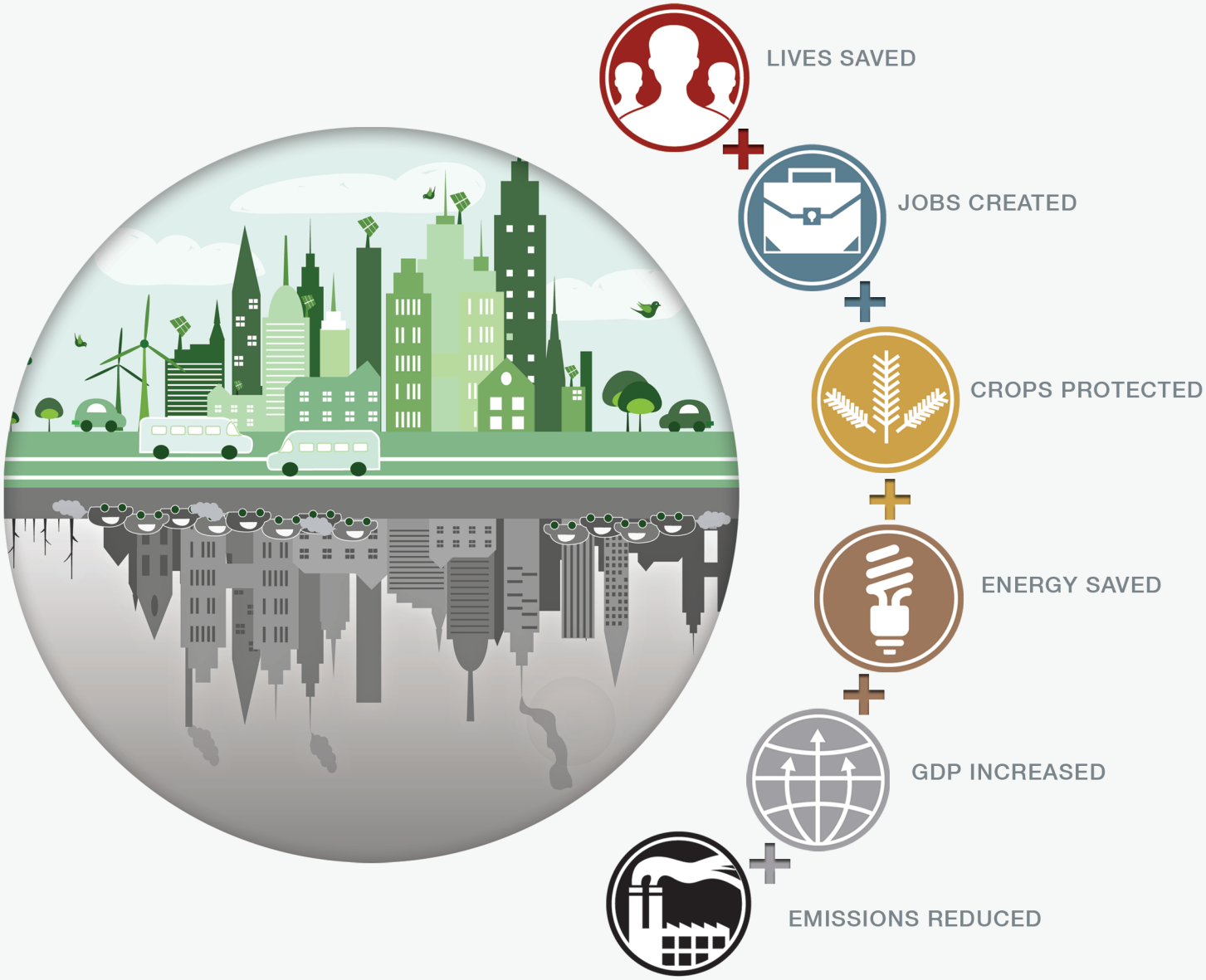
88908 v2

Climate-Smart Development

Adding up the benefits of actions that help build prosperity, end poverty and combat climate change



EXECUTIVE SUMMARY

ClimateWorks FOUNDATION
WORLD BANK GROUP

Climate-Smart Development

Adding up the benefits of actions that help build prosperity, end poverty and combat climate change

EXECUTIVE SUMMARY

Acknowledgements

The ClimateWorks Foundation and the World Bank would like to thank the modeling teams, the reviewers, and the project task teams for their contributions to the development of this report.

