

Climate Change and Development Series

OVERVIEW

SHOCK WAVES

**Managing the Impacts of
Climate Change on Poverty**

Stephane Hallegatte, Mook Bangalore,
Laura Bonzanigo, Marianne Fay,
Tamaro Kane, Ulf Narloch,
Julie Rozenberg, David Treguer,
and Adrien Vogt-Schilb

Overview

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Contents of Shock Waves: Managing the Impacts of Climate Change on Poverty

Overview

- 1** From Climate Change to Poverty and Back: A Framework
- 2** Bad Seed: Climate Change, Agriculture, and Food Security
- 3** Threat Multiplier: Climate Change, Disasters, and Poor People
- 4** Under the Weather: Climate Change, Health, and the Intergenerational Transmission of Poverty
- 5** Lend a Hand: Poor People, Support Systems, Safety Nets, and Inclusion
- 6** A Window of Opportunity: Climate-Informed Development and Pro-Poor Climate Policies

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Overview

Introduction

Climate change threatens the objective of sustainably eradicating poverty. Poor people and poor countries are exposed and vulnerable to all types of climate-related shocks—natural disasters that destroy assets and livelihoods; waterborne diseases and pests that become more prevalent during heat waves, floods, or droughts; crop failure from reduced rainfall; and spikes in food prices that follow extreme weather events. Climate-related shocks also affect those who are not poor but remain vulnerable and can drag them into poverty—for example, when a flood destroys a microenterprise, a drought decimates a herd, or contaminated water makes a child sick. Such events can erase decades of hard work and asset accumulation and leave people with irreversible health consequences. Changes in climate conditions caused by increasing concentrations of greenhouse gases (GHGs) in the atmosphere can worsen these shocks and slow down poverty reduction.

Ending poverty will not be possible if climate change and its effects on poor people are not accounted for and managed in development and poverty-reduction policies. But neither can the climate be stabilized without

acknowledging that ending poverty is an utmost priority. The goal of maintaining climate change below a 2°C increase in global temperature above preindustrial levels—the very goal the international community has committed to—will require deep structural changes in the world economy. These changes will affect the conditions under which poor people succeed or fail to escape poverty. Emissions-reduction policies can increase energy and food prices, which represent a large share of poor people’s expenditures. But these same policies can be designed to protect, and even benefit, poor people—for instance, by using fiscal resources from environmental taxes to improve social protection.

Ending poverty and stabilizing climate change will be two unprecedented global achievements and two major steps toward sustainable development—that is, development that balances the economic, social, and environmental considerations. But these two objectives cannot be considered in isolation: they need to be jointly tackled through an integrated strategy.

This report brings together these two objectives—ending poverty and stabilizing climate change—and explores how they can more easily be achieved if considered together. It examines the potential impact of climate

change and climate policies on poverty reduction. It also provides guidance on how to create a “win-win” situation so that climate change policies contribute to poverty reduction and poverty-reduction policies contribute to climate change mitigation and resilience building.

The key finding of the report is that climate change represents a significant obstacle to the sustained eradication of poverty, but future impacts on poverty are determined by policy choices: rapid, inclusive, and climate-informed development can prevent most short-term impacts whereas immediate pro-poor, emissions-reduction policies can drastically limit long-term ones:

- **Climate-related shocks and stresses, already a major obstacle to poverty reduction, will worsen with climate change.**

Climate is involved in most of the shocks that keep or bring households into poverty—notably, natural disasters (such as floods that cause asset loss and disability); health shocks (such as malaria that results in health expenditures and lost labor income); and crop losses and food price shocks (due to drought or crop disease).

Poor people are disproportionately affected—not only because they are often more exposed and invariably more vulnerable to climate-related shocks but also because they have fewer resources and receive less support from family, community, the financial system, and even social safety nets to prevent, cope, and adapt. Climate change will worsen these shocks and stresses, contributing to a decoupling of economic growth and poverty reduction, thereby making it even harder to eradicate poverty in a sustainable manner.

- **In the short run, rapid, inclusive, and climate-informed development can prevent most (but not all) consequences of climate change on poverty. Absent such good development, climate change could result in an additional 100 million people living in extreme poverty by 2030.**

Between now and 2030, climate policies can do little to alter the amount of global warming that will take place. The only option, therefore, is to reduce vulnerability through both targeted adaptation investments and improved socioeconomic conditions (higher incomes and lower poverty and inequality).

Although development and adaptation cannot prevent all negative impacts from climate change, by 2030 they can prevent or offset most of its effects on poverty. But development must be rapid and inclusive to reduce poverty and provide poor people with social safety nets and universal health coverage. It also needs to be climate informed—meaning that investments and development patterns do not create new vulnerabilities and account for what we know about future climate conditions. And it needs to be accompanied by targeted adaptation (like upgrades in flood defenses or more heat-tolerant crops).

- **Immediate mitigation is required to remove the long-term threat that climate change creates for poverty eradication. Mitigation need not threaten short-term progress on poverty reduction provided policies are well designed and international support is available.**

Our ability to manage increasing climate change impacts is limited. To keep long-term impacts on poverty in check, global temperatures need to be stabilized at a safe level—which implies that net global carbon emissions be brought down to zero before the end of the century. Such an ambitious goal requires that all governments act now to implement emissions-reduction policies. These policies will unambiguously benefit poor people over the long term, thanks to reduced climate change impacts, and they can be designed not to slow down poverty reduction over the short term.

All countries should pursue options that provide local and immediate benefits (like less pollution, better health, improved energy access and efficiency, reduced energy expenditures, and higher

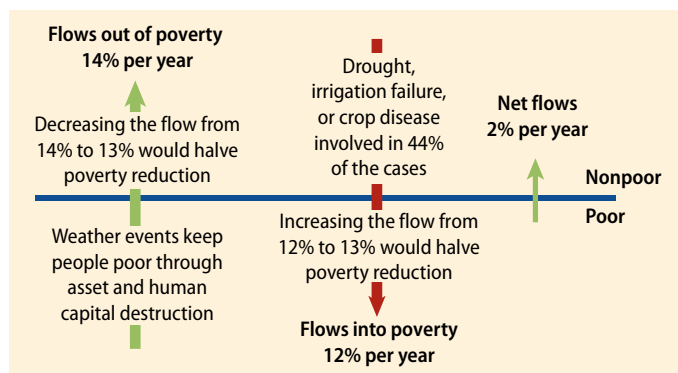
agricultural productivity). Governments can protect the poor from the consequences of those mitigation policies that could impose net costs and create trade-offs—notably by strengthening social protection and cash transfers or reducing taxes, possibly using revenues from energy or carbon taxes or fossil fuel subsidy removal. In poor countries where domestic resources are insufficient to protect poor people, support from the international community is essential. This is particularly true for investments with high upfront costs that are critical to prevent lock-ins into carbon-intensive patterns (such as for urban transport, energy infrastructure, or deforestation).

Climate change is a threat to poverty eradication

Poverty reduction is not a one-way transition out of poverty: many people exit or fall back into poverty every year. For instance, over a 25-year period, every year an average of 14 percent of households in 36 communities in Andhra Pradesh, India, escaped poverty and 12 percent of nonpoor households became poor—resulting in a net 2 percent annual decrease in poverty (figure O.1). The fact that, in practice, the net flow out of poverty is much smaller than the gross flows in and out of poverty means that a relatively small change in the gross flows in and out of poverty can significantly affect net flows and overall poverty dynamics. In the India example, if the flow into poverty increased from 12 to 13 percent per year or the flow out of poverty slowed from 14 to 13 percent per year, the pace of poverty reduction would be reduced by half.

Today, climate conditions or climate events are already involved in many cases where households fall into poverty. They include price shocks that can be linked to lower agricultural production (as occurred after the Russian droughts in 2010); natural disasters that destroy poor people's assets and affect health and education; and health shocks (such

FIGURE O.1 Flows in and out of poverty in Andhra Pradesh are larger than their net effect on poverty



Source: Based on Krishna 2006.

as death and illness) that are influenced by climate and environmental conditions (like higher rainfall and more malaria outbreaks, or higher temperatures and more frequent diarrhea). In addition, climate risks affect the behavior of people, who may reduce investments and asset accumulation because of the possibility of losses and select lower-risk but lower-return activities—a rational strategy to avoid catastrophic outcomes, but one that can keep them in poverty.

The key question then is: How much will climate change influence the flows in and out of poverty and affect poverty over time? This report reviews the evidence and provides new quantification on the issue. It does this by examining the impact of climate change on three interacting channels that are already affecting the ability of the poor to escape poverty—agricultural and ecosystem impacts, natural disasters, and health shocks—and then deriving policy implications. Here we should note that climate change will have other impacts (for example on tourism or energy prices) that are not reviewed and assessed in this report, and a comprehensive estimate of all climate change impacts remains out of reach. However, even a subset of all possible impacts reveals worrying patterns on how changes in climate conditions would threaten the objective of eradicating extreme poverty by 2030.

We find that climate change already worsens—and will further exacerbate—climate-sensitive shocks and negative trends in the three sectors that we consider, consistent with recent reports from the World Bank (2014a) and the Intergovernmental Panel on Climate Change (IPCC 2014; Olsson et al. 2014). We also show that there will be an impact on poverty and inequality because poor people (i) are more often affected by these negative shocks or trends (they are more *exposed*); (ii) lose more when affected, relative to their income or wealth (they are more *vulnerable*); and (iii) receive less support from family, friends, and community, and have less access to financial tools or social safety nets to help prevent, prepare for, and manage impacts.

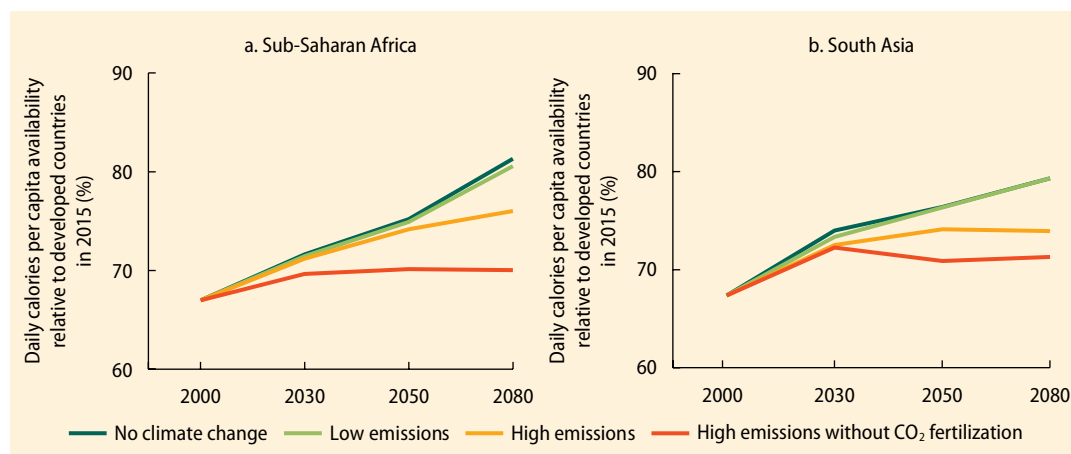
Poor people are more vulnerable to spikes in food prices and more dependent on agricultural and ecosystem-related income

Impacts on agricultural production and prices—triggered by either gradual changes in long-term climate trends or more frequent and severe natural disasters—will affect poor

people through food production impacts, higher consumption prices, and changes in rural incomes.

