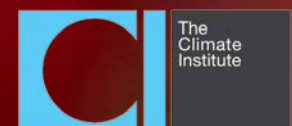


The Climate Institute



A Brewing Storm:
The climate change risks to coffee

A Brewing Storm:

The climate change risks to coffee

August 2016

Contents

Key Points	1
Introduction	2
How is climate change affecting the world's coffee regions?	4
How is climate change affecting coffee pests and diseases?	5
How is climate change likely to affect where coffee is grown?	6
What are the risks to producers, workers, and their communities?	8
What capacity do coffee farmers have to adapt?	10
What are the risks to biodiversity and carbon stores in coffee landscapes?	11
Learn, choose, demand – what coffee drinkers can do	12

Creating change takes leadership. We need people to lead: individuals, communities, investors and business leaders. We need people from all walks of life to step forward and join us as leaders of change.

DONATE www.climateinstitute.org.au/donate

Acknowledgments

The author, Corey Watts, would like to thank the following for their advice and response to drafts: Molly Harriss Olson, Stephen Nankervis, Amy Botta and Mirjam Groten at Fairtrade Australia New Zealand; Alvin Stone and colleagues at the ARC Centre of Excellence for Climate System Science, University of New South Wales; John Connor, Kristina Stefanova and Luke Menzies at The Climate Institute. Responsibility for any outstanding issues lies with the author.



Fairtrade Australia & New Zealand commissioned this report by the Climate Institute to better understand the extent to which climate change is impacting coffee production globally. It is hoped that insights gained from this report will lead to greater engagement, from the coffee industry and consumers, with key initiatives that aim to protect this valuable commodity, and the millions of livelihoods it supports around the world, for future generations.

Key Points

Coffee is a key global crop and the second most valuable commodity exported by developing countries, worth around US\$19 billion in 2015. Worldwide, around 2.25 billion cups of coffee are consumed each day. Nearly half of all Australians drink coffee regularly. The coffee market is growing, but faces big challenges coming up fast:

- + There is strong evidence that rising temperatures and altered rainfall patterns are already affecting coffee yields, quality, pests, and diseases—badly affecting economic security in some coffee regions.
- + Without strong action to reduce emissions, climate change is projected to cut the global area suitable for coffee production by as much as 50 per cent by 2050. By 2080, wild coffee, an important genetic resource for farmers, could become extinct.
- + Leading global coffee companies, such as Starbucks and Lavazza, publicly acknowledge the severe risks posed by climate change to the world's coffee supply. Consumers are likely to face supply shortages, impacts on flavour and aroma, and rising prices.
- + In the next few decades, coffee production will undergo dramatic shifts—broadly, away from the equator and further up mountains. Production will probably come into conflict with other land uses, including forests.
- + Rising CO₂ levels may boost the growth and vigour of the coffee plant, but there is no guarantee this 'fertilisation effect' will offset the risks imposed by a more hostile climate.
- + Most of the world's 25 million coffee farmers are smallholders. Alone, they have little capacity to adapt to a hotter world in which climate and market volatility conspire against them.
- + Over 120 million people in more than 70 countries rely on the coffee value chain for their livelihoods.
- + Many countries where coffee exports form a main plank of the economy are also amongst the most vulnerable to climate risk. Honduras, Nicaragua, Vietnam, and Guatemala, for instance, rank in the top-10 for climate-related damages since the 1990s.
- + Climate change is likely to significantly increase the burden on the health and wellbeing—physical and mental—of coffee producers, labourers, and communities, with consequences for productivity.
- + Crop adaptation strategies include developing more resilient production systems, diversifying crops, and shifting plantations upslope. The global trend, however, is towards intensification as producers seek to lift yields at the expense of more complex and carbon-rich landscapes. Ultimately, climate change is likely to push many producers out of coffee altogether.



CLIMATE CHANGE IS PROJECTED TO CUT THE GLOBAL AREA SUITABLE FOR COFFEE PRODUCTION BY AS MUCH AS 50% BY 2050

For coffee drinkers keen to help, the first step is to learn about the challenges faced by coffee producers and communities, and about what organisations such as Fairtrade and others are doing to make a difference. Next, most consumers can now choose brands that are carbon neutral, guarantee a fair return to smallholder farmers and their communities, and help them build their capacity to adapt to climate change. Finally, people can demand action from all companies and their governments to ensure all products, businesses, and economies are carbon neutral or better.

Introduction

For many of us, it is hard to imagine life without coffee. From Rome to Melbourne to Seattle, the intensely aromatic beverage is both a delight and a daily essential for hundreds of millions of people, who together drink more than 2.25 billion cups of coffee every day.¹ Coffee is the second most valuable commodity exported by developing countries.² In only a few centuries since coffee drinking started on the Arabian Peninsula, coffee has been adopted into cultures worldwide and taken root in landscapes right around the equator.

