



# Economic Premise

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## The Poverty Impacts of Climate Change

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*Over the last century, the world has seen a sustained decline in the proportion of people living in poverty. However, there is an increasing concern that climate change could slow or possibly even reverse poverty reduction progress. Given the complexities involved in analyzing climate change impacts on poverty, different approaches can be helpful; this note surveys the results of recent research on climate change impacts on poverty.*

The continued decline in global poverty during the last 100 years is a remarkable achievement, a decline that has been even more significant in the last three decades. In 1981, the percentage of the world population living below \$1.25 a day was 52 percent. By 2005, that rate had more than halved to 25 percent (Chen and Ravallion 2009). In recent years, poverty reduction has continued in most countries, even after the financial, food, and fuel shocks of 2008–9. This trend is expected to continue, especially if developing countries manage to sustain the rapid per capita income growth rates they achieved over the last decade. If developing countries do maintain their income growth rates, poverty headcounts at the \$1 or \$2 per day could turn out to be almost obsolete as measures of well-being over the next 50 to 100 years. However, there is a growing concern that climate change could slow or possibly even reverse progress on poverty reduction. This concern is rooted in the fact that most developing countries are more dependent on agriculture and other climate-sensitive natural resources for income and well-being, and that they also lack sufficient financial and technical capacities to manage increasing climate risk.

Climate change is a long-term problem that has been unfolding over many decades. It is likely to lead not only to changes in the mean levels of temperatures and rainfall, but also to a significant increase in the variability of climate and in the frequency of extreme events. Given the complexities involved in an analysis of the climate change impacts on poverty, different approaches may be helpful in considering these impacts. One way is to use economywide growth models incorporating climate change impacts to work out consistent scenarios for how climate change might affect the path of poverty over the next decades. Another approach is to learn about sector-specific channels through which longer-term climate change affects poverty, the size of such impacts, the potential heterogeneity of impacts, and the types of policies that may alleviate the adverse impacts. The information generated by this approach is useful in tackling poverty today, as well as in preparing for how to adapt to climate change in the future. Yet another approach is to explore how current climate variability affects poverty, and then examine the impacts of increased variability on future poverty. This note considers some recent findings from these various approaches.

## Climate Change and Global Poverty from an Aggregate Perspective: Lessons from an Integrated Assessment Model

Three scenarios to model the long-term climate change impacts on poverty are developed using an integrated assessment model, the Regional Integrated Model of Climate and the Economy (RICE) developed by Nordhaus (2010). The first scenario (baseline) simulates a world without climate change. The second (business as usual [BAU]) reflects the impact of current trends in economic growth and greenhouse gas emissions (GHGs) on the climate, and the impact of climate change on the overall economy without any emission abatement policies. The third (optimal abatement) is based on Nordhaus's calculation of an emission abatement path, with full participation by all countries, that maximizes global intertemporal economic welfare. Olivieri, Rabassa, and Skoufias (2010) translate the implications of these different growth scenarios for poverty using historical estimates of growth-poverty elasticities.

Given the limitations in knowledge and large uncertainties surrounding climate change and its impact on economic growth, and the impacts of growth on poverty, this analysis should be viewed as indicative only of the potential consequences of climate change on global poverty (see box 1).

Table 1 summarizes the main impacts of climate change on global poverty under these three scenarios. In a no climate change baseline, the model projects an annual, global, real per capita output growth rate of 2.2 percent up to 2055.<sup>1</sup> Using the

### Box 1. Sources of Uncertainty in Poverty Estimates

A major advantage of using an integrated assessment model like the RICE Model is that climate change questions can be evaluated within a consistent framework. However, results should be viewed with due caution given the many uncertainties and limitations facing all analyses of future climate change. First, the interactions among economic growth, emissions of GHGs, the climate system, economic damages, and policies are exceedingly complex and poorly understood. Second, there are profound uncertainties at every stage in global warming modeling: uncertainties about future output growth; the pace and direction of technological change, particularly for low carbon energy sources; migration patterns; climatic reaction to rising concentrations of GHGs; and about the economic and ecological responses to changing climate and how impacts should be discounted. It is also hard to predict the impact of future growth on poverty reduction over such a long time span. Olivieri, Rabassa, and Skoufias (2010) calculate regional growth-poverty elasticities using country-specific growth-poverty elasticity estimates from historical data and assume these elasticities will stay constant over time. They also assume a constant within-country distribution of per capita income over time. These two assumptions are quite restrictive, especially when used to project poverty in the distant future.

growth-poverty elasticities discussed in box 1, this contributes to more than halving the world poverty rate at the \$2 a day level to 14.1 percent by 2055. Under the RICE model's BAU scenario with climate damage, world gross domestic product (GDP) in 2055 would be 1.5 percent lower than in the baseline.<sup>2</sup> In the BAU scenario, the estimated number of poor in 2055 would be modestly higher by 10 million, compared to the no climate change scenario, with most of the additional poor located in Africa and South Asia.