Lower crop yields and higher food prices. Modeling studies suggest that climate change could result in global crop yield losses as large as 5 percent in 2030 and 30 percent in 2080, even accounting for adaptive behaviors such as changed agricultural practices and crops, more irrigation, and innovation in higher yield crops (Biewald et al., forthcoming; Havlík et al., forthcoming). Over the short term, climate change will also create some benefits, but mostly in cold and relatively rich countries, while poorer regions will be the most negatively affected. The expected yield losses are likely to translate into higher agricultural prices; and climate change will make it more difficult, even with more trade, to ensure food security in regions like Sub-Saharan Africa and South Asia. In a world with rapid population growth, slow economic growth, and high GHG emissions (that is, a scenario in which global temperatures increase by approximately 4°C by 2100), food availability in these regions could plateau at levels far below current levels in developed countries (figure O.2).

FIGURE O.2 Climate change can significantly reduce food availability in poor regions



Source: Havlík et al., forthcoming.

Note: Results are based on simulations from the Global Biosphere Management Model (GLOBIOM) in a scenario with large population growth and little economic growth.

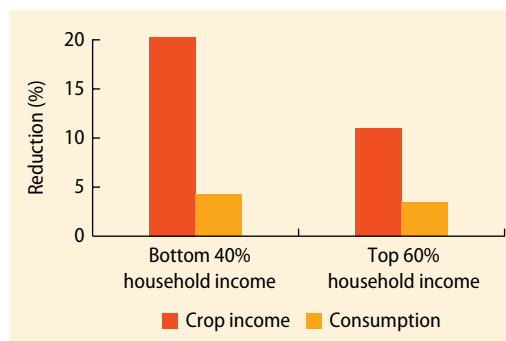
But these estimates come with a high level of uncertainty. They vary depending on the type of climate, crop, and economic model applied, as well as on assumptions about CO₂ fertilization (its presence should mean higher crop yields)—hence the –30 percent to +45 percent range in likely food price changes in 2050 that is reported by the IPCC (Porter et al. 2014). And they do not include local pollution and ozone, pests and crop diseases, food losses along the supply chain, or natural disasters that could result in temporary, but very severe, food price shocks.

In addition, emissions-reduction efforts could affect food prices and availability. The IPCC concludes that large-scale, land-based mitigation at the global scale, especially bio-energy expansion, can reduce the availability of land for food production, with implications for food security. In fact, new modeling simulations show that mitigation policies that do not consider food security could have price impacts that are larger than those of climate change (Havlík et al., forthcoming). However, more carefully designed mitigation policies could lead to price impacts that are smaller than those caused by unmitigated climate change (Lotze-Campen et al. 2014).

Changes in consumption and incomes. Losses in the agricultural sector and spikes in food prices can push vulnerable consumers into poverty—take, for example, the 2008 food price spike that caused about 100 million people to fall into poverty, or the 2010–11 episode that increased poverty by 44 million. Part of the problem is that poor people spend a larger share of their budget on food than the rest of the population, with nonagricultural rural households and urban residents the most vulnerable (Ivanic, Martin, and Zaman 2012).

In addition, farmers would directly suffer from production shocks that could reduce income and consumption. Data from Uganda between 2005 and 2011 suggest that a 10 percent reduction in water availability due to a lack of rainfall reduces crop income by an average of 14.5 percent—and almost 20 percent for the poorest households. Consumption also falls, but less so (figure O.3).

FIGURE O.3 Rainfall shocks in Uganda take a big toll on crop income, less so on consumption



Source: Hill and Mejia-Mantilla 2015.

Note: Values calculated based on Uganda National Household Survey UNHS 2005/6, UNHS 2009/10, UNHS 2012/13. Rainfall shock is represented by a 10 percent decrease in the Water Requirement Satisfaction Index, estimated for Uganda.

As for the rural poor, the situation could be mixed. If production shocks are accompanied by price rises, agricultural workers and farmers may benefit from higher wages and earnings (Jacoby, Rabassa, and Skoufias 2014). So the net effect on income depends on how food prices react to reduced global production and how demand and diets can adjust over the short term and the long term. It also depends on the balance between local changes (which affect farmers' production) and global changes (which affect global food prices). And it depends on institutions—especially labor markets—that determine how changes in revenues from agriculture are distributed between workers, landowners, and traders.

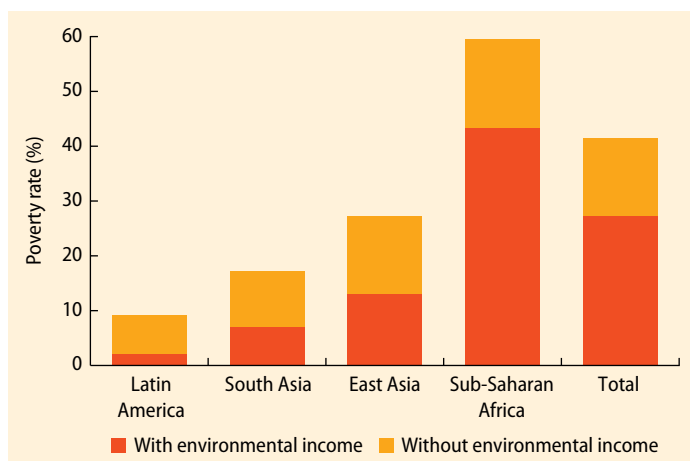
However, even if the net impact on income is positive, it is unlikely to offset the negative impacts of higher consumption prices on overall poverty. One study of 15 developing countries in various regions finds that climate-induced price rises increase extreme poverty by 1.8 percentage points (Hertel, Burke, and Lobell 2010). It also finds that, in parts of Africa and Asia, climate-related price adjustments could increase poverty rates for nonagricultural households by 20–50 percent. Similarly, another study shows that a once-in-30-year climate extreme could double the number of poor urban laborers in the most

vulnerable countries, including in Malawi, Mexico, and Zambia (Ahmed, Diffenbaugh, and Hertel 2009). Our own simulations reach similar results (see below).

Another complicating factor is that climate change—especially when combined with local stressors such as pollution and overuse—threatens ecosystems, which provide subsistence production and safety nets for many people in rural areas. Poor smallholder communities across (sub)tropical landscapes depend on the extractive use of ecosystems for up to 30 percent of their income and often rely on ecosystem resources to keep themselves above the poverty threshold (figure O.4). Even though a precise quantification remains out of reach, a growing number of studies document how increasing climate stress threatens the livelihoods of poor people in a variety of rural contexts and forces them to pursue new livelihood strategies. Over the long term, climate change will even make some ecosystems (such as small island states or low-lying coastal areas) completely uninhabitable, forcing inhabitants to move.

FIGURE O.4 Without environmental income, poverty rates could be much higher in (sub)tropical forest landscapes

(Poverty rate in (sub)tropical smallholder systems)



Source: Noack et al., forthcoming.

Note: Figure shows share of sampled households below the extreme-poverty line. Based on the Poverty and Environment Network (PEN) dataset, including data from 58 sites in 24 countries. Environmental income describes income derived from ecosystem services (such as wood gathering or root and berry picking) rather than agriculture.

Natural hazards, to which poor people are often more exposed and almost always more vulnerable, will become more intense and frequent in many regions

We are already experiencing an increase in natural hazards. About 75 percent of the moderate hot extremes over land and 18 percent of moderate precipitation extremes are attributable to global warming (Fischer and Knutti 2015). Even though some positive impacts are expected—such as fewer cold spells—the frequency and intensity of many hazards are expected to increase in most places:

- Heat waves that are considered exceptional today will become common. In Europe, the summer of the 2003 heat wave, which led to more than 70,000 deaths, will be an “average” summer at the end of this century under a high-emissions scenario (a scenario in which the global mean temperature has increased by about 4°C by 2100).
- The number of drought days could increase by more than 20 percent in most of the world by 2080, and the number of people exposed to droughts could increase by 9–17 percent in 2030 and 50–90 percent in 2080.
- The number of people exposed to river floods could increase by 4–15 percent in 2030 and 12–29 percent in 2080 (Winsemius et al., forthcoming), and coastal flood risks can increase rapidly with sea level rise (Hallegatte et al. 2013).

Will poor people bear the brunt of these climatic changes? Poor and nonpoor people settle in risky areas for many reasons. Sometimes, they lack information about the level of risk, or they do not account for this information in their decisions (World Bank 2013, chapter 2). But at-risk areas are often attractive in spite of the risk because they offer economic opportunities, public services or direct amenities, and higher productivity and incomes. In some rural areas, proximity to water offers cheaper transport, and regular

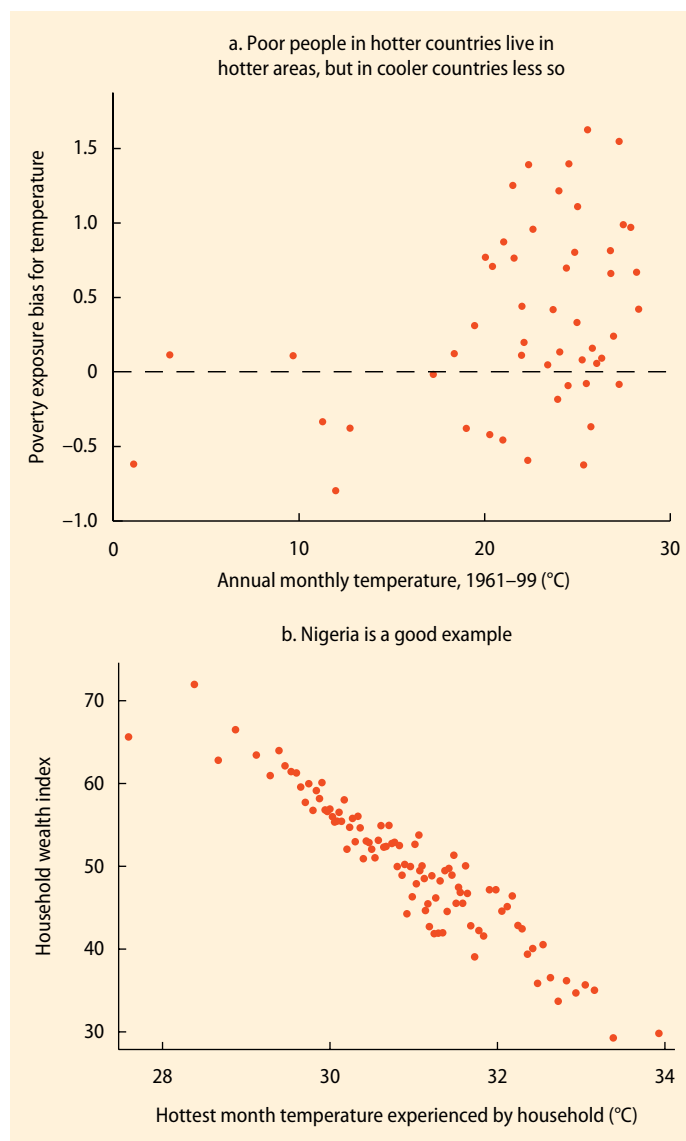
floods increase agricultural productivity. People settle in risky areas to benefit from opportunities—such as coastal areas with export-driven industries or cities with large labor markets and agglomeration spillovers. While these factors apply to rich and poor alike, local land and housing markets (or the availability of land) often push poorer people to settle in riskier, but more affordable, areas.

