Scientists Race to Save World's Rice Bowl From Climate Change

More frequent floods and droughts expected in Southeast Asia.

Swells rise into a rice field in Dhal Char, Bangladesh, making it hard to cultivate. Climate change may make such events more frequent and severe.

Photograph by Peter Essick, National Geographic

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Climate change is predicted to cause more intense and frequent floods and droughts in Southeast Asia, threatening the world's rice bowl and millions of people who live there unless preventive actions are taken soon, scientists warn.

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At the Climate Smart Agriculture in Asia workshop held in Bangkok, Thailand, last month, climatologists and agricultural researchers discussed farming practices and technologies that could help the region cope with global warming's effects, including rising temperatures, increased salinity, and sporadic rainfall.

The conference was about "bringing all these players together to look at how the research agenda needs to change in the agricultural research world in relation to climate change," said Bruce Campbell of the Consultative Group on International Agricultural Research (CGIAR), which helped organize the two-day workshop.

In addition, scientists at the meeting discussed potential ways to use agriculture to mitigate the effects of climate change by reducing greenhouse gas emissions such as methane. Agriculture, forestry, and changes in land use account for a third of greenhouse gas emissions, said Campbell, who is the program director of CGIAR's Research Program on Climate Change, Agriculture and Food Security (CCAFS).

"That's a significant portion," Campbell said, "but we can reduce it."

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Breaking the Breadbasket?

The countries of South and Southeast Asia are home to more than 30 percent of the world's population, about half of whom depend on agriculture—mainly rice, but also other crops such as wheat—for their livelihoods. But according to the World Bank, global warming could reduce agricultural productivity in the region by 10 to 50 percent in the next 30 years.

Some changes are apparent already. For instance, steadily rising sea levels have already led to an increase in the salinity of the water in Vietnam's Mekong Delta, where the Mekong River empties into the South China Sea. This has forced some people in the region to abandon rice production and shift to shrimp farming.

"In a way, they're prospering from the change because they make more money raising shrimp than from rice," said Matthew McCartney, a hydrologist with the CGIAR International Water Management Institute, who attended the workshop. "But not everybody has the capability to do that. Some people are adapting, but others are losing out as a consequence of sea level rise."

According to the United Nations Food and Agriculture Organization (FAO), rising sea levels will increase salinity in the soils of rice-growing areas in deltas and flood plains of other major rivers in Asia, including the Ganges, the Yangtze, and the Yellow Rivers.

In the long term, such changes could force Asian countries to shift their rice farms to other locations, similar to how some wineries in Australia have moved to lower—and cooler—areas to counter the harmful effects of global warming on their grapes.

"In Asia, there's the possibility that you're really going to have to think more about radical transformations in order to adapt, as the shift from rice to shrimp illustrates," Campbell said.

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Recharging Aquifers

But in other circumstances adaptation can be incremental, and require only a gradual shifting of farming systems. One such solution discussed at the Bangkok workshop was using Managed Aquifer Recharge (MAR) technology in the region. MAR involves using land in upstream areas of major rivers to capture and store floodwater in natural underground aquifers, and then pump it out during dry spells for farmers to use.

"The idea is to set aside land where you know the soil conditions and geology will allow water to infiltrate very quickly into the ground and pump it out later for irrigation," McCartney explained.

MAR has been used for water storage in arid areas such as Australia and Southern Europe, but not in relatively wet regions that get regular rainfall such as Southeast Asia, he added.

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But the use of MAR in the region makes sense, because it could simultaneously solve two major problems that scientists foresee affecting the region. First, it would create a backup source of water that farmers could draw from in times of drought. It could also lessen damage from floods by diverting water from swollen rivers.

"In Thailand, it could have had a major impact in reducing the flooding [last year] in Bangkok," McCartney said. The floods caused $40 billion in damage.

Early calculations indicate that about 40 square miles (100 square kilometers) of recharge basins could irrigate more than 770 square miles (2,000 square kilometers) of farmland. Rather than establishing one large recharge basin, the idea is to create lots of smaller basins in suitable locations across the landscape.

"You could quite easily make up the loss of production in the land that you've set aside for the recharge basin," McCartney said.

Juliet Christian-Smith, a senior researcher at the Pacific Institute in Oakland, California, agreed that groundwater storage technologies such as MAR could provide useful buffers against the increased variability in rainfall that climate models predict.

"There are a lot of positives associated with storing water underground," Christian-Smith said. "We usually think of our water supply as coming from surface water such as snowmelt and rivers, but in fact . . . much of the water that supports irrigation and our global food supply comes from groundwater and in many cases it is being depleted faster than it is being recharged, leaving room for underground storage."

Because it stores water underground, MAR isn't vulnerable to some of the problems that plague dams, she added. For example, climate simulations predict that many parts of the Earth will experience warmer temperatures, which will in turn increase evaporation rates at dams. "There's also problems with sedimentation, because if you have more flooding, you could have more subsidence and erosion," she said. "That means your dam life and the amount of water it can store is reduced."

CGIAR's McCartney said MAR use in Southeast Asia is still only at the idea stage. "It hasn't gone beyond people thinking about it," he said. "There would need to be quite a lot more research done."

One question that will need to be resolved, Christian-Smith said, is what impact recharge has on water quality. A recent study in Bangladesh, for example, indicates that repeated injection of water into underground aquifers could leach arsenic and other toxic chemicals from the ground and concentrate it in the water supply.

(Related: "Megafishes of the Mekong")

A Novel Solution for Water and Climate

Attendees at the Bangkok workshop also discussed ways to help farmers not only deal with climate change locally, but actually lessen its global impact by reducing the amount of greenhouse gases their crops produce.

One promising technology for doing this is called rice alternative wetting and drying. As the name implies, it involves alternately flooding and drying rice fields to reduce the amount of methane produced. Normally, farmers leave their rice fields submerged for the entire growing season, but this generates methane, a potent greenhouse gas. By drying the fields periodically, scientists at the International Rice Research Institute have shown that water consumption could be slashed by 30 percent and greenhouse gas emissions reduced by 25 to 50 percent, without reducing yields.

"This is a fantastic technology for water savings and greenhouse gas emission savings," Campbell said. "Rice is so important across the whole of Asia that if one could implement this technology in many different places, you could have significant reduction in methane production."

But as with MAR, the details of this technology will have to be worked out before it can be widely implemented. For example, Campbell said, farmers must put much more effort into water management; at the moment there are no incentives to encourage them to do so. In other cases, large numbers of farmers would have to coordinate their flooding and drying cycles for it to be most effective.

Long-Term Management

While promising technologies, neither MAR nor rice drying will be enough to

resolve all of the agricultural problems that scientists predict will accompany climate change, experts say.

"To mitigate negative effects of climate-induced floods and drought require the application of integrated management concepts that have been developed in the past years and are now increasingly applied," said Wolfgang Grabs, a hydrologist with the United Nations World Meteorological Organization, a co-sponsor of the Bangkok workshop.

"These include both structural and non-structural methods," Grabs said, "such as dykes and levees, land use planning, storage facilities for water, improved forecasting and management of water resources, as well as suitable climate change adaptation approaches."

CGIAR's Campbell agreed. "I don't think there's going to be a silver bullet," he said. "You're going to have to do many different things."

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