The modeling work for the report was conducted by Rita Van Dingenen (Joint Research Centre, European Commission), Sarah Hunter (Oxford Economics), and Sudhir Gota (Clean Air Asia).

The ClimateWorks task team included Surabi Menon and Laura Segafredo (co-Task Team Leaders). Ruoting Jiang, formerly at ClimateWorks, provided analysis support for the modeling work; Seth Monteith designed the graphics and Debra Jones edited the report. Management oversight was provided by Charlotte Pera.

The task team from the World Bank included Sameer Akbar and Gary Kleiman (co-Task Team Leaders), Samuel Oguah, Robert Bisset, Fionna Douglas, Stacy Morford, Venkat Gopalakrishnan, Karin Rives, and Samrawit Beyene. Management oversight was provided by Karin Kemper and Jane Ebinger. Advice on the macroeconomic analysis was provided by Kirk Hamilton, Erika Jorgenson, and Stéphane Hallegatte. The report was peer-reviewed by Masami Kojima, Andreas Kopp, Muthukumar Mani, Tijen Arin, and Carter Brandon. Inputs were also gratefully received from the following World Bank staff: Nupur Gupta, Om Prakash Agarwal, Gaurav Joshi, Sintana Vergara, Marcus Lee, Farouk Banna, Stephen Hammer, Yabei Zhang, Yun Wu, Charles Feinstein, Svetlana Edmeades, Tim Valentiner, Guillermo Hernández, Onno Ruhl, Gloria Grandolini, Klaus Rohland, and Deborah Wetzel.

Glossary of Keywords and Phrases

Anthropogenic: Human-caused.

Black Carbon (BC): A small, dark particle that warms the earth's climate. Although black carbon is a particle rather than a greenhouse gas, it is the second-largest climate warmer after carbon dioxide. Unlike carbon dioxide, black carbon is quickly washed out and can be eliminated from the atmosphere if emissions stop. Reductions would also improve human health.

Carbon Dioxide (CO_2): The greenhouse gas that contributes the most to global warming. While more than half of the CO_2 emitted is removed from the atmosphere within a century, some fraction (about 20 percent) of emitted CO_2 remains in the atmosphere for many thousands of years.

Global Burdens of Disease: A study to estimate the number of worldwide deaths annually from different diseases or environmental causes; can also be divided into different regions and groups. See http://www.healthmetricsandevaluation.org/gbd.

Global Public Goods Benefits: Benefits such as protection of ecosystem services, reduced acid deposition and infrastructure loss, and reduced climate change impacts that are realized beyond the jurisdiction where a policy is implemented or a project carried out.

Hydrofluorocarbons (HFCs): Chemical replacements for ozone-depleting substances being phased out by the Montreal Protocol. These substances are used in heating and cooling systems and as aerosols. Although less damaging to the ozone layer than what they replace, they can have very large global warming potentials.

Local Socioeconomic Benefits: Benefits such as GDP growth, employment gains, reduced energy and fuel costs, time savings, improved water and air quality, higher crop yields, improved public health, and reduced mortality that are realized in the jurisdiction that enacts the policy or project.

Methane (CH_4): A greenhouse gas that only lasts an average of 12 years in the atmosphere; it is an extremely powerful warmer during that period. One molecule of methane warms about 25 times more than CO_2 over 100 years (and 72 times as much over 20 years).

Mitigation: Actions to address climate change by decreasing greenhouse gases and other climate-forcing agents.

Ozone (O_3): A harmful pollutant and greenhouse gas that only forms though complex chemical reactions with other substances in the atmosphere (e.g., methane); it can harm human health and crops.

Radiative Forcing: A measure of the net change in the energy balance of the earth with space; that is, the incoming solar radiation minus outgoing terrestrial radiation. At the global scale, the annual average radiative forcing is measured at the top of the atmosphere, or tropopause. Expressed in units of warming rate (watts, W) per unit of area (meters squared, m^2).