To shed more light on this issue, we investigated poverty-specific exposure to flood, droughts, and extreme temperatures within 52 countries to obtain a first global estimate of the difference in exposure for poor and nonpoor people.

Our results show that *for drought*, most of the analyzed population (85 percent) lives in countries where poor people are more exposed to droughts than the average (Winsemius et al., forthcoming). Poor people are also more exposed to *higher temperatures*: 37 out of 52 countries (56 percent of the population) exhibit an overexposure of poor people, with this bias stronger in hotter countries where high temperatures are more likely to be detrimental (figure O.5). As for *river floods*, the results are mixed: poor people are more exposed than the average in half of the countries analyzed (60 percent of the population). In Africa, countries in the southwest exhibit a strong overexposure of poor people, as do those with large rivers in west Africa (like Benin, Cameroon, and Nigeria). Focusing on urban households, we find that in most countries (73 percent of the population), poor households are more exposed to floods than the average (map O.1). This might be because land scarcity is more acute in urban areas (than in rural areas), creating a stronger incentive for the poor to settle in risky areas due to lower prices. This higher exposure to flood risk for poor urban dwellers is also found using higher-resolution data on household location and flood hazards in Mumbai, India.

Given that the dynamics of disasters and poverty occur at a fine scale, studies of exposure at the national scale may miss important mechanisms and small-scale differences, from one city block to the next. An alternative way to examine whether poor people are more

FIGURE O.5 Poor people in hotter countries—like Nigeria—live in hotter areas, but less so in cooler countries



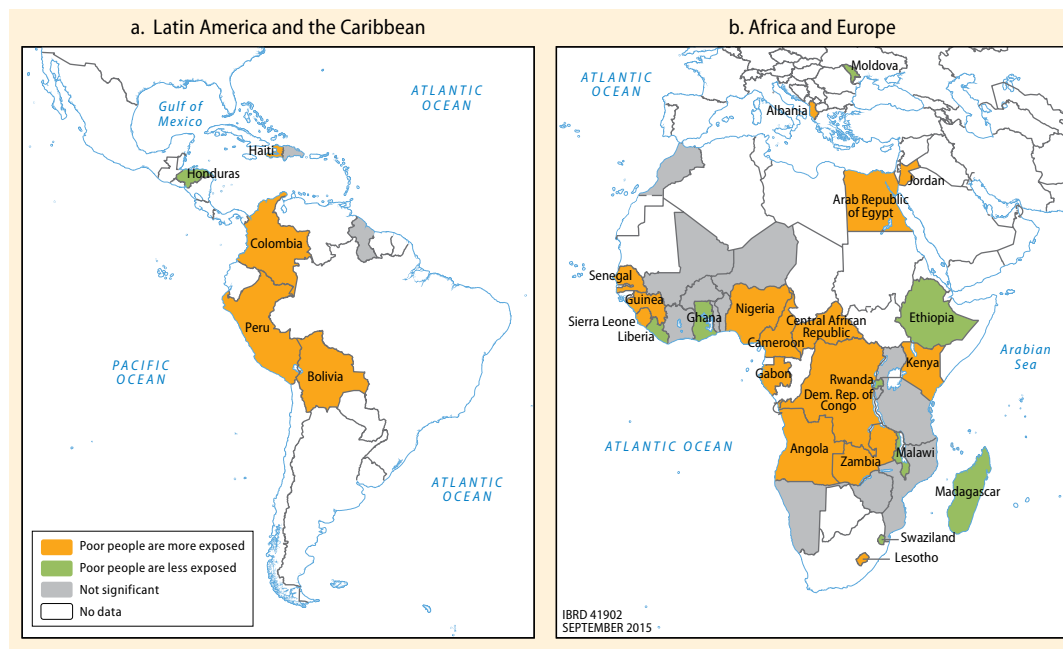
Source: Park et al., forthcoming; World Bank 2015a.

Note: Panel a plots country-level poverty exposure bias for temperatures against each country's current climate. The poverty exposure bias is the share of poor people exposed to a hazard, divided by the share of the total population exposed, subtracted by 1. A positive bias means poor people are more exposed than the average. Panel b plots household-level wealth index and temperature within a country—Nigeria.

exposed to natural hazards is through in-depth case studies, analyzing household survey data from disaster victims. Here again we find that poor people are generally more exposed, although there are exceptions—such as hurricane Mitch in Honduras (figure O.6, panel a).

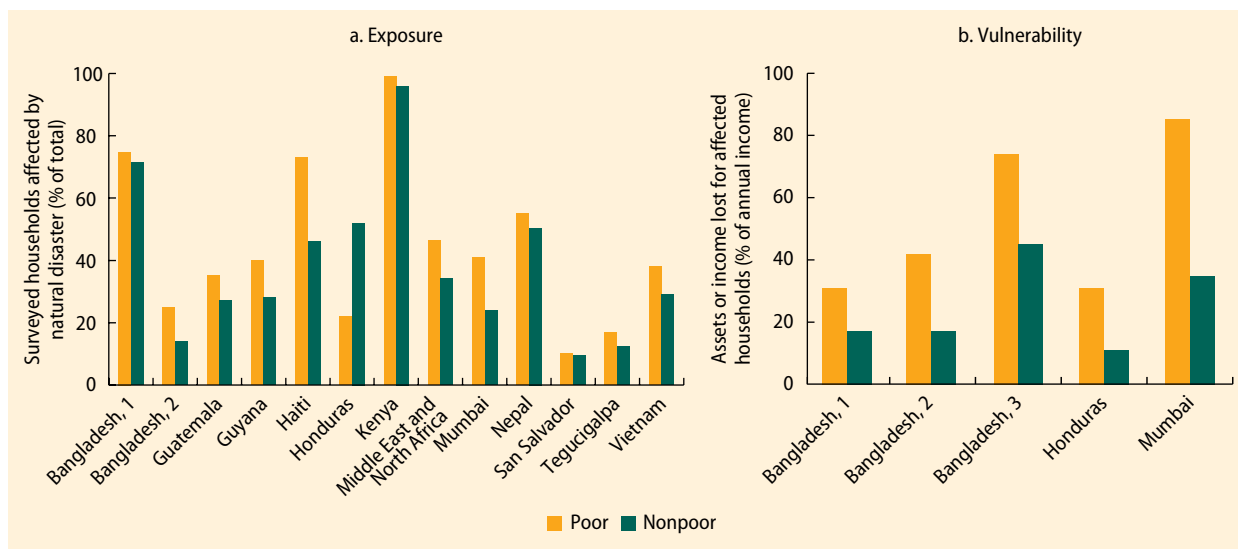
MAP 0.1 The urban poor are more exposed to river floods in many countries

(Poverty exposure bias for floods in urban areas)

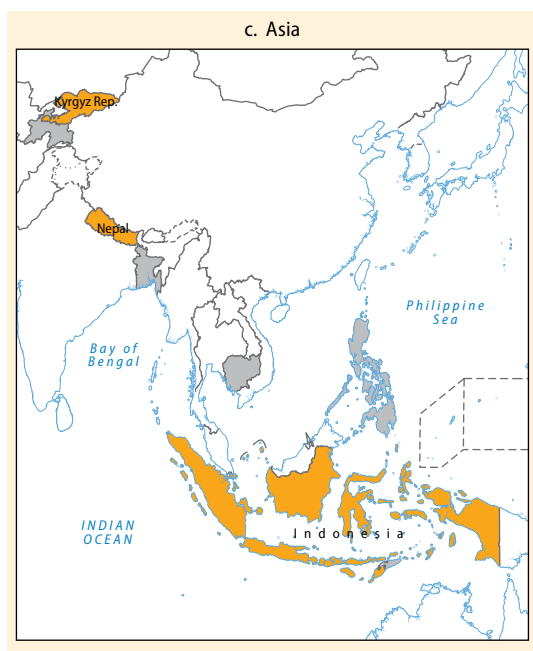


Source: World Bank (IBRD 41902, September 2015) based on Winsemius et al., forthcoming.
 Note: Exposure was calculated for river floods.

FIGURE 0.6 When disasters hit in the past, poor people were more likely to be affected (panel a) ... and poor people always lost relatively more than nonpoor people (panel b)



Source: See sources in Chapter 3.
 Note: Each Bangladesh case represents a unique study.



As for assets and income, nonpoor people lose a larger amount in absolute terms because they have more assets and higher incomes than the poor. But in relative terms, poor people always lose more than the nonpoor, according to the five surveys that report the magnitude of natural disaster losses, distinguishing by income classes (figure O.6, panel b). And it is these relative losses, rather than absolute ones, that matter most for livelihoods and welfare.

Poor people are losing relatively more to disasters for two main reasons. First, they often do not save at financial institutions, and they hold most of their wealth in vulnerable forms, such as housing for urban dwellers and livestock for rural households. Second, the quality of their assets—and the resistance of those assets to natural hazards—is often lower than average: typical houses found in a slum can be completely destroyed in a common flood whereas modern houses or multifamily buildings are much more resistant. And poor people's overall vulnerability is exacerbated

by the dependence on ecosystems and the large fraction of their budget dedicated to food.

As a result of these differences in exposure and vulnerability, natural disasters increase inequality and may contribute to a decoupling of economic growth and poverty reduction. It is thus not surprising that natural disasters are found to worsen poverty. For instance, between 2000 and 2005, floods and droughts increased poverty levels in affected Mexican municipalities by 1.5 to 3.7 percent (Rodriguez-Oreggia et al. 2013). After Ethiopia's 1984–85 famine, it took a decade on average for asset-poor households to bring livestock holdings back to prefamine levels (Dercon 2004).

Poor people are strongly affected by diseases and health issues that climate change is likely to magnify

Climate change will magnify some threats to health, especially for poor and vulnerable people—such as children. The exact impacts are still highly uncertain in what is still an emerging research field. Past progress on medical treatment offers hope that some of these issues could be solved over the long term thanks to new drugs and better health infrastructure. But short-term impacts could still be significant.

Health shocks are important for poverty dynamics and the impact of climate change for three main reasons. First, the main diseases that affect poor people are diseases that are expected to expand with climate change (such as malaria and diarrhea). Second, health expenditures are regressive, with poor households largely uninsured—such outlays push an estimated 100 million people per year into poverty—and the loss of income for the sick or the caregiver can have a large impact on family prospects (WHO 2013). Third, children are most vulnerable to these shocks and can suffer from irreversible impacts that affect their lifetime earnings and lead to the intergenerational transmission of poverty.

Malaria. Even small temperature increases could significantly affect the transmission of malaria. At the global level, warming of 2°C or 3°C could increase the number of people at risk for malaria by up to 5 percent, or more than 150 million people. In Africa, malaria could increase by 5–7 percent among populations at risk in higher altitudes, leading to a potential increase in the number of cases of up to 28 percent (Small, Goetz, and Hay 2003). Further, climate change is projected to intensify malaria along the current edges of its distribution, where malaria control programs are often nonexistent and people have no naturally acquired immunity against the disease.