It is worth stressing that this analysis focuses on the expected or mean value of the probability distribution of damage from climate change. Obviously, looking at lower probability extreme outcomes increases the estimates for GDP losses and poverty. Applying the same general methodology, Anderson (2006) reports similar results for Africa and South Asia using the mean of the predicted damage distribution. The Stern Review (2007) reports Anderson's results using the more extreme 95th percentile of damage distribution.<sup>3</sup>

Under the optimal abatement scenario, the extra number of people in poverty due to global warming in 2055 is projected to be only slightly smaller: 9 million. That is because the effects of abating global emissions of greenhouse gases on aggregate economic damages necessarily accrue more to higher-income countries. Unlike adaptation, emissions mitigation does not specifically target the poor. The major gains in poverty averted by following the optimal abatement strategy would indeed occur on a longer time horizon, by 2100 and beyond.

### *Heterogeneity of Climate Change Impacts on Poverty*

Climate change may impact household welfare through a variety of channels. For example, climate change may have a negative effect on agricultural productivity, particularly in tropical regions, and also affect poor people's livelihood through its effects on health, access to water and natural resources, homes, and infrastructure. Considering the complexities involved in modeling some of these channels, the emerging literature, including this note, has largely focused on the impacts on agricultural productivity. This section reviews the quantitative estimates of climate change impacts on poverty through its effects on agricultural productivity.

Recent research generally agrees on the significant overall negative impact of global warming on agricultural productivity and household welfare, but research also finds considerable heterogeneity in these impacts. These differences are linked to geographical location and specific household characteristics, including whether households are net producers or consumers of agricultural products; income sources; types of assets owned; ability to adapt; and ability to access credit or safety nets.

### *Location*

Geographical location obviously plays a large part in determining exposure to climatic phenomena such as rainfall variation and droughts. Location is also a key factor in access to infra-

**Table 1. Climate Change Impacts on World Poverty (at the \$2 a day level)**

Scenarios	Number of poor (millions)			Headcount poverty rate (%)		
	2005	2055	Change	2005	2055	Change
Baseline	2,069.4	1,259.1	(810.3)	32.3	14.1	(18.2)
BAU	2,069.4	1,269.2	(800.2)	32.3	14.2	(18.1)
Difference from baseline	..	10.1	10.1	..	0.12	0.12
Optimal abatement	2,069.4	1,268.5	(800.9)	32.3	14.2	(18.1)
Difference from BAU	..	(0.7)	(0.7)	..	(0.01)	(0.01)

Source: Olivieri, Rabassa, and Skoufias (2010).

structure and markets, as well as in the costs of necessary household goods.

The climate change impacts on agriculture can be heterogeneous even within a single country. In a recent study of Brazil, Assunção and Chein (2009) estimate that, on average, agricultural output per hectare could decrease by 18 percent by 2040 as a result of climate change, but that at the municipality level, impacts could range from a decrease of 40 percent to an increase of 15 percent. They predict that the poverty rate of rural areas in Brazil will increase by 3.2 percentage points overall, though, again, there is significant geographical variation, with already poor regions being more affected. Jacoby, Rabassa, and Skoufias (2011) use household level data to show that there is also significant heterogeneity in the impact of climate on per capita consumption across rural districts of India. They estimate that increases in mean surface temperature by 2040 could lead to consumption impacts ranging from no change in some locations to an 11 percent decrease in others.

#### *Structure of assets, incomes, and expenditures*

Climate change impacts on the welfare of rural households depend on a number of interrelated factors, including the household's assets, its potential income sources (diversification), and the structure of its expenditures. For instance, climate change might reduce physical productivity on an agricultural household's cereal land. But a general decline in agricultural productivity will also raise food prices, benefiting the same household as long as it is a net producer of cereals. Also, the extent to which a decline in agricultural productivity translates into lower rural wages depends on the diversification of the local economy and the ability of labor to move into other occupations.

