# How climate change will alter our food

July 26 2018, by Renee Cho

A flooded rice field. Credit: Photo: Nonie Reyes / World Bank

The world population is expected to grow to almost 10 billion by 2050. With 3.4 billion more mouths to feed, and the growing desire of the middle class for meat and dairy in developing countries, global demand for food could increase by between 59 and 98 percent. This means that agriculture around the world needs to step up production and increase

yields. But scientists say that the impacts of climate change—higher temperatures, extreme weather, drought, increasing levels of carbon dioxide and sea level rise—threaten to decrease the quantity and jeopardize the quality of our food supplies.

A recent study of global vegetable and legume production concluded that if greenhouse gas emissions continue on their current trajectory, yields could fall by 35 percent by 2100 due to water scarcity and increased salinity and ozone.

Another new study found that U.S. production of corn (a.k.a. maize), much of which is used to feed livestock and make biofuel, could be cut in half by a 4˚C increase in global temperatures—which could happen by 2100 if we don't reduce our greenhouse gas emissions. If we limit warming to under 2˚ C, the goal of the Paris climate accord, U.S. corn production could still decrease by about 18 percent. Researchers also found that the risk of the world's top four corn exporters (U.S., Brazil, Argentina and the Ukraine) suffering simultaneous crop failures of 10 percent or more is about 7 percent with a 2˚C increase in temperature. If temperatures rise 4˚C, the odds shoot up to a staggering 86 percent.

"We're most concerned about the sharply reduced yields," said Peter de Menocal, Dean of Science at Columbia University and director of the Center for Climate and Life. "We already have trouble feeding the world and this additional impact on crop yields will impact the world's poorest and amplify the rich/poor divide that already exists."

But climate change will not only affect crops—it will also impact meat production, fisheries and other fundamental aspects of our food supply.

## Weather extremes

Eighty percent of the world's crops are rainfed, so most farmers depend

on the predictable weather agriculture has adapted to in order to produce their crops. However, climate change is altering rainfall patterns around the world.

When temperatures rise, the warmer air holds more moisture and can make precipitation more intense. Extreme precipitation events, which are becoming more common, can directly damage crops, resulting in decreased yields.

Flooding resulting from the growing intensity of tropical storms and sea level rise is also likely to increase with climate change, and can drown crops. Because floodwaters can transport sewage, manure or pollutants from roads, farms and lawns, more pathogens and toxins could find their way into our food.

Hotter weather will lead to faster evaporation, resulting in more droughts and water shortages—so there will be less water for irrigation just when it is needed most.

About 10 percent of the crops grown in the world's major food production regions are irrigated with groundwater that is non-renewable. In other words, aquifers are being drained faster than they're refilling—a problem which will only get worse as the world continues to heat up, explained Michael Puma, director of Columbia's Center for Climate Systems Research.

This is happening in major food producing regions such as the U.S. Great Plains and California's Central Valley, and in Pakistan, India, northeastern China, and parts of Iran and Iraq.

"Groundwater depletion is a slow-building pressure on our food system," Puma said. "And we don't have any effective policies in place to deal with the fact that we are depleting our major resources in our major

food producing regions, which is pretty disconcerting."

Climate projections show that droughts will become more common in much of the U.S., especially the southwest. In other parts of the world, drought and water shortages are expected to affect the production of rice, which is a staple food for more than half of the people on Earth. During severe drought years, rainfed rice yields have decreased 17 to 40 percent. In South and Southeast Asia, 23 million hectares of rainfed rice production areas are already subject to water scarcity, and recurring drought affects almost 80 percent of the rainfed rice growing areas of Africa.

Extreme weather, including heavy storms and drought, can also disrupt food transport. Unless food is stored properly, this could increase the risk of spoilage and contamination and result in more food-borne illness. A severe summer drought in 2012 reduced shipping traffic on the Mississippi River, a major route for transporting crops from the Midwest. The decrease in barge traffic resulted in significant food and economic losses. Flooding which followed in the spring caused additional delays in food transport.