The so-called 'Bean Belt' (Fig. 1 'Climate change around the Bean Belt') comprises around 70 countries, the chief producers of which include Brazil, Vietnam, Colombia, Ethiopia and Indonesia. The livelihoods of more than 125 million people rely on a global trade worth over US\$19 billion.³

World production has more than trebled since the 1960s, consumption goes up by 5 per cent every year, and the industry boasts a strong potential for further growth.⁴ In Australia coffee recently supplanted tea as our lead stimulant-of-choice, with 46 per cent of us now enjoying it daily.⁵

Market growth, however, risks being put into reverse in a rapidly warming world. In just a few decades, climate change could halve the area suitable for growing coffee and push production upslope and away from the equator, with far-reaching consequences.

Since 1850, the average global temperature has already risen by nearly 1°C. By 2100, the world is projected to warm by a further 2.6°C to 4.8°C in a likely scenario.⁶ This may sound like a small change but the consequences for global agriculture and development will be far-reaching, complex, and dire.⁷ Between 80 and 90 per cent of the world's 25 million coffee farmers are smallholders—they are among the people most exposed to climate change. As the world warms, market and climate volatility will combine to cause problems for producers and consumers.⁸

The evidence is now clear that climate change is already beginning to impact on coffee production, along with other key world crops.⁹ So clear, that leading companies, including Starbucks and Lavazza, as well as the International Coffee Organization, have publicly acknowledged the severity of the risks (Box 1).¹⁰

Box 1. What are global coffee industry leaders saying about climate risk?

"What we are really seeing as a company as we look 10, 20, 30 years down the road—if conditions continue as they are—is a potentially significant risk to our supply chain... If we sit by and wait until the impacts of climate change are so severe that is impacting our supply chain then that puts us at a greater risk."

Jim Hanna,
Director, Environmental Affairs, Starbucks

"We have a cloud hovering over our head. It's dramatically serious. Climate change can have a significant adverse effect in the short term. It's no longer about the future; it's the present."

Mario Cerutti,
Green Coffee & Corporate Relations
Partner, Lavazza

"Changing climatic conditions and rising global temperatures pose one of the most significant threats to world coffee production."

International Coffee Organization

**COFFEE IS THE SECOND MOST
VALUABLE COMMODITY EXPORTED
BY DEVELOPING COUNTRIES**

Climate change around the Bean Belt

Distribution of coffee production across the world.
Highlighting worldwide and regional/country based impacts.



World



US\$19 billion in global coffee exports (p/a)



2.25 billion cups of coffee consumed daily



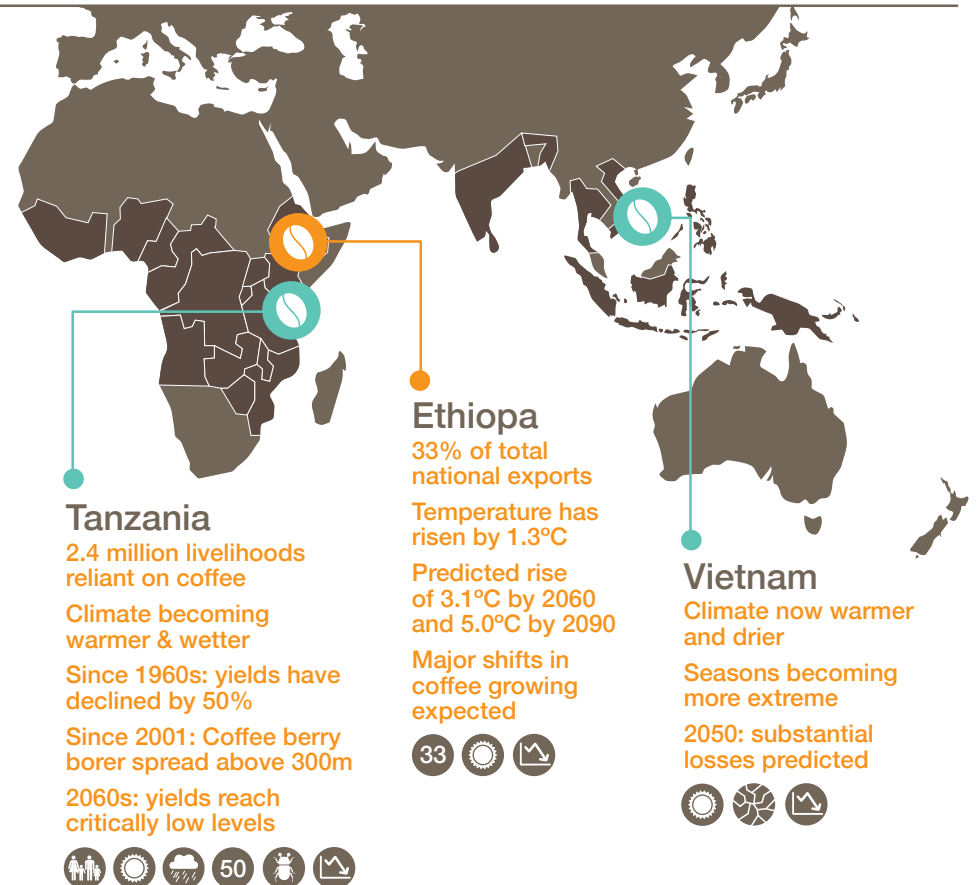
125 million livelihoods reliant on coffee



25 million coffee farmers, mostly smallholders



70 countries growing coffee



How is climate change affecting the world's coffee regions?



