Kiribati, Seawall.
Image: Johanna Mustelin.

Essay 2

The impacts of climate change in the Tropics

Richard T. Corlett
Center for Integrative Conservation, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun, Yunnan, China

Richard Corlett obtained his rst degree from the University of Cambridge in 1974, followed by a PhD in plant ecology at the Australian National

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The climate is changing in the Tropics, as it is in the rest of the world (IPCC, 2013). The effects of steadily rising concentrations of greenhouse gases on the climate may be less obvious to tropical residents, however, because they are overlain by considerable natural variability. Much of this variability is driven by the El Niño-Southern Oscillation (ENSO) (see Figure E2.1). The Tropics has warmed by 0.7–0.8°C over the last century—only slightly less than the global average—but a strong El Niño made 1998 the warmest year in most areas, with no signi cant warming since. Climate models predict a further 1-2°C warming by 2050 and 1–4°C by 2100, but the rise will certainly not be as smooth as the graphs that are produced by averaging many different climate models.

Trends in rainfall over the last century are much less clear than those in temperature. Many tropical areas are now signi cantly wetter or drier than they were a century ago, and others show marked uctuations. Predictions for future rainfall vary between models in most regions, reducing con dence in their usefulness. Climate extremes are even harder to predict, but the low day-to-day variability of tropical temperatures means that a rise in mean temperatures of only a few degrees is almost certain to bring temperature extremes higher than any that occur today. There are good reasons to believe that other extremes—droughts, oods and high-intensity cyclones—will also increase in much of the Tropics, although none of these predictions are made with high con dence (IPCC, 2013).

Tropical climates have changed in the past, with the most recent major change being the several-degree warming at the end of last glacial period, between 20,000 and 10,000 years ago. Temperatures have also been higher than now [illegible] First, the models suggest that the rates of change will be faster than any known from the past, leaving little time for adaptation or movement to cooler areas. Second, although the Tropics have been warmer before, most of the last 3 million years has instead been cooler, suggesting modern species will be unlikely to have retained adaptations to these higher temperatures. Finally, and perhaps most important, rapid climate change is only one of the many stresses on plants, animals and people in the 21st century. Many of these other stresses will interact with climate change in ways that increase the negative impact of both. For example, the fragmentation of most natural habitats in the Tropics by agriculture [illegible] species to respond to climate change by moving.

The impacts of climate change: observed and predicted

High natural climatic variability, coupled with the rarity of long-term records in the Tropics, has

The impacts of warming also extend out into the tropical oceans, with shifts in the distributions of species already observed and expected to intensify in the coming decades. By mid-century there are predictions that the species richness and productivity of tropical oceans will have declined markedly as species shift polewards and are not replaced.

Natural systems have an innate capacity to adjust to climate change, by changes in the distribution and abundance of species and ecosystems, as well as by the acclimation (i.e. adjustments within the lifetime of an individual organism) and evolution (i.e. genetic changes over multiple generations) of individual species. There must be limits to this capacity, but we are currently unsure when they will be reached: another 1°C? 2°C? more? In practice, thresholds for irreversible change will certainly vary between species and may already have been exceeded in some of the more sensitive organisms.

Impacts on human societies

There is historical evidence that climate change—or, at least, a succession of 'bad' years—has triggered the collapse of civilisations in the past, and there have been suggestions that the coming decades will see increased civil unrest and violent con ict as a result of rapid climate change. Flash-points could include competition for water or food, or the impact of extreme climate events. However, the globalisation of disaster relief has made the world less vulnerable to localised disasters, and these predictions may be excessively pessimistic.

Mitigation and adaptation

Both climate and sea-level have a delayed response to rising greenhouse gases, so the Earth is already committed to some additional warming and sea-level rise, even if greenhouse gas concentrations could be stabilised at present levels. At least in theory, any additional change is under our control, and could be avoided, although the long working life of expensive energy infrastructure, such as coal- red power stations, makes a rapid reduction in emissions extremely unlikely. Reducing the amount of future climate change by reducing greenhouse gas emissions (or increasing sinks, such as forests) is known as climate-change mitigation, and is distinguished from climate-change adaptation, which is reducing the vulnerability of human and natural systems to change.

Mitigation has been considered a task for international bodies, with the support of national governments, but the failure to reach a binding international agreement limiting future emissions suggests that this approach is not working well. Local governments and businesses have sometimes had more success in promoting low-carbon alternatives, but the real need is for a cultural change away from our current, unsustainable, dependence on fossil fuels. Cultures change from the bottom up, suggesting a key role for individuals and communities in achieving the necessary global goals. Unfortunately, the politicisation of climate change issues in many countries has made this more dif cult, since attitudes to action on climate change have become packaged with unrelated issues, leading to an exaggerated polarisation of views.

Adaptation is not an alternative to mitigation, since rapid climate change will continue until we stabilise greenhouse gas concentrations and must eventually exceed even the most optimistic assessment of our capacity to adapt. However, adaptation is essential and in many cases can result in a signi cant reduction in adverse impacts. Uncertainties in the predictions for future climates favour 'low regrets' strategies which provide bene ts under current climate conditions as well as a range of future climates. Some of these measures produce co-bene ts for other development goals, making them particularly attractive.

For example, increasing trees and other greenery in urban areas would help reduce the 'urban heat island effect', which increases the threat from heat waves, but will also have co-bene ts, such as improved public health. Similarly, forest restoration can contribute to mitigation by storing carbon and to adaptation by directly cooling the local climate, while also bene tting biodiversity conservation. Other potential low-regrets measures include better early-warning systems, climate-proo ng of infrastructure, climate-sensitive land-use planning, and improvements to environmental education.

There are other adaptation options where the bene ts depend on speci c future climate scenarios. While these measures may be less easy to get implemented than those with current bene ts, their potential impacts can be greater. Examples include breeding new crop varieties for tolerance of future climatic conditions, extending protected areas to include land that will be critical for conservation in the future, and the 'assisted migration' of threatened plant and animal species to locations where suitable future climates are expected. Conservationists are currently working to identify the species that will be most vulnerable to climate change so that conservation effort can be focussed where needed.

released by burning them is withdrawn from the atmosphere during growth, while at the same time providing economic bene ts to the tropical countries that grow them. In practice, a net carbon gain has been hard to achieve with biofuel crops, because carbon-rich vegetation is often cleared for their cultivation. Moreover the economic bene ts have been partly offset by negative impacts on food production and con icts over land use. Improved land-use planning and new technologies that can utilise a wider range of plant materials may make biofuels a viable mitigation option for the Tropics, with social and environmental co-bene ts, but a cautious approach is needed.

Conclusions

The global risks to natural and human systems from climate change are becoming increasingly obvious (IPCC, 2014), but most of the evidence come from outside the Tropics. In consequence, the word 'uncertainty' appears many times in this essay. Climate change impacts depend on interactions between complex physical, biological and social systems, none of which are well understood at present. The global climate models are gradually improving and now incorporate feedbacks from ecosystems, but their predictions depend heavily on the trajectory of greenhouse gas emissions over the coming decades, which in turn will be in uenced by socioeconomic factors and technological change. This suggests that although the overall uncertainties in impact prediction can be reduced, they cannot be eliminated. Uncertainties are inherent in any complex system, but climate scientists have so far done a poor job of communicating this to decision-makers and the general public. This is unfortunate because the most important message from the recent IPCC reports is that our fate is in our own hands.

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Flooding from Cyclone Nargis, Burma/Myanmar.
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