In the case of rural India, Jacoby, Rabassa, and Skoufias (2011) estimate that increased mean surface temperature could lead to a 13 percent reduction in agricultural productivity by 2040 (after taking into account adaptation by farmers in terms of changes to crop mix, production methods, and so forth). This substantial decrease in output translates into a more modest 6 percent decline in average per capita consumption for rural households because households derive more income from their labor endowment. This result varies according to house-

hold characteristics; land-owning households face a smaller reduction in consumption relative to landless households, about 5 percent, because the beneficial impact of higher prices for net agricultural producers offsets the decline in land productivity.

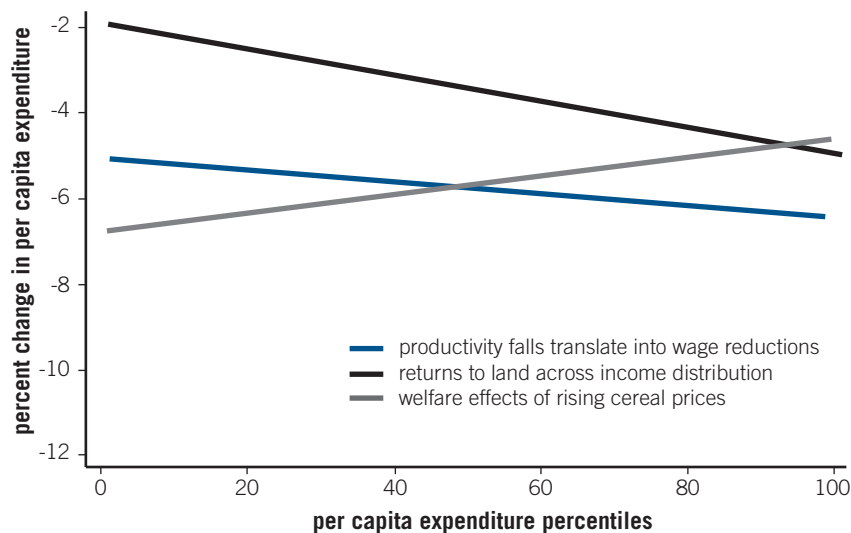
Focusing on the impact of climate change on the Indian rural population as a whole, rural poverty could increase between 1 and 6 percentage points by 2040, compared to the counterfactual of zero warming (Jacoby, Rabassa, and Skoufias 2011). Further, climate change impacts tend to be regressive, falling more heavily on the poor than the rich. This result can be decomposed into three parts: the effect on the returns to land and labor, and the effect on cereal prices. The incidence curves depicted in figure 1 show that productivity losses will negatively affect returns to land across the entire income distribution, but that the rich lose proportionately more than the poor because they hold the lion's share of land (black line). Additionally, productivity falls will also translate into wage reductions, but this effect is more distributionally neutral (blue line, which aggregates the impact of returns to land and labor). It is only after accounting for the welfare effects of rising cereal prices that the combined climate change affects the poor more than the rich (gray line, which accounts for the total impact).

The discussion so far has looked at climate change impacts on rural households. Ahmed, Diffenbaugh, and Hertel (2009) and Hertel, Burke, and Lobell (2010) provide a broader perspective by looking at economywide impacts using a general equilibrium model of global production, trade, and income distribution. A key finding in these studies is that the most significant climate change impacts on poverty are likely to occur among urban wage laborers, who are the most negatively affected by food price increases. Agricultural, self-employed households in rural areas are less affected because they benefit from higher prices.

#### *Adaptation and risk management*

The extent to which climate change impacts poverty also depends on the extent of adaptation by households in response to emerging circumstances. Jacoby, Rabassa, and Skoufias (2011) calculate the welfare benefits from autonomous adaptation in agriculture in India. In this context, autonomous adaptation can be defined as market-based responses to climate

**Figure 1. Climate Change Incidence Curve**



Source: Authors' illustration.

change by individuals, households or firms, typically by adjustments over time in their production and consumption patterns.<sup>4</sup> Jacoby, Rabassa, and Skoufias (2011) show that adaptation (that is, changes in cropping patterns, input use, and technology) reduces the average long-term loss in per capita consumption from climate change by about half (the decline in consumption is 11 percent in the case of a weather shock, compared to 6 percent when autonomous adaptation is factored in).

Migration, the most extreme adaptation measure, can also help reduce the potential longer-term welfare impacts of climate change. For Brazil, Assunção and Chein (2009) show that allowing for labor mobility across sectors or across municipalities reduces the climate-based increase in the rural poverty rate from 3.2 to 2 percentage points.

These studies of adaptation show that the ability of households to adapt to climate change over the longer term is vital, and that this ability can be strengthened by disseminating information about longer-term risks and anticipatory investments. However, longer-term impact reduction through adaptation would not necessarily diminish substantial adjustments costs.