Grown predominantly in tropical highlands, Arabica coffee (*Coffea Arabica*) dominates global production, making up about 70 per cent of supply. Low-lying areas supply Robusta (*Coffea canephora*) destined mainly for the low-quality, instant coffee market. The yield and flavour of coffee, as well as pest and disease activity, are tightly linked to climate and weather, particularly temperature and moisture. Robusta is less heat-sensitive but Arabica performs best at 18–21°C.¹¹ Above 23°C, the plant grows too fast and fruits too early, damaging bean quality, with plant health declining with prolonged warmer conditions. Even half a degree at the wrong time can make a big difference in coffee yield, flavour, and aroma.¹² Around the Bean Belt, rising minimum growing temperatures, changes in rainfall patterns, and rising pest and disease incidence, are already making life harder for coffee farmers.¹³

Ethiopia's average annual temperature, for example, has risen by 1.3°C between 1960 and 2006.¹⁴ In Mexico, Guatemala, and Honduras mean temperatures have risen by as much as 1°C and rainfall has declined by up to 15 per cent since the 1980s.¹⁵ In Nicaragua, changes in rainfall since the mid-1990s have affected the flowering, maturation, and fruiting of coffee crops.¹⁶ Further south, in Brazil's Minas Gerais coffee-growing areas, the number and intensity of hot spells rose significantly while cold extremes diminished between 1960 and 2011.¹⁷ In the last 50 years, yields in Tanzania, where 2.4 million people's livelihoods rely on coffee, have fallen by about 137 kilograms per hectare for every 1°C rise in Arabica's minimum temperature, or around 50 per cent since the 1960s.¹⁸



EVEN HALF A DEGREE AT THE WRONG TIME CAN MAKE A BIG DIFFERENCE IN COFFEE YIELD, FLAVOUR, AND AROMA. AROUND THE BEAN BELT, RISING MINIMUM GROWING TEMPERATURES, CHANGES IN RAINFALL PATTERNS, AND RISING PEST AND DISEASE INCIDENCE, ARE ALREADY MAKING LIFE HARDER FOR COFFEE FARMERS.

How is climate change affecting coffee pests and diseases?



In 2012, following unusually high temperatures and high-altitude rains, Central America was hit by a wave of Coffee Leaf Rust (*Hemileia vastatrix*). The plant disease spread quickly through highlands, affecting more than 50 per cent of the crop, with some Guatemalan producers losing up to 85 per cent of their crop.¹⁹ In Colombia, the fungus is being reported in mountainous regions previously too cool for it to survive.²⁰ In 2012–13, crop damages amounted to around US\$500 million with nearly 350,000 Central American labourers put out of work.²¹

The Coffee Berry Borer (*Hypothenemus hampei*), a major pest originating in Congo but now seen around the Bean Belt, causes crop damage in excess of \$US500 million annually.²² Since 2001, the borer, previously confined to crops below 1,500 metres above sea level, has spread upslope, drawn by hotter, wetter conditions in places like Tanzania, Uganda, and Indonesia.²³ On Mt Kilimanjaro, the borer is now found 300 metres higher than where it was last century. Warming of 1–2°C will see the borer's numbers explode, spreading outwards from the equator and upwards to higher altitudes.



THE COFFEE BERRY BORER, A MAJOR PEST ORIGINATING IN CONGO BUT NOW SEEN AROUND THE BEAN BELT, CAUSES CROP DAMAGE IN EXCESS OF \$US500 MILLION ANNUALLY.

How is climate change likely to affect where coffee is grown?

The coming decades are likely to see dramatic shifts in where and how much coffee is produced worldwide. Regional studies suggest rising temperatures could render much Mexican coffee unviable by the 2020s,²⁴ and most of Nicaragua will lose majority of its coffee zone by 2050,²⁵ and Tanzanian Arabica yields are projected to reach critically low levels by 2060.²⁶

According to a 2015 global study, hotter weather and changes in rainfall patterns are projected to cut the area suitable for coffee in half by 2050 across different emissions scenarios.²⁷ The details differ markedly with locality, but the impacts are likely to be heaviest at low latitudes and low altitudes. Elsewhere, the predicted effects are still negative albeit less pronounced. Brazil and Vietnam—two of the biggest producers—appear set to experience substantial losses.²⁸ Conversely, the climate of 2050 seems to favour some areas, particularly in the highlands of East Africa—as well as in Indonesia, Papua New Guinea, and the Andes. Before the century is out, however, conditions are set to become inhospitable for Arabica coffee in the wild in East Africa—its centre of origin (see Box 3).²⁹

Today, the CO₂ concentration in the air is 40 per cent higher than at any time for at least 800,000 years, and may double before 2100, unless emissions are cut.³⁰ One recent two-year study suggests that extra CO₂ boosts coffee yields significantly.³¹ It remains unclear if and to what extent the CO₂ fertilisation effect might offset crop losses and little is known about how elevated CO₂ levels affect quality. Unfortunately, coffee farmers will have to operate not just in an atmosphere richer in CO₂ but a hotter, more hostile climate, characterised by more intense and frequent weather extremes. The geography of coffee is unlikely to be rearranged in a straightforward and orderly fashion. Instead, a warming world is a more erratic, less predictable one, characterised by more frequent and intense weather events, such as torrential downpours and droughts, as well as long-term climatic shifts.

