate adaptation and sustainable livelihoods with biodiversity benefits.

CEADIR organized or contributed to 64 knowledge-sharing events—webinars, workshops, and forums. These events reached a total of 6,533 people. The activity trained 2,485 stakeholders (41 percent women) and increased the capacity of 40 organizations to address climate change issues in 32 countries. CEADIR produced 78 assessments and provided analysis, design, and implementation support on Low Emissions Development Strategies (LEDS), Nationally Determined Contributions (NDCs), and National Adaptation Plans (NAPs), and climate financing.

2. CLEAN ENERGY



HIGHLIGHTS: CLEAN ENERGY

- Training and TA to increase bank lending for renewable energy and energy efficiency in four countries in Central America and eight in West Africa
- Prepared analyses to support USAID DCA partial loan guarantees for CE lending in El Salvador, Guatemala, and Honduras
- Expanded lending for off-grid renewable energy by developing a pipeline of bankable loan applications in Ghana and Rwanda and matchmaking suppliers and sources of financing in Uganda
- Assessed the market for parametric insurance for utility-scale renewable energy in four Central American countries
- Prepared guidelines to reduce hydrological uncertainty in small hydropower planning
- Assessed energy efficiency and carbon market policies in Mexico
- Organized two workshops on CE financing and private sector engagement in South and Southeast Asia
- Analyzed reverse auction designs and financing arrangements in eight countries
- Assessed policies and procurement processes to create a level playing field for utility-scale battery energy storage systems
- Developed guidelines for distributed energy resource roadmaps and plans

2.1 INCREASING BANK LENDING FOR CLEAN ENERGY IN FOUR COUNTRIES IN CENTRAL AMERICA

Many domestic commercial banks in Central America have been reluctant to provide loans for clean energy companies and users due to high perceived risks and a limited understanding of relevant technologies, business models, and investment viability. Banks willing to provide CE loans often did not have loan products that were well adapted to the sector. RE loans typicall require long repayment periods, non collateral requirements, or loans denominated in local currency. In addition, domestic commercial banks often lack experience in raising capital from multilateral development banks and funds, bilateral donors, and impact investors. The USAID Regional Mission for El Salvador, Central America, and Mexico (ECAM) asked CEADIR to help commercial banks in El Salvador, Guatemala, Honduras, and Panama increase lending for renewable energy and energy efficiency.

The prior USAID-funded Analysis for Investments in Low-Emissions Growth (AILEG) Activity developed a Clean Energy Lending Toolkit (CELT). This toolkit contained useful diagnostics, procedures, and case studies to help commercial banks assess the profitability of renewable energy and energy efficiency lending to households, commercial and institutional clients, and energy product and service suppliers (Counts *et al*. 2014). However, it was only available in English, limiting its usefulness in Latin America. The CELT was designed to be applied and adapted by trainers and TA providers working closely with bank management and staff to meet their specific institutional needs.

CEADIR began by reviewing existing documentation and interviewing key stakeholders in the four countries. CEADIR translated the CELT into Spanish and prepared powerpoint presentations and other training materials for use in the region. Twelve banks then requested additional training to learn about CE technologies, risks, business models, and appropriate loan products. CEADIR also developed additional tools, such as technology checklists to help bank staff quickly assess the feasibility of different types of CE loans. Between October 2015 and December 2017, CEADIR trained 1,276 bank managers and staff in El Salvador, Guatemala, Honduras, and Panama (53 percent women). These trainings addressed the CELT modules and technical topics such as EE, solar power, and hydropower.

CEADIR prepared energy audits to help five business clients of a bank in El Salvador save money on electricity and reduce voltage fluctuation problems. These audits found that the businesses could reduce their annual electricity consumption by as much as 64 percent through energy efficiency measures and installation of photovoltaic (PV) panels.

To reduce the risks of CE lending, CEADIR facilitated meetings with some interested banks, bank regulators, USAID/DCA ECAM, and country mission staff about partial, portfolio loan guarantees. CEADIR also prepared analyses that led to DCA approval of loan guarantees in El Salvador, Guatemala, and Honduras.

The trainings and TA enabled five banks in El Salvador and Guatemala to develop or expand, or improve CE credit lines for small- and medium-sized businesses. CEADIR assistance led to DCA approval of a 15-year loan guarantee for nearly $54 million in SME lending, including up to

$10.8 million (20 percent) for CE loans. This was the first DCA loan guarantee for CE in Central America. Subsequently, three additional banks in El Salvador, two in Guatemala, and one in Honduras received DCA guarantees for CE lending.

2.2 INCREASING BANK LENDING FOR CLEAN ENERGY IN EIGHT WEST AFRICAN COUNTRIES

West Africa has also experienced major challenges to increasing bank CE lending. The enabling environment, energy investment risks, and bank capacity and financial resources varied considerably across countries in the region. In 2016, the USAID West Africa Regional Mission requested CEADIR training and TA to help banks increase CE lending in eight countries -- Cote d'Ivoire, Ghana, Guinea, Liberia, Niger, Nigeria, Senegal, and Sierra Leone.

Power Africa funding supported this work, which was also based on the AILEG Clean Energy Lending Toolkit (Counts *et al*. 2014). It was implemented between October 2016 and March 2018. CEADIR began by assessing the barriers and opportunities to CE lending in the eight countries and translating the CELT into French. CEADIR delivered 23 training workshops for a total of 605 participants representing 43 banks in the eight countries. The workshops addressed general as well as region-specific opportunities, such as PayGo supplier financing for home solar systems, commercial and industrial solar power, and minigrids. The workshops also facilitated matchmaking of interested banks and CE suppliers. Following the trainings, CEADIR helped nine banks conduct diagnostics and provided more intensive TA. Topics included CE technologies, business models, and risks, development of appropriate loan products, and loan application appraisals.

Many of the banks that participated in the trainings and TA subsequently engaged with prospective CE borrowers. Some banks discussed the possibility of accrediting energy developers and vendors as a service for their CE loan clients. Some banks began discussions with multilateral development banks and development assistance organizations on accessing loan capital for CE lending on more favorable terms. CEADIR also helped banks in the region connect with the Private Financing Advisory Network (PFAN), World Bank's Regional Off-Grid Electrification Program (ROGEP), and the Niger Solar Electricity Access Project (NESAP). CEADIR supported donor coordination reporting for the USAID-funded Power Africa Transactions and Reforms Program (PATRP).

Between December 2017 and March 2018, CEADIR held 23 workshops for 43 banks in eight West African countries—Cote d'Ivoire, Ghana, Guinea, Liberia, Niger, Nigeria, Senegal, and Sierra Leone—on needed product and processes for lending to CE projects in PayGo, rooftop solar, mini-grids, and energy efficiency. These workshops featured case studies from 37 local companies and served as a matchmaking platform between banks and CE firms to launch discussions.

2.3 EXPANDING SMALL-SCALE, OFF-GRID RENEWABLE ENERGY LENDING IN GHANA, RWANDA, AND UGANDA

In 2015, the Power Africa Beyond the Grid (BTG) Program supported a USAID Development Credit Authority (DCA) loan guarantee for up to $75 million in off-grid, renewable energy (RE) lending in Sub-Saharan Africa. Concerned about the low rate of use of the existing DCA guarantee for Ecobank in Ghana, Power Africa asked CEADIR to provide TA to increase the bank's lending for off-grid energy. Power Africa subsequently asked CEADIR to support the development of new DCA loan guarantees in the pipeline for Rwanda and promote bank lending for off-grid RE in Uganda.

CEADIR began by identifying constraints to off-grid RE lending in SSA and use of the DCA guarantees. CEADIR reduced these constraints by providing training and TA to a total of 27 banks in Ghana, Rwanda, and Uganda; building a pipeline of bankable BTG loan applications; and providing transaction support to potential borrowers. In Ghana, Rwanda, and Uganda, CEADIR led over a dozen workshops for commercial banks on lending for off-grid renewable energy. These workshops discussed renewable energy technologies and business models and their implications for designing appropriate loan products.

In Ghana and Rwanda, CEADIR subcontracted with Business Advisory Service (BAS) providers to help develop the pipeline of bankable loan applications. The BAS providers were local companies with experience in helping clients develop successful applications for RE project finance. CEADIR used an innovative, pay-for-performance approach to increase the incentives for the BAS providers to help their clients obtain loans. The BAS providers were paid specific amounts set in their contracts based on their success in completing four milestones: 1) identification of a potential transaction and preparation of a work plan to support the borrower, 2) submission of a loan application to the bank, 3) proof of loan approval, and 4) proof of loan disbursement. The bulk of the total remuneration was tied to loan approval. In Uganda, CEADIR organized an industry matchmaking event for banks, solar home system distributors, minigrid developers, other USAID partner organizations, development finance institutions, impact investors, and potential off-grid solar power customers.

CEADIR tried to help residential PV companies in Rwanda obtain loans from Banque Populaire du Rwanda (BPR). Most were international companies with access to capital from development assistance organizations or impact investors at lower interest rates than commercial bank loans in domestic currency, but with foreign exchang risks. Few local companies could meet domestic commercial bank requirements for loans. Consequently, CEADIR switched its focus to loans for commercial and industrial (C&I) clients interested in rooftop PV installations.

In April 2019, another bank announced a plan to acquire a majority stake in BPR. The resulting management uncertainty stopped BPR progress on the agreed workplan for marketing RE loans. As a result, CEADIR ended its assistance to BPR. Instead, USAID/Rwanda asked CEADIR to provide TA to AB Bank Rwanda (ABR) for six months. CEADIR was only able to assist ABR for a few months before the COVID-19 pandemic shutdown in Rwanda.

CEADIR helped Ecobank bring three BTG loan transactions to financial closure, resulting in $6,642 million in financing for 6.8 MW of new RE generation capacity and 1,467 new electric power connections. In August 2019, BPR approved a $59,000 loan for a 40 kW installation for a K-12 school in Kigali that was already connected to the power grid. AB Bank Rwanda sought to install a rooftop solar system at its head office.

2.4 FOLLOW-ON TRAINING AND TA FOR CLEAN ENERGY LENDING IN SENEGAL

In late 2019, the USAID/Senegal Mission asked CEADIR to provide follow-on training and TA on CE lending to two banks, building on lessons learned from its previous work in eight West African countries (including Senegal) and other training resources CEADIR had prepared for Ghana, Rwanda, and Ugandan. USAID/Senegal recommended Banque Internationale pour le Commerce et l'Industrie du Senegal (BICIS) and La Banque Agricole (LBA) as the focus banks. These two banks had demonstrated substantial interest in expanding CE lending. USAID/Senegal also asked CEADIR to offer more limited training to other banks in Senegal. Implementation began in February of 2020 and the planned period of performance was just six months.

Due to the short duration of this subtask, CEADIR conducted rapid assessments of the two banks' priorities and interests for short-term TA and flexible work plans for each bank. CEADIR provided weekly or biweekly virtual TA based on the CELT.

Unfortunately, startup coincided with the covid-19 pandemic outbreak in Senegal. CEADIR had envisioned delivering in-person TA and trainings for the two banks and holding a half-day dissemination workshop for other banks. As a result of the pandemic, CEADIR provided all TA virtually. CEADIR prepared a CE market assessment for Senegal. CEADIR also held two webinars that reached six other banks operating in the country.

The first webinar was co-led by the Power Africa Beyond the Grid Activity. It covered the policy and regulatory environment and institution for CE in Senegal and technologies, business models, and the market potential for CE lending for 1) solar-powered irrigation; 2) solar-powered agroprocessing; 3) solar-powered cold storage, 4) solar home systems, 5) rooftop solar for commercial and industrial clients; 6) minigrids; 7) biomass; 8) biogas; and 9) energy efficiency.

The second webinar discussed bank readiness for CE lending, development of appropriate loan products for CE, and loan approval processes. CEADIR had also hoped to collaborate with the USAID-funded Feed the Future Kawolor Activity on solar irrigation pumps and the Dekkal Guedj Activity on solar-powered cold storage for fish, but was unable to do so due to the pandemic shutdown.

CEADIR helped BICIS develop a CE lending strategic plan through 2021 as input for a subsequent corporate strategy revision for 2021-2024. BICIS identified rooftop PV systems and energy efficiency as priority areas for CE lending focusing on residential as well as commercial and industrial clients. CEADIR helped LBA develop a CE lending strategic plan for 2020-2020 and prepared an Excel model for financial analysis of PV systems. CEADIR fulfilled BICIS request for help developing a shortlist of EPC firms in Senegal for rooftop solar installations to enable the bank to facilitate its due diligence reviews of loan applications, refer clients to the shortlisted firms, and ask the EPC firms to refer their customers to BICIS for loan requests.

LBA identified the following priority areas for lending: solar-powered irrigation pumps, solar-powered cold storage for crops, biogas biodigesters, and energy efficiency throughout the agricultural value chain. For both banks, CEADIR prepared loan profile sheets for each of

their priority areas and guides for evaluating technical and financial proposals and monitoring and reporting. CEADIR trained a total of 28 people (32 percent women) in BICIS, LBA, and the other seven banks.

2.5 PARAMETRIC INSURANCE FOR RENEWABLE ELECTRIC POWER PRODUCERS IN CENTRAL AMERICA

The intermittency of RE resources affects renewable electric power generation from wind, solar, and hydro power. Most projections foresee large fluctuations in precipitation in Central America, a region already subject to periodic severe drought and floods. Weather-indexed parametric insurance can reduce the resource risk. This type of insurance pays policyholders a fixed, agreed amount of money when insufficient or excessive resource flows reach a predefined threshold. Unlike damage-based insurance, parametric insurance does not require a costly, slow, and conflict-prone adjustment process to determine payouts to policyholders.

Parametric insurance reduces the risk of cash flow problems from potential revenue losses and contract penalties. Payout amounts are agreed in advance and tied to specified triggers based on readily available hydrometeorological data from independent sources. As a result, clients can obtain payouts relatively quickly. RE companies and the banks that financed them have borne these risks, instead of sharing and diversifying the risks with insurers. Weather-indexed insurance has not been available for RE generators in El Salvador, Guatemala, Honduras, or Panama, although there have been some limited weather-indexed insurance opportunities for farmers. The demand for parametric insurance for RE is likely to grow with continued expansion of RE power generation and concerns about weather and climate risks.

Some reinsurance companies already sold parametric insurance for large RE generation investments in major markets, such as Brazil and Mexico. They were open to offering this insurance in smaller countries if there was sufficient demand, but had high minimum policy sizes. For example, Swiss Re was willing to sell parametric insurance policies with annual premiums of at least $100,000, which could be feasible for hydropower facilities with 1) a capacity of 10 MW or more, 2) a plant factor of at least 35 percent, 3) an electricity price of $0.09/kWh, and 4) an annual turnover of at least $2.76 million. GCube and Munich Re have also offered parametric insurance for utility-scale RE generation in some countries.

CEADIR assessed the potential market for parametric insurance for RE in El Salvador, Guatemala, Honduras, and Panama. Domestic insurance companies were in these countries only willing to offer this insurance if reinsurance companies were willing to partner with them to share the risks. Panama was the only country in the region with a substantial, domestic reinsurance industry. Primary insurers in the other three countries would have to partner with international reinsurance companies. Domestic insurance companies were also concerned that potential clients would find parametric insurance too costly. RE developers in the four countries had a limited understanding of the characteristics, advantages, and disadvantages of parametric insurance.

The high transaction costs of serving a large number of small renewable electric power facilities can be reduced by allowing owners of multiple RE generation units to buy bundled coverage for all of their facilities. Transaction costs can also be reduced by selling group parametric insurance policies through RE industry associations. Many renewable electric power generation facilities are capital intensive and require financing for 10-15 years or more. Banks often provide loans for up to 70-80 percent of the capital costs for developers with long-term contracts to sell electricity, especially if there is a guaranteed minimum price in a stable or inflation-adjusted currency. Banks could require their

utility-scale RE generator borrowers to purchase parametric insurance to reduce loan repayment risks and some might be willing to offer a lower interest rate or partial premium credit to policy holders.

2.6 GUIDELINES TO REDUCE HYDROLOGICAL UNCERTAINTY IN THE DESIGN OF SMALL-SCALE HYDROPOWER

CEADIR reviewed a feasibility study of a small hydropower project for a bank in Guatemala and found serious weaknesses in the design and assumptions. USAID/ECAM asked CEADIR to prepare guidelines to help energy planners and banks understand the technical studies that should be done in the prefeasibility and feasibility stages of planning small-scale hydropower to reduce implementation risks:

- Data collection, analysis, and projections from previous hydrological, climatological, and hydrometeorological studies, including cartographic or GIS information (local data may be limited in remote sub-basins of developing countries);
- Soils, vegetation, and current and anticipated land uses from the tributary basin to the run-of-river intake site or entrance to a hydropower dam;
- Design flow requirements for hydropower infrastructure, including hydraulic works (intakes, channels, and pipes) and electromechanical works (turbines);
- Minimum flow requirements for other uses (based on allocations for residential, commercial, agricultural and industrial water supply and legal responsibilities for ecosystem maintenance);
- Probability, magnitude, and impact of floods, droughts, and other extreme weather events that may affect decisions on siting, design, and operations; and
- Sediment rates from soil erosion in the tributary basin.

The main sources of uncertainty in hydrological study results and recommendations for reducing the uncertainty are listed below:

- Errors in the fitting of state-discharge rating curves can overestimate low flows, creating uncertainty about the financial viability of a hydropower investment, especially for a run-off-river facility;
- Underestimated extreme event flow hydrographs can jeopardize the safety of intake works at run-of-the-river and dams and powerhouse infrastructure at reservoir-based hydropower units;
- If legal regulations for water use in the tributary basin are inadequate or poorly enforce, other upstream uses of water can affect the water flows needed for a hydropower facility. However, this is likely to be less of a problem for small hydropower than large hydropower.

- Deforestation and land use changes in the tributary basin can increase sediment flows that can reduce the useful life of hydropower infrastructure and increase maintenance costs. These changes can also reduce water flows in the dry season and increase flooding from extreme rainfall events.
- Overestimates of the design flow for a hydropower facility can increase the projected benefits and costs;
- Hydrometeorological (hydromet), soil, land use, and land cover data from a nearby sub-basin can be used to calibrate a hydrological model for a site without sufficient local climate, streamflow, and sediment data; and
- If adequate climate and hydrology are unavailable data for a proposed site as well as nearby sub-basins, a new hydromet station to measure rainfall and streamflows for at least one year. The cost of installing and operating a hydromet station and preparing a good hydrological study are generally low relative to the cost of a small hydropower facility. Better data and modeling can make a hydropower investment more profitable with less risk.

2.7 ENERGY EFFICIENCY AND CARBON POLICY ASSESSMENT IN MEXICO

USAID/Mexico asked CEADIR to assess the potential for GHG emission reductions from changes in the legal and institutional framework (including carbon market policies) and greater energy efficiency in urban transportation; buildings, industries, and municipal services (street lighting, water supply and wastewater treatment, and solid waste management). The assessment recommended the following actions to improve the legal and institutional framework for GHG mitigation in Mexico:

- Integrating federal and subnational public and private sector efforts on energy and climate change mitigation;
- Strengthening the National GHG Emissions Registry and improving using its data to support policy development;
- Establishing a GHG cap-and-trade mechanism or energy savings certificates; and
- Increasing the institutional capacity of Mexican states to plan and implement CE policies.

CEADIR recommended the following options to increase energy efficiency:

Multisectoral

- Rethink electricity subsidies;
- Target interventions to different types of electricity users, recognizing their specific challenges;
- Develop an energy efficiency roadmap;
- Establish a carbon cap and trade mechanism or market for energy savings certificates;
- Link the power markets and carbon markets in Mexico and California; and

- Develop institutional capacities for the energy sector at the state level.

Transport and urban development

- Reduce use of private vehicles, establishing a vehicle scrappage program, improving the fuel efficiency of school buses and government vehicles, promoting ride sharing, and using parking meters to increase driving costs;
- Increase accessibility, security, and quality of public transport through multimodal integration, peak pricing strategies, and reduction of gender-based violence in public transport; and
- Policies and financing to encourage denser urban development, facilitating public-private partnerships (PPPs) for urban mobility, and mobilizing finance for public transportation and protected bicycle lanes.

Industrial energy efficiency

- Help stakeholders assess the advantages and disadvantages of various energy efficiency standards;
- Encourage financial institutions to link lending to efficient energy management systems;
- Expand energy efficiency insurance and developing standardized contracts for providers and clients of energy efficiency technology.
- Encourage small and medium firms that sell to large firms interested in improving the energy and environmental performance of the suppliers and distributors in their value chains;
- Support energy audits and reducing carbon taxes if a firm has made substantial energy efficiency improvements; and
- Help the federal and state governments finance industrial energy efficiency in priority industries through a public-private trust fund.