Climate change is likely to lead not only to changes in the mean levels of temperatures and rainfall, but also to a significant increase in the variability of climate and in the frequency of extreme weather-related shocks. The impact of an increase in climatic variability on household welfare will depend in part on the ex ante and ex post risk management strategies employed by households.<sup>5</sup> One way to understand the impacts of these risk management strategies is to examine how they are used to address current climate variability. For example, Skoufias, Essama-Nssah, and Katayama (2011) show that climatic variability—weather shocks—has significant impacts on the average well-being of rural households in Indonesia. In particular, a de-

crease in the amount of rainfall in the 90-day postmonsoon period is associated with a 14 percent reduction in the per capita expenditures of rice farmers. Rice farm households do manage to protect their food expenditures, however, but typically by reducing nonfood expenditures. This result is consistent with earlier findings on how households cope with shocks by cutting spending on things such as health and education, which in turn has an adverse long-term effect on poverty by reducing human capital investment in children.

There is a considerable literature suggesting that, in the absence of adequate credit and insurance markets and other ex ante means for mitigating risks, ex post risk mitigation strategies by the poor can result in lower long-term income growth and increased poverty. Skoufias, Essama-Nssah, and Katayama (2011) con-

firm that the availability of credit, social protection, and community-based programs are among the strongest factors mitigating the impacts of extreme weather events on the well-being of rural households.

### Conclusions and Some Policy Implications

Climate change will slow the pace of global poverty reduction, but—based on the mean or expected value of climate damages used in mainstream analyses such as Nordhaus's (2010) RICE model or the Stern Review (2007)—the expected poverty impact will be relatively modest and far from reversing the major decline in poverty that is expected to occur over the next 40 years as a result of continued economic growth. However, a couple of qualifications are in order: first, much of the poverty impact is expected to be concentrated in Africa and South Asia, both of which would see more substantial increases in poverty relative to a baseline without climate change. Second, the occurrence of less probable but more extreme climate damage scenarios would naturally result in larger poverty increases. Third, aggregate projected damages are relatively low over the time horizon analyzed in this note (mid-century). As climate change continues to unfold during this and the next century, aggregate damages could be substantial and have a larger effect on poverty.

Recent empirical studies confirm that changes in climatic means and variability can have substantial impacts on agricultural output, household welfare and poverty, but that there is considerable heterogeneity in outcomes based on geographical location, the assets and income earning potential of the household, whether the household is a net agricultural producer or consumer, and on the opportunities for adaptation and risk management available to the household. Adaptation to climate change can reduce poverty impacts substantially.

The evidence also suggests there is much that policy makers can do to help the poor better adapt and cope with climate change and extreme weather events without compromising human capital, which is the long-term foundation of household welfare. Adaptive policies can include creating well-targeted and scalable safety nets; improving the poor's access to credit and insurance markets; reducing impediments to occupational mobility; improving governance of common-pool natural resources; investing in irrigation and/or improved water management to deal with extreme precipitation events; and smoothing the food price impacts of regional or country-specific climate shocks through, for example, greater openness to international trade. Fortunately, many of the policies that can be effective for reducing the climate change impacts on poverty are also effective for reducing poverty and promoting economic growth.

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## Notes

1. Projected annual per capita growth rates by RICE are decreasing over time. The annual world output growth also masks considerable regional disparities; for example, while China and India are expected to grow at a 3.6 annual per capita rate, the European Union will grow at a 1.8 annual rate.
2. It is useful to benchmark Nordhaus's (2010) business as usual scenario against other well-known climate change scenarios. The *Stern Review* (2007), for example, estimates that the mean loss in world output in 2100 would be 2.9 percent under its high climate scenario, inclusive of nonmarket and catastrophic effects. The Nordhaus business as usual scenario presumes a somewhat larger 3.3 percent loss in 2105. Differences in inferences from various models depend more on whether one examines mean impacts of uncertain climate change or the tails of the impact distribution.

3. For example, Anderson (2006) reports that poverty in sub-Saharan Africa in 2100 would be 0.5 percentage points higher than in a *no climate change* baseline using the mean of the damage distribution, but would be 2 percentage points higher using the 95th percentile.

4. Autonomous adaptation is typically distinguished from *planned adaptation*, which refers to policy-based actions that are needed when market failures or other coordination problems hinder relevant collective responses to climate change.

5. World Bank (2010) surveys private and public risk mitigation strategies in the face of natural hazards.

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