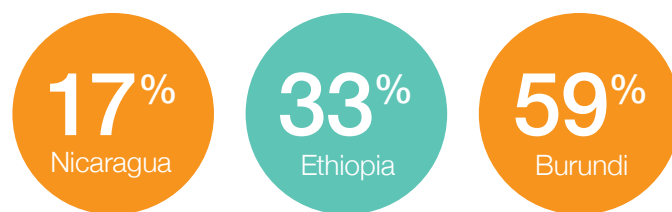
As today's suitable areas shrink, some producers will try to push further up the mountain, potentially bringing coffee into conflict with other land uses (Fig. 2 'Coffee Farming in a Changing Climate') and driving migration out of coffee-producing countries. In Asia especially, any expansion of coffee is likely to come at the expense of tropical forests, pushing up emissions and accelerating the warming.³²

ACCORDING TO A 2015 GLOBAL STUDY, HOTTER WEATHER AND CHANGES IN RAINFALL PATTERNS ARE PROJECTED TO CUT THE AREA SUITABLE FOR COFFEE IN HALF BY 2050

How vulnerable are coffee-exporting countries to climate risks?

Coffee is a key industry in many producer countries where it can account for a substantial part of export earnings, including Nicaragua (17 per cent), Ethiopia (33 per cent), and Burundi (59 per cent).³³ If the risks to coffee production from climate change unfold more or less as expected, pushing yields and quality down, and causing upheaval in production areas, many countries face substantial economic damage.

Many coffee-exporting countries are also amongst the most vulnerable to climate risk. Honduras, Nicaragua, Vietnam, and Guatemala, for instance, rank in the top-10 for climate-related damages since the 1990s.³⁴