Municipal services

- Expand power generation from solid waste combustion by providing municipal officials with technical and financial resources
- Increase energy efficiency in municipal lighting and water pumping;
- Obtain rapid energy assessments for municipal buildings and financing cost-effective EE investments; and
- Provide financial and technical support for feasibility studies.

Residential, commercial, and public buildings

- Offer tax incentives and financing for solar water heaters (e.g., billing with property taxes);
- Train and hire women technicians to reach female household heads;
- Establish and enforce energy-efficient building codes;

- Train public officials, engineers, and architects to improve construction techniques and use energy-efficient materials and equipment;
- Support financial analyses and market assessments for energy efficiency;
- Promote green certification by replicating successful programs in large cities and developing a building labeling program;
- Improve planning and incentives for rehabilitation of industrial, commercial, and residential buildings; and
- Help banks increase energy efficiency lending for new housing and retrofits.

This assessment helped inform USAID/Mexico's design of the Mexico Low Emissions Development Program II (MLED II).

2.8 TWO WORKSHOPS ON PRIVATE CLEAN ENERGY INVESTMENT IN SOUTHEAST AND SOUTH ASIA

On March 27-28, 2017, CEADIR conducted a workshop on "Enabling Private Sector Clean Energy Investment in Southeast and South Asia" in Bangkok. This two-day workshop included 87 participants from 12 countries, representing businesses, governments, and development assistance organizations. The workshop focused on strategies and near-term opportunities to increase corporate commitments for large-scale CE development in the region. It highlighted successful examples of large-scale RE procurement and EE improvements in corporate supply chains and explored country-specific barriers inhibiting CE development.

The workshop participants made the following recommendations:

Improve the Policy and Regulatory Environment

- Review and revise existing policies and regulations that conflict with renewable energy development goals or create market uncertainties;
- Institute new policies and incentives that provide clear direction and support the business case for renewable energy investment;
- Prepare actionable plans with clear targets; and
- Improve electricity price forecasting and allow cost-reflective tariffs that reflect changing technology and enable renewable energy to compete.

Strengthen the Clean Energy Financing Environment

- Develop the capacity of domestic commercial banks to increase clean energy lending and obtain additional capital; and
- Help clean energy developers access finance.

Increase Government Capacity and Public-Private Collaboration

- Governments can improve their capacity to support renewable energy markets at the national and subnational levels;
- Increase meaningful engagement with various private sector stakeholders; and
- Collaborate with the private sector on pilot or demonstration projects where needed.

Participants also relayed region- and country-specific requests for support from international development assistance organizations.

CEADIR organized a subsequent workshop on mobilizing private sector CE investment in Southeast and South Asia as a pre-event before the Asia Clean Energy Forum 2017 in Manila. Key partners for the workshop included the Asia Low Emission Development Strategies (LEDS) Partnership, Bloomberg New Energy Finance (BNEF), Allotrope Partners, the USAID-funded Clean Power Asia Activity, the Private Financing Advisory Network Asia, and USAID and other USG representatives.


Photo credit : CEADIR

This June 5, 2017 event engaged 167 participants from 25 countries. The workshop highlighted recommendations and insights from private sector leaders on regional and country-specific actions that governments can take to accelerate investment in CE solutions in the region. It also showcased strategies and approaches of corporations, governments, utilities, investors, and development partners.

Key conclusions of this workshop included

- Increased public-private sector engagement is essential to achieve country targets and corporate goals for clean energy investment and development;
- Private sector leaders are increasing their investments in clean energy and are committed to investing at scale;
- Government action is necessary to help enable private sector investment at scale;
- Private capital will move into markets with strong enabling environments for clean energy investment; and
- USAID has played an effective role in convening the private and public sectors to help facilitate a clean energy transformation.

The Asia LEDS Partnership identified specific recommendations from this workshop that it planned to promote over the next year. CEADIR shared findings and recommendations from these workshops in a *CEADIR Series Accelerating Private Sector Financing for Clean Energy in Southeast Asia* webinar and engaged with the USAID-funded Clean Power Asia Activity and the Clean Energy Investment Accelerator (CEIA) to encourage follow-on actions.

2.9 ANALYSES OF UTILITY-SCALE RENEWABLE ENERGY AUCTIONS

When renewable sources of electricity were more expensive than fossil-fuel generation, some countries offered *feed-in-tariffs* (FiTs) -- premium prices for renewable electric power under long-term contracts as an incentive for making environmentally preferable investments. However, in recent years, utility-scale RE costs have become competitive or lower than electricity from nonrenewable sources. As a result, many countries have moved away from subsidized FiTs to auctions for procurement of renewable electric power capacity or generation. Auctions have proven to be the most efficient and effective procurement mechanism for expanding renewable electric power capacity in developed and developing countries. Unlike negotiated procurements or feed-in tariffs, auctions can reduce the costs of developing new power generation capacity by promoting competition and efficient price discovery as the technology has improved and production costs have declined. Auctions can also reduce costs by increasing fairness and transparency in government and utility procurement processes.

In a *reverse auction,* potential suppliers are asked to bid the lowest price that they would accept for provision of specified goods and services. Some RE auctions have focused on one or more specific technologies. Although technology-specific auctions can diversify the types of energy resources on the power grid, they limit competition and might not produce a least-cost mix of technologies. Technology-neutral renewable energy (TNRE) auctions are less prescriptive because they focus on capacity or generation targets, rather than how to achieve them.

CEADIR interviewed key stakeholders and analyzed experiences with RE reverse auctions in El Salvador, Mexico, Peru through 2017, focusing on the policy and regulatory environment, investment risks and mitigants for bidders, and ability of winning bidders to obtain financing. CEADIR also gathered secondary information for briefer descriptions of RE auction experiences in Brazil, India, and South Africa. Key risks included uncertainty over the auction process and power sector reforms, approval and construction delays, trouble obtaining permits and licenses, and absence of off-takers. Important risk mitigants for bidders included long-term power purchase agreements (PPAs) of 15-20 years, capacity or power payments denominated in U.S. dollars and indexed to the U.S. inflation rate, and expedited approval of licenses and permits, grid access, and payment guarantees posted by the power off-takers.

Access to financing has varied. International companies typically tapped corporate equity or obtained *balance sheet debt financing*. Smaller independent power producers and domestic energy developers often need long-term, limited-recourse *project debt financing*. In many countries, international development finance institutions and government development banks have been the main sources of long-term project financing for RE development over the past decade have been, although there has been increasing participation by commercial banks in recent years.

Commercial banks and institutional investors have gained confidence in the technical and financial viability of renewable electric power generation due to the technological improvements and cost reductions. Nevertheless, the relatively long tenors and high leverage ratios needed for many RE investments have been challenging for many commercial bank sand pressures to reduce long-tenor lending to meet the more stringent international minimum capital, leverage, and liquidity requirements under the Basel III agreement for 2017 to 2027.

Some banks have adapted financing structures for long-term RE development, such as mini-perm loans, bonds, or energy investment trusts. *Mini-perm loans* have medium-term tenors and are refinanced after the RE facility has a sufficient track record of revenue generation. *Project bonds* can be issued on foreign or domestic capital markets for a large project or set of projects. Bonds can provide institutional investors with moderate, but relatively stable, long-term returns backed by project revenues. The risks of bonds are relatively low and can be mitigated by government or donor guarantees. Since bonds are tradeable, they also offer the advantage of liquidity. Infrastructure revenue bonds can attract new

international capital into the country and may also attract domestic pension funds and insurance companies with continuing obligations for local currency payments. Commercial bank or development bank loans can also be securitized into bonds after a large portfolio of loans has been accumulated or sold. *Energy investment trusts* can offer higher investment returns with higher risks and can be sold on equity markets for greater liquidity.

In a separate report, CEADIR interviewed a small sample of developers and investors that participated in the 2017 RE auctions in Thailand and Malaysia, as well as some nonparticipants. This report assessed the cost-effectiveness of these auctions in mobilizing private investment and finance and perceptions and recommendations for improving future auctions. The recommendations focused on 1) achieving government objectives for energy reliability and security; 2) addressing grid access and interconnection challenges; 3) improving transparency in the bidding process; 4) promoting improved technologies, innovation, and sustainability; 5) increasing financial incentives; 6) expanding foreign investment to expand the market for larger-scale RE projects; and 7) addressing post-award requirements more efficiently.

2.10 POLICIES AND PROCUREMENT PROCESSES FOR A LEVEL PLAYING FIELD FOR UTILITY-SCALE BATTERY ENERGY STORAGE SYSTEMS

RE resources are intermittent and may not be available when and where they are needed to meet peak power demand on the grid. Utility-scale battery energy storage systems (BESS) can also help *firm up* RE supplies by reducing the impacts of intermittency on the ability to meet market demand, especially peak loads. Although BESS costs have been relatively high, they have been declining rapidly and are anticipated to continue falling. To date, utility-scale (front-of-the-meter) BESS has been dominated by lithium-ion batteries, but new technologies (such as flow batteries) that allow longer duration storage are now being commercialized.

Utility-scale BESS can enable utilities to avoid or defer costly capital investments in generation capacity that would otherwise be needed to meet peak loads without outages or reductions in the quality of the power. In some places, RE combined with BESS, is already replacing natural gas peaking plans. BESS will bring new opportunities to reduce costs, increase service reliability, and reduce GHG emissions and other environmental impacts. BESS has already proven to be technically and economically viable. However, most developing countries have not yet revised their policy and regulatory frameworks for the power sector to allow BESS to compete with power generation energy on a level playing field. Investments in BESS are hindered when utilities have monopolies over power supply, transmission, and distribution and there are no wholesale power markets supplied by independent producers. They are also hindered by regulatory frameworks that do not allow *value stacking* (payments for the multiple services that this technology can provide for the grid such as black start, spinning reserves, non-spinning reserves, and voltage and frequency regulation).

Most auctions for RE energy in developing countries have not specifically solicited utility-scale BESS, although some have not excluded bids with BESS. However, RE auction pricing rules often put BESS at a disadvantage by not allowing value stacking.

CEADIR analyzed ways to improve the enabling environment for BESS and create a level playing field for BESS in auctions. It examined the importance of new regulatory frameworks, time-differentiated tariffs, and value stacking to provide fair compensation for the grid services provided. It discussed the impact of the bidding rules, including auction prequalification requirements, evaluation criteria, structuring of

contracts in TNRE auctions, winning bidder liabilities, local content requirements, and battery recycling and safety issues. This report recommended that

- Government agencies and utilities need to modify rules, procedures, and rate provisions in RE auctions to provide a level playing field for bids that include BESS.
- Auction rules and requirements should not limit the eligibility and competitiveness of bids that include BESS as a standalone resource or in combination with other resources. RE auctions should generally be technology neutral and allow bids for standalone BESS and co-located or hybrid systems of BESS plus RE capacity. Auctions that allow higher prices or scoring based on domestic content can deter investments in BESS.
- Policymakers should consider auctioning contracts with different levels of firmness to meet the specific needs of the power system. There is an international trend toward transferring part of the RE resource intermittency risk away from buyers to sellers. The regulatory framework and procurement and market rules should give sellers the necessary flexibility to manage RE intermittency risks.
- At current technology prices, the ability to charge for the multiple services that BESS can provide to the grid (value stacking) is important for investment returns. Storage can provide other services for the grid or large users in addition to firm power. Although the unit costs of BESS have fallen, the financial viability of the investments may still depend on value stacking from multiple services. There are currently no industry standards or markets for pricing all BESS services, particularly in developing countries. Auctions can promote value stacking for storage assets.
- CEADIR identified seven business models for BESS that may require different product specifications, rules, and price and nonprice award criteria in auctions. As the market for BESS matures, more sophisticated auction designs can facilitate competition and innovation and expand the range of products and services provided. New markets for ancillary services can be introduced in countries with relatively sophisticated power markets.
- Risks in competitive procurement of RE paired with BESS include underbidding and undercontracting. Power purchase agreement (PPA) implementation risks include nonrealization risks, construction risks, and operational risks.

2.11 GUIDELINES FOR A DISTRIBUTED ENERGY RESOURCES PLAN OR ROADMAP

Distributed energy resources (DER) include distributed generation, distributed power, smart grids, and demand response. *Distributed generation* technologies produce electricity near the point of use, whether connected to a macrogrid, minigrid, or microgrid or only serving off-grid users. *Distributed power technologies* include gas turbines, reciprocating engines, back-up generators, and stationary energy storage. Smart grids integrate advanced sensing and measurement technologies, information and communication technologies, and automatic controls in transmission and distribution systems. *Demand response programs* include energy efficiency technologies, incentives or penalties to motivate grid customers to reduce their total or peak period electricity consumption, and bidirectional vehicle charging systems.

Distributed energy resources can have many financial, economic, environmental, and social benefits for utilities, power markets, and end users. They can help meet peak power requirements, enabling utilities to defer or reduce costly, new capital investments in centralized power generation and transmission and distribution. DER also offer the potential for better service reliability and power quality. They can increase energy security and improve the balance of trade for countries that rely on imported fuels for power generation. Decentralized power generation often relies on RE resources that produce little or no air and water pollution and GHG emissions.

However, a high reliance on variable RE resources can lead to a mismatch between the supply and demand for electric power unless balanced by a mix of different RE resources from different locations or energy storage and smart grid and metering technologies. DER expansion can reduce short- and medium-term revenues and profits from power generation and transmission and distribution even if the long-term impacts are positive. Distributed generation can increase the complexity of grid operations, including power control and dispatchability, voltage regulation, and system responses during disruptions. However, distributed power technologies and demand response programs can also reduce these challenges.

A *DER roadmap* is a planning study, guidance document, or action plan that can help government planners and regulators, utilities, and other stakeholders make better decisions on distributed energy resource investment and use. It can identify national or subnational goals and targets for electric power generation, transmission, and distribution systems and the major milestones needed to reach them. The term roadmap is often used as a synonym for a plan, but a roadmap is sometimes viewed as less prescriptive on the timetable for achieving targets.

A DER roadmap or plan can help achieve various desired outcomes for the power generation and transmission and distribution systems, including affordability, environmental and social sustainability, flexibility, reliability, resiliency, and security. DER roadmaps and plans should discuss available and emerging technologies, technology research and development priorities, gaps in human and institutional capacity that need to be addressed for successful implementation, impacts of current and new policies or regulations, the value of DER investment decisions for the public and private sectors and communities, and coordination and monitoring of DER investments and use. A DER plan or roadmap can help develop a consensus on plans for procurement, financing, and implementation of investments, reducing regulatory delays and increasing public and private support.

CEADIR conducted desktop research on good practices for DER roadmaps and plans and interviewed representatives of U.S. utilities, government regulatory agencies, and regional grid market operators that have participated in state or regional DER planning. CEADIR also conducted interviews on DER policies and planning in Colombia, Mexico, and Vietnam. CEADIR identified the following key themes for DER policies, adoption, and planning:

- DER can play an important role in helping developing countries increase affordability, reliability, and access to electricity;
- Many developing countries were still at an early stage of DER adoption and governments may need to consider policy, regulatory, and market reforms to create a more favorable enabling environment for scaling up DER investment rates;
- DER can help balance grid demand and supply at multiple timescales, enabling utilities to defer or reduce new capital investments in generation, transmission, and distribution;

- DER technologies can be disruptive, straining transmission and distribution systems, especially when data are insufficient on their capacity and location, power production profile, behavior during disturbances, controllability, and impact on regulating voltages;
- Utilities need to monitor customer adoption of grid-connected distributed generation and forecast future growth to plan their investments;
- Utilities need more data from their customers with grid-connected, distributed generation, storage, and EV charging systems to manage and plan their operations;
- DER roadmaps and plans can smooth the transition from a centralized grid to a distributed electric power system;
- DER planning in most developing countries has lagged adoption rates;
- Diverse stakeholders should be included in a DER roadmap or planning process; and
- DER are rapidly evolving and technologies are improving and unit costs are declining, which creates uncertainty about optimal adoption rates and timing.

2.12 EXPANDING MARKETS FOR U.S. SUPPLIERS OF RE AND GRID TECHNOLOGIES AND SERVICES

CEADIR organized a "Renewable Energy and Smart Grid Suppliers Forum" in Denver, Colorado, on May 1, 2018, for U.S. companies interested in selling products and services in developing countries. The event had four main objectives:

- Highlighting opportunities for selling equipment, technologies, and services in key emerging markets;
- Offering guidance on working with partners and potential sources of financing and investment;
- Discussing market challenges and marketing strategies; and
- Facilitating networking.

Photo credit: CEADIR

This forum focused on equipment sales for utility-scale wind and solar power, smart transmission and distribution, related information and communication technologies (ICTs), demand-response tools, and energy storage. It also focused on provision of technical services for utility and grid planning, reverse auctions, grid integration of variable RE, and RE zones. It highlighted recommendations and insights from private sector leaders that have successfully expanded sales of RE, smart grids, and energy storage products and services in developing countries. It also identified the types of assistance that the following USG agencies can provide to U.S. firms: USAID, the Power Africa Initiative, the U.S. Trade

and Development Agency (USTDA), the International Trade Administration (ITA), the Overseas Private Investment Corporation (OPIC), and the National Renewable Energy Laboratory (NREL). A total of 71 participants attended the forum.

On March 7, 2019, a CEADIR webinar addressed opportunities for U.S. suppliers of smart grid and minigrid technologies in Africa. This webinar included speakers from the West Africa Power Pool; GRIDCo (a utility in Ghana); PowerGen Renewable Energy (a company in Kenya); the USG's Power Africa Initiative, U.S. Department of Commerce's International Trade Administration, and U.S. Trade and Development Agency. A recording of this webinar and the presentation are available at https://www.climatelinks.org/resources?f%5B0%5D=resources_project%3A1915&f%5B1%5D=resources_type%3A249#view

On March 12, 2019, CEADIR held a half-day workshop in Washington, DC on "Emerging Markets for U.S. Smart Grid Suppliers and Investors in Africa, Asia and Latin America." The event focused on technologies and services for grid modernization and grid flexibility, integration of renewables and other distributed energy resources, smart transmission and distribution, demand response, minigrids, and utility-scale BESS. This workshop highlighted recommendations and insights from private sector leaders that have successfully deployed smart grid, mini-grid, and energy storage technology products and services in developing countries. It identified the types of assistance and support offered by USG agencies to help American firms assess market opportunities and enter or increase sales in developing countries. It also included open discussions with representatives of the Embassies of Chile, India, and Mexico in the United States. There were 117 participants (79 in-person and 39 online). The presentation slides and background materials from the forum are available at https://www.climatelinks.org/resources/emerging-markets-us-smart-grid-suppliers-and-investors-forum.

2.13 LINKS TO CLEAN ENERGY PRODUCTS

TABLE 1: Selected Clean Energy Products

PRODUCTS
Critical Issues for Clean Energy Financing and LEDS Support to Central America
Clean Energy Market Assessment for El Salvador
Beyond the Grid Constraints Assessment
Expanding Small Scale, Off-Grid RE Lending in Ghana, Rwanda, and Uganda: Effectiveness Assessment
Off-Grid Renewable Energy Policy Framework and Availability of Local Bank Lending in Uganda
Uganda Off-Grid Risk and Mitigant Assessment for Financial Institutions (presentation)
Uganda Off-Grid Assessment of RE Lending Progress, Process, and Terms (presentation)
Clean Energy Market Assessment for Senegal
CEADIR Follow-on Assistance for Clean Energy Lending in Senegal: Final Activity Report
Parametric Insurance for Renewable Electric Power Producers in Central America
Mexico Energy Efficiency and Carbon Market Assessment for Greenhouse Gas Emissions Mitigation

Enabling Private Sector Clean Energy Investment in Southeast and South Asia: Workshop Report
Enabling Private Sector Clean Energy Investment in Southeast and South Asia: Deep Dive Workshop Report
Recommendations to Accelerate Private Investment in Clean Energy in Southeast and South Asia
Private Sector Recommendations for Renewable Energy Auctions in Thailand and Malaysia
Guidelines to Reduce Hydrological Uncertainty in the Design of Small-Scale Hydropower
Analysis of Renewable Energy Auctions in Six Countries
Creating a Level Playing Field for Battery Energy Storage Systems Through Policies, Regulations, and Renewable Energy Auctions
Recommendations for Preparation of a Distributed Energy Resources Plan or Roadmap
RE and Smart Grid Suppliers Forum: Emerging Opportunities for U.S. Firms
Emerging Markets for U.S. Smart Grid Suppliers and Investors in Africa, Asia, and Latin America
CEADIR translations of the AILEG Clean Energy Lending Toolkit into Spanish and French

3. SUSTAINABLE LANDSCAPES

HIGHLIGHTS: SUSTAINABLE LANDSCAPES

- Prepared literature reviews on the economic and environmental impacts of large-scale hydropower, rural road development and improvement, mangrove valuation methods, and climate-smart cacao production
- Conducted cost-benefit analyses of mangrove restoration versus an earthen dike for flood protection in Mozambique, mangrove conservation versus shrimp pond conversion in Indonesia, improved pasture management for ruminant livestock in Ethiopia, and improved cacao production methods in Ghana
- Prepared cost-benefit analyses on household cooking fuel production and use in Malawi and Zambia
- Convened a workshop on increasing private investment in climate-smart agriculture and forestry in South and Southeast Asia

3.1 LITERATURE REVIEW ON THE IMPACTS OF RURAL ROAD DEVELOPMENT

Rural roads can make remote areas more accessible for the expansion of human settlements and reduce the costs of bringing goods to and from markets. Economic benefits depend on how well the roads are sited and maintained. In some cases, there can be political or institutional motivations for building roads. Potential adverse environmental impacts include increased GHG emissions from deforestation, forest degradation, and other land use changes, as well as vehicle energy use. Motor vehicle use can increase mortality risks from air pollution, particularly in urban areas. Roads contribute to wildlife habitat losses and increased animal mortality from vehicle collisions. The environmental impacts can extend far beyond the land area occupied by roads.