Diarrhea. Climate impacts could increase the burden of diarrhea by up to 10 percent by 2030 in some regions (WHO 2003). Indeed, higher temperatures favor the development of pathogens, and water scarcity affects water quality and the hygiene habits that can prevent diarrhea. An estimated 48,000 additional deaths among children under the age of 15 resulting from diarrheal illness are projected by 2030 (Hales et al. 2014). And climate change could contribute to outbreaks of other waterborne diseases such as cholera and schistosomiasis.

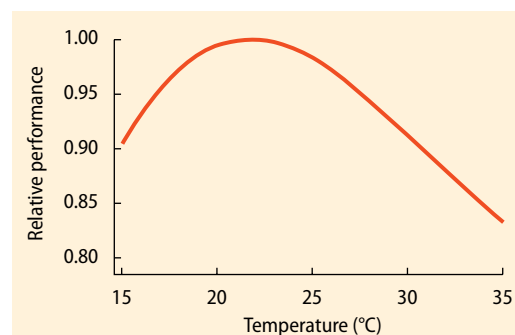
Stunting. In part because of its impacts on agriculture (figure O.2), climate change will increase undernutrition and could sharply increase severe stunting among children. By 2030, an additional 7.5 million children may be stunted (Hales et al. 2014). Climate change could even lead to an *absolute* increase in the number of stunted children in some parts of Africa, with the negative effect of climate change outweighing the positive effect of economic growth (Lloyd, Kovats, and Chalabi 2011). And recent evidence suggests that the nutritional quality of food (for example, its content in terms of micronutrients such as iron, iodine, vitamin A, folate, and zinc) could also be affected by climate change, even though little is known about potential impacts (Myers et al. 2014).

Even less is known about the combined effects of multiple health stressors. For instance, it is well known that undernourished children are more vulnerable to malaria

and other vectorborne or waterborne diseases, but these interactions have not yet been investigated in the context of climate change. Also impossible to quantify is the impact on mental disorders and stress due to increased risk, disasters, or indirect impacts through physical health, household dynamics, or community well-being. And changes in climate and environmental conditions will interact with local air pollution and allergen distribution, exacerbating respiratory diseases. One estimate is that climate change could cause annually an additional 100,000 premature deaths associated with exposure to small particulate matter and 6,300 premature deaths associated with ozone exposure (Fang et al. 2013).

Another concern is that high temperatures will reduce labor productivity of those who are poorer and often work outside or without air conditioning (figure O.7). The impact on labor productivity could be large and reduce income by several percentage points. Moreover, this effect is not accounted for in any of the studies we reviewed on estimates of agricultural production, although it could magnify food security issues. In addition, new research suggests that extreme temperature stress in either direction—hot or cold—is suboptimal for economic activity, even when considering only nonfarm activities. These results imply that the temperature-related loss in performance observed in

FIGURE O.7 If it gets too hot, productivity falls
(Task performance under different temperatures)



Source: Based on Seppänen, Fisk, and Lei 2006.

laboratories and at the individual level may be observable at the macroeconomic level, and that climate change could hurt overall income through this channel (Deryugina and Hsiang 2014; Heal and Park 2013; Park et al., forthcoming).

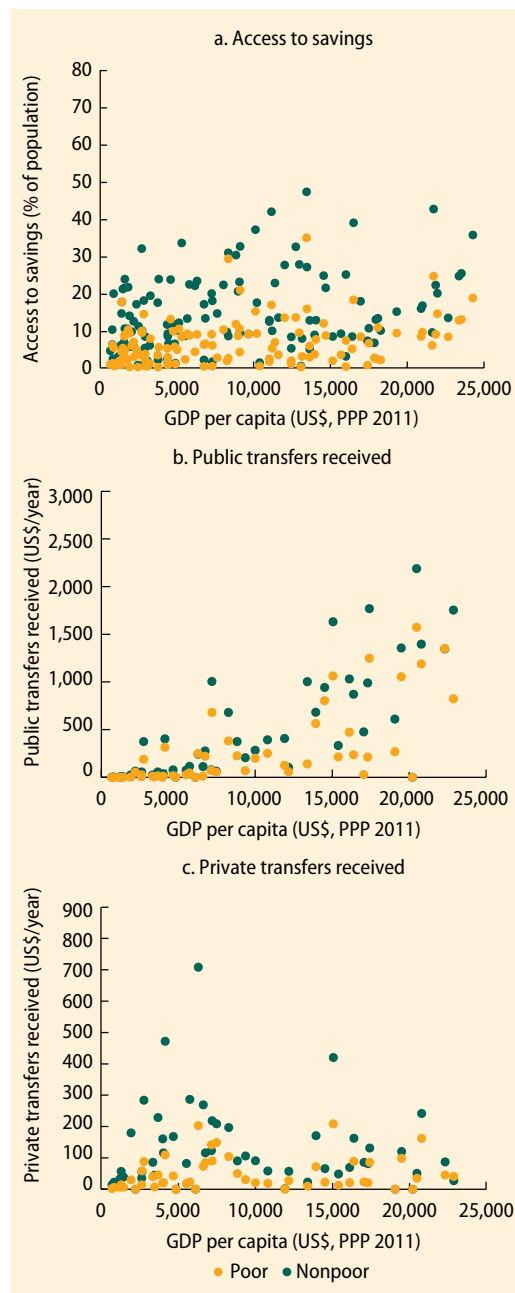
Poor people receive less support from friends and family and have more limited access to financial tools and social safety nets

Many policy instruments exist that could help poor people prevent, adapt to, and cope with climate shocks and changes (World Bank 2013), but poor people have only limited access to them (figure O.8). Take the case of financial inclusion—meaning access to formal savings, borrowing, and insurance products (figure O.8, panel a). People may lack access to these formal financial tools for several reasons, including the cost of bank accounts, distance and time to access a financial agent, lack of documentation, or mistrust in banks. Some people also prefer to stay in the informal sector, or are not aware of the benefits of using financial tools for risk management (Allen et al. 2012).

Poor people also receive limited support from social safety nets, ranging from cash transfers to work programs (figure O.8, panel b). In many countries, social programs cover less than half of the poorest quintile. In addition, even when poor households are covered by social protection schemes, amounts received are often too small to make a big difference and prevent negative coping strategies. In Bangladesh after the 1998 floods, poor affected households had to borrow an amount equal to six to eight times the level of government transfers (del Ninno, Dorosh, and Smith 2003).

Then, too, migration and remittances play a key role in managing shocks—but migration requires resources and assets that the poorest lack, and data show that remittances tend to benefit nonpoor people more than poor people (figure O.8, panel c). As a result, poor people are disproportionately affected by

FIGURE O.8 Poor people have less access to financial tools, social protection, and private transfers



Source: World Bank computation based on the FINDEX and ASPIRE databases.

Note: Panel a is based on data from FINDEX. Panels b and c are based on data from ASPIRE. Each country is represented with two dots. Poor people are those in the bottom 20% (ASPIRE) or bottom 40% (FINDEX). Nonpoor people are those in the top 80% (ASPIRE) or top 60% (FINDEX). PPP = purchasing power parity.

climate change and natural shocks, not only because they are more exposed and vulnerable to them but also because they receive less support.

By 2030, rapid, inclusive, and climate-informed development can prevent most (but not all) climate change impacts on poverty

Just how large might these impacts be on poverty by 2030 and how much can development help? We know that between now and then, climate policies will have minimal impacts on warming, given the long lag between the introduction of mitigation policies, their impact on emissions, and the effect of emissions reductions on the climate system (IPCC 2014). This means that, by 2030, the only way to reduce climate change impacts will be by lowering socioeconomic vulnerability to these impacts—which will require climate-informed development and specific actions to adapt to climate change.

The magnitude of future climate change impacts on poverty depends on today's choices

In this report, we try to get a sense of the magnitude of future climate change impacts—and how this magnitude depends on today's choices—by creating two scenarios for what the future of poverty could be by 2030 in the absence of climate change (figure O.9). The first one, “*Prosperity*,” assumes that the World Bank's goals of extreme poverty eradication and shared prosperity are met by 2030 (in particular, less than 3 percent of the world population remains in extreme poverty), and that access to basic services is quasi-universal. The second scenario, “*Poverty*,” is much more pessimistic in terms of poverty reduction and inequalities (for instance, 11 percent of the world population remains in extreme poverty).

We then introduce into each of these scenarios estimates of climate change impacts on food price and production, natural disasters, and health and labor productivity, based on the reviews and analyses presented in the report. But we do so with two climate change impact scenarios—a *low-impact* and a *high-impact* scenario—given that the physical and biological impacts will be highly uncertain, dependent on (i) how ecosystems adapt and physical systems (like glaciers and coastal zones) respond and (ii) how sectors spontaneously adapt (like adopting new agricultural practices or improved hygiene habits).

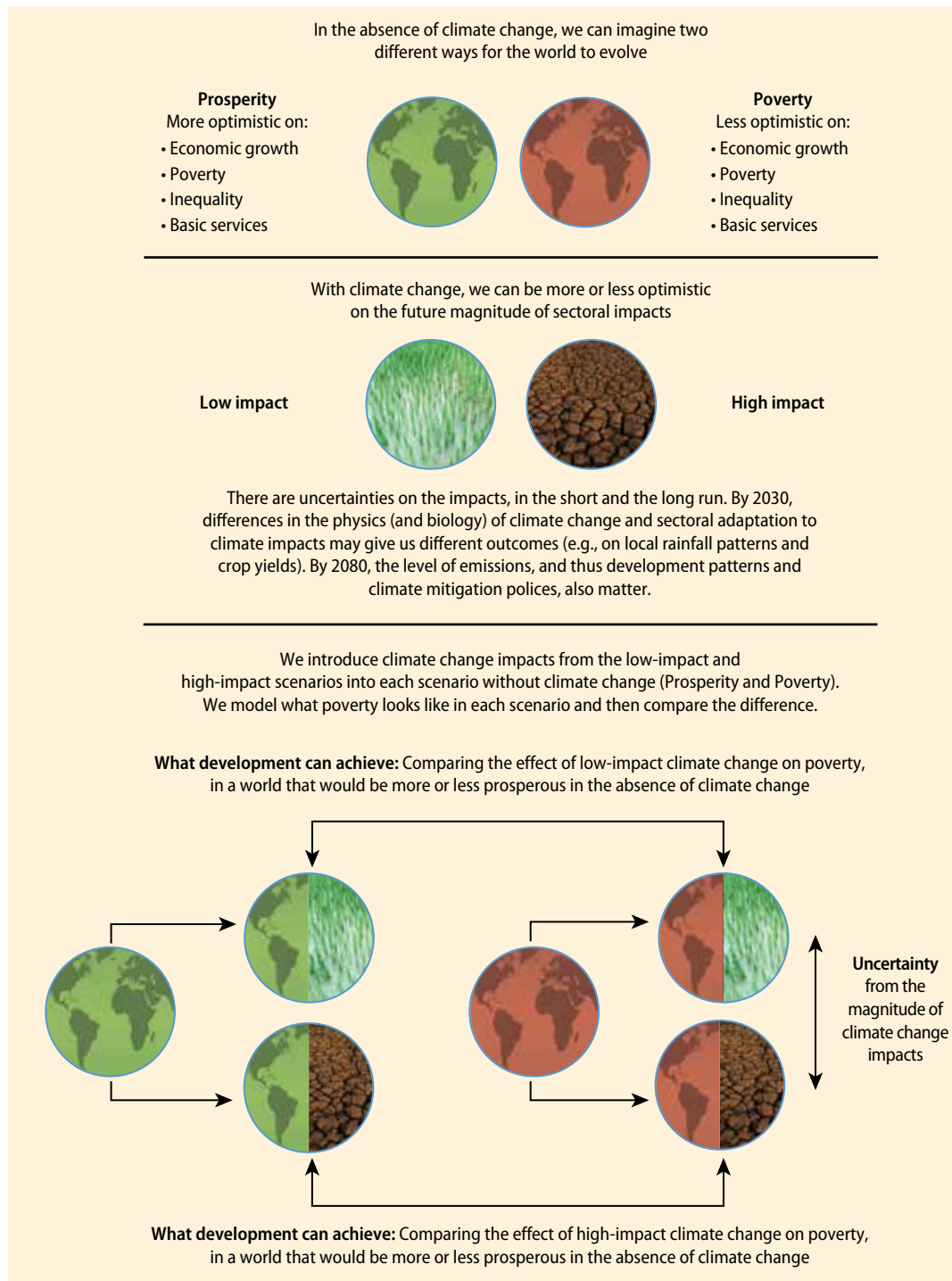
We do not attribute probabilities or likelihoods to the development and climate impact scenarios because we are not interested in forecasting the future of poverty (it is probably impossible). What interests us is the contrast across scenarios rather than the absolute numbers. That is why we focus on how the impacts of climate change on poverty would differ if development is rapid and inclusive (“*Prosperity*”) as opposed to slow and noninclusive (“*Poverty*”).