% of export earnings from coffee production

Coffee Farming in a Changing Climate

Climate vs Coffee Timeline



Since 1850
Global mean
temperature 0.8°C



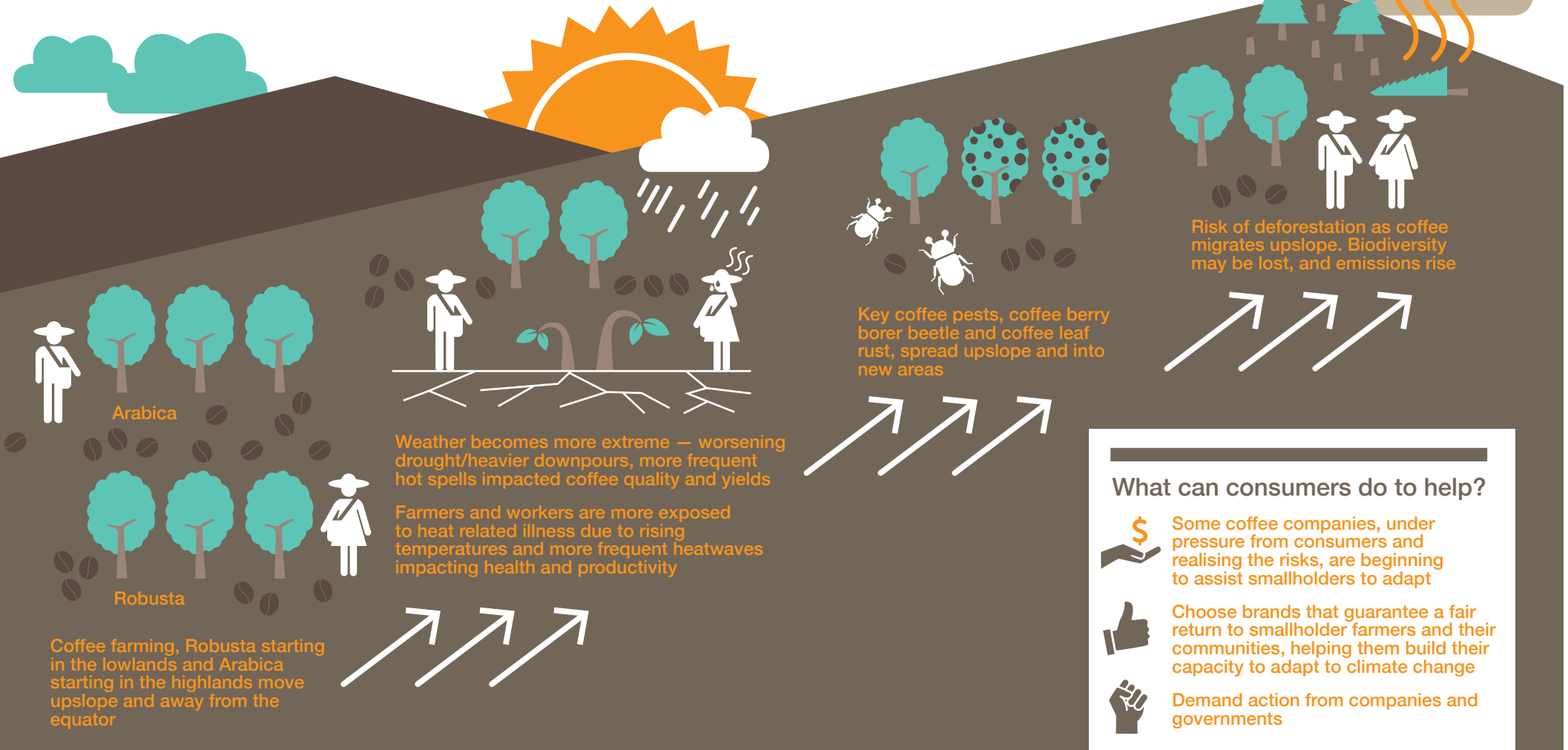
2050

Total global coffee growing area reduced by 50%
Production moving away from equator & upslope
Increased deforestation risk



2100

4.8°C hotter
Wild coffee extinct



What are the risks to producers, workers, and their communities?



Agriculture is not simply crops and commodities, but the farmers, farmworkers, and those who rely on them. In poor countries, climate change has the potential to become a major driver of multiple risks to equity (see Box 2), health, and food security.³⁵

Most of the world's 25 million coffee farmers are smallholders with little capacity to build greater resilience. For most, coffee is their main or only source of income. Whole regional communities are dependent upon their continued viability. In Mexico and Central America alone, the coffee supply chain employs about 8.5 million people, many of them indigenous, with the livelihoods of 4 million people wholly dependent on production for their livelihoods.³⁶ Workers on coffee farms typically labour under hard conditions for low wages and poor job security.³⁷ Wage slavery, forced labour, and child labour are widespread.

Many coffee communities are in a fragile economic position and seasonal hunger is common,³⁸ worsened by extreme weather. More than 30 per cent of Guatemalans already suffer food insecurity—the highest proportion of any country.³⁹ The recent outbreak of Coffee Leaf Rust in Latin America undermined already tenuous incomes and caused widespread job losses, leaving many to go hungry. High coffee prices alone do not guarantee better nutrition, especially if the cost of staple foods is also high, as they were in the late 2000s.⁴⁰

Box 2. Climate risks to gender equity in coffee regions

In many under-developed rural areas, women and girls are already disadvantaged, with stark inequities in power, labour, health and other areas. Climate change could drive another wedge into the gap between women and men. Female farmers tend to be denied the same access to market knowledge and new technologies, such as mobile phones, increasingly used to garner information on climate and weather. Where water access becomes even more difficult, women—who are often the traditional water carriers—may face a greater burden, with consequences for the health and education of their children. Men may be forced to migrate to new areas in search of paid work, further hampering the women left behind.

Coffee labourers in tropical countries are among those most exposed to heat strain and heat stroke—a situation certain to worsen.⁴¹ Ethiopia's climate, for instance, is projected to warm by as much as 3.1°C by 2060 and around 5°C by 2090 under the most likely emissions scenarios produced by the Intergovernmental Panel on Climate Change.⁴² Vietnam is becoming both hotter and drier, with a more pronounced wet season.⁴³ Hotter conditions are already cutting productivity in Asia and Africa.⁴⁴ Warmer, moister conditions also favour the spread of mosquito-borne diseases like malaria.⁴⁵ Drought, on the other hand, is associated with a deep and disturbing sense of failure, loss, powerlessness, heightened anxiety, stress, depression, and an increased suicide rate among farmers.⁴⁶



WORKERS ON COFFEE FARMS
TYPICALLY LABOUR UNDER HARD
CONDITIONS FOR LOW WAGES
AND POOR JOB SECURITY. WAGE
SLAVERY, FORCED LABOUR, AND
CHILD LABOUR ARE WIDESPREAD.

What capacity do coffee farmers have to adapt?

Although some further warming is already locked in, the international community has set itself the goal of limiting it to under 2°C, if not 1.5°C. Even half a degree is likely to make a big difference in terms of risks to agriculture and other sectors.⁴⁷ There is widespread agreement that warming beyond 2°C makes the task of adaptation and risk management much more difficult. As things stand, most coffee producers in developing countries are poorly prepared for even a 2°C world, let alone one of 3°C or 4°C.

Already, many are in a precarious position in an oversupplied market. Unrelenting price volatility hurts farmers, making it hard to plan ahead.⁴⁸ As global warming stirs up climatic volatility it will exacerbate the price volatility that already plagues coffee farmers more than most.⁴⁹ Despite progress, few growers are organised into co-operatives, and most lack the training, education, and time to implement optimal production strategies today, let alone prepare for climate change.⁵⁰ Many have only poor access to credit, market information, and risk-management tools.