The indirect emissions associated with roads, mainly from the clearing or degradation of nearby forests, can be up to 10 times larger than the direct emissions from construction. Roads can increase the feasibility and incentives for converting forests to agriculture or human settlements. They can increase opportunities for illegal and legal logging, mining, wildlife hunting, and fishing. Road development can affect ecosystem functions for considerable distance; for example, hydrologic buffering and habitat for biodiversity. Roads can drive deforestation because they increase access to forest resources and provide opportunities to convert forests to agricultural or human settlements. The most common use of converted forestland worldwide has been agriculture, which utilizes land for crops and pastures. Data on the projected and actual deforestation associated with specific rural roads in developing countries are generally inadequate.

CEADIR prepared a literature review examines rural road construction, improvement, and use in developing countries and impacts on forests, GHG emissions, and economic growth. It compared the GHG emissions from road development, vehicle use of roads, and deforestation and forest degradation associated with roads under different land tenure systems. It also summarizes the economic and social impacts of rural roads on local populations. It briefly addressed impacts on wildlife, the permanence of road impacts, and the relative impacts of roads and rail transport.

This report summarized the relative magnitude of GHG emissions from road construction, land use changes, and increased road traffic. It included a framework for a qualitative assessment of deforestation and forest degradation impacts based on road project attributes. It also discussed tools and data analysis methods for quantitative impact projections. It discussed ways to reduce the GHG emissions from deforestation and forest degradation. The environmental impacts of rural roads can be reduced through better design and siting decisions or development of rail transport as an alternative. Improved road network planning can reduce the direct and indirect impacts of greater accessibility. Other important remedies include establishing or improving conservation of protected areas and more effective management and regulation of natural forests. It contained a case study on the reconstruction of Highway B-319 in the Brazilian Amazon.

3.2 LITERATURE REVIEW ON THE IMPACTS OF LARGE-SCALE, RESERVOIR-BASED HYDROPOWER

Most hydropower facilities have substantially lower GHG emissions than generating electricity from fossil fuels. Due to the long time required for planning, siting, and construction, large-scale hydropower is not a short-term solution for an increasing demand for electricity. In addition,

lengthy delays in completion are common and increase cost overruns. Capital costs tend to increase with dam scale and height, but power generation capacity also increases with dam size. As a result, there is not a strong correlation between the scale of a hydropower dam and the cost per unit of electricity generated.

CEADIR prepared a literature review on the environmental, social, and economic impacts of large-scale, reservoir-based hydropower. Tree clearing and decomposition and reservoir operations have direct and indirect effects on carbon dioxide and methane emissions. Although hydropower dams typically have lower life cycle GHG emissions per unit of electricity produced than coal, petroleum, or natural gas fired power plants, there are examples of large hydropower systems with emissions as high or higher than fossil fuel power generation. There is still much uncertainty about the direct and indirect GHG emissions from large hydropower dams. Hydropower has some advantages as a source of electricity. It has good black-start capability to supply power after a blackout at lower cost than coal or natural gas turbines. It can balance electricity demand and supply from variable or intermittent renewable energy sources and help meet peak loads. Pumped storage dams can reduce the need for new power generation capacity, but may become less competitive in the future as battery storage costs continue to decline.

Characteristics of hydropower dams that are positively correlated with GHG emissions include location in the tropics, quantity of biomass flooded, reservoir age below 15 years, high water temperatures, eutrophic river systems with high nutrient loadings, and shallow reservoir depth. The most important drivers of the lifecycle GHG emissions from hydropower are reservoir size and climatic zone. Large, shallow hydropower reservoirs in the tropics generally had the highest measured GHG emissions, but more research is needed on the GHG emissions in other locations.

The risks of high GHG emissions from hydropower reservoirs can be reduced by

- Ensuring a high power density, preferably over 1 watt per square meter of reservoir surface area;
- Minimizing the inundated area and removing terrestrial biomass before inundation;
- Siting nutrient sources upstream from reservoirs and implementing nutrient reduction strategies;
- Incorporating design features, equipment, and operating measures to reduce CH4 emissions from degassing of turbines and emissions downstream of the impoundment (including drawing water for the turbines close to the reservoir surface); and
- Re-engineering old reservoirs to increase power production, for example, through sediment removal; and
- Decommissioning reservoirs with declining power output that cannot be improved.

Other environmental and sociocultural impacts of large-scale hydropower dams can be substantial. These impacts vary considerably by location, prior land cover, climatic zone, age, size, and type of hydropower facility, proximity of human settlements, and the need to relocate populations. The other environmental impacts may include changes in water flow regimes and downstream water quality, lower fish populations and diversity, and flooding of terrestrial habitat important for biodiversity. Displacement of people during dam establishment is a major concern and the frequency and impacts may be particularly harmful for indigenous groups, marginalized populations, and women. Internal displacement can lead to unemployment and underemployment, loss of access to key resources, reduced income from farming, disruption of social and community

networks, and public health risks. Displaced populations have rarely received adequate compensation. Hydropower can have serious local and downstream effects if dam safety is breached or waterborne disease vectors increase.

Despite the site specificity of the impacts and research gaps, there are some general principles for reducing the negative environmental and social impacts of dams. Protocols, assessment tools, and standards have been developed to assess and reduce or mitigate the negative environmental and social impacts of large-scale hydropower. However, none are broadly acceptable to key stakeholders and most have not been widely used yet. Some multilateral development banks have recently improved their standards for environmental and social safeguards for the hydropower investments that they finance.

New hydropower investments can stimulate national or subnational economic development and electricity self-sufficiency or exports. Increased employment from construction of a large dam can continue for a decade or longer. Multipurpose reservoirs can increase economic production from irrigated agriculture, aquaculture, and impoundment fisheries. Reservoir dams can help in managing river flow, capture heavy rainfall to mitigate drought, and reduce flooding. They can also provide water for irrigation and human and animal consumption. However, the financial costs of hydropower have often been underestimated or reduced by subsidies and the financial and economic benefits have often been overestimated. However, the environmental and social costs have generally not been valued in monetary terms.

The actual financial and economic viability of large-scale hydropower has often been below projections. The economic costs of hydropower have often been underestimated or reduced by subsidies and the economic benefits have often been overestimated. Previous financial and economic analyses of hydropower have rarely accounted for sediment management costs to extend the useful life of reservoirs. As a result, sedimentation has reduced the benefits of large-scale hydropower dams by decreasing the life and capacity factor of the reservoir and turbines. Severe droughts have also kept many dams from achieving their planned electric power generation rates.

In addition, the environmental and social costs have generally not been valued at all. Capital costs tend to increase with dam scale and height, but power generation capacity also increases with dam size. As a result, there is not a strong correlation between the scale of a hydropower dam and the cost per unit of electricity generated. Due to the long time required for planning, siting, and construction, large-scale hydropower is not a short-term solution for an increasing demand for electricity. In addition, lengthy delays in completion are common and increase cost over-runs.

3.3 LITERATURE REVIEW ON MANGROVE ECOSYSTEM VALUATION

CEADIR assessed the strengths and weaknesses of various methods for valuing the market and extramarket goods and services provided by mangrove ecosystems and compared the estimated values. CEADIR analyzed 28 studies that quantified the value of mangroves in developing countries and contained information on the study areas. These studies were published between 1982 and 2014. The area of mangroves valued in the studies ranged from 111 to 300,000 ha and averaged 44,337 hectares. To make studies prepared in various years for different areas of mangroves comparable, CEADIR adjusted the reported values to January 2016 U.S. dollars per hectare values.

Many of the studies only valued a limited range of the goods and services provided by mangroves and none valued habitat services. Many studies valued extractive goods at the gross revenues from marketed sales without accounting for costs of harvesting, transporting, and processing. Some valued extractive goods at the net revenues after subtracting the costs. The studies did not use the sum of producer surplus and consumer surplus, which is the economic measure for marketed goods and services. A few used contingent valuation surveys or interviews to

estimate option and existence values. Most studies only reported annual values. A few calculated net present values over time, accounting for the time value of money. Most of these methods only produced lower-bound estimates, but they can still be useful input to influence decisions on the use, conservation, and restoration of mangroves.

Ecosystem regulating services had the highest average annual value of mangroves -- $2,218/ha in 12 studies. *Cultural services* had an average annual value of $524/ha in seven studies. *Provisioning services* (food, fish, and forest products) had an average annual value of $403/ha in 17 studies. The *total, average annual value* was $7,350/ha of mangroves in the few studies that estimated this for mangroves. The adjusted values from the reviewed studies varied substantially by valuation method. The average annual value per hectare was $3,212 with benefit transfer methods, $2,145 with replacement cost and alternative cost methods, $920 with the travel cost approach, $348 with contingent valuation, and $298 with market valuation methods. The median values were generally lower than the averages, which were skewed by a small number of relatively high values. Few studies valued the carbon sequestration benefits of mangroves.

3.4 LITERATURE REVIEW ON CACAO PRODUCTION PRACTICES IN AFRICA

CEADIR prepared a literature review on cacao production practices in Africa to inform the selection of production practices, locations, and data sources for a cost-benefit analysis of improved cacao production practices in Ghana. Much of the cacao production in Cameroon, Côte d'Ivoire, Ghana, and Nigeria has low productivity due to the old age of the trees and inadequate maintenance, pest and disease control, shade management, and fertilizer use. Despite efforts to promote more sustainable production practices and certification, cacao production has continued to be associated with deforestation and, in some countries, child labor. In many areas, the sustainability of cacao production is threatened by climate change. Deforestation and climate change risks are highest under the full-sun, high-input model that was previously promoted by many governments and development assistance organizations in West Africa.

Higher temperatures and changes in precipitation patterns are expected to reduce the area suitable for cacao production in Ghana. There is more uncertainty about local changes in precipitation and cacao pests and diseases than temperature changes. The importance of improving farmer and worker livelihoods from cacao, reducing GHG emissions from cacao-related deforestation, and increasing farmer resilience to climate change have prompted governments, companies, and NGOs to promote more sustainable production alternatives to full-sun production.

Some cost-benefit analysis or more limited studies of the costs or benefits of certification and improved production practices for cacao have been conducted. The results have varied with the sites and the specific production practices included and key assumptions. Many of these studies had some methodological or data limitations. Several studies found that the benefits of improved cacao production practices can outweigh the costs. However, the net present value and relatively long payback period may not be sufficient to motivate small-scale farmers to make these investments, especially if they do not receive a price premium for organic, environmentally certified, or fair trade cacao. Certification is costly, and the benefits of more intensive input use are also available without certification. Even if the discounted net financial returns of certification and more sustainable production practices are positive, barriers limit their adoption by small-scale farmers -- lack of available financing for the capital investments, insecure land and tree tenure, insufficient access to training and extension services, input supplies, information on local climate risks, and the uncertain benefits of climate adaptation measures.

With climate change, higher maximum temperatures and reduced water availability in the dry season may make some existing production areas unsuitable for cacao production (*transformation zone*). The most vulnerable areas in Africa include the forest–savanna transitional zone in Nigeria and eastern Côte d'Ivoire. Less vulnerable areas include southern parts of Cameroon, Ghana, Côte d'Ivoire, and Liberia. In other areas, cacao production can continue if *incremental adaptation* or *systemic adaptation* strategies are adopted, including shade-grown production and climate-smart practices. There may be some areas where new possibilities open up for cacao production (*opportunity zone*).

In March 2019, CEADIR co-hosted a workshop on climate-smart agricultural practices for cacao with the World Cocoa Foundation (WCF). The World Cocoa Foundation provided an update on the Cocoa and Forests Initiative and the Climate-Smart Cocoa Program. The International Institute for Tropical Agriculture summarized the findings of the Climate Change, Agriculture and Food Security (CCAFS) work on cacao production in Ghana.

3.5 COST-BENEFIT ANALYSIS OF MANGROVE RESTORATION FOR COASTAL FLOOD PROTECTION IN MOZAMBIQUE

More than half of Mozambique's population lives in low lying coastal areas and is highly vulnerable to severe flooding from cyclones. USAID/Mozambique funded the Coastal City Adaptation Project (CCAP) to help coastal cities increase their resilience to climate change impacts. One of CCAP's interventions was to restore 22 hectares (ha) of mangroves to reduce flood risks in two low-income, coastal communities in Quelimane (Icídua and Mirazane). USAID/Mozambique asked CEADIR to conduct a cost-benefit analysis on this mangrove restoration pilot.

With cost records from CCAP and other primary and secondary data, CEADIR compared the financial and economic costs and benefits of mangrove restoration and another potential alternative for reducing flood risks -- a 5,000-meter earthen dike around the two communities. The mangrove restoration was done with manual labor, without any earthmoving equipment. Mangrove restoration costs were $3,565/ha for seedlings, bags, transport, local labor, safety equipment, seedling maintenance, and $404/ha the hydrological restoration needed for successful mangrove establishment. The total cost for the 22 ha of mangroves was $87,318, excluding CCAP staff time and travel costs. The estimated construction cost for the earthen dike was $246,060 (at $15 per foot). Annual maintenance costs for the dike were estimated at five percent of the construction cost. CEADIR did not include the alternative of a concrete structure because the cost would have been much higher.

CEADIR estimated that the pilot area of mangrove restoration could protect 33-67 percent of the houses in the two communities from medium-sized or severe cyclones. CEADIR estimated that the earthen dike could protect most of the houses from medium storms, but would provide no protection from severe storms with flood waters that exceed its height. It would take 10 years after planting for mangroves to provide full protection. The earthen dike would be effective after construction is completed. The earthen dike would require annual maintenance costs and would have to be completely rebuilt after a large storm.

The houses in the two communities are typically made of mud and mangrove poles and assembled with local labor. The estimated cost of the materials and labor for this type of house was $915. Because of the low cost of replacing these houses, the capital cost of the earthen dike could not be justified by the benefits of reduced flood damage to houses (the financial and economic net present value was negative at discount

rates of 3, 7, and 12 percent). Due to lack of data, CEADIR did not consider differences in the cost of human mortality risks from floods with either the earthen dike or mangrove restoration.

Unlike the earthen dike, mangrove restoration provided other economic and environmental benefits. Mangrove restoration had positive financial and economic net present values due to these other benefits. The most important benefits from mangrove restoration were from carbon sequestration and the increased value of near-shore fish and shellfish catches and both greatly exceeded the avoided housing replacement costs. Mangroves also provide important spawning and nursery areas for fish in deeper waters, but these benefits were not included in the analysis. The social cost of carbon was valued at $0, $8, $15, and $25 per metric ton of carbon dioxide equivalent (tCO_2e). The carbon sequestration benefits were substantial at all nonzero values of the social cost of carbon. The analysis also included apiculture in mangroves, but the net benefits of this honey production were low.

3.6 COST-BENEFIT ANALYSIS OF MANGROVE CONSERVATION VERSUS SHRIMP AQUACULTURE IN INDONESIA

Half of the world's total mangrove deforestation since 2000 has been in Indonesia, where the main driver has been conversion for shrimp aquaculture. CEADIR conducted a cost-benefit analysis that compared the financial and economic value of mangrove conservation versus partial conversion for shrimp ponds. The study focused on Bintuni Bay and Mimika District in Papua and West Papua in Indonesia. These locations have some of the largest intact areas of mangroves in the country and relatively little mangrove deforestation. They also have relatively large proportions of indigenous ethnic groups, a special autonomous governance status, and high biodiversity. Bintuni Bay has a mangrove harvesting concession for wood chips that has operated at a sustainable extraction rate since 1988.

The cost-benefit analysis considered two scenarios: 1) the baseline mangrove conversion rate of 0.05 percent per year for human settlements and infrastructure, and 2) conversion of an additional 0.75 percent of the mangrove area per year for shrimp ponds. CEADIR gathered data on the financial costs and benefits of local activities supported by mangroves through a survey of 120 households. These activities included near-shore fishing, farming, hunting and gathering, wood harvesting, and mangrove palm products for roofing materials and food and beverages. Shrimp ponds in former mangrove areas have a usable life of only 10 years or less.

Income losses from mangrove-supported activities eventually outweighed shrimp revenues in the converted areas. Over a 50-year period at a 12 percent high discount rate, the financial value of partial conversion of mangroves for shrimp aquaculture was only 2-4 percent higher than mangrove conservation. This small difference could easily be offset by the uncounted benefits mangrove forests provide by acting as biodiversity hotspots, as well as spawning and nursery areas for deep sea fish. The financial benefits were lower for shrimp aquaculture than mangrove conservation at lower discount rates (the three percent and seven percent per year rates that the U.S. Government uses in domestic cost-benefit analyses). Mangrove conservation was also financially preferable at the 12 percent discount rate over a 100-year time period.

The economic analysis also valued the carbon storage benefits of mangroves at social costs of carbon ranging from $5 to $25 per metric ton of carbon dioxide equivalent. When the carbon storage benefits of mangroves were included, the economic analysis favored mangrove conservation, with higher values than partial conversion for shrimp ponds. The economic advantages of mangrove conservation increased with

changes in three key assumptions: 1) higher social costs of carbon (the economic damage from GHG emissions); 2) lower discount rates (the annual percent decrease in the value of money over time); and 3) a longer time period for the analysis. At a low social cost of carbon of \$5/tCO_2e and a 12 percent discount rate, mangrove conservation had a 5.5 percent higher economic value than partial conversion for shrimp ponds. At a \$25/ tCO_2e and a three percent discount rate, the economic benefits from mangrove conservation were 18-22 percent higher than partial conversion for shrimp ponds over a 100-year period.

CEADIR also examined the effects of including probability distributions for many key assumptions, using a Monte Carlo Analysis that varied assumption values over 10,000 simulation runs. Even without the carbon storage benefits, mangrove conservation was more valuable than partial conversion for shrimp ponds in 23–37 percent of the model runs at the 12 percent discount rate. When carbon storage benefits were counted, mangrove conservation was more valuable than partial conversion for aquaculture in nearly all model runs. The financial value of aquaculture was sensitive to the risks of lower profits per hectare of shrimp ponds and a shorter useful life for the ponds. The Monte Carlo Analysis found little likelihood that the economic value of conversion to shrimp ponds would be higher than mangrove conservation at a social cost of carbon of \$5/ton or more.

The two study areas had a very low historical risk of cyclones and tsunamis, unlike many mangrove areas in Indonesia and other countries. To make the findings more relevant for other locations, CEADIR considered the effects of including an annual risk of 0.5 percent for cyclones or tsunamis and probability distributions for the value of statistical lives lost and housing damage when a cyclone or tsunami occurred. Due to insufficient data, this analysis did not value other ecosystem services from mangroves, such as water quality improvements or biodiversity conservation. Inclusion of additional ecosystem service values would further increase the economic superiority of mangrove conservation over shrimp aquaculture in the study areas. Including the additional impacts of mangroves on reducing human mortality and housing damage from cyclones and tsunamis for other locations did not affect the financial or economic results very much.