The bottom line is that, even though our analysis looks only at the short term with limited changes in climate conditions, it still finds that climate change could have a large effect on extreme poverty: by 2030, between 3 and 16 million people in the *prosperity* scenario and between 35 and 122 million people in the *poverty* scenario would be in poverty because of climate change.

That said, these estimates are likely an underestimate for several reasons. First, we follow a bottom-up approach and sum the sector-level impacts, assuming they do not interact. Second, we consider only a subset of impacts, even within the three sectors we focus on. For instance, we do not include losses in ecosystem services and reduced nutritional quality of food; we consider only consumption poverty, disregarding outcomes like the nonmonetary effects of disease; and we do not include secondary impacts of disasters (like the potential effect on migrants and refugees). Third, we cannot assess the poverty impact everywhere. Our scenarios are developed based on a household

FIGURE 0.9 Our model for estimating the number of people in poverty due to climate change

(A schematic to represent the modeling undertaken to estimate the impact of climate change on extreme poverty in 2030 under different scenarios of future development, and thus in worlds with different levels of exposure and vulnerability)



Note: Photos © Masaru Goto / World Bank (low impact image) and Arne Hoel / World Bank (high impact image). Further permission required for reuse.

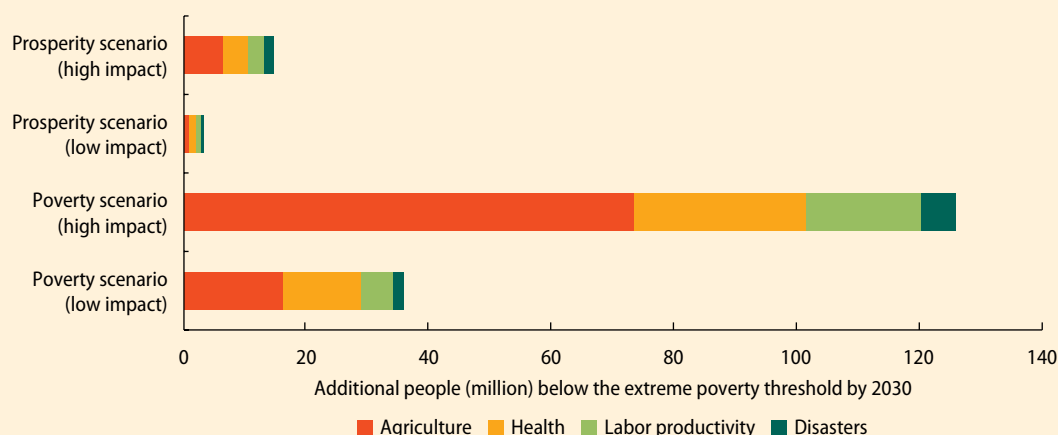
BOX O.1 Agriculture is the key driver for climate change's impact on poverty

Which poverty channel is the dominant influence in our four scenarios? As figure BO.1.1 shows, agriculture is the main driver of the impact on poverty (in all four scenarios)—although its impact is possibly an underestimation because all climate scenarios assume CO₂ fertilization. Then, health

impacts (diarrhea, malaria, and stunting) and the labor productivity effects of high temperature have a second-order but significant role. Disasters have a relatively limited role, but this may be because only the direct impact on income losses was taken into account.

FIGURE BO.1.1 Agriculture is the main sectoral driver explaining higher poverty due to climate change

(Summary of climate change impacts on the number of people living below the extreme poverty threshold, by driver)



Source: Rozenberg and Hallegatte, forthcoming.

database that represents only 83 percent of the developing world's population. Some high vulnerability countries (such as small islands) could not be included because of data limitations, in spite of the large effects that climate change could have on their poverty rate.

Although climate change has a significant impact on poverty up to 2030—working primarily through the agricultural channel (box O.1)—it remains a secondary driver, as evidenced by the nearly 800 million person difference between the two socioeconomic scenarios in the absence of climate change (table O.1). This does not mean that climate change impacts are secondary at the local scale: in some particularly vulnerable places

(like small islands or in locations affected by large disasters), the local impact could be massive.

Note that the large range of estimates in our results may incorrectly suggest that we cannot say anything about the future impact of climate change on poverty. The main reason for this wide range is not scientific uncertainty on climate change and its impacts. Instead, policy choices dominate—particularly those concerning development patterns and poverty-reduction policies between now and 2030. While emissions-reduction policies cannot do much regarding the climate change that will happen between now and 2030 (because that is mostly the result of past emissions), development

TABLE O.1 Climate change threatens to worsen poverty, but good development can help

Policy choices	Climate change scenario			
	No climate change	Low-impact scenario		High-impact scenario
	Number of people in extreme poverty by 2030	Additional number of people in extreme poverty due to climate change by 2030		
Prosperity scenario	142 million	+3 million		+16 million
		Minimum +3 million	Maximum +6 million	Minimum +16 million Maximum +25 million
Poverty scenario	900 million	+35 million		+122 million
		Minimum −25 million	Maximum +97 million	Minimum +33 million Maximum +165 million

Source: Rozenberg and Hallegatte, forthcoming.

Note: The main results use the two representative scenarios for prosperity and poverty. The ranges are based on 60 alternative poverty scenarios and 60 alternative prosperity scenarios.

choices can affect what the impact of that climate change will be.

Also note that the range of possible impacts is even larger than the one represented by our four scenarios because there is an infinite number of possible socioeconomic pathways by 2030, even without climate change. To assess the robustness of our results, we create 60 alternative *prosperity* and 60 alternative *poverty* scenarios. We find that the range of possible impacts on poverty remains limited in the *prosperity* scenario: development not only reduces the impacts but also protects us from the uncertainty. In the *poverty* scenario, on the other hand, the range of possible outcomes is extremely large: the worst-case estimate increases up to 165 million, and some scenarios show a *decrease* in global poverty numbers—these are scenarios where climate change impacts remain moderate (low-impact) and where farmers benefit the most from higher agricultural prices.

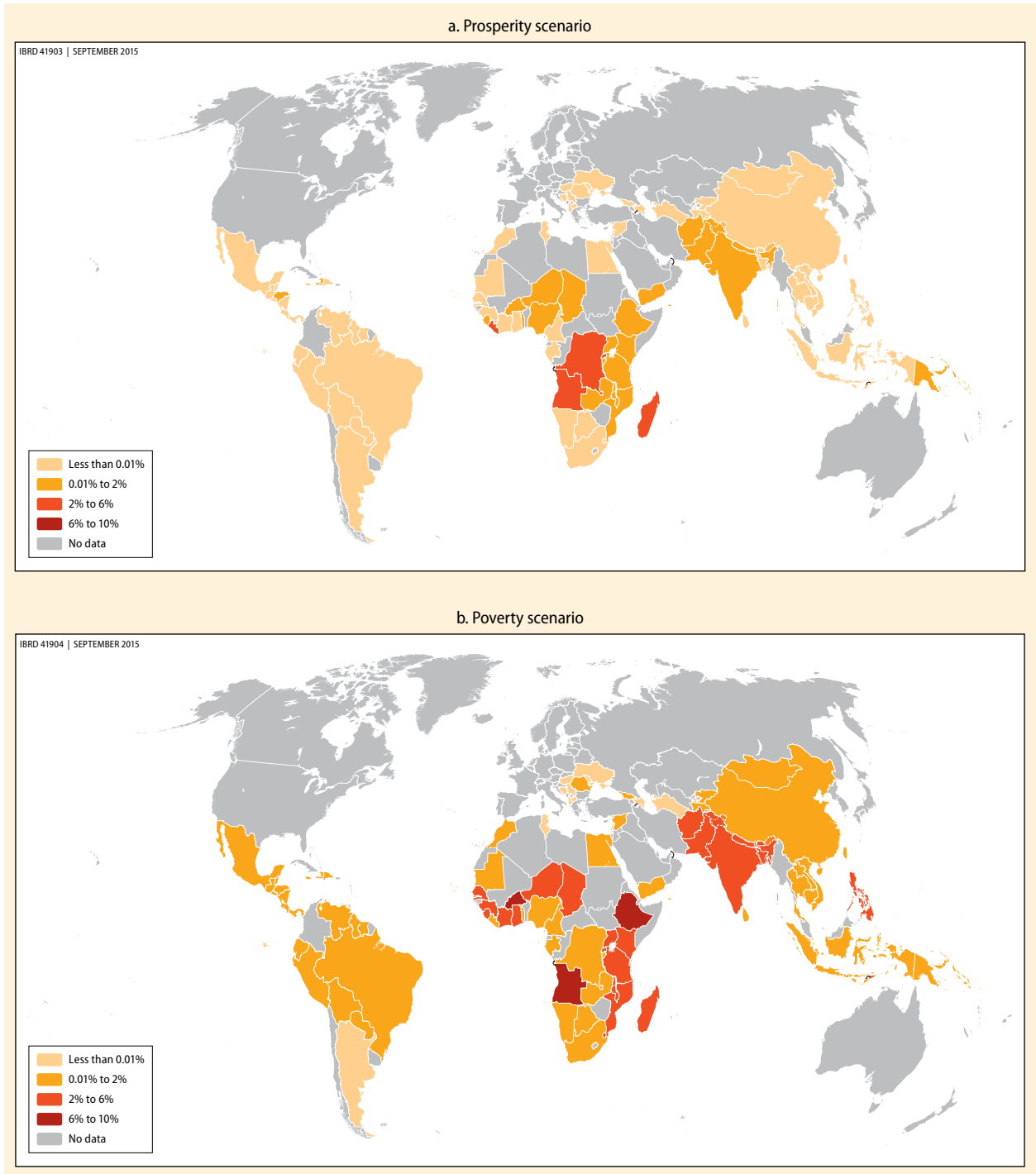
The lower vulnerability of the developing world to climate change in the *prosperity* scenario comes from several channels. First, people are wealthier and fewer households live with a daily income close to the poverty line. Wealthier individuals are less exposed to health shocks such as stunting and diarrhea, and are less likely to fall back into poverty when hit by a shock. And with fewer farmers, the population is less vulnerable to the negative impacts of climate change on yields. Second, the global population is smaller in the

prosperity scenario in 2030, by 2 percent globally and by up to 20 percent in some African countries due to more migration. A smaller population mitigates the impact of climate change on food prices. In addition, the *prosperity* scenario assumes more technology transfers to developing countries, which further reduces the agricultural loss due to climate change. In the *prosperity* scenario, a more balanced economy and better governance also mean that farmers capture a larger share of the income benefits from higher food prices.