Already, coffee companies, recognising climate risks, are beginning to fund smallholder assistance programmes: in 2010, several leading companies set up the *initiative for coffee & climate*, in partnership with development NGOs and agencies, to provide farmers with training and tools to better respond to climate change.⁵¹ The *Fairtrade Carbon Credits* initiative aims to empower farmers to both cut emissions and raise their resilience to climate change.⁵²

Crop adaptation strategies include developing more resilient production systems, diversifying crops, and shifting plantations upslope. While farmers are generally resourceful and creative, their flexibility and resilience is not unlimited. Their capacity to grapple with change is tied to education, access to information, health, equity, food security, and other factors, some of which are beyond their control, such as global markets.⁵³

Box 3. What if wild coffee goes extinct?

A 2012 paper by scientists at Kew's Royal Botanic Gardens looked specifically at wild Arabica coffee, suggesting that climate change could push it to extinction by 2100. In the Congo basin, where Robusta coffee originated, the wild plant may become locally extinct by 2050. Neither wild Robusta nor Arabica seem capable of weathering even middle-of-the-range climate change scenarios. Wild coffee plants form a storehouse of genetic resources that could prove vital in the development of new, drought- and disease-tolerant Arabica varieties—at the very time when coffee farmers need them most.

While some regions may see new opportunities, many producers will not be in a position to realise them. Migrating coffee plantations to new areas is not straightforward, not least because it takes several years for new plants to become productive. With some exceptions, smallholder farmers, particularly in Africa, are not well organised.⁵⁴ Few are members of cooperatives and those that do exist are weak. Moreover, investment in research, development, and extension is meagre, with little knowledge sharing. Most coffee farms show low productivity, relatively poor management, and are slow to adopt best practices.

It usually takes decades for new and improved practices, and new crop varieties, to be developed and then adopted by farmers (Box 3).⁵⁵ These long lead-times heighten the climate risk to coffee producers, especially given how fast the world is warming and new risks emerging. Smallholder farmers seldom have the wherewithal to simply pick up the farm and move somewhere else. Faced with declining profitability and land health, many may simply abandon coffee altogether.

AS THINGS STAND, MOST COFFEE PRODUCERS IN DEVELOPING COUNTRIES ARE POORLY PREPARED FOR EVEN A TWO-DEGREE WORLD, LET ALONE ONE OF THREE OR FOUR.

What are the risks to biodiversity and carbon stores in coffee landscapes?

Traditional coffee farms are very rich in biodiversity.⁵⁶ From the air the observer is hard-pressed to see the crop through the trees. Climate change, however, in tandem with global market instability, may make it much harder for many farmers to make a living. Many will have few options but to compromise practices that conserve natural resources as they struggle to turn a profit. And where coffee production is forced to move, it is likely to come into conflict with other land uses, including conservation.⁵⁷ In Vietnam's Central Highlands, for example, areas likely to become more suitable for production as the climate changes also contain nature reserves, which would have to be cleared to make way for new crops.⁵⁸

Around the Bean Belt, more and more coffee farms are intensifying production at the expense of traditional polycultures: improving profitability but becoming more dependent on fertilisers and other costly external inputs. Where coffee farms are abandoned they may be opened up to other uses, such as cattle grazing.⁵⁹ The loss of complex coffee polycultures and forests is also likely to erode critical ecosystem services, including carbon storage and disease control. Coffee leaf rust, for example, is an airborne disease more easily spread through cattle pastures and other open spaces than through intact forest.⁶⁰

TRADITIONAL COFFEE FARMS ARE VERY RICH IN BIODIVERSITY. FROM THE AIR THE OBSERVER IS HARD-PRESSED TO SEE THE CROP THROUGH THE TREES.

What will climate change cost consumers?

Climate change will make planning ahead much more difficult for everybody in the coffee value chain, with companies and farmers forced to invest more to manage increasing uncertainty and risk. Beyond crop damage, there are significant climate risks emerging for key commercial infrastructure, including roads and shipping.⁶¹ It seems certain coffee companies will be obliged to pass on an ever-larger part of the cost burden to consumers.

Climate shocks can significantly affect the world market.⁶² In 2014, the Brazilian state of Minas Gerais, which produces around a quarter of the country's coffee, faced severe drought and unusually high temperatures, cutting yields by about a third. It was reported that speculators were moving in on the market, anticipating higher prices.⁶³ Looking ahead, it is hard to see how consumer prices cannot be anything but badly affected by the projected long-term decline in growing area and other impacts of a more hostile climate. More and more extreme weather events in major coffee-producing regions seem set to create supply shortages, and hotter conditions will impair flavour and aroma. Even instant coffee is likely to be hit hard in a world of 3°C or more.