## Rising temperatures

Global warming may benefit certain crops, such as potatoes in Northern Europe and rice in West Africa, and enable some farmers to grow new crops that only thrive in warmer areas today. In other cases, climate change could make it impossible for farmers to raise their traditional crops; ideal growing conditions may shift to higher latitudes, where the terrain or soil may not be as fertile, resulting in less land available for productive agriculture.

The ultimate effect of rising heat depends on each crop's optimal range of temperatures for growth and reproduction. If temperatures exceed

this range, yields will drop because heat stress can disrupt a plant's pollination, flowering, root development and growth stages.

According to a 2011 National Academy of Sciences report, for every degree Celsius that the global thermostat rises, there will be a 5 to 15 percent decrease in overall crop production.

Heat waves, which are expected to become more frequent, make livestock less fertile and more vulnerable to disease. Dairy cows are especially sensitive to heat, so milk production could decline.

Parasites and diseases that target livestock thrive in warm, moist conditions. This could result in livestock farmers treating parasites and animal diseases by using more chemicals and veterinary medicines, which might then enter the food chain.

Climate change will also enable weeds, pests and fungi to expand their range and numbers. In addition, earlier springs and milder winters will allow more of these pests and weeds to survive for a longer time.

Plant diseases and pests that are new to an area could destroy crops that haven't had time to evolve defenses against them. For example, new virulent mutant strains of wheat rust, a fungal infection that had not been seen for over 50 years, have spread from Africa to Asia, the Middle East and Europe, devastating crops.

## Higher levels of carbon dioxide

Because plants use carbon dioxide to make their food, more CO2 in the atmosphere can enhance crop yields in some areas if other conditions—nutrient amounts, soil moisture and water availability—are right. But the beneficial effects of rising carbon dioxide levels on plant growth can be offset by extreme weather, drought or heat stress.

While higher CO2 levels can stimulate plant growth and increase the amount of carbohydrates the plant produces, this comes at the expense of protein, vitamin and mineral content. Researchers found that plants' protein content will likely decrease significantly if carbon dioxide levels reach 540 to 960 parts per million, which we are projected to reach by 2100. (We are currently at 409 ppm.) Studies show that barley, wheat, potatoes and rice have 6 to 15 percent lower concentrations of protein when grown at those levels of CO2. The protein content of corn and sorghum, however, did not decline significantly.

Moreover, the concentrations of important elements—such as iron, zinc, calcium, magnesium, copper, sulfur, phosphorus and nitrogen—are expected to decrease with more CO2 in the atmosphere. When CO2 levels rise, the openings in plant shoots and leaves shrink, so they lose less water. Research suggests that as plants lose water more slowly, their circulation slows down, and they draw in less nitrogen and minerals from the soil. Vitamin B levels in crops may drop as well because nitrogen in plants is critical for producing these vitamins. In one study, rice grown with elevated CO2 concentrations contained 17 percent less vitamin B1 (thiamine), 17 percent less vitamin B2 (riboflavin), 13 percent less vitamin B5 (pantothenic acid), and 30 percent less vitamin B9 (folate) than rice grown under current CO2 levels.

## A warmer, more acidic ocean

540 million people around the world rely on fish for their protein and income—but seafood will be impacted by climate change, too. Since 1955, the oceans have absorbed over 90 percent of the excess heat trapped by greenhouse gas emissions in the atmosphere. As a result, the ocean is warmer today than it's ever been since recordkeeping began in 1880.

As the oceans heat up, many fish and shellfish are moving north in

search of cooler waters.