3.7 COST-BENEFIT ANALYSIS OF IMPROVED LIVESTOCK MANAGEMENT PRACTICES IN THE OROMIA LOWLANDS OF ETHIOPIA

CEADIR analyzed the costs and benefits of three improved management practices for cattle and other ruminants, on communal rangelands in the Oromia lowlands of Ethiopia. The analysis focused on agropastoralists with settled farm locations who graze livestock extensively. It addressed three types of improved livestock management practices:

1. *Deferred-rotation grazing*. Intensive pasture management with a longer resting period between periods of livestock grazing, typically two years. During the resting period, enclosures exclude livestock so that the vegetation can regenerate naturally. Natural regeneration increases the vegetative cover, plant diversity, soil tilth and fertility, and carbon sequestration. It reduces water runoff and soil erosion.

2. *Active restoration of degraded rangeland*. Planting or seeding desired herbaceous species and removal of woody plants to restore productivity for grazing.

3. *Fodder cultivation (supplementation)*. Planting crops for products or byproducts with high nutritional value for livestock to supplement grazing or reduce use of purchased feeds. Adding high-quality fodder to the diet of ruminants can also reduce their methane emissions per unit of animal product produced.

Each pilot test involved only one of the improved practices, with multiple households working together.

CEADIR collaborated with the International Center for Tropical Agriculture (CIAT) on household surveys and focus group interviews with livestock farmers who had participated in pilot tests of these improved management practices at three sites. The data included years with normal rain, moderate droughts, and one severe drought. The survey included livestock farmers in areas where the improved management practices had been used for at least two years and who had at least five years of livestock production experience before and after the pilot test. The sample size was 28 or 29 households for each of the improved practices. After the individual surveys, CEADIR had group discussions with the three pastoralist associations.

The time horizon for the financial analysis reflected the time required to implement the improved practice and its effective life, ranging from 15 to 20 years. The land area for each of the pilots varied: 1.74 ha for fodder cultivation, 0.5 ha for active restoration of degraded rangeland, and 2.5 ha for deferred-rotation grazing. At a 12 percent real discount rate, only active restoration of degraded rangeland and fodder cultivation were profitable. All three alternatives, including deferred-rotation grazing, were profitable at a 3 percent discount rate, but the long payback period would make it difficult for farmers to adopt them in the absence of long-term financing or subsidies -- four years for fodder cultivation, six years for active restoration of degraded rangeland, and 12 years for deferred rotation grazing.

The economic analysis had a 50-year time horizon and accounted for differences in carbon sequestration benefits and the costs of methane emissions. These impacts included increased carbon sequestration and storage from improved vegetative cover net of higher methane emissions from increases in the ruminant population density. Ethiopian livestock farmers maximum herd size to store wealth in the form of livestock. Over time, the higher methane emissions would offset the increased carbon storage from the improved practices. The U.S. EPA estimated that methane has 28-36 times the global warming potential of CO_2 over 100 years. CEADIR applied three values for the social cost of carbon -- $8, $15, and $25 per tCO_2e. At the 12 percent discount rate, which gives little weight to impacts after 30 years, inclusion of the net greenhouse gas emissions at these social cost levels, had only a small effect on the economic viability of the three options (slightly positive for deferred-rotation grazing and slightly negative for the other two alternatives). The rankings of the alternatives were similar at the 3 and 7 percent discount rates.

3.8 COST-BENEFIT ANALYSIS OF IMPROVED CACAO PRODUCTION METHODS IN GHANA

CEADIR conducted a cost-benefit analysis (CBA) of nine cacao production models in Ghana:

- Low-input business-as-usual (BAU) model;
- Medium-input BAU model;
- High-input BAU model;
- CGIAR Climate Change Agriculture and Food Security (CCAFS) climate-smart agriculture (CSA) model for coping zones that only requires limited changes in cacao production practices with projected climate changes;
- CCAFS CSA model for adjustment zones that needs incremental or systemic adaptation measures for cacao production with projected climate changes; and
- Four models for rehabilitating existing cacao farms. The four rehabilitation models differed in the use of hybrid or open-pollinated cacao varieties, amounts and types of inputs used, timing of cacao yields, and whether crops were interplanted before cacao trees began producing.
    - Rehabilitation model 1: Hybrid cacao harvesting starting in year three. Interplanting with cassava and cocoyams or malanga before cacao begins bearing.
    - Rehabilitation model 2: Similar to high-input BAU production with intercropping of plantains.
    - Rehabilitation model 3: Open-pollinated cacao that begins bearing in year six and intercropping with plantains.
    - Rehabilitation model 4: No interplanting of other crops with cacao.

The time horizon was 25 years for the financial analysis (the expected productive life of new cacao plantings) and 50 years for the economic analysis. The financial analysis reflected the perspective of the farmers. The economic analysis valued differences in carbon storage benefits at the relatively low social cost of carbon of $5 per metric ton of carbon dioxide equivalent.

The low-input BAU production had the lowest financial NPV. Medium-input BAU production was more profitable than low-input BAU production, but required farmers to cover or finance the additional costs and obtain the necessary TA and inputs. High-input BAU production was more costly and more profitable than medium-input BAU production. Some of the production systems were only applicable under specific agroclimatic and economic conditions. For example, the two CSA production systems should not be compared because they were designed for geographic areas with different climate risks for cacao production. The CSA adjustment zone model was relevant for large areas of the Ashanti, Brong Ahafo, and Eastern Regions. The CSA coping zone model was relevant for parts of the Central, Western, and Volta Regions. The CSA

coping zone model can be compared to the BAU production systems. With climate change, comparisons of the profitability of the CSA adjustment zone model and the BAU production systems will become less valid.

Since the cacao rehabilitation models involve removal and replacement of unproductive stands, their profitability should not be directly compared to the profitability of establishing new cacao farms. The rehabilitation models included extra costs for cutting and removing the existing cacao trees and increasing fertilizer use to compensate for soil nutrient depletion. The profitability of the four rehabilitation models can be compared, with two caveats. First, before comparing rehabilitation model 4, it would be reasonable to add the average, incremental NPV from plantains in the other three rehabilitation models. Second, the four rehabilitation models were developed for specific locations that may have different weather and site conditions. Cacao yield assumptions were similar in rehabilitation models 1-3, the two CSA models, and high-input BAU production. Cacao yield assumptions were similar for rehabilitation model 4 and medium-input BAU production.

In the base case, the rankings for the various production models were the same for both the financial and economic analyses. However, the economic NPVs were substantially higher than the financial NPVs due to the value of the carbon emission reductions. Financial NPVs were substantially higher at the lower discount rates, but changes in the discount rate only resulted in small changes in the rankings of the four cacao rehabilitation models.

The economic analysis included sensitivity testing with a 100-year time horizon and four other values of the social cost of carbon ($0, $8, $15, and $25 per tCO_2e). At the four nonzero social costs of carbon, inclusion of the GHG benefits substantially increased the economic NPVs of shade-grown cacao and the magnitude of the gain increased with carbon prices. The economic NPVs increased as the discount rate decreased and the time horizon increased.

CEADIR conducted a Monte Carlo analysis to examine the effects of producer price risks for cacao and plantains due to the volatility of world market prices and potential changes in COCOBOD pricing policies. CEADIR considered the effect of increases or decreases in cacao producer prices of up to 30 percent from the base case price of $1,557 per metric ton. Plantains are produced for the domestic market and have had periodic price declines in Ghana due to excess supply. CEADIR allowed the price of plantains to decrease up to 25 percent from the base case price of $0.43 per bunch. CEADIR assumed a triangular distribution for the prices of both crops. The base case price was the most likely outcome and the probability of other values decreased in linear proportion to the change in the base case price.

The rankings of the cacao production models were similar in the Monte Carlo analysis and the base case. The two CSA models and the high-input BAU model had the highest financial and economic NPVs. More input-intensive, shade-grown production systems for cacao are financially beneficial for farmers due to the potential for substantially higher yields. Shade-grown cacao is also economically preferable if the increased carbon sequestration and storage in aboveground biomass is valued. The economic benefits would be greater if soil carbon storage and other environmental benefits were counted, but these benefits were not estimated in this cost-benefit analysis. Some of the major cacao production areas in Ghana will face pressures from climate change that will require moderate or major changes in production practices or a shift to other crops.

Despite the favorable financial analysis, few cacao farmers in Ghana have adopted input-intensive, shade-grown production practices. Hybrid and improved, open-pollinated cacao varieties comprise a relatively small portion of the total planted area. Most cacao farmers were using low-input, sun-grown production systems. High-input, shade-grown cacao comprised less than 10 percent of the total planted area of cacao in Ghana. Climate-smart production models for the cacao coping and adjustment zones in Ghana were also financially viable, but have not

progressed much beyond pilot implementation. Furthermore, large areas of cacao in Ghana require rehabilitation to replace old or diseased trees that are no longer productive. Good models for rehabilitation of these cacao stands exist and are also financially viable, but also accounted for a small share of the planted area.

Because of its labor intensity, cacao is a crop for small-scale farmers and they the financing needed to cover the higher establishment and operating costs of intensive, shade-grown production. Small-scale cacao farmers also need training and extension services and may need help in overcoming input supply problems. Hybrid and improved, open-pollinated varieties comprised a relatively small portion of the total planted area of cacao. Although three major sustainable cacao certification systems were operating in Ghana, much of the certified cacao was sold without any price premium and price premiums for certification were generally only available to cooperatives. Many cacao farmers, particularly women, only had access to land under sharecropping arrangements that reduced their incentives for higher yields.

3.9 COST-BENEFIT ANALYSIS OF HOUSEHOLD COOKING FUEL PRODUCTION AND USE IN LILONGWE, MALAWI

CEADIR compared the financial and economic costs of charcoal production in three types of charcoal kilns (traditional earth mound, brick kiln, and portable steel drum kiln). It also analyzed the financial and economic costs of using various household cook stoves and fuels in Lilongwe, the capital and largest city in Malawi:

- Wood burned over a three-stone stove (open fire) at a very low fuel efficiency;
- Wood burned in an improved, all-ceramic stove (Chitetezo Mbaula) at a moderately low efficiency;
- Charcoal burned in a local artisan produced Kenya ceramic-lined metal jiko (KCJ) at a medium fuel efficiency;
- Charcoal burned in three imported, mass manufactured stoves (the medium fuel efficiency Envirofit SmartSaver, higher fuel efficiency Jikokoa, and highest fuel efficiency EcoZoom Jet);
- Bambriq briquettes of compressed, pyrolyzed bamboo and acacia wood burned in the KCJ;
- Malasha briquettes from carbonized agricultural wastes burned in the KCJ;
- Biogas stove;
- Liquefied petroleum gas (LPG) stove; and
- Single-burner hotplate run on grid electricity.

The economic analyses of kilns and stoves and fuels included producer or household costs plus the social costs of GHG emissions, mortality risks from fine particulate ($PM_{2.5}$) emissions, and forest product revenue losses from unsustainable wood harvesting. Since most Lilongwe households cook with wood or charcoal outdoors, $PM_{2.5}$ exposures were relatively low.

CEADIR also analyzed the financial and economic viability of commercial plantations of a fast-growing tree (*Grevillea robusta*) and a noninvasive bamboo species (*Dendrocalamus asper*) for sustainable fuelwood or charcoal production. For kilns and stoves and fuels, the time horizon was 10 years for the financial analysis and 50 years for the economic analysis. The time horizon was 50 years for the financial and economic analysis of the plantations.

The brick kiln had by far the lowest financial costs per unit of production, followed by the earth mound kiln and the steel drum kiln. Lower unit costs were associated with larger production volumes (capacity per cycle and number of cycles per year). The three kilns had the same cost rankings in the economic and financial analyses, but, the discounted economic costs were substantially higher. The brick kiln had the lowest discounted economic costs per ton of charcoal, followed by the earth mound kiln, and the small steel drum kiln. However, the substantial potential cost savings from the brick kiln can only be realized if charcoal producers can afford the much higher, initial capital costs.

Most households in Lilongwe bought charcoal daily in small quantities at a high unit price because it required a large share of their daily budgets. Some households bought charcoal locally in bulk at a lower unit price. CEADIR included high and low unit prices of charcoal in the analysis. Electricity prices were relatively low due to the abundance of hydropower. At the low unit price of charcoal, the discounted financial costs were lowest with charcoal in the EcoZoom Jet stove, followed by the electric hotplate, and charcoal in the other three stoves. LPG had higher discounted financial costs than cooking with charcoal, but lower than briquettes in the KCJ, and wood in an improved woodstove. Biogas was the second most expensive option. At the high unit price of charcoal, the electric hotplate had the lowest discounted financial costs, followed by charcoal in the EcoZoom Jet, LPG, and the other charcoal stoves. The discounted financial costs were highest for wood in the three-stone stove, biogas, briquettes, and wood in an improved stove.

Many of the rankings changed in the economic analysis. The electric hotplate became the least-cost option, followed by the LPG stove although it was almost twice the cost of the hotplate. The third lowest discounted economic costs were for charcoal in the EcoZoom Jet stove, closely followed by biogas, and charcoal in relatively fuel-efficient stoves. Wood and briquettes remained the highest economic cost options. Charcoal in the KCJ stove was the fifth costliest option.

Plantations can reduce deforestation and forest degradation by achieving higher wood yields than natural forests. The financial NPV of tree plantations was negative due to the conservative assumed yields and low stumpage price of wood for charcoal production in Malawi. Bamboo plantations had a positive financial NPV because of much higher yields. Per hectare, bamboo plantations store more carbon than tree plantations, substantially increasing their economic NPV. At a social cost of carbon of \$8/tCO_2e, the economic NPV of the tree plantation was slightly negative, but bamboo plantations had a positive economic NPV. The tree and bamboo plantations had substantially higher economic NPVs at the higher social cost of carbon values and lower discount rates.

The analyses led to the following recommendations:

- Test the Casamance kiln, a low-cost earth mound kiln with a chimney and better air circulation to improve the carbonization efficiency and quality of the charcoal;

- Estimates of the impact of changing household cooking fuels and stoves need to account for the multiple fuels and stoves used by many urban households;
- Promote cleaner combustion technologies and substitution of charcoal, fuelwood, and briquettes with alternative fuels to reduce the economic costs of GHG emissions and health risks from fine particulate exposures;
- Promote electric hotplates;
- Consider the potential for large increases in world market prices of petroleum and LPG and quantify the lifecycle GHG emissions to more accurately assess the true economic costs of LPG use;
- Quantify and value other ecosystem service losses associated with unsustainable wood harvesting for woodfuels;
- Continue promoting adoption of more efficient wood and charcoal stoves;
- Assess the ongoing experience with commercial production and distribution of biogas before promoting expansion; and
- Improve the financial incentives for commercial tree plantations for fuelwood and charcoal production.

3.10 COST-BENEFIT ANALYSIS OF HOUSEHOLD COOKING FUEL PRODUCTION AND USE IN LUSAKA, ZAMBIA

CEADIR compared the financial and economic costs of charcoal production in three types of charcoal kilns (traditional earth mound, brick kiln, and portable steel drum kiln). It analyzed the financial and economic costs of using various household cook stoves and fuels in Lusaka, the capital and largest city in Zambia:

- All-metal, Traditional Mbaula charcoal stove;
- All-metal, Improved Mbaula charcoal stove made by informal sector artisans;
- Imported, mass manufactured, fuel efficient EcoZoom Jet charcoal stove;
- Ethanol gel stove;
- Liquefied petroleum gas (LPG) stove; and
- Single-burner hotplate run on grid electricity.

CEADIR also analyzed the financial and economic viability of commercial plantations of a fast-growing tree (*Grevillea robusta*) and a noninvasive bamboo species (*Dendrocalamus asper*) for charcoal production. For kilns and stoves and fuels, the time horizon was 10 years for the financial analysis and 50 years for the economic analysis. The time horizon was 50 years for the financial and economic analysis of the plantations.

The economic analysis of kilns and stoves and fuels included producer or household costs plus the social costs of GHG emissions, mortality risks from $PM_{2.5}$ emissions, and forest product revenue losses from unsustainable wood harvesting. Since most Lusaka households cook with wood or charcoal outdoors, $PM_{2.5}$ exposures were relatively low.

Per unit of charcoal produced, the earth mound kiln had the lowest financial costs, with substantially higher costs for the brick kiln and enormously higher costs for the steel drum kiln. Earth mound kilns were relatively large in Lusaka District, with a capacity of 125 m^3 of wood. There are no capital costs for a traditional earth mound kiln, just labor costs for rebuilding the kiln each production cycle. The brick kiln had relatively high capital costs and a smaller capacity -- 45 m^3 of wood. The single steel drum kiln had low capital costs, but a tiny production capacity of only 0.058 m^3 of wood. Since the steel drum kiln is portable, it can be moved near sources of wood, but that is only a major advantage in areas where wood is very scarce or access to natural forests is well controlled. The brick kiln had the lowest discounted economic costs because of the lower social cost of GHG emissions than the earth mound kiln.

Most households in Lusaka bought charcoal daily in small quantities at a high unit price because it required a large share of their daily budgets. Some households bought charcoal locally in bulk at a lower unit price. CEADIR included high and low unit prices of charcoal in the analysis. Electricity prices were relatively low due to the abundance of hydropower.

The electric hotplate had the lowest discounted financial costs, followed by the EcoZoom Jet charcoal stove. The Improved Mbaula was less fuel-efficient and more expensive than the Traditional Mbaula, but had a longer expected life and lower $PM_{2.5}$ emissions. Cooking with ethanol or LPG had the highest discounted financial costs by far. The financial cost rankings of the six stoves and fuels were the same at the high and low charcoal prices.

The discounted economic costs of the stove and fuel combinations were higher than the discounted financial costs because of the environmental and social costs and the rankings differed. The charcoal stoves did not rank as well in the economic analysis. The higher charcoal price increased the discounted economic costs of the charcoal stoves, but the economic cost rankings were the same at both charcoal prices. The electric hotplate remained the least-cost choice in the economic analysis. The LPG stove ranked second, but was over six times more expensive than the electric hotplate.

The financial net present value (NPV) of *Grevillea robusta* tree plantations was negative (-$473/ha) due to the low, government-administered stumpage price of wood and relatively low yields assumed. The financial NPV of *Dendrocalamus asper* plantations was also negative (-$185/ha) because the bamboo stumpage value was based on the government-administered wood price adjusted for the differences in the heating value of bamboo and wood. The financial results were less negative for the bamboo plantations because of its substantially higher assumed yield. Lower discount rates made the financial NPV of the tree plantations more negative because of continuing financial losses over time. However, lower discount rates improved the financial NPV of the bamboo plantations. When a higher wood stumpage price of $12.75/$m^3$ was combined with a 7 percent discount rate, the *Grevillea robusta* plantations had a positive NPV of $194 per hectare. Even at a wood stumpage price of $8.50/$m^3$, the *Dendrocalamus asper* plantation had a positive NPV of $285/ha at the 12 percent discount rate.

Inclusion of the GHG benefits resulted in positive economic NPVs for both types of plantations. At a low social cost of carbon of \$8/tCO_2e and the 12 percent discount rate, economic NPV was \$194/ha for *Grevillea robusta* plantations and \$1,336/ha for *Dendrocalamus asper* plantations. At the \$51/tCO_2e social cost of carbon, the economic NPVs skyrocketed to \$3,778/ha for wood plantations and \$9,515 for bamboo plantations at the 12 percent discount rate.

CEADIR noted the following conclusions, recommendations, and research needs:

- There is still considerable uncertainty about the average, annual amount of cooking fuel used by households in Lusaka and other locations in Zambia;
- Charcoal kiln sizes and their capital and operating costs vary locally and should be validated in further studies. The initial capital costs of more efficient kilns are an obstacle to adoption by informal sector producers.
- Estimates of the impact of changing household cooking fuels and stoves need to account for the multiple fuels and stoves used by many urban households;
- Promote cleaner combustion technologies and substitution of charcoal with alternative fuels, to reduce the economic costs of GHG emissions and health risks from fine particulate exposures;
- Promote adoption of electric hotplates;
- Efficient charcoal stoves can reduce household cooking fuel costs over a relatively short time. Most households in developing countries are not concerned about the social cost of their GHG emissions in cooking. However, lessons learned from other improved stove projects, including the importance of high quality, mass manufactured stoves over low quality stoves from local artisans should be assessed.
- The high financial costs of ethanol gel and LPG stoves and fuel are serious constraints to household adoption;
- Quantify the lifecycle costs of LPG to more accurately assess the true economic costs of LPG stove utilization;
- Government or donor subsidies to make LPG more affordable are likely to increase net GHG emissions even if they reduce deforestation and forest degradation from woodfuel use. USG policy has changed and USAID will need to avoid subsidizing consumption of fossil fuels, including LPG fuel or stoves.
- The Government of Zambia should substantially increase government stumpage prices for wood sales;
- Assess land availability for plantations and integrated charcoal production;
- Collect data on the growth rates, biomass characteristics, and potential for multiple products from various tree and bamboo species in plantations and agroforestry systems in other countries with similar agroclimatic and soil conditions;

- After identifying species with the best potential for particular locations in Zambia, test their survival and growth rates within the country under various management practices. Assess the costs and benefits of specific management practices to prepare recommendations for a range of sites and species.
- Trees grow slowly and wood for fuel use or charcoal production is a relatively low value product. he USAID (2015) guidelines for cost-benefit analysis recommend a 12 percent real discount rate for economic analyses. This is much higher than the typical economic returns from plantation forestry investments. Commercial forestry projects are generally analyzed at discount rates substantially lower than 12 percent.
- The global benefits of reducing GHG emission by obtaining biomass for charcoal production from sustainable tree or bamboo plantations instead of natural forests can provide a strong economic justification for greater international development assistance support and access to REDD+ and voluntary carbon offset markets.