Short-lived Forcers or Short-lived Climate Pollutants (SLCPs): Substances such as methane, black carbon, tropospheric ozone, and some hydrofluorocarbons that have a significant impact on near-term climate change and a relatively short

lifespan in the atmosphere compared to carbon dioxide and other longer-lived gases.

Synergistic Economic Benefits: Macroeconomic benefits from multiplier effects, forward linkage of investment, and potential cross-sector interactions; for example, indirect health and agriculture benefits that would result from the electrification of the transport sector if the power sector simultaneously reduced its carbon intensity and co-pollutant emissions due to a performance standard or a renewable energy mandate.

Systems Approach: An approach capturing the direct and indirect benefits of policies and projects and quantifying their macroeconomic impacts; it is meant to capture the interconnectedness between identified benefits.

Tropospheric Ozone: Sometimes called ground-level ozone, this refers to ozone that is formed or resides in the portion of the atmosphere from the earth's surface up to the tropopause (the lowest 10–20 km of the atmosphere).

Acronyms and Abbreviations

Ag	Agriculture
BAU	Business-as-usual scenario
BenMAP	Environmental Benefits Mapping and Analysis Program of the U.S. EPA
BC	Black carbon
BRT	Bus rapid transit system
CapEx	Capital expenditures
CCAC	Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants
CCS	Carbon capture and storage
CGE	Computable General Equilibrium model
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CW	ClimateWorks Foundation
EU	European Union (refers to EU27)
EV	Electric vehicle
EPA	U.S. Environmental Protection Agency
FASST	Fast Scenario Screening Tool for Global Air Quality and Instantaneous Radiative Forcing
GAINS	Greenhouse Gas and Air Pollution Interactions and Synergies: a model that provides a framework for the analysis of co-benefits reduction strategies from air pollution and greenhouse gas sources
GBD	Global burden of disease
GDP	Gross domestic product
GHG	Greenhouse gas
GEIM	Global Energy and Industry Model of Oxford Economics
GEF	Global Environment Facility
GNI	Gross national income
GOM	Government of Mexico
Gt	Gigaton (billion metric tons)
IBRD	International Bank for Reconstruction and Development
IIASA	International Institute for Applied Systems Analysis
ICE	Internal combustion engine
KCAL	Kilocalories
LFG	Landfill gas
LPG	Liquefied petroleum gas
MACC	Marginal Abatement Cost Curve
MOUD	Ministry of Urban Development (of the Government of India)
Mt	Megaton (million metric tons)
MSW	Municipal solid waste
NMVOC	Non-methane volatile organic compounds
NPV	Net present value
N_2O	Nitrous oxide
O_3	Ozone
OC	Organic carbon
OpEx	Operational costs or expenditures
PAD	Project Appraisal Document
PM	Particulate matter
$PM_{2.5}$	Particulate matter with an aerodynamic diameter less than 2.5 microns
PPP	Purchasing power parity
PV	Photovoltaic
RoW	Rest of world
SLCP	Short-lived climate pollutants
SRC	Source receptor coefficient
TM5	Chemical Transport Model (maintained by the European Commission's Joint Research Center and the model on which the FASST tool is based)
TEEMP	Transportation Emissions Evaluation Models for Projects
TSP	Total suspended particulates
U.S.	United States
UNEP	United Nations Environment Programme
WAVES	Wealth Accounting and the Valuation of Ecosystem Services
WB	World Bank

Foreword

The evidence is clear that climate change is already hurting the poor. It is damaging infrastructure, threatening coastal cities, and depressing crop yields, as well as changing our oceans, jeopardizing fish stocks, and endangering species.

The UN Intergovernmental Panel on Climate Change (IPCC) has shown more clearly than ever before that climate change is real, and that it has impacted every continent and all oceans. Consecutive IPCC reports make clear that we are ill-prepared to manage the risks of climate change and the impact it brings, and that global emissions of greenhouse gases are rising faster than ever before, despite reduction efforts.

No one will escape the impact. Climate change poses a severe risk to global economic stability. Without urgent mitigation action, ending extreme poverty by 2030 will not be possible.