Off the U.S. northeastern coast, American lobster, red hake and black sea bass have shifted their range an average of 119 miles northward since the late 1960s. In Portugal, fishermen have recently caught 20 new species, most of which migrated from warmer waters. And Chinook salmon, usually found around California and Oregon, are now entering Arctic rivers. Moving into new territory, however, these species may face competition with other species over food, which can affect their survival rates. The range shifts are affecting fishermen, too, who must choose whether to follow the fish they're used to catching as they move north or fish different species. As these ecosystems change, fishing regulations are having a hard time keeping up, jeopardizing the livelihoods of fishermen whose quotas for certain species of fish may no longer be relevant.

Warmer waters can alter the timing of fish migration and reproduction, and could speed up fish metabolism, resulting in their bodies taking up more mercury. (Mercury pollution, from the burning of fossil fuels, ends up in the ocean and builds up in marine creatures.) When humans eat fish, they ingest the mercury, which can have toxic effects on human health.

Higher water temperatures increase the incidence of pathogens and of marine diseases in species such as oysters, salmon and abalone. Vibrio bacteria, which can contaminate shellfish and, when ingested by humans, cause diarrhea, fever and liver disease, are more prevalent when sea surface temperatures rise, too.

In addition to heating up, the ocean has taken up almost a third of the carbon dioxide that humans have generated, which has changed its chemistry. Seawater is now 30 percent more acidic than it was during the Industrial Revolution.

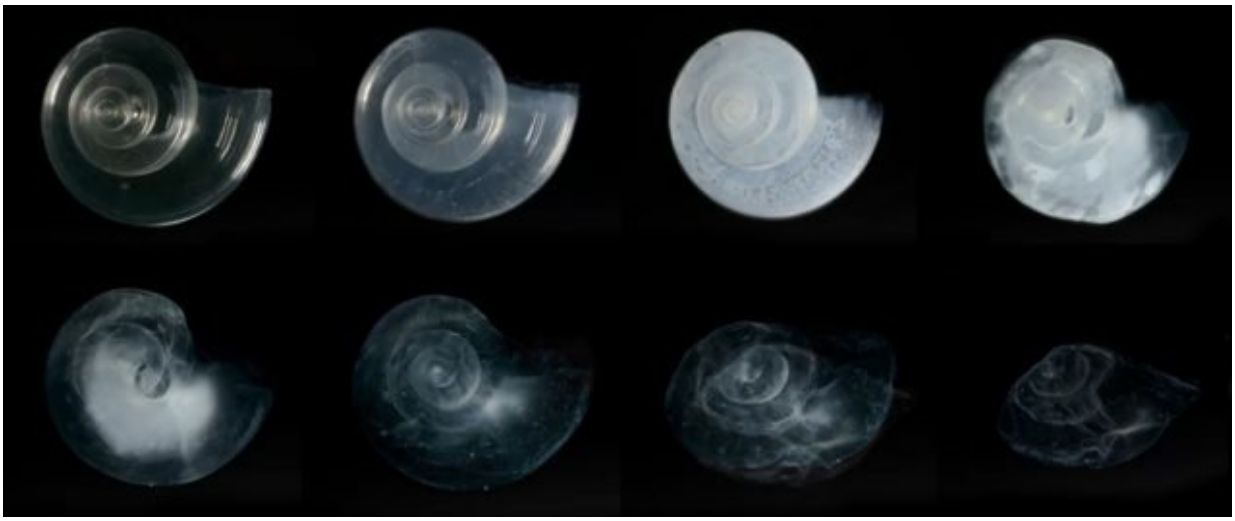
As ocean acidity increases, there are fewer carbonate ions in the ocean for the marine species that need calcium carbonate to build their shells and skeletons. Some shellfish, such as mussels and pterapods (tiny marine snails at the base of the food chain) are already beginning to create thinner shells, leaving them more vulnerable to predators. Ocean acidification can also interfere with the development of fish larvae and disrupt the sense of smell fish rely on to find food, habitats and avoid predators. In addition, It disturbs the ecosystems that marine life depends upon.