3.11 ACCELERATING PRIVATE INVESTMENT FOR SUSTAINABLE LANDSCAPES IN SOUTH AND SOUTHEAST ASIA

CEADIR worked to accelerate private sector investments for climate change mitigation in agriculture, forestry, and land use in South and Southeast Asia, with a particular focus on Cambodia, Indonesia, the Philippines, and Vietnam. Key outputs included

- Analysis of the NDCs of the four countries and other national and sectoral plans and priorities for climate change mitigation and opportunities for private investment;
- Analysis of private sector investment and finance commitments to scale up climate-smart agriculture and forestry, to identify key players and effective pathways for strengthening public-private sector engagement;
- Convening private sector and government leaders to discuss NDCs; identify and priorities for private investment that contributes to achievement of the NDC targets; and develop regional and country-specific recommendations to accelerate financing;
- Analysis of country-specific needs to accelerate private investment in climate-smart agriculture and forestry and increase public-private sector coordination and analysis of business models for private investment in sustainable landscapes;
- Engaging broader regional and global audiences of private sector stakeholders and development assistance organizations.
    - Convening Private Sector Investment in Climate-Smart Commodity Production in Southeast Asia (March 29, 2017). CEADIR organized this conference in Bangkok with 88 participants from international and domestic companies, partner governments, and development assistance organizations. Participants identified the top five constraints on private investment in climate-smart

agriculture and forestry; recommended roles for governments and donors to address these challenges; and created a network of private sector leaders for engagement with governments and donors in the region.

- Scaling Up Private Sector Investment and Finance for Sustainable Landscapes in Southeast Asia (May 25, 2017): Webinar with 77 participants from 23 countries.
  - Accelerating Investment for Climate-Smart Agriculture and Forestry in Asia (April 26, 2018): Webinar with 82 participants from 17 countries.
  - Climate Action for Agriculture in Asia (October 10-12, 2017): FAO-funded workshop in Bangkok with CEADIR leading the third-day discussions on for climate-smart agricultural investments.
  - Briefers with country-specific recommendations for increasing investments in climate-smart agriculture and forestry in Cambodia, Indonesia, Philippines, and Vietnam;
  - CEADIR engaged with other strategic partners, including the USAID-funded Green Invest Asia Activity.

3.12 LINKS TO SUSTAINABLE LANDSCAPES PRODUCTS

TABLE 2: Selected Sustainable Landscapes Products

PRODUCTS
The Impacts of Rural Road Development on Forests, Greenhouse Gas Emissions, and Economic Growth in Developing Countries
Greenhouse Gas and Other Environmental, Social, and Economic Impacts of Hydropower: A Literature Review
Mangrove Ecosystem Valuation: Methods and Results
The Value of Climate-Smart Cacao Production: A Literature Review
Cost-Benefit Analysis of Mangrove Restoration for Coastal Protection and an Earthen Dike Alternative in Mozambique
Cost-Benefit Analysis of Mangrove Conservation Versus Shrimp Aquaculture in Bintuni Bay and Mimika, Indonesia
Cost-Benefit Analysis of Improved Livestock Management Practices in the Oromia Lowlands of Ethiopia
Cost-Benefit Analysis of Improved Cacao Production Methods in Ghana
Cost-Benefit Analysis of Charcoal and Wood Use for Household Cooking and Demand- and Supply-Side Alternatives for Forest Conservation in Lilongwe, Malawi

Cost-Benefit Analysis of Charcoal Use for Household Cooking and Demand- and Supply-Side Alternatives for Forest Conservation in Lusaka, Zambia

Recommendations to Accelerate Private Investment in Climate-Smart Agriculture and Forestry Production in Cambodia, Indonesia, the Philippines, and Vietnam

Enabling Private Sector Climate-Smart Agriculture and Forestry Investment in Southeast Asia: Forest Stewardship Council

Enabling Private Sector Climate-Smart Agriculture and Forestry Investment in Southeast Asia: Sustainable Rice Platform

Assessing Capacity Development Needs for Climate-Smart Forestry and Agriculture:
Snapshots of Cambodia, Indonesia, the Philippines, and Vietnam

Recommendations to Accelerate Investments in Climate-Smart Agriculture and Forestry Production:
Cambodia, Indonesia, the Philippines, and Vietnam

Convening Private Sector Investment in Climate-Smart Commodity Production in Southeast Asia

4. CLIMATE ADAPTATION

HIGHLIGHTS: CLIMATE ADAPTATION

- Developed 10 public-private partnerships for disaster risk reduction and climate adaptation in four cities in India
- Training and analysis for climate adaptation and financing for sustainable livelihoods in Madagascar
- Presentations at four National Adaptation Plan Global Network events
- Training and TA for National Adaptation Plans in Peru and Senegal

4.1 PUBLIC-PRIVATE PARTNERSHIPS FOR DISASTER RISK REDUCTION AND CLIMATE RESILIENCE IN FOUR CITIES IN INDIA

India is highly vulnerable to floods, cyclones, tsunamis, and droughts and could tap the substantial capabilities and resources of the private sector to improve disaster risk reduction (DRR) and response. In June 2016, USAID/India awarded a grant to the United Nations Development Program (UNDP) for the Developing Resilient Cities through Risk Reduction to Disaster and Climate Change activity. In 2017, USAID/India requested that CEADIR collaborate with UNDP in helping to develop public-private partnerships (PPPs) for disaster risk mitigation (DRR) and climate change adaptation in Cuttack, Navi Mumbai, Vijayawada, and Visakhapatnam.

India's Companies Act of 2013 requires formal sector companies to make corporate social responsibility (CSR) contributions of two percent of their average net profits each year. These contributions must provide economic, social, or environmental benefits and cannot support the company's own direct business interests. CEADIR collaborated with The Energy and Resources Institute (TERI) in India to identify and design specific opportunities for urban DRR investments and help the cities leverage CSR funds through PPPs. The PPPs were supported by CSR funds from private sector companies, public financing from municipal budgets, and a project challenge fund.

These PPPs addressed diverse local priorities such as reducing flood risks through better solid waste management, municipal plans and strategies for disaster risk reduction, emergency response operations, mapping of critical community facilities and evacuation routes, rehabilitation of community facilities for community shelters, public awareness, and resilience to extreme heat events. The 10 PPPs are listed below:

Cuttack

- Decentralized municipal solid waste management to reduce flood risks

Vijayawada

- Mapping critical community facilities
- Information, education, and communications for disaster risk reduction
- Increasing community resilience to heat stress
- Reducing heat stress for outdoor workers

Visakhapatnam

- Developing a health information management system for disaster risk reduction
- Integrating emergency health services in the City Operations Centre

- Mapping critical community facilities
- Rehabilitating critical community facilities for disaster shelters
- Information, education, and communications for community disaster response

After CEADIR assistance ended, UNDP continued working to develop an additional PPP in Navi Mumbai.

4.2 TRAINING AND ANALYSIS ON CLIMATE ADAPTATION AND FINANCING FOR SUSTAINABLE LIVELIHOODS IN MADAGASCAR

Madagascar is highly vulnerable to climate stressors, that threaten its rich biodiversity and the natural resource base for rural livelihoods in this low-income country. USAID/Madagascar had two current activities, Hay Tao and Mikajy, working to improve sustainable natural resource management for rural livelihoods and biodiversity conservation. It asked CEADIR to increase the capacity of the two activities to assess climate adaptation and financing opportunities for sustainable livelihoods in key value chains and promote subnational government and private sector perspectives in Madagascar's National Adaptation Plan (NAP) process. The USAID GCC Office agreed to provide the funding.

A joint CEADIR and USAID/W team and two local consultants delivered a two-day training-of-trainers (TOT) in Antananarivo for the staff of Hay Tao, Mikajy, and other USAID partners. The ToT covered identification and analysis of options for integrating climate adaptation into sustainable livelihoods and biodiversity conservation, methods for stakeholder engagement in local adaptation plans, and lessons learned from experiences with conservation enterprises and climate adaptation in other countries. The training also included modules on cost-benefit and cost-effectiveness analysis, and economic valuation of the environment and natural resources to support other work of the Hay Tao and Mikajy activities. The ToT served 22 participants from Hay Tao and Mikajy and their partners (evenly split between men and women).

The CEADIR and USAID/W team then helped the trained Hay Tao and Mikajy staff apply what they had learned in the ToT in their own two-day Sava Region workshop in Antalaha the following week. The main purposes of the Climate Change Adaptation and Value Chains Workshop for the Sava Region were to raise awareness about climate vulnerability and identify priority climate adaptation measures for the four key local value chains -- vanilla and cloves, small livestock, fisheries, and ecotourism. The Antalaha workshop brought together 25 participants from private companies, farmers, local associations, district and municipal government units, and NGOs. The Antalaha workshop identified needs for additional support in climate data, preparation of vulnerability assessments, and the mainstreaming of adaptation in subnational development plans and sectoral strategies. Key findings from the workshop:

- The types of inputs and enabling conditions needed were similar across the four value chains -- the natural environment and infrastructure services (sufficient supplies of clean water, transportation, and electricity).
- Although certain stressors were more important than others in particular value chains, most climate stressors and their potential impacts had major consequences across value chains. Cyclones and flooding were particularly important risks in the Sava region. Other

common risks were high rainfall events and temperatures as well as droughts.

- Most participants considered non-climate stressors to be more urgent than most climate stressors. These non-climate stressors included environmental degradation, corruption, pollution, and inflation. Some participants found it difficult to separate climate and non-climate stressors because of their combined impacts.
- Climate impacts varied, but were often related quality and quantity of agricultural and fisheries products, the degradation of biodiversity and the surrounding environment, and loss of income for communities.
- Adaptation measures should address climate and non-climate stressors. There have been efforts to respond to cyclones, but more needs to be done to protect people and key value chains in the region. Many of these adaptation measures identified were related to avoiding the disruption of value chain services and economic delivery.
- Some workshop participants recommended that Local Committee in Disaster Risk Management lead planning and implementation of climate sensitization, vulnerability assessments, and adaptation measures.
- Weak institutional and legal frameworks often constrain implementation of climate adaptation measures. Since no single organization is responsible for coordinating and implementing adaptation measures, future actions are uncertain.
- Small farmers do not have access to technical advice and guidance, financing, and insurance that would allow them to respond to climate changes flexibly.
- Climate data quality and accessibility are insufficient to enable farmers to improve resilience through adaptation (e.g., product diversification, protective measures, improved storage, and value-added processing).
- The Sava region has benefited from some prior NGO support in private sector engagement in climate adaptation planning. However, NGOs are often dependent on relatively short-term, donor project funding and lack the financial resources to continue work over the long term.
- The development of strategic links between national and subnational adaptation planning is a key issue for the NAP process in Madagascar. To date, the formal NAP process has involved limited consultations at the local level.

After the regional workshop, CEADIR hosted a one-day training in Antananarivo on climate finance. The Climate Finance Workshop served 24 participants, including USAID/Madagascar staff and partners and national government staff. This training provided background on financial terms and instruments and options for mobilizing public and private sector finance for climate adaptation and sustainable landscapes. It addressed ways to increase obtain financing from international funds, development assistance organizations, REDD+ programs, and international and domestic private investment. Participants learned about examples of how various options for increasing climate finance have been tested or scaled and examples of climate mitigation and adaptation projects around the world. This training helped participants increase their understanding of opportunities and challenges for accessing different types of funds and provide recommendations for potential pathways to improve the enabling environment, strengthen capacity and information, and leverage and access climate finance instruments.

CEADIR also conducted a subsequent half-day training on climate vulnerability assessments and climate risk screening. It also prepared a report on integrating climate adaptation in biodiversity, agriculture, and fisheries policies, plans, and strategies at the regional and local levels and the potential for obtaining financing from impact investors.

A single report discussed all of CEADIR's work in Madagascar. The report contains annexes with links to the training presentations in English and French as well as the recorded presentations.

4.3 PRESENTATIONS AT FOUR NATIONAL ADAPTATION PLAN GLOBAL NETWORK EVENTS

The National Adaptation Plan Global Network (NAPGN) was established in 2014, with support from the U.S. Department of State and German Federal Ministry of Economic Cooperation and Development. It supports national adaptation planning through peer learning and exchanges, and improved coordination and support for NAP development and implementation in selected partner countries. The International Institute for Sustainable Development serves as the secretariat for the network. With USAID GCC Office funding, CEADIR delivered presentations at four NAPGN events:

- Targeted Topics Forum: Financing National Adaptation Plans-Options for Implementation, Kingston, Jamaica, March 2016. Presentation on "Engaging the Private Sector for NAP Implementation: The Role of the Public Sector."
- Caribbean NAP Assembly, St. George's, Grenada, October 2016. Presentation on financing building blocks and facilitated small group discussions on NAP financing strategies and mechanisms.
- NAP Assembly: Advances and Challenges of the National Adaptation Plan for Climate Change, Lima, Peru, December 2016. Presentation on "From Planning to Implementation: Towards a NAP Financing Strategy."
- Targeted Topics Forum: Financing National Adaptation Planning Processes, Mexico City, Mexico, June 2017. Presentation on "Addressing Financing in the National Adaptation Planning Process in Peru."

4.4 TRAINING AND TA FOR PERU'S NATIONAL ADAPTATION PLAN

In 2016, Peru's Ministry of Environment (MINAM) was given lead responsibility for drafting a National Adaptation Plan (NAP). The plan was intended to describe climate vulnerabilities and impacts in five priority sectors (agriculture, fisheries and aquaculture, water, forests, and health) and establish adaptation goals for each of these sectors. In December 2016, MINAM and the NAP Global Network (NAPGN) co-organized a workshop to identify institutional arrangements and technical assistance partners to support activities to finalize the NAP. MINAM requested CEADIR assistance in developing a NAP financing strategy and the USAID GCC Office agreed to fund this work.

Initially, CEADIR TA was limited to helping MINAM and the NAP working groups develop a financing strategy for adaptation in the five sectors: 1) assessing the enabling environment, capacity development and information, and financing instruments and markets for adaptation; 2) developing options for strengthening these finance building blocks; 3) identification and assessment of measures to meet adaptation goals; and 4) analysis of options for financing the adaptation measures.

At an early stage of the work, MINAM asked CEADIR to provide additional support for the adaptation project development process, rather than developing a full financing strategy. CEADIR then developed a work plan that involved extensive stakeholder engagement to identify and develop preliminary profiles of sector-level adaptation measures.

CEADIR organized two multi-day workshops to identify and assess priority adaptation measures and potential financing sources in the five sectors. Participants divided into separate working groups to develop profiles of adaptation measures in each of the sectors. The profiles were expected to include information on specific programs and projects (including implementing entities; duration; expected results; qualitative descriptions of benefits and co-benefits; qualitative descriptions of costs or quantitative cost estimates; and potential sources of financing).

At the first workshop in March 2017, CEADIR spent three days assisting the three working groups on health, agriculture, and fisheries and aquaculture. These three working groups developed profiles for adaptation projects (13 for health, 3 with multiple components for agriculture, and 10 for fisheries and aquaculture).

During the second workshop in August 2017, CEADIR spent two days working with the two working groups on water and forests. At MINAM's request, the second workshop was shorter than the first so the working groups had less time to develop the profiles. Both the water and forests working groups developed two profiles for adaptation projects.

Drawing from the draft NAP, sector development strategies and plans, and the sector profiles, CEADIR developed adaptation portfolios for the health, agriculture, and fisheries and aquaculture sectors. The sector portfolios contained background on the development context, climate vulnerabilities and impacts, adaptation goals, and institutional structure and capacity for responding to climate change. CEADIR also identified public and private sector financing mechanisms and instruments for funding adaptation projects and conducted a preliminary assessment of the adaptation finance building blocks. However, further progress during the period of CEADIR's involvement was slowed by political changes in the Government of Peru and personnel changes in MINAM.

4.5 TRAINING AND TA FOR NATIONAL ADAPTATION PLAN FINANCING IN SENEGAL

USAID/Senegal requested USAID GCC Office funding to enable CEADIR to provide training on climate adaptation financing for fisheries and agriculture sectors to Government of Senegal (GoS) staff, in collaboration with the USAID-funded Collaborative Management for a Sustainable Fisheries Future (COMFISH Plus) Activity. The GoS had already completed its first sectoral NAP, addressing fisheries, but had not yet begun preparing a NAP for agriculture.

In June 2018, CEADIR delivered this training for representatives of the National Committee on Climate Change, the National Platform for Fisheries and Climate Change, the Ministry of Fisheries and Marine Economy, and the Ministry of Environment and Sustainable Development. There were 65 participants at the three-day training workshop. The participants with responsibilities for fisheries were divided into three working groups. Each of these three working groups designed a potential adaptation project for fisheries consistent with the sectoral NAP, including an estimated budget and potential sources of financing. The working group on agriculture described climate impacts and vulnerabilities, adaptation objectives, and potential adaptation actions for inclusion in the NAP for the sector.

4.6 LINKS TO CLIMATE ADAPTATION PRODUCTS

TABLE 3: Selected Climate Adaptation Products

PRODUCTS
Public-Private Partnerships for Disaster Risk Reduction and Climate Resilience in Four Cities in India
Local Governance and Private Sector Opportunities for Climate Adaptation, Sustainable Livelihoods, and Biodiversity in Madagascar
Engaging the Private Sector for NAP Implementation: The Role of the Public Sector

5. CROSS-CUTTING WORK ON CLIMATE FINANCE

HIGHLIGHTS: OTHER CROSS-CUTTING SUPPORT FOR CLIMATE FINANCE

- Assessed options for development assistance organizations to increase public and private sector financing for clean energy, sustainable landscapes, and climate adaptation
- Conducted a climate finance situation analysis for the Government of Bangladesh
- Prepared a market assessment for green bonds in Peru
- Developed a roadmap for issuing a climate bond

5.1 CLIMATE FINANCE ASSESSMENT

Available development assistance resources for financing climate change mitigation and adaptation are small relative to the amounts needed to solve the problems. National governments have multiple, urgent, competing needs for public expenditures, recently exacerbated by the global pandemic and economic recession. Private sector investment already exceeds international and domestic public sector investment in renewable energy. Greater private sector engagement, more access to international and domestic capital markets, and new sources of financing from institutional investors and impact investors are needed. Development assistance organizations can play a major role in helping partner countries leverage new private sector financing, but will have to adopt new approaches to scale up the impacts. There are some common challenges and opportunities for increasing investment in clean energy, sustainable landscapes, and adaptation, but also some key differences.