At the World Bank Group, we know it doesn't have to be like this. We believe it is possible to reduce emissions and deliver jobs and economic opportunity, while also cutting health care and energy costs. This report provides powerful evidence in support of that view.

This publication, *Climate-Smart Development*, highlights scalable development solutions and builds on research to quantify the social benefits of climate action. The report simulates case studies of policies that could lead to emissions reductions in three sectors: transportation, industry, and the energy efficiency of buildings.

It also describes the national-level impact that scaling-up development solutions could have in five large countries and the European Union. If enacted together, these policies could reduce greenhouse gas emissions by the same amount as taking two billion cars off the streets.

The report also looks at four country-specific projects and the impact they would have if scaled-up nationwide. For example, if India built 1,000 kilometers of new bus rapid transit lanes in about twenty large cities, the benefits over 20 years would include more than 27,000 lives saved from reduced accidents and air pollution, and 128,000 long-term jobs created. It would also have large, positive effects on India's GDP, its agriculture, and the global climate.

Climate-Smart Development is a collaboration with the Climate-Works Foundation, and provides a framework to better understand the climate risks and benefits in everything we do. The report's findings show clearly that development done well can deliver significant climate benefits.

I recommend this publication to policy makers and development practitioners alike.

Dr. Jim Yong Kim
President, World Bank Group

Executive Summary

Officials responsible for a nation's economy have been primarily concerned with delivering jobs, stimulating growth, and promoting competitiveness. They are also becoming worried about the effects climate change will inflict on their country's economic future. Increasingly, these officials want to know if there are investments and efforts that can advance urgent development priorities and, at the same time address the challenges of our rapidly warming world.

Thanks to a growing body of research, it is now clear that climate-smart development can boost employment and can save millions of lives. Smart development policies and projects can also slow the pace of adverse climate changes. Based on this new scientific understanding, and with the development of new economic modeling tools to quantify these benefits, it is clear that the objectives of economic development and climate protection can be complementary.

This report uses new modeling tools to examine the full range of benefits ambitious climate mitigation policies can produce across the transportation, industry and building sectors in the United States, China, the European Union, India, Mexico and Brazil. This report also describes the multiple benefits of four development project simulations scaled up to the national level.

The report builds on recent efforts to estimate the development benefits[1] that come with a reduction in climate pollutants. These include economic growth, new jobs, improved crop yields, enhanced energy security, healthier people, and millions of lives saved. In many cases these benefits accrue quickly, and they accrue locally, primarily in the nation where action is taken.

Why emissions matter

Climate change impacts impose undeniable burdens on economic development by causing significant damage to agriculture, water resources, ecosystems, infrastructure, and human health. These impacts are proving to be devastating for the world's most vulnerable populations.

Emissions of carbon dioxide and other greenhouse gases must be substantially reduced to keep the world from exceeding the 2°Celsius threshold of global warming.[2] While efforts to reduce these climate pollutants, despite some progress, have been slow, recent scientific evidence suggests that cutting so-called "short-lived climate pollutants," which are responsible for up to 40 percent of the current warming, can have immediate climate impacts.[3] Complementary actions on greenhouse gases and short-lived climate pollutants can slow the rate of near-term warming, push back dangerous tipping points[4] and provide time to allow the world's poorest people to adapt to the changing climate.

Among the short-lived climate pollutants, black carbon and methane are climate forcers but they are also air pollutants that injure human health and diminish agriculture production. By reducing them, it is possible to prevent the deaths of 2.4 million people and boost crop production by 32 million tons of crops that would have been lost each year.[5] In rural areas, millions of people can be saved from premature death by switching to clean

1 Note that the term co-benefit is not used in this report as it implies a primary benefit whereas this work seeks to demonstrate the many reasons for undertaking emission reductions without assigning a preference for one benefit over another.

2 "Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided," World Bank, 2012a.

3 Short-lived Climate Pollutants (SLCPs) such as methane, black carbon, tropospheric ozone, and some hydrofluorocarbons have a significant impact on near-term climate change and a relatively short lifespan in the atmosphere compared to carbon dioxide and other longer-lived gases.