According to research being done at Columbia's Center for Climate and Life, ocean warming and acidification may end up restructuring microbial communities in the ocean. Because these sensitive microbes are the basis for the global food chain, what happens to them could have unforeseen and huge impacts on our food supplies.

## Sea level rise

Some experts predict that sea levels could rise one meter by 2100 due to melting polar ice caps and glaciers. In Asia, where much of the rice is grown in coastal areas and low-lying deltas, rising seas will likely disrupt rice production, and saltwater that moves further inland could reduce yields.

Aquaculture of fresh water species is also affected by sea level rise as saltwater can move upstream in rivers. For example, in the Mekong Delta and Irawaddy region of Vietnam and Myanmar, the booming catfish aquaculture could be affected by saltwater intrusion. If this occurs, fish farms would have to be moved further upstream because catfish have little tolerance for saline conditions.



In an experiment, this pterapod shell dissolved over 45 days in seawater with ocean chemistry projected for the year 2100. Credit: Photo: NOAA

**Who will feel the effects?**

Climate change will not only affect food production and consumers; as optimal growing conditions shift with the climate, communities that depend on fishing or farming for their livelihoods will be disrupted.

Some higher latitude areas may benefit and become more productive, but if emissions continue to rise, the outlook for food production from 2050 to 2100 is not good. Wealthy nations and temperate regions will probably be able to withstand most of the impacts, whereas tropical regions and poor populations will face the most risks. Children, pregnant women, the elderly, low-income communities and those with weakened immune systems or chronic medical conditions will be most susceptible to the changes in food access, safety and nutrition.

In addition, because food is a globally traded commodity today, climate

events in one region could raise prices and cause shortages across the globe. Starting in 2006, drought in major wheat producing countries was a key factor in a dramatic spike in food prices. Many countries experienced food riots and political unrest.

## How science can head off impacts

"Food security is going to be one of the most pressing climate-related issues, mainly because most of the world is relatively poor and food is going to become increasingly scarce and expensive," said de Menocal. "So what kind of solutions can science provide to help?"

Of course, the best way to reduce these risks to our food supply is to implement policies to cut greenhouse gas emissions. Earth Institute researchers, however, are working on some ambitious and potentially far-reaching projects to reduce risks to the food system.

Columbia's International Research Institute for Climate and Society is leading a project called Adapting Agriculture to Climate Today, for Tomorrow, or ACToday. Part of Columbia World Projects, ACToday will help to maximize food production and reduce crop losses by more precisely predicting and managing flood and drought risk, improving financial practices, and, when a food crisis unfolds, identifying the need for relief efforts earlier. The project introduces state-of-the-art climate information and prediction tools in six countries: Ethiopia, Senegal, Colombia, Guatemala, Bangladesh and Vietnam.

In case of a significant disruption in the global food system, there is no agency within the U.S. government whose responsibility it is to take charge, said Puma. His focus has been on trying to understand potential disruptions, which could be related to extreme weather, the power grid, conflict, or other factors. "We want to understand the food system in greater depth so we can identify vulnerabilities and adjust the system to

deal with those," he said. Working with colleagues at the Potsdam Institute for Climate Impact Research in Germany, he is building quantitative economic models to examine vulnerabilities in the food system under different scenarios; they will use the tool to explore how altering certain policies might reduce the vulnerabilities of the food system to disruptions.

The Center for Climate and Life is putting its efforts into building bridges between the business community and the science community in New York, to help clarify for investors the financial risks and opportunities of climate change. Large investment firms with long-term views have trillions of dollars in assets that could be jeopardized by climate change. De Menocal believes more intelligent investment strategies can be pursued with a science-based approach. "If you engage the largest deployments of money on the planet, that's what's going to shape behavior," he said. "If we can educate them about how climate change will impact things that matter to people, then they can act on that knowledge in advance of these things happening."

*This story is republished courtesy of Earth Institute, Columbia University* http://blogs.ei.columbia.edu.

Provided by Earth Institute, Columbia University