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Calculating the Costs of Climate Change

By Emily Miller

When the weather changes dramatically, so does economic productivity. If it's too hot or too cold, workers' cognitive performance drops, sleep is disrupted, and illnesses increase. Droughts often associated with high temperatures make land harder to farm and harvests smaller.

In a world where the mercury is rising, Stanford's Marshall Burke is examining how warming temperatures will affect global output.

In recent work, Burke and co-authors Ted Miguel and Sol Hsiang show that a single degree increase in average temperature results in one percentage point less of growth in countries that are already fairly warm. The impact varies by country, as shown in the interactive map below. Two percent is considered a normal growth rate for countries, so a one-degree rise in temperature can cut growth in half. Slowing growth constrains rising incomes, which is particularly worrisome for the 700 million people still living in poverty.

Based on how climate scientists expect temperatures to evolve over the next century, Burke calculates a predicted loss of 20 percent of global GDP due to climate change by 2100. This potential loss is about 10 times larger than estimates currently used in policy debates, which are based on earlier and less sophisticated empirical work. Knowing now that the stakes are higher, this means that certain mitigation or adaptation measures to curb global warming previously thought to be too costly might now be worth the investment to fend off large losses in economic output.

Climate change will disproportionately affect agriculture – the industry most reliant on weather, and also the industry employing most of the world's poor. Burke has conducted fieldwork in sub-Saharan Africa and Eastern Africa to begin to get a picture of rural livelihoods, farming techniques and yield sizes, and economic development.

But good local data is hard to come by. Government data is often untrustworthy and household surveys are expensive and time-intensive, meaning they are rare and often small-scale.

So Burke, a SCID Faculty Affiliate and Assistant Professor of Earth System Science, has turned to computer scientists for help. Using machine learning techniques, Burke is mapping where the poor live using passively collected data like satellite imagery. Processing huge quantities of satellite imagery, machines "learn" clues to spot impoverished areas and develop powerful prediction abilities. Some clues are distinguishable to the human eye such as tin roofs, lack of urban infrastructure, small houses, while others are based on algorithms.

In addition to mapping the poor, Burke and collaborators are using satellite imagery to predict agricultural productivity. Crop yields and seed costs are notoriously difficult to measure through surveys. But droughts, floods, and average temperatures spell the difference between a boom or bust harvest for farmers. Determining agricultural productivity is a first step in understanding how climate change threatens food security and in designing policies to reduce hunger.

Linking the macro with the micro, Burke is asking the big questions about climate change's impact on economic development and building the data needed to answer them. Burke’s interest in climate change's human impacts has its roots in the “World Food Economy” class he took as a Stanford undergrad, which combined his passion for the environment with a people-focused development angle.

Fifteen years later, Burke will be back in that class next quarter. This time, though, he’ll be teaching it.

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