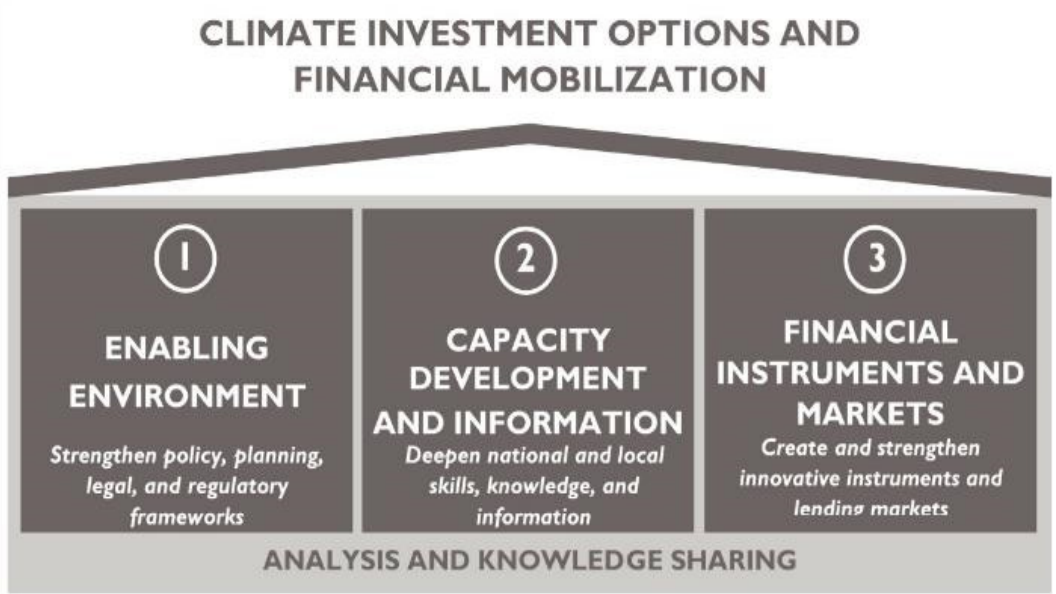
- **Clean energy**: Renewable energy is now more economically and financially viable than nonrenewable sources in many cases. However, barriers remain in the incentives and disincentives for suppliers and consumers, awareness of the benefits and costs of RE and EE, bank willingness to provide appropriate loan products, capacity and interests of government agencies and utilities, and use of public-private partnerships (PPPs) and innovative procurement approaches to increase competition.
- **Sustainable landscapes**: Many investments in forestry, agriculture, and other land uses can increase productivity and profitability while reducing GHG emissions. However, it can take many years to recoup the capital costs of planting and maintaining trees. Many developing countries lack the resources and capacity needed to reduce deforestation and forest resource degradation. Greater investment in sustainable landscapes is often hindered by lack of clear land tenure or resource use rights. Furthermore, the environmental benefits of sustainable landscapes are often unquantified or are not valued in monetary terms.
- **Adaptation**: It is generally more cost-effective to prevent or reduce the negative impacts from climate variability or change since the economic damages from the impacts of these stressors can be quite large. However, the willingness to make adaptation investments is often limited by uncertainty about the types, extent, and timing of climate impacts. There are also challenges in identifying appropriate adaptation measures for the public and private sectors and estimating their potential benefits against their relative costs. As a result, most developing countries are not sufficiently well-adapted to existing climate variability (such as a typical five-year flood), let alone the projected impacts from potential future with climate changes.

This report discusses options for development assistance organizations to help national, subnational, and local governments; commercial banks; private companies; and communities scale up financing for clean energy, sustainable landscapes, and climate adaptation. These options can be applied across sectors, countries, and investment contexts under a variety of scenarios. This report categorized these options for development assistance organization support under three building blocks:

- **Enabling environment** (policy and regulatory framework and economic conditions) to increase incentives for public and private sector investment and reduce barriers;
- **Capacity development and information** (governments, public and private implementers, and investors to plan, design, implement, and finance climate investments); and

- **Financial instruments and markets**, including risk reduction (Figure 2).

FIGURE 2: Three Building Blocks of Climate Finance



Within each of these building blocks, CEADIR identified examples of opportunities for development assistance organizations to help scale up climate finance in clean energy, sustainable landscapes, and climate adaptation. In 2021, the USAID Energy Office asked the National Renewable Energy Laboratory (NREL) to assess opportunities for USAID to deepen support for financing clean efficiency, building off and updating the 2019 CEADIR Climate Finance Assessment and recent analyses of utility-scale solar and wind power, smart grids, and microgrids.

TABLE 4: Examples of Climate Finance Options

	ENABLING ENVIRONMENT	INFORMATION AND CAPACITY DEVELOPMENT	FINANCIAL INSTRUMENTS AND MARKETS
Clean Energy	• Create smart, competitive incentives for CE markets • Encourage robust fiscal, tax, investment, and legal policies • Standardize contracts and quality assurance programs • Foster PPPs • Align and integrate investment with climate strategies	• Rapid assessments of capacity gaps and programs • Improve quality, access, and use of CE resource information • Develop financial institutions' (FIs) capacity to increase CE lending • Support financing networks and platforms • Support CE innovation labs and business incubators	• Provide technical assistance for analyzing appropriate CE risk mitigants • Support CE lending facilities or funds • Support green credit lines in commercial or development banks • Support green bonds for CE lending • Support innovative payment systems for beyond-the-grid RE energy users
Sustainable Landscapes	• Support certifications and sustainability standards • Improve policies and incentives for SL investments • Foster PPPs • Develop SL investment strategies and financing plans	• Support innovation through labs and technology • Develop capacity in financing, implementation, and reporting for SL investments • Improve information collection, analysis, and dissemination on SL investments • Support climate finance readiness	• Support insurance and risk mitigants • Support loan aggregation and warehousing • Support payment for environmental services • Promote SL-focused funds
Adaptation	• Align adaptation financing with strategies, plans, and targets • Improve policies and incentives • Foster PPPs	• Increase adaptation finance readiness • Increase capacity for adaptation investment design, implementation, and M&E • Increase willingness and capacity of FIs to finance • Improve quality, accessibility, and use of climate information	• Provide technical assistance or grants for pre-investment work • Support investment funds and credit lines • Support insurance mechanisms

5.2 BANGLADESH CLIMATE FINANCE SITUATION ANALYSIS

USAID/Bangladesh asked CEADIR to assess the policy environment, institutional arrangements, and capacity of the Government of Bangladesh (GoB) to develop and implement climate change projects and manage climate finance in Bangladesh. This assessment consisted of a literature review and key informant interviews with donors, implementers, the Government of Bangladesh (GoB), and civil society representatives. CEADIR reviewed government policies, strategies, and plans as well as annual reports and assessment documents related to climate change finance and implementation. CEADIR focused the analysis on three general aspects of the climate-related finance experience: 1) enabling environment, 2) institutional structures and functions, and 3) institutional capacity. CEADIR reviewed government policies, actions, regulations, and strategies and the experience with domestic and external resources for climate finance.

CEADIR identified four priorities for improving climate finance in Bangladesh:

- Demonstrating greater political will by elevating climate changes issues in the development agenda and using the authority and convening power of government;
- Strengthening political and technical leadership on climate change to make better policy, regulatory, investment, and implementation decisions;
- Increasing coordination and collaboration of public sector institutions for cohesive and harmonized action; and
- Improving the accountability and transparency of government processes and systems for full compliance with international standards for financial management, reporting, and verification.

To address these priorities, CEADIR developed and analyzed five options to consider for strengthening climate finance in Bangladesh. The first option focused on addressing technical gaps in project preparation and analysis while the other four options were designed to improve the government's capacity to manage domestic and external climate finance:

- Establish a project preparation facility to improve the quality of projects developed by government ministries;
- Establish a Climate Change Commission as an apex institution to take a lead role in accessing and implementing climate finance;
- Establish a Climate Finance Board to set priorities for types and sources of external finance for climate change projects;
- Restructure the Bangladesh Climate Change Trust Fund as a national climate fund by diversifying its role in supporting public and private sector projects and capacity to obtain external and domestic funding; and
- Create a new National Climate Foundation or fund to manage climate finance as an independent entity replacing the Bangladesh Climate Change Trust Fund.

5.3 MARKET ASSESSMENT FOR GREEN BONDS IN PERU

A *green bond* is a tradeable debt security that finances investments with environmental benefits and complies with the International Capital Market Association's Green Bond Principles (https://www.icmagroup.org/green-social-and-sustainability-bonds/green-bond-principles-gbp/). Green bonds can be issued by governments, multilateral development banks, international, or corporations. They can raise large amounts of money from the capital markets for bank lending or other investments. However, they often require a minimum size of $80-100 million or more to attract investors and cover the costs of issuing a bond. Banks interested in refinancing their loan portfolios with a green bond may need government or multilateral development bank support to aggregate and warehouse loans until this volume of financing can be accumulated. Green bonds have generally not carried lower interest rates than similar conventional bonds because it is still a nascent market. However, it may be easier to sell a green bond to impact investors and international financial institutions than a conventional bond.

In 2014, the International Finance Corporation (IFC) issued the first green bond denominated in Peruvian soles. This AAA-rated, 20-year zero-coupon bond was for the local currency equivalent of $42 million. It offered no income during the bond life, but was priced to provide an implied yield of 5.3 percent per annum on maturity. The entire issuance was sold to Rimac Seguros, a domestic insurance company commited to incorporating environmental and social criteria in its investment decisions.

In 2015, USAID/Peru requested that CEADIR assess the market for green bonds to finance municipal investments in clean energy, sustainable landscapes, and climate-resilient transportation and water supply infrastructure. The USAID GCC Office agreed to fund this market assessment, which focused on:

- Legal/regulatory and financial impediments and incentives;
- Size and volume of potential green bond issuances for the domestic and regional capital markets;
- Regions and municipalities in Peru that could use green bonds to develop green infrastructure;
- Private sector companies that may be interested in developing green infrastructure projects;
- Available public information on national, department-level, and Inter-American Development Bank (IDB) pipelines of green infrastructure projects that could be financed through green bonds; and
- Potential inclusion of green bonds by the National Climate Change Management Program (NCCMP) and USAID/Peru program portfolio.

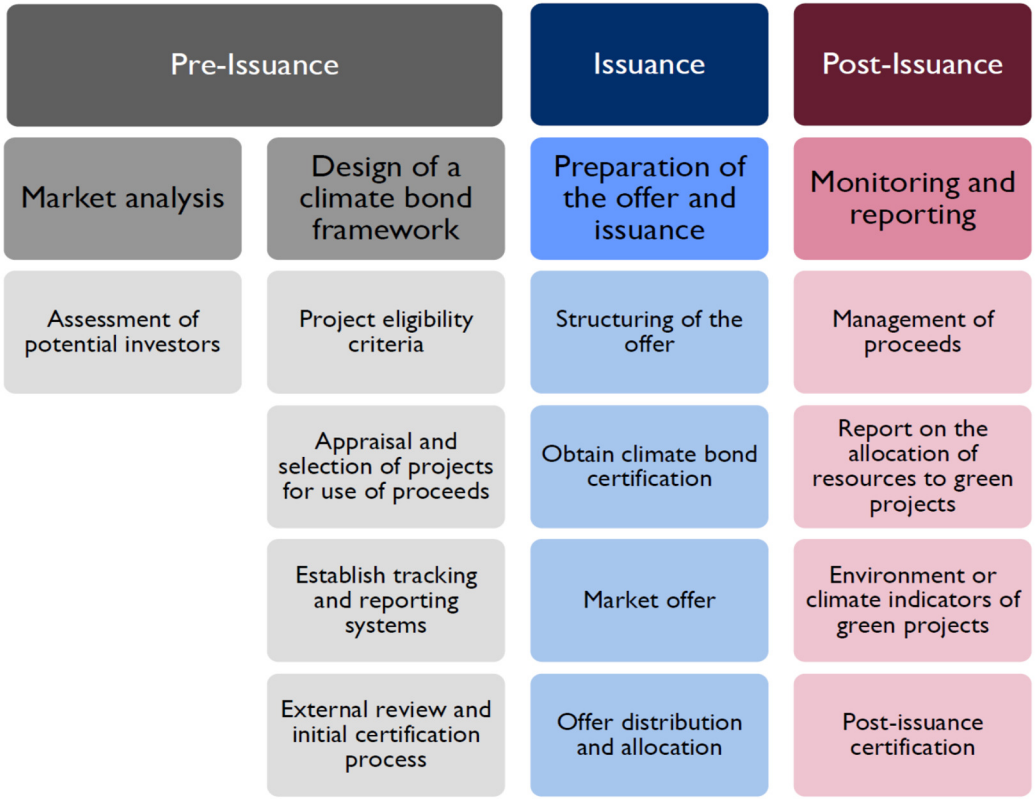
CEADIR found that there could be domestic capital market interest in green bond issuances in Peru, particularly by pension funds and insurance companies that need locally currency for annual expenditures. However, CEADIR concluded that most municipalities in Peru had not yet demonstrated the creditworthiness required to attract private sector buyers of green bonds, but offered recommendations for how cities could increase market interest in municipal bond issues in the future. CEADIR noted that national development banks could be viable issuers of marketable green bonds for the domestic market. In addition, a climate bond could be of interest to international investment funds and impact investors that emphasize environmental, social, and governance issues.

5.4 ROADMAP FOR ISSUING A CLIMATE BOND

A *climate bond* is a type of green bond that meets more rigorous climate qualification criteria of the Climate Bonds Initiative for specific sectors that have been developed or are pending (https://www.climatebonds.net/standard/available). Following the green bond market assessment discussed in the previous section, USAID/Peru provided CEADIR with funding to help a government development bank plan a green bond for clean energy denominated in local currency. However, institutional problems at that bank led USAID/Peru to recommend a different government development bank, Banco Agropecuario (AgroBanco), which expressed interest in 2017 in converting to a green bank and developing a climate bond to finance reforestation efforts by indigenous populations.

CEADIR prepared a roadmap for issuing a climate bond that could be useful for AgroBanco or any other bank. Figure 3 shows the general steps in issuing a climate bond. The roadmap contained detailed guidance on each of these steps, including a potential timetable.

FIGURE 3: Steps in Issuing a Climate Bond



5.5 NEEDS ASSESSMENT FOR ECONOMIC MODELING OF LOW EMISSION DEVELOPMENT STRATEGIES IN JAMAICA

Low emission development strategies (LEDS) integrate economic, social, and environmental objectives, including the reduction of greenhouse gas (GHG) emissions. There are often opportunities in developing countries to reduce economic costs by decreasing consumption of energy and improving natural resource management. LEDS modeling can help the private and public sectors identify these opportunities. LEDS economic modeling is a tool to assess various development pathways and policies consistent with economic growth and environmental objectives.

The Government of Jamaica (GoJ) requested USAID assistance in preparing a needs assessment for economic modeling of low emission development strategies (LEDS). USAID/Jamaica funded CEADIR to prepare this needs assessment with a particular focus on the energy, transport, solid waste management, and finance sectors. CEADIR subcontracted with the Caribbean Policy Research Institute (CAPRI) to conduct this assessment, which had the following objectives:

- Assess institutional awareness and capacity in LEDS and LEDS economic modeling and identify capacity needs;
- Conduct a data inventory to determine availability and suitability of data for LEDS modeling;
- Identify one or more models appropriate for LEDS planning work; and
- Identify policies and plans to be integrated into LEDS modeling work.

The needs assessment included the following conclusions:

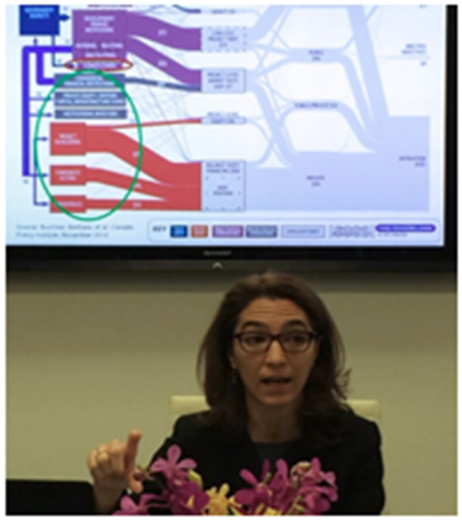
- **Awareness of LEDS and capacity in LEDS economic modeling in Jamaica was generally low.** LEDS economic modeling was not integrated into sectoral or economy-wide planning processes.
- **Good data were generally available for LEDS modeling in the energy sector (particularly for electricity generation, but needed to be improved for road transportation and other sectors).** LEDS modeling could be improved by greater harmonization of data with methods with methods recommended by the Intergovernmental Panel on Climate Change (IPCC).
- **The most feasible models for LEDS planning in Jamaica were T21-Jamaica and LEAP.** T21 is an economy-wide model developed specifically for Jamaica and used in academic institutions. LEAP is a user-friendly model developed by the Stockholm Environment Institute. LEAP initially focused on energy, but was later expanded to include forestry and other land uses and integrate with the WEAP model for water resources. Both models cover key sectors with sufficient granularity for GHG emissions modeling.

It also contained recommendations on capacity development, data needs, LEDS models, and policies for LEDS modeling, for specific governmental and nongovernmental entities in Jamaica.

5.6 LINKS TO CROSS-CUTTING FINANCE PRODUCTS

TABLE 5: Selected Cross-Cutting Climate Finance Products

PRODUCTS
Climate Finance Assessment: Opportunities for Scaling Up Financing for Clean Energy, Sustainable Landscapes, and Adaptation
Climate Finance in Bangladesh: Situation Analysis
Using Green Bonds and Other Financial Instruments to Develop Climate-Friendly Infrastructure in Peru
A Climate Bond Road Map for AgroBanco in Peru
Jamaica Low Emission Development Strategy Economic Modeling Needs Assessment



6. TRAININGS AND OTHER WORKSHOPS AND COMMUNICATION PRODUCTS

HIGHLIGHTS: TRAININGS AND OTHER WORKSHOPS AND COMMUNICATION PRODUCTS

- CEADIR convened a total of 33 in-person knowledge-sharing events and/or online webinars webinars between the CEADIR Series on "Navigating the Climate Economy" and the subsequent CEADIR/ClimateLinks Series. These events reached 2,700 participants directly, an average of 82 attendees per event. Additional audiences were reached through recordings and presentations posted on ClimateLinks.
- CEADIR and USAID/EP and GCC staff collaborated on two one-week trainings on the economics and planning of climate change mitigation and adaptation for USAID country and regional mission staff in Mozambique.
- A CEADIR consultant served as the chapter lead for the fourth National Climate Assessment chapter on the impacts of climate change on U.S. international interests
- CEADIR staff delivered presentations and led discussions in conferences organized by other USAID-funded activities and other development assistance organizations.

6.1 CEADIR SERIES: NAVIGATING THE CLIMATE ECONOMY

Between February 2015 and March 2019, CEADIR organized 27 discussion events. Most were in-person events in Washington, DC with additional online participation, including questions and answers. These events were labeled as the CEADIR Series on "Navigating the Climate Economy". A total of 2,000 participants from over 87 countries attended one or more CEADIR Series events was, an average of 74 participants per event. Over one-third of the participants joined more than one event.

The CEADIR series began with overviews of climate change economics and private investment and subsequently addressed specific financial instruments and mechanisms, financing sources, and case studies. It focused on

- Importance of engaging the private sector;
- The role of international and public climate finance;
- Specific financial instruments and sources;
- Climate planning processes at the national and subnational levels and inclusion of local civil society and vulnerable populations; and
- Financial and economic methods for analyzing the benefits and costs of climate-related investments.

Most of the early CEADIR Series events discussed the work of USAID, other USG agencies, development assistance organizations, or the private sector in clean energy, sustainable landscapes, climate adaptation, and climate-related financing. Many of the later events presented CEADIR analyses and experiences in implementation of TA work. Recordings of the CEADIR Series events are available at https://www.youtube.com/playlist?list=PLlx7qQJhxSJHA2g1YElNz2O2VcglYqydQ

CEADIR prepared a synthesis paper on the first 17 of the 27 events that identified the following common themes:

- Climate-related investment was rising, but still far short of the demand for mitigation and adaptation investments in developing countries.
- There was wider recognition of the importance of engaging with the private sector as an active partner as a source of capital and also for its ability to design and implement climate actions.
- Public financial institutions and international funds have been essential sources of climate finance. Although a small share of the global financial system, these efforts can help leverage much larger amounts of financing from commercial sources.
- Impact investors and private foundations have taken on an increasing role in climate-related finance. They were often willing to accept lower, but positive financial returns on investments with significant environmental or social benefits.
- Long-term asset managers (pension funds and insurance companies) could be potential sources of large amounts of additional capital for climate change mitigation and adaptation, but ways of attracting their interest needed further testing and implementation.

- Blended finance that mixes grants or concessional financing with market rate financing has become increasingly important. Over time, private sector investors are likely to provide an increasing share of climate-related financing.
- Creative financing approaches have evolved to address the gaps between the demand and supply of capital for climate change mitigation and adaptation. Examples of these innovations include green bonds, weather or resource-indexed insurance, and equity funds for renewable energy entrepreneurs.
- Finance alone was often not enough to bring about climate investments. Other barriers also need to be addressed, such as unfavorable policy and regulatory environments, the shortage of qualified developers, and risks unrelated to the project or technology, such as currency risks. These issues vary by region and country, and often require time and patience to resolve.
- Purely commercial approaches have not succeeded in addressing climate targets for and other land uses. Often, a mix of international and domestic public sector resources and private sector efforts is needed to address the needs of resource users and local communities in developing countries.
- Private sector activity has been much slower for adaptation to climate change and investment has lagged relative to mitigation. However, awareness of the need to take climate risks into account in business financial disclosures has increased.
- Many developing countries have demonstrated high-level commitments to climate change mitigation and/or adaptation, but implementation has lagged in some countries due to resource and capacity constraints. Outreach and consultation with a wide range of stakeholders including the private sector, local governments, and civil society are essential.
- More attention should be paid to the impacts of climate change on the poorest and most vulnerable populations and groups, including urban population in rapidly growing coastal cities and remote rural populations. Finding workable solutions for highly vulnerable groups is complex and intertwined with other development challenges.
- Many banks and investment management companies have been paying increasing attention to climate risks that may affect their portfolios.
- There is an increasing role for subnational governments, especially cities, in obtaining climate-related financing and as advocates and implementers for climate policies and solutions.