If global warming is not reined in, taxpayers in countries like Australia will be expected to meet mounting overseas aid costs—projected to be an additional US\$600 billion annually by 2050.⁶⁴ Given the economic importance of coffee to many countries and the world, much is riding on how well climate risks can be reduced and managed. Otherwise climate related damage to the coffee industry will only compound pressure on aid budgets.

With warming of at least 1.5°C now seemingly inevitable, greater resilience and adaptive capacity in farming communities and supply chains is essential. While governments have agreed to limit global warming to under 2°C, the sum of all policy actions to date would still allow warming beyond this global guardrail.

Learn, choose, demand – what coffee drinkers can do



For most coffee farmers, communities, and companies the consequences of unrestrained global warming are hard to imagine. Governments and companies that aim to avoid the economic, social and environmental costs of dangerous global warming, are recognising we need products, business models and economies with at least zero net greenhouse gas emissions.

Many companies and governments have begun to recognise the dangers of global warming—not least because of pressure from consumers and citizens—but their actions do not yet match the scale and urgency of the task.

However, the future for coffee and the world is not yet set. Several coffee companies have responded to customer demands for climate action, and many nations are making substantial efforts. Fairtrade, for example, has moved to ensure the production and supply chains for its Fairtrade Climate Neutral Coffee don't add more heat-trapping greenhouse gases and that steps are taken to build safer, more resilient, more sustainable workplaces. Positive changes are brewing from above and below.

For coffee drinkers, the first step is to learn about the challenges faced by coffee producers and communities, and about what Fairtrade and others are doing to make a difference. Next, most consumers can now choose brands that are carbon neutral, guarantee a fair return to smallholder farmers and their communities, and help them build their capacity to adapt to climate change. Finally, people can demand action from all companies and their governments to ensure all products, business models and economies are carbon neutral or better.

WITH EACH CUP THEY DRINK, COFFEE LOVERS HAVE THE POWER TO HELP SMALLHOLDER FARMERS AND OTHERS WEATHER WHAT LIES AHEAD.

Endnotes

1. S Ponte, 'The "Latte Revolution"? Regulation, Markets and Consumption in the Global CoffeeChain,' *World Development* 30 (2002): 1099–1122 doi:10.1016/S0305-750X(02)00032-3.
2. J M Talbot *Grounds for Agreement: The Political Economy of the Coffee Commodity Chain* (Lanham, etc.: Rowman & Littlefield, 2004).
3. International Coffee Organization, *World coffee trade (1963–2013): A review of the markets challenges and opportunities facing the sector* (London: International Coffee Organization, 2014).
4. International Coffee Organization, 2014. Ibid.
5. Australian Bureau of Statistics, *Australian Health Survey: Nutrition First Results—Foods and Nutrient 2011–12* (Canberra: Australian Government, 2014) <http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/4364.0.55.007~2011-12~Main%20Features~Non-alcoholic%20beverages~701>, accessed 8 July 2016
6. T F Stocker et al., 'Technical Summary,' in: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [T F Stocker et al. (eds.)] (Cambridge & New York: Cambridge University Press, 2013). http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_TS_FINAL.pdf
7. IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [C B Field et al. (eds.)] (Cambridge & New York: Cambridge University Press, 2014); World Bank, *Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided* (Washington, DC: World Bank, 2012).
8. International Coffee Organization, *World coffee trade (1963–2013): A review of the markets challenges and opportunities facing the sector* (London: International Coffee Organization, 2014).
9. D B Lobell, W Schlenker & J Costa-Roberts, 'Climate Trends and Global Production since 1980,' *Science* 333/6042 (2011): 616–620.
10. International Coffee Organization, 2014, Ibid. p. 22; S Goldenberg, 'Starbucks concerned world coffee is threatened by climate change,' *The Guardian*, 14 October 2011, <https://www.theguardian.com/business/2011/oct/13/starbucks-coffee-climate-change-threat>, accessed 27 June 2016; C Salins, 'Coffee and Climate Change,' *Food Wine Travel*, 27 October, 2015. <http://www.foodwinetravel.com.au/food/food-features/coffee-and-climate-change/>, accessed 29 June 2016.
11. A P Davis et al., 'The Impact of Climate Change on Indigenous Arabica Coffee (*Coffea arabica*): Predicting Future Trends and Identifying Priorities,' *PLoS ONE* 7/11 (2012): e47981. doi:10.1371/journal.pone.0047981
12. E Rosenthal, 'Heat Damages Colombia Coffee, Raising Prices,' *New York Times* (9 March 2011), http://www.nytimes.com/2011/03/10/science/earth/10coffee.html?_r=0, accessed 8 July 2016.
13. C Woodside, 'Coffee Growers Facing New Risks; Changing Climate Putting Production at Risk,' *Yale Climate Connections*, <http://www.yaleclimateconnections.org/2011/06/climate-changes-putting-coffee-production-at-risk/>, accessed 8 July 2016.
14. C McSweeney, M New & G Lizcano, *UNDP Climate Change Country Profiles: Ethiopia* (United Nations Development Programme, 2010) <http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/>, accessed 8 July 2016.
15. G Schroth et al., 'Towards a climate change adaptation strategy for coffee communities and ecosystems in the Sierra Madre de Chiapas, Mexico,' *Mitigation and Adaptation Strategies for Global Change*, 14/7 (2009): 605–625.
16. M Baca et al. 'An integrated framework for assessing vulnerability to climate change and developing adaptation strategies for coffee growing families in Mesoamerica,' *PLoS ONE*, 9/2 (2014): e88463. doi: 10.1371/journal.pone.0088463
17. R R Cárdenas, *Climate change assessment for Minas Gerais—Brazil with emphasis on coffee areas Part I—Recent past (1960–2011)* (Hamburg: Coffee & Climate, 2014).
18. A C W Craparo et al., 'Coffea arabica yields decline in Tanzania due to climate change: Global implications,' *Agricultural & Forest Methodology* 207 (2015): 1–10.
19. N B Mendoza, 'Coffee and climate: The development imperative for smallholders,' *Devex Impact* (29 June 2016), <https://www.devex.com/news/coffee-and-climate-the-development-imperative-for-smallholders-88360>, accessed 8 July 2016; International Coffee Organization, 2014, Ibid.
20. J Koebler 'Buzzkill? How Climate Change Could Eventually End Coffee,' *US News & World Report* (27 March 2013), <http://www.usnews.com/news/articles/2013/03/27/buzzkill-how-climate-change-could-eventually-end-coffee>, accessed 8 July 2016.
21. International Coffee Organization, 2014, Ibid.
22. J Jaramillo et al., 'Some Like It Hot: The Influence and Implications of Climate Change on Coffee Berry Borer (*Hypothenemus hampei*) and Coffee Production in East Africa,' *PLoS ONE* 6/9 (2011): e24528.
23. Jaramillo et al., 2011. Ibid.
24. Schroth et al., 2009. Ibid. C Gay Garcia et al. Potential impacts of climate change on agriculture: a case of study of coffee production in Veracruz, Mexico,' *Climatic Change* 79 (2006): 259–288;
25. P Läderach et al., 'Predicted impact of climate change on coffee→ supply,' in: *The Economic, Social and Political Elements of Climate Change* [W L Filho (ed.)] (Berlin: Springer Berlin Heidelberg, 2011), pp. 703–723.
26. Craparo et al., 2015. Ibid.
27. C Bunn et al. 'A bitter cup: climate change profile of global production of Arabica and Robusta coffee,' *Climatic Change* 129/1 (2015): 89–101.
28. O Ovalle-Rivera et al. 'Projected Shifts in Coffea arabica Suitability among Major Global Producing Regions Due to Climate Change,' *PLoS ONE* 10(4) (2015): e0124155 doi:10.1371/journal.pone.0124155.
29. Davis et al., 2012. Ibid.
30. Stocker et al., 2013. Ibid.
31. R Ghini et al., 'Coffee growth, pest and yield responses to free-air CO₂ enrichment,' *Climatic Change* 132/2 (2015): 307–320.