At the country and regional level, the hotspots are Sub-Saharan Africa and—to a lesser extent—India and the rest of South Asia (map O.2). Almost all countries are less vulnerable to climate change in the *prosperity* scenario, often dramatically: in India, the high-impact climate change scenario brings 2 million people into poverty in the *prosperity* scenario, compared to almost 50 million in the *poverty* scenario. One exception is the Democratic Republic of Congo, where climate change is found to bring more people into poverty in the *prosperity* scenario. This occurs because, in the *poverty* scenario without climate change, the poverty rate is extremely high (70 percent): climate change draws fewer people into poverty than in the *prosperity* scenario only because so many people are already in poverty.

Such a result warns us against using a poverty headcount as the unique indicator of the

MAP 0.2 Climate change impacts on poverty vary greatly across scenarios, with Africa and South Asia the most vulnerable
(Increase in number of extreme poor people due to climate change in the high-impact climate scenario (% of total population))



Source: World Bank (IBRD 41903 and IBRD 41904, September 2015) based on Rozenberg and Hallegatte, forthcoming.

impact of climate change on poverty. Because it does not measure poverty depth, it does not capture the impact on people who are already poor. For instance, in a high-impact climate scenario, climate change reduces the income of the bottom 40 percent in 2030 by more than 4 percent in most of the countries in both the *prosperity* and *poverty* scenarios. And, in most Sub-Saharan African countries and Pakistan, climate change reduces the income of the bottom 40 percent by more than 8 percent.

Climate-informed development needs to be complemented with targeted adaptation interventions and a more robust safety net system

Rapid and inclusive development can prevent most of the impact of climate change on poverty, but only if new investments and developments are *climate informed*—that is, designed to perform well under changing climate conditions so that they do not create new vulnerabilities to climate impacts. For example, new water and sanitation infrastructure can make a big difference for diarrhea, but only if it can absorb the more extreme rainfall episodes that are expected in many regions. Similarly, new settlements in safe areas will reduce the long-term vulnerability only if the selected areas remain safe in spite of sea level rise and accelerated erosion.

However, even a rapid, inclusive, and climate-informed development will not cancel out the need for targeted actions that are aimed at lowering people's vulnerability to climate change impacts. Although some of them are pure climate change adaptation measures (like adapting building norms to new environmental conditions), others (like increasing financial inclusion) can be seen as “good development” and would make sense even in the absence of climate change.

Our report highlights potential options in the three sectors that we focus on (agriculture and ecosystems, natural disasters, and health) and emphasizes the potential of social protection and financial tools to boost the resilience of households and economies to all sorts of

shocks, including those magnified by climate change (table O.2). Of course, each country can identify its own priorities, based on the impacts of climate change that are expected on its territory, but also on synergies and convergence with other policy priorities. For instance, where urban planning is a policy priority, mainstreaming natural hazards and climate change into its design is a low-hanging fruit waiting to be plucked.

Climate-smart agriculture and protected ecosystems. Climate-smart agricultural practices can increase productivity and resilience (Cervigni and Morris 2015). More productive and more resilient practices, however, require a major shift in the way land, water, soil nutrients, and genetic resources are managed to ensure that these resources are used more efficiently (FAO 2013). Crop improvement, smarter use of inputs, approaches to strengthen crop resistance to pests and diseases, and reduction of post-harvest losses can contribute to the sustainable intensification of agriculture—thereby leading to greater food production (Beddington 2010; Tilman et al. 2011).

For this to happen, innovation is needed to keep increasing yields, and the new techniques that result from innovation must actually be broadly adopted, including by poor farmers. These two conditions are challenging. First, yield increases have plateaued in recent years, even exhibiting abrupt decreases in some regions (Grassini, Eskridge, and Cassman 2013). The low and declining levels of investment in agricultural research and development in the developing world are a major constraint to realize further yield gains in poor countries (Pardey, Alston, and Chan-Kang 2013). Second, disseminating improved technologies and making them accessible to poor farmers is difficult, and even promising innovations sometimes have low or no uptake. High implementation costs, cultural barriers, and lack of access to information and education need to be overcome. Agricultural extension services can help farmers make better use of new technologies. In Uganda, extension visits increased household agricultural income by around 16 percent when new crop

TABLE O.2 Many targeted actions can lower poor people's vulnerability to climate change impacts

Sectoral options to reduce vulnerability	Private sector	Governments	International community
Agriculture, ecosystems, and food security			
Adopt climate-smart technologies and agricultural practices, with support from agricultural extension	X	X	
Develop higher yielding and more climate-resistant crop varieties and livestock breeds, adapted to developing country contexts and climate conditions	X	X	X
Develop transport infrastructure and facilitate market access (domestic and international)		X	X
Reduce non-climate stresses on ecosystems, including through conservation and ecosystem-based adaptation		X	X
Natural disasters and risk management			
Increase financial inclusion and participation in banking to reduce the vulnerability of poor households' assets	X	X	
Improve households' and firms' preparedness and ability to act upon warnings (contingency plans, regular drills)	X	X	
Improve access to risk information, invest in hydro-meteorological services—for observation and forecasting—and link with early warning and evacuation systems, and collect more data on disaster consequences		X	X
Enact risk-sensitive and enforceable land use regulation and building norms		X	
Improve tenure to incentivize investments in housing quality and resilience, and enforceability of building norms		X	
Invest more and better in infrastructure by leveraging private resources and using designs that account for future climate change and the related uncertainty	X	X	X
Health			
Increase R&D and eradication/control efforts toward health issues that affect poor people and are expected to increase with climate change	X	X	X
Invest in health infrastructure and access; train health workers		X	
Implement or strengthen effective surveillance and monitoring systems to detect emerging health risks		X	X
Increase health coverage to lower the share of expenses that are out of pocket		X	
Support systems: financial sector, social protection, remittances, and governance			
Develop market insurance for the middle class to concentrate public resources on poor people	X	X	
Enact well-targeted and easily scalable social safety nets designed to maintain incentives for long-term adaptation investments and grant portable benefits		X	
Manage the government's formal liability using reserve funds, contingent finance (such as Cat-DDOs), and insurance products, along with developing and scaling-up tools to share risks internationally		X	X
Facilitate flow of remittances and reduce cost burden on remitters	X	X	
Improve governance and give a role to poor people in the decision-making process		X	

Note: Cat-DDO = Catastrophe Deferred Drawdown Option; R&D = research and development.

varieties were available (Hill and Mejia-Mantilla 2015).

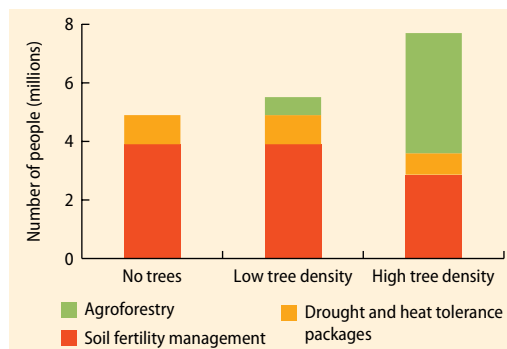
Poor people can become more resilient to shocks in agriculture thanks to trade and food reserves that can overcome local shortages in times of need, better access of poor farmers to markets, and improved technologies and climate-smart production techniques. Access to functioning markets, however, depends on better infrastructure and better institutions. In Ethiopia, the incidence of poverty decreased by 6.7 percent following farmers' access to all-weather roads (Dercon et al. 2009). In Burkina Faso, maize price volatility is found to be greatest in remote markets (Ndiaye, Maitre d'Hôtel, and Le Cotty 2015). Investments in transport infrastructure improve market integration, reduce price uncertainty for farmers, and improve food security.

For ecosystem-based income, the main option is to reduce the nonclimate stresses on ecosystems to make them better able to cope with changes in environmental conditions. Conservation and ecosystem-based strategies are critical for making ecosystems more resilient and for protecting the resources on which many poor people in rural areas depend. Healthy ecosystems are generally quite resilient, so protecting them and restoring degraded lands can increase their ability to withstand climate-related disturbances. Integrating trees in agricultural systems can also reduce vulnerability to drought and increase the store of carbon (figure O.10).

Land use regulations and better and more infrastructure for natural hazards. Land use regulations can ensure that new development occurs in places that are safe, or easy and cheap to protect using hard or soft infrastructure. But effective implementation of such regulations remains challenging. First, it requires appropriate data on risk and hazard, which remains limited in low-income environments despite recent progress (including the Global Facility for Disaster Reduction and Recovery's [GFDRR] Open Data for Resilience Initiative that makes risk data available for governments and the public).

FIGURE O.10 Drought vulnerability is reduced by agricultural techniques that integrate trees and store carbon

(Reduction in average annual number of drought-affected people)



Source: Cervigni and Morris 2015.

Second, strong institutions are needed to ensure that land use plans are actually enforced, and even the highest-capacity countries struggle to reduce flood exposure. Third, one needs to take into account the reasons why people decide to live in risky places, namely a trade-off between safety and access to jobs and services (Hallegatte 2012a). In a new survey, poor households in Mumbai say they would relocate to a safer place but only if they had access to cheap transport, health services, schools, and social networks (Patankar, forthcoming). Thus, land use planning can realistically function only if accompanied by investments in transport and other infrastructure to make it possible for people to settle in safe places while maintaining access to the same (or comparable) jobs and services.

Poor people lack the type of protective infrastructure that is common in richer countries. For instance, poor households are often exposed to recurrent floods due to the lack, or poor maintenance, of infrastructure (especially drainage systems)—even if these events do not attract media and policy maker attention, they can represent a large burden on poor people. Solving these problems requires investing *more* and investing *better*. Around \$1 trillion per year would be

needed in developing countries to close the infrastructure gap, with about \$100 billion for Africa alone. Closing this gap is difficult, but it would go a long way toward reducing the vulnerability of poor people. Recommendations typically include leveraging private resources to make the most of available capital, which involves well-known steps like improving the investment climate, developing local capital markets, and providing a pipeline of “bankable” projects (Fay et al. 2015).

But infrastructure investments will reduce the long-term vulnerability of the population and contribute to long-term poverty reduction only if they serve poor people. In particular, investing where it is most cost-efficient would risk concentrating resources on wealthier populations at the expense of poor communities (Tschakert, forthcoming). New infrastructure also needs to be designed to remain efficient in spite of changes in climate and environmental conditions. Innovative methods for managing the uncertain risks of climate change and multiple (and sometimes conflicting) policy objectives can be applied to meet these challenges (Kalra et al. 2014). Several World Bank pilot projects using these methods have been completed or are under way, including on water supply in Lima, flood risk management in Ho Chi Minh City and Colombo, hydropower investment in Nepal, and adaptation of road networks in Peru and across Africa.