6.2 CEADIR-CLIMATELINKS SERIES

In 2020, CEADIR collaborated with the USAID-funded SEEK Activity on six webinars organized in conjunction with the Climatelinks website. These webinars addressed the following topics:

- Scaling Up Financing for Clean Energy, Sustainable Landscapes, and Adaptation;
- Mangrove Conservation Versus Shrimp Aquaculture: A Cost-Benefit Analysis;

- Using Parametric Insurance to Reduce the Risks of Utility-Scale Renewable Energy Resources;
- Improving Livestock Management for Higher Productivity and Climate Resilience (with the International Center for Tropical Agriculture [CIAT]);
- Creating a Level Playing Field for Utility-Scale Battery Energy Storage Systems; and
- Preparing Distributed Energy Resource Roadmaps and Plans.

The CEADIR-Climatelinks series reached 686 direct participants, an average of 114 at each event. Additional audiences benefited subsequently from the recordings and presentations posted at https://www.climatelinks.org/resources?f%5B0%5D=resources_project%3A1915&f%5B1%5D=resources_type%3A249#view

Photo credits: CEADIR

6.3 CEADIR/USAID TRAININGS ON ECONOMICS AND PLANNING FOR CLIMATE MITIGATION AND ADAPTATION

CEADIR collaborated with USAID EP and GCC Office staff on two major training courses for USAID regional staff in Maputo, Mozambique. The first course was on «Economics and Planning for Climate Change Mitigation» and was held on October 20-24, 2014. The presentations from the climate mitigation economics training can be obtained at https://drive.google.com/drive/folders/0B8r5H7GPqWjuWDdDNDFXTnJpRzQ or at https://dec.usaid.gov/dec/content/Detail_Presto.aspx?vID=47&ctID=ODVhZjk4NWQtM2YyMi00YjRmLTkxNjktZTcxMjM2NDBmY2Uy&rID=NTE2Mzkw. The second training covered "Economics and Planning for Climate Change Adaptation» and was held from October 27-31, 2014. The presentations from the climate adaptation economics training can be obtained at https://drive.google.com/drive/folders/0B8r5H7GPqWjuaGxzZmNMbUY1XzQ or at https://dec.usaid.gov/dec/content/Detail_Presto.aspx?vID=47&ctID=ODVhZjk4NWQtM2YyMi00YjRmLTkxNjktZTcxMjM2NDBmY2Uy&rID=NTE2Mzkx. Although the trainings were mainly for USAID staff, staff of some other donors and NGOs were invited to participate. Seven organizations provided participants in one or both of the courses. A total of 43 people were trained, including 22 women.

In 2020, GCC asked the USAID-funded Sharing Environment and Energy Knowledge (SEEK) Activity to work with the CEADIR COR, Eric Hyman, in preparing some online training course modules that built on and updated some of the Mozambique training materials and two later presentations based on the CEADIR Climate Finance Assessment.

6.4 FOURTH NATIONAL CLIMATE ASSESSMENT CHAPTER ON U.S. INTERNATIONAL INTERESTS

The U.S. Global Change Research Act of 1990 required the Executive Branch of the USG to prepare a National Climate Assessment (NCA) every four years. The USAID GCC Office asked a CEADIR consultant to serve as the lead author of a new chapter in the fourth NCA report (NCA4) on how climate change and variability affect U.S international. This report was published on November 23, 2018 and received widespread attention in the media within and outside the United States. Key findings of this chapter included

- U.S. trade has already been affected and will be experience larger, impacts in the future.
- Climate change can slow or reverse development in developing countries, increasing the need for humanitarian assistance and disaster relief.
- Climate change can exacerbate conflicts, in conjunction with other factors, Climate change is already affecting the military, and the military is planning for future change.

- Shared resources along our borders are vulnerable to climate impacts, and multinational frameworks governing such resources are accounting for climate change.
- International scientific cooperation significantly enhances understanding of climate variability and change in the United States.

6.5 OTHER PRESENTATIONS AT EXTERNAL CONFERENCES

Clean Energy

- Latin American and Caribbean Council for Renewable Energy's "Clean Energy Finance Summit" in Miami, June 2017: Several CEADIR consultants delivered presentations on the use of the AILEG Clean Energy Lending Toolkit in Central America; potential for green bonds in Latin America; implications of Nationally Determined Contributions for renewable energy financing; and climate financing opportunities from the Green Climate Fund, the Global Environment Facility, and Norfund.
- USAID-funded Clean Power Asia workshop on "Renewable Energy Auctions: A New Paradigm for Asia" in Manila, June 8, 2018: A CEADIR consultant discussed work on private sector feedback on the 2017 renewable energy auctions in Malaysia and Thailand.
- POWER-GEN Asia conference in Jakarta in September 2018: A CEADIR consultant presented "Renewable Energy Auctions: Lessons from Private Investors in Thailand and Malaysia."
- Asia EDGE Workshop on Best Practices for Designing Competitive Procurement of Renewable Energy in Bangkok November 20, 2019 organized by the USAID-funded Clean Power Asia and Scaling Up Renewable Energy Activities: CEADIR presented preliminary findings from its work on "Incorporating Battery Energy Storage in Renewable Energy Auctions."

Sustainable Landscapes

- Ecological Society of America Annual Meeting in New Orleans, August 2018: A CEADIR consultant and a former USAID/Mozambique staff person presented the cost-benefit analysis of mangrove restoration versus and earthen dike for flood protection in Quelimane, Mozambique.

Cross-Cutting Climate Finance

- The USAID COR presented the CEADIR Climate Finance Assessment at the global USAID Environmental Officer's Conference in Arlington, Virginia in July 2019 and at the virtual USAID Economic Growth Officer's Training in February of 2021. Two CEADIR consultants presented the Climate Finance Assessment at the online Annual Market Systems Symposium organized by EcoVentures International with USAID funding in May of 2021.

6.6 LINKS TO TRAINING AND OTHER WORKSHOP AND COMMUNICATION PRODUCTS

TABLE 6: Selected Training and Other Workshop and Communication Products

PRODUCTS
Individual CEADIR Series webinars
Synthesis of CEADIR Series Events: February 2015 – December 2016
CEADIR Navigating the Climate Economy webinars
Economics and Planning of Climate Change Mitigation (training presentations)
Economics and Planning for Climate Adaptation (training presentations)
U.S. National Climate Assessment Chapter on Impacts on U.S. International Interests

7. LESSONS LEARNED

7.1 LESSONS LEARNED ON CLEAN ENERGY

- Commercial banks in many developing countries were still hesitant about CE lending due to incorrect perceptions of the technology costs, business models, and risks. Partial loan guarantees can be helpful, but have not been sufficient by themselves in unlocking bank lending.
- Training and TA has helped change the perceptions of participating bank management and staff. The Clean Energy Lending Toolkit provided a useful common ground for starting, but the assistance had to be customized to the needs of specific banks and participants. This proved most effective when bank engagement lasted 18 months or longer, involved senior managers, and included bank commitments to collaborate.
- Bank staff often needed to see renewable energy technologies in use to gain greater confidence that the systems worked. Facilitating a dialogue between a bank and potential clients was also useful in designing loan products. However, some banks remained hesitant to finance suppliers of PayGo home solar systems for low-income customers due to concerns about the risks.
- Banks often reported a shortage of bankable loan applications.
    - TA to help potential bank clients prepare acceptable loan applications helped to stimulate some lending, but the process was relatively costly and time consuming.
    - CEADIR tested a pay-for-results approach to compensating local business development service (BDS) consultants based on milestones in the loan application development process, with the bulk of the payment provided for loan approval. This approach avoided unnecessary expenditures on unproductive efforts of the consultants. However, it may cause consultants to direct their time to applicants with the best prospects for loan approval, rather than the lowest-income clients. Furthermore, the BDS providers would only agree to this type of contract when the payments for successful resultss were relatively high. It is also unclear whether this approach could be rolled out on a large scale.
    - Matchmaking events that bring energy developers and suppliers together with banks and investors can stimulate clean energy financing.
- Many U.S. firms are interested in entering or expanding sales of utility-scale, renewable energy and smart grid and minigrid products and services in developing countries due to the large and growing markets. However, many U.S. firms but are unfamiliar with the opportunities, challenges, and risks in these markets and the services available from USG agencies and foreign embassies.
- Developing country stakeholders also want to learn about the technologies, business models, and institutional structures, and that have been successful in the US and other developing countries.
- Many policy reforms are still needed in developing as well as developed countries, such as removal of fossil fuel subsidies, the ability to charge cost-reflective tariffs for electricity, ending utility monopolies over power generation, separating power transmission and distribution services from generation, use of competitive auctions, establishment of wholesale power markets, and intranational or international transmission infrastructure and supply agreements.

- Renewable energy auction rules need to be clear and transparently administered. There are many different and complex ways of structuring auctions. Technology restrictions and domestic content requirements can lead to inefficiencies. There is an increasing trend toward transferring risks from the buyer to the suppliers, which will be reflected in price bids. Long-term power purchase agreements (15-20 years) with prices set in inflation-indexed U.S. dollars or euros are important for successful development of proposed projects.
- Utility-scale battery energy storage systems can make it feasible to increase renewable electric power generation and reduce or defer costly expansion of transmission and distribution networks, and increase the quality and reliability of electricity. BESS costs are expected to continue declining sharply, including newer technologies with longer duration storage capabilities and are likely to have transformative effect on power systems. Supplier pricing rules should allow compensation for the full range of services that BESS can provide.
- Distributed energy resources will also have transformative benefits for the power system in developing countries, but they can be disruptive without good advance planning.

7.1 LESSONS LEARNED ON SUSTAINABLE LANDSCAPES

- **When environmental goods and services are valued, natural and managed ecosystems can be more valuable with conservation or sustainable management than development.** Even conservative lower bound estimates of the value of environmental goods and services can provide a strong economic justification for more sustainable management and conservation policies, investments, and management decisions. The cost-benefit analysis of mangrove conservation versus shrimp pond conversion in Indonesia is a good example.

  Some environmental goods and services are relatively easy to value using market prices, such as the net value of forest and fishery products or ecotourism. Revealed preference methods based on avoided costs, defensive expenditures, alternative costs, and travel costs are also easy to justify in economic analyses. There are also tangible costs for preventing or treating illnesses associated with air and water pollution or disease vectors. Economic techniques are available for valuing the social cost of premature deaths, although controversial. Other ecosystem services such as watershed maintenance are critically important, but the causal relationships are complex and site-specific. Some goods and services, such as biodiversity and ecosystem functioning are difficult to value in economic terms because they are not priced in markets. Stated preference methods based on surveys, interviews, or bidding games have been used to value less tangible environmental benefits, including non-use values, but have a less well-accepted theoretical basis and are subject to serious problems of validity, reliability, instrumental bias, and strategic behavior.
- **Significant gaps remain in ex ante and ex post environmental impact data. Better data can be obtained to improve t estimates of the value of many environmental goods and services, but** require additional time and budget resources, including location-specific field data or benefit transfer data from other areas.

  Estimated carbon stocks are available for many ecosystems around the world as well as carbon losses from conversion of these lands to developed uses. Many of these estimates rely on crude assumptions. More accurate estimates of changes in terrestrial carbon stocks require considerable expertise, although remote sensing data are improving coverage and data quality. Coastal protection benefits can be estimated with moderate certainty, but the bulk of the damage to human settlements; infrastructure; and agriculture forests, and other

land uses, comes from less common, extreme events. Relatively few studies have examined the indirect effects of large hydropower development and rural road construction and improvement, despite the potential magnitude of these impacts on land uses.

- **High discount rates make slow-maturing investments with long-term environmental benefits (such as plantation forestry and natural forest restoration) difficult to justify. USAID should change its discount rate guidance for economic analyses.** A 12 percent discount rate places essentially no value on environmental benefits that occur after 30 years; this is particularly problematic for carbon emissions that persist in the atmosphere and affect global climate for 300-1,000 years (https://climate.nasa.gov/news/2915/the-atmosphere-getting-a-handle-on-carbon-dioxide/#:~:text=Once%20it's%20added%20to%20the,timescale%20of%20many%20human%20lives). Some notable economists have recommended use of lower or even zero percent discount rates for economic analyses of GHG emission reductions (Goulder and Williams 2012).

  USAID should consider changing its 2015 cost-benefit analysis guidelines for an *economic analysis* by replacing the 12 percent discount rate with the 3 percent and 7 percent discount rates that the U.S. Government uses in domestic investment and regulatory analyses. The USAID guidelines already allow use of a discount rate based on the cost of available loan financing (annual percentage rate reflecting the interest rate and fees) in a *financial analysis*. Since cost-benefit analyses typically use *real* (inflation-adjusted) values, this discount rate for a financial analysis would be calculated by removing the projected inflation rate from the financing cost.

- **Lower GHG emissions and greater carbon sequestration and can have large economic benefits over long periods of time, even at relatively low values of the social cost of carbon and with discounting for the time value of money.** Most of CEADIR's economic cost-benefit analyses included sensitivity testing of multiple social cost of carbon values ranging from \$5-\$25/tCO_2e. At a time horizon of 50-100 years and discount rates of 3, 7, or 12 percent, the present value of GHG emission reductions made a large difference in the results of most of the economic analyses.

  In March 2021, the USG adopted a higher social cost of carbon of \$51/tCO_2e, based on a preliminary analysis. CEADIR's most recent cost-benefit analysis (on household cooking fuel production and use in Lusaka, Zambia) included the \$51/tCO_2e social cost of carbon value. At this higher social cost of carbon value, all but one of the earlier CEADIR cost-benefit analyses would have substantially higher economic benefits for the conservation or more environmentally sustainable alternatives. The only exception was the cost-benefit analysis of improved pasture management practices in Ethiopia where higher methane emissions from increasing livestock populations eventually outweighed the increases in carbon storage. The USG plans to revisit this estimate as new data and additional studies increase the understanding of the magnitude and likely impacts of climate change in different regions over time.

- **Wood and charcoal for urban household cooking will continue to contribute to deforestation in many developing countries and there are strong cultural preferences for cooking at least some foods with these fuels.** Informal sector charcoal producers cannot afford the capital costs of large brick kilns. Improved earth mound kilns may be an affordable alternative with a moderately higher carbonization. Imported, mass manufactured charcoal stoves are the most promising approach for more efficient use of charcoal in cooking. Improved stoves produced by informal sector artisans cannot achieve the same efficiency levels or durability. In major urban areas with good grid access and relatively low electricity prices (such as Lilongwe and Lusaka), a single-burner electric hotplate was the lowest cost alternative in financial and economic terms. LPG and biomass gel stoves and briquettes were far more costly for households. LPG prices are subject to volatile world market prices of petroleum and domestic currency exchange rate risks

and the International Energy Agency projected large petroleum price increases between 2020 and 2026 (Bosoni *et al.* 2021). New USG policy does not allow subsidization of fossil fuels, such as LPG. Fast-growing tree plantations can increase the sustainable supply of woodfuels if good yields can be achieved and policy and price incentives are adequate (they were not in Malawi and Zambia). Some noninvasive species of bamboo can provide substantially higher yields of biomass for charcoal production than trees.

7.1 LESSONS LEARNED ON CLIMATE ADAPTATION

- **In many developing countries, national adaptation planning needs to devote more attention to subnational and municipal planning.** A participatory process with strong community engagement is important.
- **Adaptation financing should be considered early and integrated throughout the adaptation planning process.**
- **While the benefits of adaptation investments can be large, the timing is uncertain and depends on the magnitude, impact, and location of climate impacts.** It is generally much more costly to respond to disasters and climate risks than to prevent or reduce them. Many climate adaptation investments do not produce revenue streams that can be used to pay off bank loans. The private sector often spends money to increase resilience to climate change, but these incremental costs are not generally reported.
- **Where they exist, requirements for corporate social responsibility contributions can be tapped for public-private partnerships to reduce disaster and climate risks.**
- **A whole-of-government approach to climate adaptation be effective in increasing and coordinating domestic resource allocations and increasing support from international development assistance organizations.**

7.1 LESSONS LEARNED ON CROSS-CUTTING FINANCING

- **Developing countries face domestic budget constraints and many competing priorities despite increasing awareness of the importance of the large need for climate mitigation and adaptation financing.** Mitigation financing will need to increase to since prior NDC targets have not generally achieved and more ambitious targets will be needed. Adaptation financing from domestic and international sources has been relatively low and most developing countries are not resilient to typical past weather conditions, let alone climate change. Processes for accessing funding from international climate funds have been slow and cumbersome.
- **International REDD+ support has also been slow and below the expectations of most countries, but may be improving.** The REDD+ rules were close to being finalized, development assistance organizations have already spent considerable resources on REDD readiness, and large, new potential sources of funding have emerged, prospects for increasing REDD+ funding may be improving. Voluntary carbon market prices have increased substantially in 2021, particularly in European Union markets. However, the international trend is for supporting jurisdictional (national-level) REDD+ programs, rather than individual projects.
- **Greater private sector engagement and investment are critical for scaling up climate-related financing.** The policy and regulatory environment and macroeconomic conditions are critical for increasing public and private sector financing for climate change mitigation and adaptation. Development assistance organizations can help leverage private investment for blended finance.

ANNEX A: STANDARD INDICATOR RESULTS

Global Climate Change Indicators	CE	SL	AD	TOTAL[1]
Number of people trained	2,176	52	337	**2,485**
Number of institutions with improved capacity	37	6	7	**40**
Amount of investment mobilized	$17,559,540	$97,722	-	**$17,657,261**
CE generation capacity that achieved financial closure (MW)	6.84	-	-	**6.84**
CEADIR Custom Indicators	**CE**	**SL**	**AD**	**TOTAL**
Innovations	10	4	1	**15**
Number of official knowledge exchange events used to relay information	55	27	26	**64**
Instances of stakeholders accessing information through a knowledge exchange event	3,180	1,852	1,625	**4,702**
Assessments	52	18	20	**78**
Number of financial institutions receiving TA	89	-	-	**89**
Power Africa Indicators	**CE**	N/A	N/A	**TOTAL**
Number of new grid and off-grid projected direct connections	1,467	-	-	**1,467**
Number of transactions that have reached final closure	4	-	-	**4**
Amount of investment mobilized for energy projects	$6,700,901	-	-	**$6,700,901**
Total public and private funds leveraged by USG for energy projects	$6,700,901	-	-	**$6,700,901**

[1] Some totals are less than the sum of the pillar results to avoid double counting.

Commitments made by Power Africa private sector partners	$5,414,235	-	-	**$5,414,235**
Number of MW from transactions that achieved financial closure	6.84	-	-	**6.84**
Number of transactions that have not yet achieved financial closure	27	-	-	**27**
Person hours of training completed in technical energy fields	4,601	-	-	**4,601**
Indicators Aggregated by Gender	**Men**	**Women**		**TOTAL**
Total number of people trained	**1,473 (59%)**	**1,012 (41%)**		**2,485**

ANNEX B: CUSTOM INDICATOR RESULTS

CEADIR created a custom indicator to capture innovations such as tools, technologies, or methodologies developed, tested, and/or adopted as a result of USG assistance.

CLEAN ENERGY INNOVATIONS

Product Name	CEADIR Financial Memorandum
CEADIR Activity	Scaling Up Clean Energy Lending in West Africa
Number of Products Developed	1 (multiple iterations)
Product Description	Memorandum listed financing sources available to West African banks for long-term capital needed for CE financing. The memorandum helps financial institutions understand types of funding sources available for CE financing, from what sources, and how to access them. Being educated about these CE funding options is important because CE lending requires longer timeframes for investment returns than other sectors, this requires longer tenors than is usually available, as most African lending (including countries' federal reserves) are focused on short-term financing. In addition to giving banks access to longer-term capital that they can pass along onto their own borrowers, these sources of funding also generally provide better lending terms than is typically available in the region, which is particularly critical for the funding of off-grid and small-scale projects.
CEADIR Role	CEADIR solely developed this.