4 With warming beyond 2°C, the risk of crossing activation thresholds for nonlinear tipping elements in the Earth System and irreversible climate change impacts increases. These include Amazon rain forest die-back, ocean ecosystem impacts, and ice sheet destabilization, "Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided," World Bank, 2012a.

5 "Integration of Short-Lived Climate Pollutants in World Bank Activities," World Bank, 2013a.

cooking solutions. In cities, commuters can save time, and many thousands of asthma and heart attacks can be alleviated, through improved transit systems. Limiting these pollutants through smart development enhances economies, stimulates production, leaves populations healthier and slows the rate of climate change.

Achieving development and climate goals simultaneously

Policies that reduce GHG emissions and other short-lived climate pollutants can have clear economic, health, and other social benefits. For example, a policy that encourages more efficient transportation—including fuel efficient vehicles, and effective public transit—will save fuel and time which improves energy security and labor productivity. These policies can also reduce smog-related respiratory problems, thus saving lives, and improve visibility, benefiting local investment in sectors such as tourism and recreation. Similarly, a project to improve solid waste management may initially be pursued for its sanitation and health benefits; it can also reduce methane emissions that may boost crop yields and save energy. All these gains directly contribute to economic growth.

At the project level, these benefits have often been left out of economic analyses because many health and environmental benefits were not easily quantifiable. This has left decision makers with analyses that are incomplete. Recent efforts to better estimate the full impacts of proposed development projects have produced several new analytical tools and models. With these new tools, economists can more fully assess the multiple impacts of pollutants and estimate the value of emission reductions. Today's tools can also model the synergistic impacts of harms and benefits as they flow through the economy.

A framework to assess benefits

This report attempts to quantify investments that represent a true economic gain in terms of increased economic productivity.[6] It does so by applying new modeling tools that give a fuller accounting of the benefits of near-term and long-term climate and development interventions. The report:

- Introduces a holistic, adaptable framework to capture and measure the multiple benefits of reducing emissions of several pollutants
- Demonstrates how local and national policymakers, members of the international development community, and others can use this framework to design and analyze policies and projects
- Contributes a compelling rationale for effectively combining climate action with sustainable development and green growth worldwide

The report responds to demand from countries that are striving to advance local development priorities and needs for resilient, low carbon growth. By looking at policies and projects more holistically, one can better assess the overall value of actions that reduce emissions of GHGs and short-lived climate pollutants, and provide a more compelling case for coordinated development and climate action.

The report proposes the following framework to analyze policies and projects:

1. **Identify the full range of benefits** that result from a project or policy, including improved health, crop yields, energy savings, job growth, labor productivity, and economic growth
2. **Select appropriate assessment tools** that provide insight on each measurable benefit
3. **Choose the appropriate macroeconomic tool** to analyze direct and synergistic economic benefits
4. **Estimate the full range of benefits** and present results using metrics relevant to the audience

Several simulated case studies are used in this study to demonstrate how to apply this analytical framework. The case studies cover multiple pollutants (particulate matter, primarily black carbon; and GHGs, including methane, a precursor to ozone, and CO_2) and multiple sectors (transportation, industry, buildings, waste, and agriculture). They demonstrate the frameworks' benefits from two perspectives: sector policies applied at the national or regional level, and projects implemented at the sub-national level. By applying the framework to analyze both types of interventions, the report demonstrates the value of this approach for national and local policymakers, international finance organizations, and others.

The report focuses on assessing the multiple benefits of simulated policy and project case studies. These analyses should be viewed as "full implementation simulations"[7] relative to a business-as-usual scenario. The benefits quantified have an optimistic bias because they do not necessarily include transaction costs, risks, market distortions, and other factors that would be included in a policy implementation evaluation. Nonetheless, they offer an important building block to refine the approaches, methods, and tools for multiple-benefit analysis. The results also

6 Work has already been undertaken to expand consideration of some hidden costs of mitigation, such as Paltsev, S. and Capros, P. (2013). A similar effort on benefits is needed.

7 Here "full implementation" means that it is assumed that policies and programs achieve their full technical potential. Additional education and outreach or other program costs may be required to achieve this full potential.

highlight the need to fine-tune the modeling tools to represent real-world conditions more accurately.