As discussed earlier, poor people lose a larger fraction of their assets and income because their dwelling is often their main asset and because they live in buildings with low resistance to natural hazards. In addition to financial inclusion—which could help people save in less vulnerable ways—improving tenure security could incentivize investment in housing, including in risk reduction, to make them more resistant. In Peru, the issuance of property titles to over 1.2 million urban dwellers encouraged households to invest more in their homes, thereby reducing their vulnerability (Field 2007).

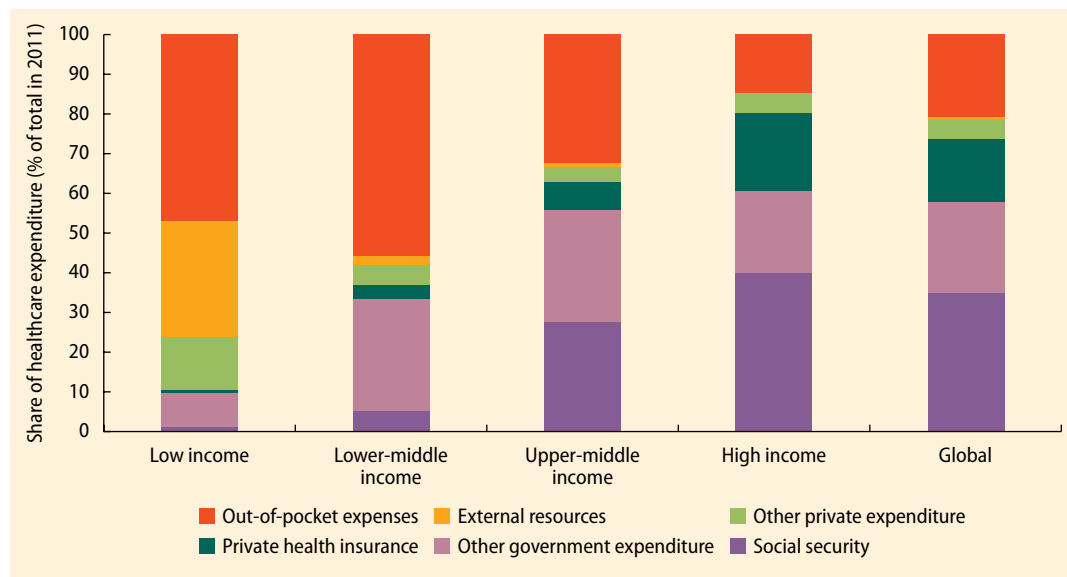
Early warning systems—combined with observation systems and evacuation

preparedness—can save many lives at a low cost. When Cyclone Phailin made landfall near Gopalpur, India, in 2013, it killed fewer than 100 people. While still a significant loss, it is much smaller than the 10,000 deaths that a similar storm caused in 1999. More generally, early warning systems are very cost-effective investments, with each dollar invested yielding more than \$4 in avoided losses (Hallegatte 2012b). However, over the past 15–20 years, the situation of many hydrometeorological services in developing countries has worsened (Rogers and Tsirkunov 2013). As a result, the ability to monitor local climate change and increases in natural risks has eroded, making developing countries less able to detect, anticipate, and adapt to climate change.

Better health infrastructure and universal health care. Poor people in low- and lower-middle-income countries have limited access to health care, and face out-of-pocket expenditure exceeding 50 percent of health expenses—much higher than the less than 15 percent that is common in rich countries (figure O.11). But examples show that better health coverage is possible everywhere. In Colombia, thanks to a multilevel government scheme and cross-subsidization from contributory schemes, the poor are covered against primary care and catastrophic event costs—with coverage of the poorest quintile up to 47 percent in 1997 from only 3–8 percent in 1993. In Rwanda, the government invested in universal health coverage after the 1994 genocide, and today nearly 80 percent of its population is insured.

However, benefits from better access to care depend on the quality of care, and in most countries parallel efforts are required to develop and improve health infrastructure. Climate change makes this need even more important. Countries should have strong monitoring and surveillance systems able to detect new health issues that will periodically arise in response to changing climate conditions. They also need research and development on the diseases that affect poor people and that are expected to increase with climate change.

FIGURE O.11 In poorer countries, half of all health expenditures are paid out of pocket, unlike in richer ones



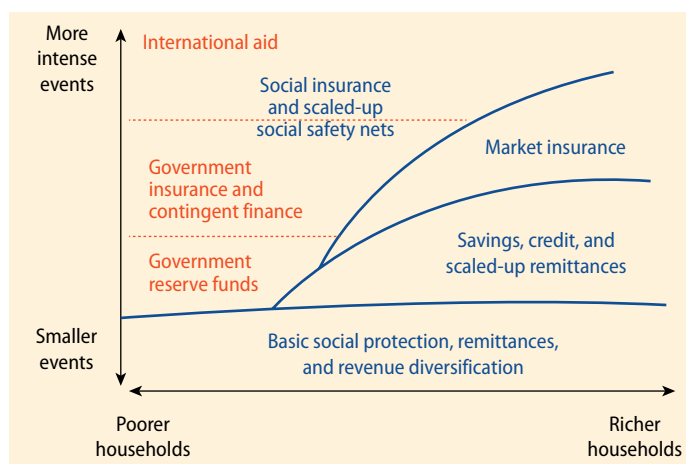
Source: Watts et al. 2015.

Social safety nets and financial tools. A growing body of evidence shows that insurance and social safety nets are efficient tools to support poor people when they are affected by natural disasters or environmental and economic shocks. In Mexico, beneficiaries of *Prospera*, the national cash transfer program (previously known as *Oportunidades* or *Progresa*), are less likely to respond to shocks by withdrawing their children from the classroom (de Janvry et al. 2006; Fiszbein, Schady, and Ferreira 2009; Gertler 2004).

To ensure that the financial sector and social safety nets provide instruments relevant to climate change, governments need to design a holistic risk management and climate change strategy, giving a voice to poor people and making their protection a priority. Such a strategy will necessarily include a range of instruments, targeted to specific disasters or social groups (figure O.12).

Basic social protection and revenue diversification can help households at all income levels cope with small and frequent shocks. But for larger shocks, additional tools are

FIGURE O.12 Poorer households need different types of solutions



needed. For relatively wealthier households, savings and market insurance can offer efficient protection for larger losses. But the poorest households have minimal savings, and high transaction costs make it difficult to offer them private insurance. Instead, the government needs to provide social safety

nets that are well targeted and can be scaled up rapidly after a shock.

A key challenge is to strike a balance between providing rapid support when needed and precisely targeting those most in need. Case studies in Ethiopia and Malawi suggest that the cost of a drought to households can increase from zero to about \$50 per household if support is delayed by four months, and to about \$1,300 if support is delayed by six to nine months (Clarke and Hill 2013). This rapid increase, which is due to irreversible impacts on children and distress sales of assets (especially livestock), helps explain why most postdisaster responses have multiple stages. Typically, initial support is delivered quickly—even at the expense of targeting and accuracy—and larger recovery and reconstruction efforts are provided later with more emphasis on appropriate targeting.

Experience shows that countries at all income levels can implement social safety nets to protect their population, even though the appropriate instruments depend on local capacity. Preexisting social protection programs with large and flexible social registries help provide prompt support to affected people so that they do not have to resort to costly coping strategies. For instance, by using the preexisting conditional cash transfer system (the 4Ps), the government of the Philippines was able to quickly release a total of P550.5 million (US\$12.5 million) between November 2013 and February 2014 in emergency unconditional cash transfers to 4Ps beneficiaries affected by Typhoon Yolanda (Bowen, forthcoming). When droughts in Ethiopia caused food shortages and famine in 2011, the *Productive Safety Net Program* expanded its coverage from 6.5 million to 9.6 million people in two months and increased the duration of benefits from six to nine months per year (Johnson and Bowen, forthcoming). These safety nets remain affordable and reduce the need for costly humanitarian interventions.

However, adaptive social protection systems create an additional liability for governments, who may then need to turn to specific

instruments such as reserve funds, regional mechanisms, contingent finance or reinsurance products (like the World Bank's Catastrophe Deferred Drawdown Option, or Cat-DDOs), or even international aid if local capacities are exhausted (Ghesquiere and Mahul 2010). In response to Cyclone Pam in March 2015, the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), a regional mechanism, provided Vanuatu with a rapid \$1.9 million payment that supported the immediate response.

Social protection schemes also need to maintain incentives to invest in long-term adaptation to economic and environmental changes. Poorly designed social safety nets can reduce the incentive for people to quickly adapt and change occupation or activity when the first effects of climate change appear (Chambwera et al. 2014). This problem is not new and specific to climate change: efforts are already under way to ensure that social protection is a facilitator of—and not an obstacle to—long-term change and adaptation, for instance by facilitating migration (Brown, Zelenska, and Mobarak 2013; Bryan, Chowdhury, and Mobarak 2014) or making benefits more portable if the recipient decides to move to capture better opportunities (World Bank 2015b).

Combining rapid, inclusive, and climate-informed development with targeted interventions and stronger safety nets would largely reduce the *short-term* threat from climate change—and, fortunately, developing countries have a window of opportunity to go in that direction before most of the climate change impacts materialize. In parallel, the international community can do much to support them. This includes offering resources for climate risk analysis and project preparation, and ensuring that financial instruments and resources are available for development and poverty reduction investments—especially when higher resilience implies higher upfront costs. The international community can also build resilience by strengthening international risk-sharing mechanisms and generalizing access to contingent finance in emergency situations.

Emissions-reduction policies are required to remove the long-term threat from climate change, and need not threaten progress on poverty reduction

In the absence of mitigation policies, risks for development and poverty eradication will grow over time and only emissions reduction can limit long-term risks (IPCC 2014). While this report proposes options to reduce climate risks, it also points to the limits of these options: land use planning faces difficult political economy obstacles, financial constraints make it tough to invest in protection infrastructure, and the provision of health care in rural areas remains challenging. And, although social safety nets and health insurance help households cope with shocks, they do not reduce the direct and immediate impact on well-being and assets and will become increasingly costly—even unaffordable—if shocks become more frequent and intense (Carter and Janzen, forthcoming). There are clear limits to what adaptation can achieve, and these limits will be tested by climate change.

Moreover, some long-term risks could prove catastrophic—such as those related to the response of ice sheets and ecosystems—and remain impossible to quantify in terms of consequences or probability. Uncertainty is not a reason to delay climate change mitigation action. On the contrary, the need for climate stabilization arises from both a risk-management approach that accounts for threats created by long-term impacts and the fact that GHG emissions lock us into irreversible warming. Indeed, these long-term risks largely explain why the international community has committed to the goal of stabilizing climate change.

Maintaining global warming below 2°C, or even below 3°C, will require bringing emissions down to zero by 2100, a goal recognized by the leaders of the major industrial countries at the 2015 summit of the G7. And there is a consensus that current development trends are incompatible with these

internationally agreed climate targets (IPCC 2014). Thus, policies are needed now to make development and climate change stabilization compatible: modern living standards will need to be supported in a more efficient and radically less carbon-intensive way, and residual emissions offset through natural carbon sinks like forests (Fay et al. 2015).

