# Editorial[i]

## Climate Change and Tropical Agriculture: an Uncertain Picture

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The first quantitative predictions of the "hothouse effect" were made by in Sweden by Svante Arrhenius in 1896. Arrhenius correctly predicted a temperature rise of 4°C with a doubling of carbon dioxide concentrations, but, based on the low carbon emissions of the time, thought that this would take many centuries to achieve. Moreover, influenced no doubt by Sweden's cool climate, he thought that this warming would be good for agriculture, writing that "we may hope to enjoy ages with more equable and better climates…when the earth will bring forth much more abundant crops than at present, for the benefit of rapidly propagating mankind."

Despite the accuracy of Arrhenius's calculations, it was not until the 1980s that a global scientific consensus on anthropogenic global warning was established. As climate models have improved since then, increasingly sophisticated projections have been made about the likely impacts on agricultural production. As Arrhenius foresaw, some temperate areas would benefit from longer growing seasons and, perhaps, the still-debated CO2-fertilization effect. In other parts of the globe, crops yields are expected to decline as a result of an increasing frequency and intensity of droughts and other extreme events. Overall, however, it is still a very fuzzy picture, with no agreement on overall global trends.

The uncertainties are greatest in the tropics, particularly in the 'maritime continent' of Southeast Asia, where the intimate mix of sea and land plays havoc with climate models. Here, as in much of the tropics, different climate models give such different predictions for future changes in rainfall that no reliable conclusions can be drawn. Temperature predictions are more robust, but the impacts of warming on tropical crop yields are less well understood than those of drought. Farmers in England need only look south to see their agricultural future, since analogues to their expected future climate already exist in southern France or Spain, but there is nowhere warmer than the lowland tropics to serve as an example. By 2100, and probably by 2050, these areas will experience climates that exist nowhere on Earth today. The best way to assess the likely

impacts of these novel climates on crop yields is by field experiments, but while it is relatively easy to make a growing crop wetter or drier, it is very difficult to create a warmer climate on a realistic scale. Greenhouse experiments are more practical, at least for small plants, but less easy to interpret in terms of final yields.

Clearly we need better climate models, with more accurate representations of tropical rainfall. However, the accuracy of even the best models is constrained by uncertainties in the future emissions of greenhouse gases. The idea that we should try to keep global warming below 2°C seems to have been quietly shelved, with most observers convinced that squabbling politicians will make this target unattainable (if, indeed, it ever was). Most scientists working on impacts and adaptation assume a 3-4°C rise, but these figures are only a little less arbitrary. If we do not stabilize emissions over the next couple of decades, global temperatures will continue to rise indefinitely, with an increasing risk that positive feedbacks will make the process self-sustaining. It is hard to imagine the lowland tropics 6°C warmer than it is now, but that is within the confidence limits of the current climate models and the greenhouse gas scenarios.

Uncertainty is part of being a farmer, with good years and bad years averaging out over time, and high yields in one area compensating for low yields in another. But uncertainty on a global scale is harder to live with. What happens when climate change is unidirectional, rather than fluctuating, and correlated across vast areas? This year's droughts in the United States and their impacts on global food prices may be an example of things to come. Or, perhaps Arrhenius was right, and with intelligent adaptation on the part of farmers and agricultural scientists, "the earth will bring forth much more abundant crops". I hope it is true, but I would not want to bet my children's future on it. As scientists, we need to work on three levels: understanding the impacts of the projected climate changes on tropical crops; adapting agricultural crops and practices to the climate change that now appears inevitable; and doing whatever is necessary to hasten a binding global agreement on limiting future greenhouse gas emissions.

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Professor Richard Corlett obtained his first degree from the University of Cambridge in 1974, followed by a PhD in plant ecology at the Australian National University, with fieldwork in the highlands of Papua New Guinea. He has subsequently held teaching posts at the University of Chiang Mai (1980-82), National University of Singapore (1982-87), University of Hong Kong (1988-2008) and National University of Singapore (2008-12). In July 2012, he moved to the Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences in Yunnan, to take charge of a new Centre for Integrative Conservation. His major research interests include terrestrial ecology and biodiversity conservation in tropical East Asia, plant-animal interactions, urban ecology, invasive species, and the impacts of climate change. In addition to numerous scientific papers, he is the author or co-author of several books, including "The Ecology of Tropical East Asia", published in 2009 by Oxford University Press, and "Tropical Rain Forests: an Ecological and Biogeographical Comparison", which he co-authored with Richard Primack, with a second edition published by Wiley in 2011. He is a Lead Author for Chapter 24, "Asia", in the Working Group II contribution to the Fifth (2014) Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and a member of the Steering Committee of the IUCN Species Survival Commission Climate Change Taskforce. He was elected President of the Association for Tropical Biology and Conservation (ATBC) for 2012.

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