Case studies demonstrate sizeable benefits

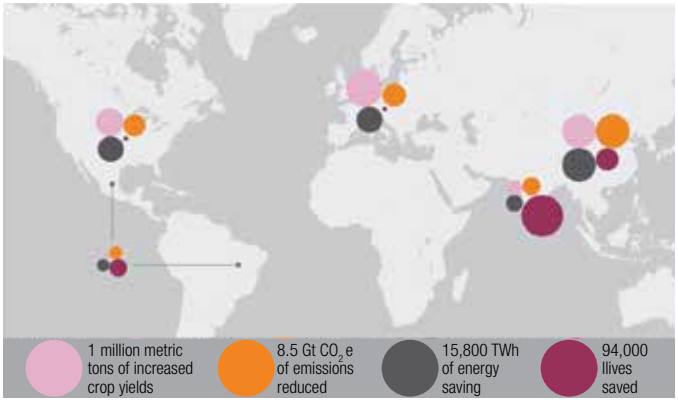
Three simulated case studies analyzed the effects of key sector policies to determine the benefits realized in six regions[8] (the United States, China, the European Union, India, Mexico, and Brazil) and the impact on global GDP. The sector policies include regulations, taxes, and incentives to stimulate a shift to clean transport, improved industrial energy efficiency, and more energy efficient buildings and appliances.

The annual benefits[9] of just these policies in 2030 include an estimated GDP growth of between $1.8 trillion and $2.6 trillion. Approximately 94,000 premature pollution-related deaths could be avoided. Additionally, the policies would avoid production of 8.5 billion metric tons of carbon dioxide equivalent (CO_2e)[10] emissions and almost 16 billion kilowatt-hours of energy saved, a savings roughly equivalent to taking 2 billion cars off the road. These policies alone would account for 30 percent of the total reduction needed in 2030 to limit global warming to 2°C.[11] Figure E.1 illustrates annual benefits for three case studies in 2030 for key sectors.

This report also presents results of four simulated case studies that analyzed several sub-national development projects, scaled up to the national level, to determine the additional benefits (beyond the economic net present value typically calculated in project financial analysis) over the life of each project, generally 20 years. Four project simulations were studied: expanded bus rapid transit in India, integrated solid waste management in Brazil, cleaner cookstoves in rural China, and biogas digestion and solar photovoltaics in Mexican agriculture.

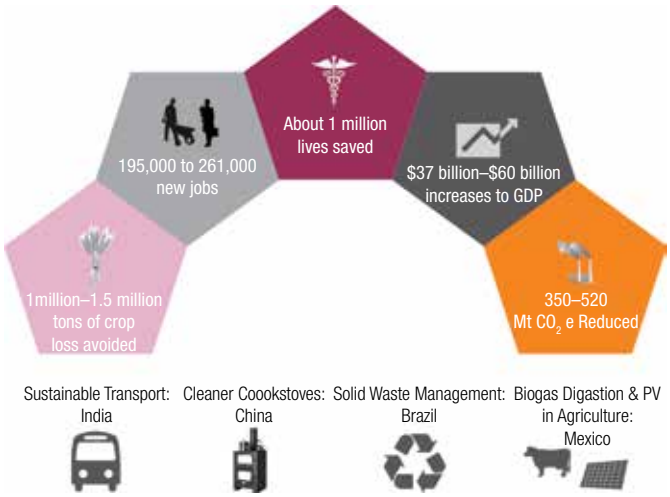
The aggregate benefits over the life of the projects are estimated to include more than 1 million lives saved, about 1 million–1.5 million tons of crop losses avoided, and some 200,000 jobs created. These projects could reduce CO_2e emissions by 355 million–520 million metric tons, roughly equivalent to shutting down 100–150 coal-fired power plants. This equates to about $100 billion–$134 billion in additional value for just three of these projects in India, Brazil, and Mexico when accounting for health benefits, avoided crop losses, GDP benefits, and the social benefits of carbon mitigation (beyond direct project benefits such as the value of carbon finance assets, reduced operating costs and other project-related economic benefits). In China, the estimated value of avoided premature death alone would come to more than $1 trillion. Figure E.2 illustrates potential benefits for four project simulations scaled to the national level.