The first step is for all countries to enact comprehensive packages of emissions-reduction policies (IPCC 2014)—ranging from carbon pricing and innovation support to environmental performance standards, information labels, financing facilities, and land use and urban planning (Fay et al. 2015; NCE 2014; OECD 2015). Priority should go to implementing the policies and measures that are urgently needed to prevent irreversibility and lock-ins into carbon-intensive patterns (such as those regarding deforestation, energy infrastructure, or urban transport).

These policy packages must be designed in a way that does not threaten the objective of eradicating poverty by 2030. This can be done in three complementary ways: (i) building on no-regret options and cobenefits; (ii) protecting the poor and vulnerable populations against potential adverse consequences of emissions-reduction options; and (iii) in the poorest countries, using support from the international community to offset possible trade-offs between poverty reduction and climate change mitigation.

All countries should embrace the mitigation policies that generate short-term cobenefits that exceed costs—like lower air pollution and higher energy efficiency. Recent studies have found that, in all regions, the benefits for health and agricultural yields from less pollution alone could exceed the cost of mitigation, at least until 2030 (Shindell et al. 2012). For example, a pathway leading to lowering CO₂ concentrations would avoid 0.5 million premature deaths annually in 2030, 1.3 million in 2050, and 2.2 million in 2100, compared to a scenario with only the progress that can be expected from the historically observed uptake of pollution-control technologies.

Many other cobenefits are likely to occur in various sectors (World Bank 2014b).

Better public transit would reduce congestion and traffic accidents, and greater energy efficiency would bode well for productivity. Yet many countries, facing strong financing constraints, tend to favor technologies with lower upfront capital costs, at the expense of higher operation costs—in effect, favoring less energy-efficient technology and reducing overall productivity (World Bank 2012).

Governments need to enact policies to actively promote the adoption of no-regret options that reduce GHG emissions and accelerate development. A recent World Bank report reviews market and government failures that hamper the adoption of these no-regret options—such as incorrect pricing, split incentives, poor enforcement of existing regulations, lack of information, behavioral failures, and limits to the financing capacity of stakeholders—and offers solutions to overcome them (Fay et al. 2015). The international community can help developing countries by providing a combination of technical assistance and better access to green technologies (for instance to help them implement performance standards for vehicles, lighting, and appliances). It can also help them mobilize private capital to relax existing investment constraints and favor technologies with higher upfront costs but better efficiency, drawing on innovative financial instruments or the resources from bilateral and multilateral development banks.

In addition, all countries need to avoid negative impacts of mitigation policies on food security, since the resulting effects on global food prices could have a detrimental impact on the poor. Promisingly, many land-based mitigation options also provide an opportunity to strengthen the productivity of agriculture and ecosystems and to boost local incomes. They can be implemented through payments for ecosystem services, which can provide a source of income for the poor. An estimated 25–50 million low-income households could be benefitting from them by 2030 (Milder, Scherr, and Bracer 2010).

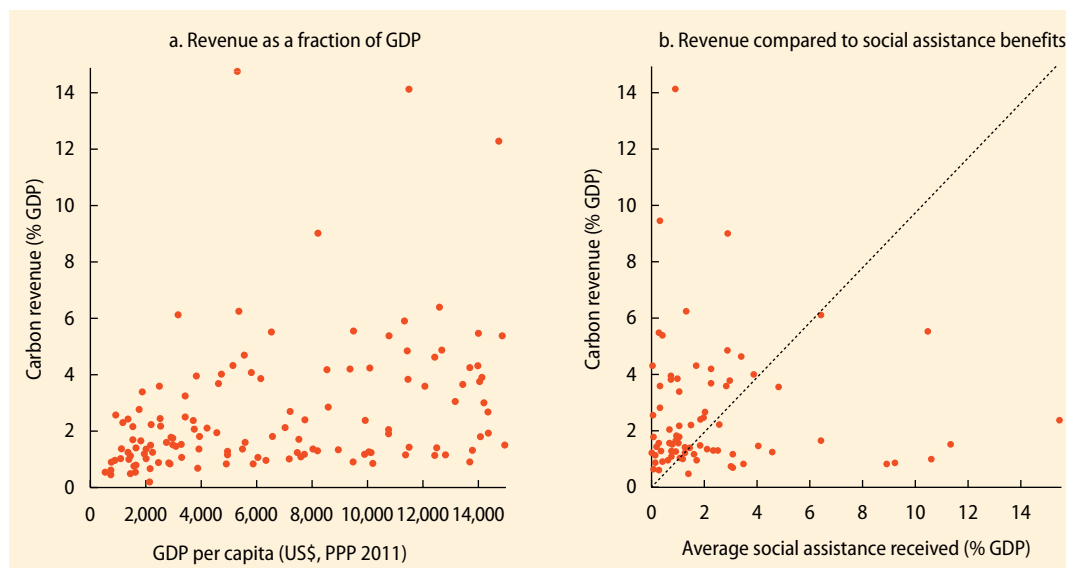
But to stay on a pathway compatible with the complete decarbonization of the economy before 2100, countries will have to do more

than implement win-win options, sometimes creating net costs and trade-offs. Fortunately, governments can protect the poorest, using specific instruments or their existing social protection systems, possibly strengthened by the resources raised by climate policies. For instance, climate policies need to ensure that they do not slow down the switch from traditional biomass to modern cooking fuels, for example by subsidizing efficient cookstoves. This matters greatly because traditional cooking fuels not only are unhealthy but also worsen gender imbalances and affect educational opportunities, given the time women and children often spend collecting wood and other traditional fuels (WHO 2006).

There are many options to make climate policies pro-poor—such as introducing a carbon or energy tax and recycling the revenues through a universal cash transfer that would benefit the poor. An analysis of 20 developing countries shows that for each \$100 of additional energy tax collected and redistributed, the bottom quintile gains \$13 while the richest quintile loses \$23, and overall the bottom 60 percent would benefit from the measure (Arze del Granado, Coady, and Gillingham 2012; Fay et al. 2015).

Similarly, we can estimate how the resources that could be raised by a carbon tax in one country (or an equivalent reform of energy subsidies) compare with current social assistance transfers. Based on current CO₂ emissions and without any international transfer, a \$30/tCO₂ (tons of CO₂) domestic carbon tax would raise resources amounting to more than 1.5 percent of national GDP in half of the 87 countries where data are available (figure O.13, panel a). And in 60 out of the 87 countries, a \$30/tCO₂ domestic carbon tax would provide the resources to more than double current levels of social assistance in the country (figure O.13, panel b). Even a low carbon tax at \$10/tCO₂ would make it possible to significantly scale up social assistance or other investments that benefit poor people (like connections to sanitation and improved drinking water or access to modern energy).

More generally, the impacts of climate mitigation policies on inequality can be corrected

FIGURE 0.13 Using the revenue from a carbon tax could boost social assistance

Source: World Bank calculations using data from WDI and ASPIRE (World Bank 2015c, 2015d).

Note: Panel a: Revenue of a \$30/tCO₂ carbon price expressed as a fraction of GDP. Each dot represents a country. Panel b: How this revenue compares to current social assistance benefits in each country. In 60 out of 87 countries for which data are available, a \$30/tCO₂ tax would provide the resources to more than double current social assistance transfers (dots above the diagonal line for panel b). Calculations assume unchanged energy consumption. PPP = purchasing power parity; tCO₂ = tons of carbon dioxide.

using policies specifically designed to redistribute income in the economy—such as using income or consumption taxes to fund cash transfers or social safety net programs (Borenstein and Davis 2015; Gahvari and Mattos 2007; Lindert, Skoufias, and Shapiro 2006). A World Bank study based on household surveys reveals that countries with GDP per capita above \$4,000 (in purchasing power parity) have sufficient internal resources to redistribute poverty away, and thus can protect poor people against the possible negative effects of climate mitigation (Ravallion 2010). This is important because around 70 percent of people in extreme poverty live in these countries that are able to protect them.

But in very poor countries, it may be difficult for economic, political, or institutional reasons to accomplish this. In particular, the same World Bank study shows that countries with a GDP per capita below \$4,000 (in purchasing power parity) would find it nearly impossible to rely on internal resources for redistribution. In these countries, even if most of the cost of climate mitigation is paid for by the wealthier quintiles of the population,

climate mitigation could still worsen poverty, because the top quintiles are still in, or close to, poverty. In these cases, international support will be essential to offset potential trade-offs between poverty reduction and climate change mitigation.

This is especially the case for investments that involve high immediate costs—and therefore large trade-offs with other investments—but are urgently needed to prevent irreversibility and lock-ins into carbon-intensive patterns. The typical example is urban transit. While transit-oriented development may require higher upfront costs than road-based low-density urbanization, there is now a unique window of opportunity to build efficient transit-oriented cities, because of high urbanization rates in many developing countries and the extended lifetime of urban forms and transit infrastructure.

In conclusion

Bringing together the short-run (up to 2030) and long-run views, this report emphasizes how climate change could set back poverty

eradication efforts—including the risk that unabated climate change creates for the internationally agreed objective of eradicating extreme poverty. In parallel, it demonstrates that the future is not set in stone. We have a window of opportunity to achieve our poverty objectives in spite of climate change by pursuing both (i) rapid, inclusive, and climate-informed development, combined with targeted adaptation interventions, to cope with the short-term impacts of climate change and (ii) immediate pro-poor mitigation policies to limit long-term impacts and create an environment that allows for global prosperity and the sustainable eradication of poverty.

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Climate change threatens the objective of eradicating poverty. Poor people and poor countries are already vulnerable to all types of climate-related shocks—natural disasters that destroy assets and livelihoods; waterborne diseases and pests that become more prevalent during heat waves, floods, or droughts; crop failure from reduced rainfall; and spikes in food prices that follow extreme weather events. Such shocks can erase decades of hard work and leave people with irreversible human and physical losses. Changes in climate conditions caused by increasing concentrations of greenhouse gases in the atmosphere will worsen these shocks and slow down poverty reduction.

The good news is that, at least until 2030, “good development” can prevent most of these impacts. By “good development,” we mean development that is rapid, inclusive, and climate informed; includes strong social safety nets and universal health coverage; and is complemented with targeted adaptation interventions such as heat-tolerant crops and early warning systems. Absent such good development, many people will still be living in or close to extreme poverty in 2030, with little resources to cope with climate shocks and adapt to long-term trends, and climate change could increase extreme poverty by more than 100 million people by 2030.

In the longer run, beyond 2030, our ability to adapt to unabated climate change is limited. To keep the longer-term impacts on poverty in check, immediate emissions-reduction policies are needed that bring emissions to zero by the end of the 21st century. These policies need not threaten short-term progress on poverty reduction—provided they are well designed and international support is available for poor countries.

Ending poverty and stabilizing climate change will be unprecedented global achievements. But neither can be achieved without the other: they need to be designed and implemented as an integrated strategy. *Shock Waves: Managing the Impacts of Climate Change on Poverty* brings together those two objectives and explores how they can more easily be achieved if considered together. The book provides guidance on how to design climate policies so they contribute to poverty reduction, and on how to design poverty reduction policies so they contribute to climate change mitigation and resilience building.