Product Name	Solar Rooftop Installation Model
CEADIR Activity	Scaling Up Clean Energy Lending in West Africa
Number of Products Developed	2
Product Description	A spreadsheet for banks to quickly assess the payback period of a rooftop solar project for both residential, commercial, and industrial clients. Typically, banks want to understand how profitable a project is and when they can expect return on their investment. The model was developed to help banks understand how to analyze the viability of rooftop solar projects, given the complexities of the technology involved (as well as to help estimate economic savings for the end user). The model involves things like core elements of the solar system (e.g., the panel, the inverters, the batteries), helping banks estimate in how many years they can expect to be repaid (typically 3 or 5 years for return on investment).

CEADIR Role	CEADIR solely developed this.
Product Name	Green Loan Product
CEADIR Activity	Scaling Up Clean Energy Lending in West Africa
Number of Products Developed	1 for Heritage Bank Ghana
Product Description	A product concept paper for a Heritage green loan product for employees of approved institutions for up to 50,000 Ghanaian Cedis (GHS) (approximately $10,475 as of June 30, 2018) for residential solar or biogas systems from approved vendors. The resulting Heritage Green Loan Product will offer loans to bank customers who are employees of approved institutions, for principal of up to GHS 50,000 to finance installation of residential solar or biogas systems implemented by approved vendors. Product includes a mechanism for tracking 'green lending' to create a distinction between core lending and green lending transactions - this is useful for accessing financial resources like the Green Climate Fund, for example.
CEADIR Role	Financial institution developed this product with input from CEADIR

Product Name	ESCO Loan Product and Pilot
CEADIR Activity	Scaling Up Clean Energy Lending in West Africa
Number of Products Developed	1 for Heritage Bank Ghana
Partner Financial Institution	
Product Description	Heritage and CEADIR developed an ESCO loan product and pilot to test the viability of Heritage certifying ESCOs as approved vendors of EE and RE services for its existing commercial and industrial borrowers. CEADIR helped Heritage design the loan product and pilot, develop an MOU with an ESCO (KATA Solar), and prepare some loan applications for the ESCO and its clients.
CEADIR Role	Financial institution developed this, led by CEADIR

Product Name	Roadmap for Developing ESCO Loan Products
CEADIR Activity	Scaling Up Clean Energy Lending in West Africa
Number of Products Developed	1 for Stanbic Bank Ghana
Product Description	The road map outlines a plan for developing ESCO loan products for developers and end users from Stanbic Bank's existing borrowers. The concept and model are very similar to that of Heritage Bank Ghana.
CEADIR Role	Financial institution developed this product with input from CEADIR
Product Name	Financial Model for PayGo Solar/Mobile Phone Transaction
CEADIR Activity	Scaling Up Clean Energy Lending in West Africa
Number of Products Developed	1 for First Bank Nigeria (FBN) Sierra Leone

Product Description	Excel-based financial project cash flow projections model, incorporating uncertainty. Sample operational model of the entire PayGo Solar/Mobile Phone loan product, explaining the various risk acceptance criteria and product requirements. The Excel-based financial model can be modified by the bank for their own use.
CEADIR Role	Financial institutions developed this, led by CEADIR

Product Name	USAID Clean Energy Lending Toolkit translated into French
CEADIR Activity	Scaling Up Clean Energy Lending in West Africa
Number of Products Developed	1
Product Description	CEADIR translated into French the Clean Energy Lending Toolkit (CELT) prepared under the prior, USAID-funded Analysis for Investments in Low-Emissions Growth (AILEG) activity.
CEADIR Role	Translated by CEADIR

Product Name	USAID Clean Energy Lending Toolkit translated into Spanish
CEADIR Activity	Scaling Up Clean Energy Lending in Central America
Number of Products Developed	1
Product Description	CEADIR translated into Spanish the Clean Energy Lending Toolkit (CELT) prepared under the prior, USAID-funded Analysis for Investments in Low-Emissions Growth (AILEG) activity.
CEADIR Role	Translated by CEADIR

Product Name	Payments for Results Terms of Reference for Business Advisory Service (BAS) Providers
CEADIR Activity	Expanding Small-Scale, Off-Grid Renewable Energy Lending in Ghana, Rwanda, and Uganda
Number of Products Developed	2 for Ghana and Rwanda
Product Description	To support Power Africa's transaction-oriented goals, CEADIR provided transactional support in Ghana, Rwanda, and Uganda. CEADIR sought to identify a pipeline of viable bankable projects which it could bring forth to the banks for loan applications. CEADIR's subcontracted with Business Advisory Service (BAS) providers, local consultants with knowledge of the country's energy sector and experience with project finance. CEADIR developed innovative performance-based Terms of Reference (TORs) for the BAS providers. Multiple BAS providers enabled CEADIR to diversify performance risk and generate more competition among providers to accelerate transaction sourcing (given that there was a limited amount of funds set aside for results-based payments).
CEADIR Role	Developed and implemented by CEADIR

ADAPTATION INNOVATIONS

Product Name	MS Excel CBA sheet to conduct cost benefit analysis of mangrove restoration and rehabilitation (MRR) and earthen dike to increase resilience of coastal communities to climate change impacts
CEADIR Activity	Cost-Benefit Analysis of Mangrove Restoration for Coastal Protection and an Earthen Dike Alternative in Mozambique
Number of Products Developed	1
Product Description	Refer to the activity description in Section 3.2 The report can be found at http://pdf.usaid.gov/pdf_docs/PA00MXMG.pdf The Excel workbook can be found at http://www.abtassociates.com/Tools/2017/Mozambique-Mangrove-CBA-Workbook.aspx
CEADIR Role	Developed by CEADIR

SUSTAINABLE LANDSCAPES INNOVATIONS

Product Name	Development of the mangrove valuation survey instrument, for quantifying the economic value of mangroves, including household surveys and secondary data
CEADIR Activity	Indonesia Mangrove Economic and Policy Valuation Assessment
Number of Products Developed	1
Product Description	Refer to the activity description in Section 3.2
CEADIR Role	Developed by CEADIR, in collaboration with Blue Forests

Product Name	Three electronic surveys for tablet data collection on active restoration of degraded land, fodder cropping data, and rangeland improvement
CEADIR Activity	Ethiopia Cost-Benefit Analysis of Improved Production Practices for Beef Cattle and Poultry
Number of Products Developed	1
Product Description	Refer to the activity description in Section 3.2
CEADIR Role	Developed by the International Center for Tropical Agriculture (CIAT), with the support of CEADIR

REFERENCES

Anderson, Glen; Charlotte Mack; M. Zakir H. Khan; Rezai Khondker; and Eric Hyman. 2017. *Climate Finance in Bangladesh: Situation Analysis.* Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Anderson, Glen; Eric Hyman; Charlotte Mack-Heller; Alan Miller; Marcia Trump; and Jonathan Cook. 2019. *Climate Finance Assessment: Opportunities for Scaling Up Financing for Clean Energy, Adaptation, and Sustainable Landscapes*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Bosoni, Toril; Christophe Barret; Olivier Lejeune; Peg Mackey; Toril Bosoni; Anna Kloss; Kristine Petrosyan; Masataka Yarita; and Jeremy Moorhouse. 2021. *Oil 2021: Analysis and Forecast 2021 to 2026*. Paris: International Energy Agency. https://www.iea.org/reports/oil-2021

Cooley, David; Kait Siegel; Santiago Enriquez; Eric Hyman; Mikell O'Mealy; Takyi Sraha; and Denise Mainville. 2021. *Cost-Benefit Analysis of Improved Cacao Production Methods in Ghana*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Córdova, José; Rodolfo Camacho; and Eric Hyman. 2021. *Guidelines to Reduce Hydrological Uncertainty in the Design of Small Hydropower Facilities*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Counts, Lauren; Nienke Stam; Katherine Vilnrotter; Manuel Alegre; Arjan Visser; Alex Blake; Marcia Gowen Trump; and Eric Hyman. 2014. *Clean Energy Lending Toolkit*. Washington, DC: Enclude and Abt Associates, Prepared for USAID. English: https://pdf.usaid.gov/pdf_docs/PA00JS5M.pdf; French: https://pdf.usaid.gov/pdf_docs/PA00MMK8.pdf; Spanish: https://pdf.usaid.gov/pdf_docs/PBAAF209.pdf.

Enriquez, Santiago; Eric Hyman; Matthew Ogonowski; José Castro; Enrique Rebolledo; Carlos Muñoz; Gwen Andersen; and Itzá Castañeda. 2016. *Mexico Energy Efficiency Assessment for Greenhouse Gas Emission Mitigation*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Enriquez, Santiago; Eric Hyman; Walter Jokisch; Diego Fernández de Velasco; Rafael Álvarez; Héctor Dada Sánchez; Edward Hoyt; and Pablo Torres. 2018. *The Clean Energy Market in El Salvador*. Washington, DC: Crown Agents-USA Ltd., Abt Associates, and Enclude Ltd. Prepared for USAID.

Enriquez, Santiago; Mikell O'Mealy; Eric Hyman; Matthew Ogonowski; and Pablo Torres. 2018. *Renewable Energy and Smart Grid Suppliers Forum: Emerging Opportunities for U.S. Firms*. Washington, DC: Crown Agents USA and Abt Associates. Prepared for USAID.

Enriquez, Santiago; Eric Hyman; Mikell O'Mealy; David Cooley; and Takyi Sraha. 2020. *The Value of Climate-Smart Cacao Production: A Literature Review*. Washington, DC: Crown Agents-USA Ltd. and Abt Associates, Prepared for USAID.

Enríquez, Santiago; Eric Hyman; Leonardo Ramírez-Leiva; Eduardo Reyes; Luis Miguel Cardona; and Carlos González-Rivera. 2020. *Parametric Insurance for Renewable Electric Power Producers in Central America*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Faye, Antoine; Pablo Torres; and Eric Hyman. 2021. *Clean Energy Market Assessment for Senegal.* Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Giangola, Lorine; Glen Anderson; Suruchi Bhadwal; Neha Bharti; Sourabh Manuja; Riya Rahiman; Tamiksha Singh; Jason Vogel; and Eric Hyman. 2021. *Public-Private Partnerships for Disaster Risk Reduction and Climate Resilience in Four Cities in India*. Washington, DC: Crown Agents USA, Abt Associates. Prepared for USAID.

Goulder, Lawrence and Roberton Williams, 2012. *The Choice of Discount Rate for Climate Change Policy Evaluation*. Washington, DC: Resources for the Future. https://media.rff.org/archive/files/sharepoint/WorkImages/Download/RFF-DP-12-43.pdf

Hoyt, Edward; and Nadia Scharen-Guivel, 2017. *Beyond the Grid Constraints Assessment*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Khananusit, Sandra; Mikell O'Mealy; Lindsay Foley; and Eric Hyman, with Keshav Jha and Sonali Malik. 2017. *Enabling Private Sector Clean Energy Investment in Southeast and South Asia: Deep Dive Workshop Report*, June 5, 2017 Manila Philippines. Washington, DC: Climate Economic Analysis for Development, Investment, and Resilience (CEADIR) Activity, Crown Agents USA and Abt Associates with the Asia Low Emission Development Strategies Partnership, Prepared for USAID.

Laird, Michèle and Eric Hyman. 2020. *A Climate Bond Road Map for AgroBanco in Peru*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Laird, Michèle; Pablo Torres; Lawrence Szott; and Eric Hyman. 2015. *Using Bonds and Other Financial Instruments to Develop Climate-Friendly Infrastructure in Peru*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Mack-Heller, Charlotte; Eric Hyman; Kait Siegel; Alan Miller; Ginna Rakotoarimanana; and Andoniaina Ratsimamanga. 2019. *Local Governance and Private Sector Opportunities for Climate Adaptation, Sustainable Livelihoods, and Biodiversity in Madagascar*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Manion, Michelle; Eric Hyman; Jason Vogel; David Cooley; Gordon Smith. 2019. *Greenhouse Gas and Other Environmental, Social, and Economic Impacts of Hydropower: A Literature Review*. Washington, DC: Crown Agents-USA and Abt Associates, Prepared for USAID.

Matek, Benjamin; Pablo Torres; Gordon Smith; Eric Hyman; Santiago Enriquez; and Khadija Mussa. 2020. *Cost-Benefit Analysis of Charcoal and Wood Use for Household Cooking and Demand- and Supply-Side Alternatives for Forest Conservation in Lilongwe, Malawi*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Matek, Benjamin; Pablo Torres; Gordon Smith; Eric Hyman; Santiago Enriquez; and Martin Lyambai. 2021. *Cost-Benefit Analysis of Charcoal Use for Household Cooking and Demand- and Supply-Side Alternatives for Forest Conservation in Lusaka, Zambia*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Miller, Alan. 2017. *Synthesis of CEADIR Series Events: February 2015-December 2016*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Molina, Javier; Nadia Scharen-Guivel; and Eric Hyman. 2018. *Analysis of Renewable Energy Auctions in Six Countries*. Washington, DC: Crown Agents USA, and Abt Associates, Prepared for USAID.

Mugimba, Crystal; Martina Akello; Fazel Reza; and Luswata Paulo. 2018. *Off-Grid Renewable Energy Policy Framework and Availability of Local Bank Lending in Uganda*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Narayan, Tulika; Lindsay Foley, Jacqueline Haskell, David Cooley, and Eric Hyman. 2017. *Cost-Benefit Analysis of Mangrove Restoration for Coastal Protection and an Earthen Dike Alternative in Mozambique*. Washington, DC: Climate Economic Analysis Development, Investment, and Resilience (CEADIR) Activity, Crown Agents USA and Abt Associates. Prepared for USAID.

Ng'ang'a, Stanley; Gordon Smith; Chris Mwungu; Sintayehu Alemayehu; Evan Girvetz; and Eric Hyman. 2020. *Cost-Benefit Analysis of Improved Livestock Management Practices in the Oromia Lowlands of Ethiopia*. Washington, DC: Crown Agents USA and Abt Associates, with the International Center for Tropical Agriculture (CIAT), Prepared for USAID.

O'Mealy, Mikell; Sandra Khananusit; and Lindsay Foley. 2017. *Enabling Private Sector Clean Energy Investment in Southeast and South Asia, Report on a Workshop in Bangkok, Thailand*, May 30, 2017. Washington, DC: Crown Agents and Abt Associates, with Allotrope Partners, National Renewable Energy Laboratory, and World Resources Institute. Prepared for USAID.

O'Mealy, Mikell; Natcha Tulyasuwan, Charlotte Mack-Heller, Lindsay Foley, and Sandra Khananusit. 2017. *Convening Private Sector to Invest in Climate-Smart Commodity Production: Workshop Report,* Bangkok, March 29, 2017. Washington, DC: Crown Agents and Abt Associates, Prepared for USAID.

O'Mealy, Mikell;; Ezham Khalid; and Eric Hyman. 2020. *Private Sector Recommendations for Renewable Energy Auctions in Thailand and Malaysia*. Washington, DC: Crown Agents-USA, and Abt Associates, Prepared for USAID.

O'Mealy, Mikell; Eric Hyman; Matthew Ogonowski; Loretta Bauer; Pablo Torres; Leah Quin; Alexa Smith-Rommel. 2021. *Emerging Markets for U.S. Smart Grid Suppliers and Investors in Africa, Asia, and Latin America*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Shaw, Suzanne; Damien King; Shanike Smart; and Eric Hyman. 2018. *Jamaica Low Emission Development Strategy Economic Modeling Needs Assessment.* Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID

Smith, Gordon; Eric Hyman; Lindsay Foley; and Charlotte Mack. 2018. *Mangrove Ecosystem Valuation: Methods and Results*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Smith, Gordon; David Cooley; and Eric Hyman. 2018. *The Impacts of Rural Road Development on Forests, Greenhouse Gas Emissions, and Economic Growth in Developing Countries*. Washington, DC: Crown Agents USA, and Abt Associates, Prepared for USAID.

Smith, Gordon; David Cooley; Benjamin Brown; Ria Fritriana; and Eric Hyman. 2020. *Cost-Benefit Analysis of Mangrove Conservation Versus Shrimp Aquaculture in Bintuni Bay and Mimika, Indonesia*. Washington, DC: Crown Agents USA and Abt Associates. Prepared for USAID.

Torres, Pablo; Nadia Scharen-Guivel; Raouf Saidi; Jeannetta Craigwell-Graham; Joel Moktar; and Eric Hyman. 2021. *Effectiveness Assessment for Expanding Small-Scale, Off-Grid Renewable Energy Lending in Ghana, Rwanda, and Uganda*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

Tulyasuwan, Natcha; Lindsay Foley; Mikell O'Mealy; and Sandra Khananusit. 2018. Recommendations to Accelerate Private Investment in Climate-Smart Agriculture and Forestry Production in Cambodia, Indonesia, the Philippines, and Vietnam. Washington DC: Crown Agents USA and Abt Associates. Prepared for USAID.

USAID. 2015. *USAID Guidelines: Cost-Benefit Analysis.* Washington, DC: U.S. Agency for International Development.

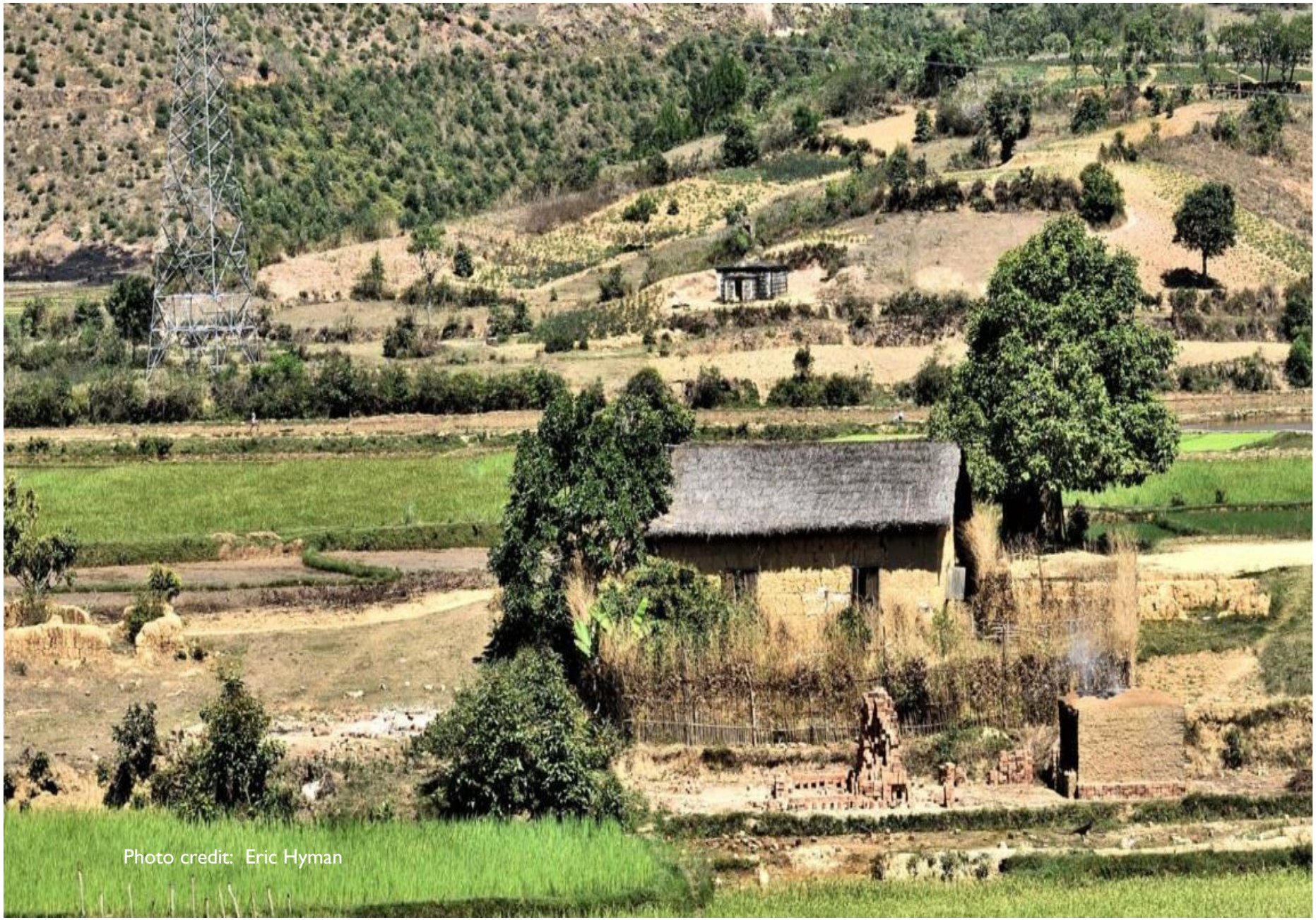


Photo credit: Eric Hyman