Figure E.1: Total annual benefits in 2030 of key sector policies in six regions



Note: (Results for Mexico are combined with Brazil's.).

Figure E.2: Aggregate benefits over 20 years of four development projects



Source: Authors.

8 These five large countries and the European Union are referred to as "six regions" throughout the report for simplicity.

9 Since the sector policy case studies covered a limited number of pollutants (methane and BC, but not other co-pollutants), the health and agricultural benefits are underestimated. However, even with the limited emissions data included in this study, the resulting benefits can be significant.

10 CO_2 equivalents (CO_2e) as used in this report include only CO_2, BC, methane (CH_4), HFCs, and nitrous oxide (N_2O).

11 To limit the average global temperature increase to 2°C, 2030 emissions must be limited to approximately 35 Gt CO_2e (UNEP, 2013; Spiegel and Bresch, 2013); business-as-usual emissions are estimated at 63 Gt CO_2e in 2030.

Conclusions and next steps

This analysis shows that by using the proposed framework, actions can be identified that secure growth, increase jobs and competitiveness, save lives and slow the rate of climate changes.

Many development efforts—across a range of sectors—hold the promise of economic growth as borne out by economic analysis. Activities that also reduce emissions—across a range of pollutants—deliver health, agriculture and other socioeconomic benefits that are integral to a broader development agenda. Quantifying and including these benefits, where possible, can reveal the broader socioeconomic value of projects while enhancing the case for climate mitigation. Given the rising cost of inaction on climate change, it is imperative that the broad benefits of smart development be included in economic analyses.

As a result of limitations in the framework and available modeling tools, this report does not provide project-level evaluation for decision making nor does it focus on policy implementation issues or costs, which are required for comprehensive policy evaluation.[12] The report does however highlight areas where additional research could improve limitations with the framework. For example, improved tools are needed to account for behavioral changes such as shifting to public transit and advanced cookstoves, and to explicitly account for the full climate change costs of emissions.[13] The framework also needs additional work to tailor its application at the individual project level. Areas for research include:

- Further benefits assessments based on more comprehensive emissions data
- Multi-sector macroeconomic analysis that better illustrates the synergistic benefits (for example, using cleaner energy sources to supply the increased power demand for electric cars could yield greater benefits than clean transport or clean power in isolation)
- Additional macroeconomic analysis to reflect the additional benefits of green versus non-green investment options

As scientists continue to clarify the many ways that local air pollution, short-lived climate pollutants, and greenhouse gases harm health, welfare, and the environment, the framework presented in this report can be honed to better account for these costs by providing more complete economic analyses.

Ultimately, climate change is an issue for the whole economy and all facets of development. All policy makers, whether in government cabinets or corporate boardrooms, need to understand where they can get development and climate benefits from the decisions they make. Similarly, those charged with informing decisions from a climate perspective need to able to present more complete analysis and evidence of the broad impacts of their projects and policies.

---

12 The policy case studies use data from a marginal abatement cost curve model that only considers project costs to implement a technology for a transition and thus is limited in use for full-scale analysis of implementation costs for policies. As a result, the outcomes presented have no prescriptive value in terms of policy evaluation. Rather, due to the limitations of existing information and assumptions, they provide illustrative simulations of how additional benefits could be quantified and integrated into policy evaluation in the future.

13 The social cost of carbon (SCC) is used to monetize the climate change damage avoided when CO_2 is reduced. Lacking specific World Bank guidance on the social cost of carbon, values developed by the US Interagency Working Group on Social Cost of Carbon (2013) are used. The SCC accounts for changes in agricultural productivity, human health, and property damage from increased flood risks (US EPA, 2013, http://www.epa.gov/climatechange/EPAactivities/economics/scc.html); however, it does not include all the damage caused by increased CO_2 and may evolve as scientific understanding develops further. This does not constitute a World Bank endorsement of these values. The SCC is very sensitive to the discount rate used. In addition, the climate change costs of black carbon emissions are not accounted for.

WORLD BANK GROUP
1818 H Street, N.W.
Washington, DC 20433