Even if the Paris Agreement is implemented, food and water supplies remain at risk

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Credit: AI-generated image (disclaimer)

If all pledges made in last December's Paris climate agreement (COP21) to curb greenhouse gases are carried out to the end of the century, then risks still remain for staple crops in major "breadbasket" regions and water supplies upon which most of the world's population depend. That's the conclusion of researchers at the MIT Joint Program on the Science and Policy of Global Change in the program's signature publication, the "2016 Food, Water, Energy and Climate Outlook," now expanded to address global agricultural and water resource challenges.

Recognizing that national commitments made in Paris to reduce greenhouse gas emissions fall far short of COP21's overarching climate target—to limit the rise, since preindustrial times, in the Earth's mean surface temperature to 2 degrees Celsius by 2100—the report advances a set of emissions scenarios that are consistent with achieving that goal.

According to the authors, meeting the 2 C target will require "drastic changes in the global energy mix." To explore what those changes might entail, MIT Joint Program researchers and contributors from the MIT Energy Initiative and the Energy Innovation Reform Project identify current roadblocks to commercializing key energy technologies and systems, and the breakthroughs needed to make them technically and economically viable.

To project the global environmental impacts of COP21 and model emissions scenarios consistent with the 2 C target, the 2016 Outlook researchers used the MIT Joint Program's Integrated Global Systems Modeling (IGSM) framework, a linked set of computer models designed to simulate the global environmental changes that arise due to human causes, and the latest United Nations estimates of the world's population.

Implications for agriculture and water resources under COP21

Assuming a global emissions path based on COP21, Joint Program researchers used statistical models they developed that replicate complex, numerically demanding globally gridded crop models to project the future productivity of the Earth's "breadbasket" regions. The projections show overall increased yields through 2100 of maize in the U.S. and wheat in Europe, but taking advantage of these increases would likely require a significant shift northward of farming operations from where these crops are currently produced. The results also show an overall increase for upland rice in Southeast Asia and soybean in Brazil, with a more mixed pattern of yield increases and decreases appearing within these broad regions.

The authors attribute much of agriculture's gains from climate change to increases in carbon dioxide concentrations, which can act like a fertilizer and also improve crops' water-use efficiency. However, they note research indicating that such yield increases may be accompanied by reductions in nutrient and protein content. They also caution that while climate change may give some areas an advantage, extreme heat and drought linked to a changing climate are likely to increase the frequency of major crop failures. In addition, significant disparities in yield changes across breadbasket regions could lead to costly relocations of farming operations. Finally, the crop models upon which this report's statistical models are based constitute an important, but recent, development, and will require more work to better represent current yields if there is to be confidence in future projections.

The 2016 Outlook also projects that under COP21, the water stress index (WSI), a common measure relating water use to water availability, will increase in most regions as a result of increasing demand due to population and economic growth (particularly in developing countries), as well as from changes in climate. The largest relative increase in the WSI is found in Africa, mainly driven by increases in population and economic growth.

The authors conclude that approximately 1.5 billion additional people will experience stressed water conditions worldwide by 2050, of which approximately 1 billion will experience heavily to extremely stressed water conditions. Uncertainty in the climate-change pattern plays a role in both where people will face water stress and what level of water stress they will face.

"Our results indicate that even the COP21 climate-mitigation actions are insufficient to curtail all risks of increasing global water scarcity by midcentury," says Adam Schlosser, deputy director of the MIT Joint Program. "To make salient risk reductions in unmet water demands by 2050, many nations will need to consider broad adaptive measures that increase the efficiency of water consumption as well as viable options to increase water-storage potential. Our continued analyses will be bringing the most cost-effective options to bear."

Implications for energy and climate under COP21

As detailed in the 2015 Outlook and reviewed in the 2016 report, assuming that COP21 pledges are met and retained in the post-2030 period, the global mean surface temperature is projected to rise 3.1–5.2 C above preindustrial levels by 2100, far higher than the 2 C threshold identified by the United Nations Framework Convention on Climate Change as necessary to avoid the most serious impacts of climate change, from rising sea levels to more severe precipitation patterns to increased wildfires. The global mean precipitation increase ranges from 3.9 to 5.3 percent by 2050 relative to the preindustrial level, and 7.1 to 11.4 percent by 2100.

By the MIT Joint Program's estimate, the planet's emissions path under COP21 will result in atmospheric greenhouse gas (GHG) levels that far exceed those consistent with the Paris Agreement's 2 C goal. Even with low climate sensitivity to GHG emissions, on this path, the 2 C target will be passed shortly after 2050. The 2016 Outlook therefore lays out three global emissions path scenarios—based on the global climate exhibiting low, medium, or high sensitivity to atmospheric GHG levels, respectively—consistent with keeping the global temperature rise below 2 C, and assesses prospects for low-cost, low-carbon energy technologies that could support those scenarios.

"The Paris Agreement made energy projections particularly important, as it calls for a goal that requires an energy system based on a radically different fuel mix that what's been developed to date," says Sergey Paltsev, deputy director of the Joint Program. "In our report we show that the timing of this shift and the exact contribution of a particular technology will depend on many economic and political variables. Such uncertainty about future costs and technologies supports a conclusion that governments should not try to pick the 'winners,' rather the policy and investment focus should be on targeting emissions reductions from any energy source."

Prospects for low-cost, low-carbon energy technologies

Depending on how technology, policy, the economy and public opinion evolve, a variety of different energy technologies such as nuclear, renewables, biomass, or carbon capture and storage could play a dominant role in enabling an emissions pathway consistent with the 2 C goal. In detailed analyses of energy technologies where innovation could facilitate a lower-carbon future, the 2016 Outlook examines technical and economic barriers and hoped-for breakthroughs in nuclear energy, biomass energy, solar electricity, electricity storage, the electricity grid, and carbon capture and storage.

Alongside these analyses, Joint Program researchers, by assuming different mixes of costs and technology-cost ranges estimated by the International Energy Agency, portray scenarios in which one or another of these advanced technologies plays a dominant role. These scenarios are illustrative, and not necessarily tied to specific advances described in the contributed perspectives.

"While it's hard to predict exactly which of these technology advances will prove out, I'm confident that with substantial R&D investment, we'll see significant advances—and cost reductions—in one or more of them." says John Reilly, co-director of the Joint Program. "As a result, the cost of stabilizing greenhouse gases will come down to a level where countries will find it much easier to move forward on climate policy."

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