32. Ovalle-Rivera et al., 2015. Ibid.
33. J Ramirez-Villegas et al., 'A Way Forward on Adaptation to Climate Change in Colombian Agriculture: Perspectives towards 2050,' *Climatic Change*, 115/3–4: 611–628.
34. S Kreft et al., *Global Climate Risk Index 2016: Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2014 and 1995 to 2014* (Bonn: Germanwatch e.v., 2016), <http://germanwatch.org/fr/download/13503.pdf>, accessed 6 July 2016.
35. P Dasgupta et al. 'Rural areas,' in: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [C B Field et al. (eds.)] (Cambridge, UK and New York, USA: Cambridge University Press, 2014) pp. 613–657.
36. Baca et al., 2014. Ibid.
37. M Zamora, 'Farmworkers Left Behind: The Human Cost of Coffee Production,' *Daily Coffee News* (17 July 2013), <http://dailycoffeenews.com/2013/07/17/farmworkers-left-behind-the-human-cost-of-coffee-production/>, accessed 10 July 2016.
38. C M Bacon et al., 'Explaining the 'hungry farmer paradox': Smallholders and fair trade cooperatives navigate seasonality and change in Nicaragua's corn and coffee markets,' *Global Environmental Change* 25 (2014): 133–149.
39. C Fox et al., *Climate Change and Coffee Communities in Latin America*, Master's Thesis, Duke University (2015), http://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/9688/CCC_Masters_Project.pdf?sequence=1, accessed 10 July 2016.
40. M Caswell, V E Méndez & C M Bacon, *Food Security and Smallholder Coffee Production: Current Issues and Future Directions*, ARLG Policy Brief # 1 (Burlington, USA: Agroecology and Rural Livelihoods Group (ARLG), University of Vermont, 2012), http://www.uvm.edu/~agroecol/CaswellEtAl_FoodSecurityCoffeeARLG%20pb1_12.pdf, accessed 10 July 2016.
41. T Kjellstrom, I Holmer & B Lemke, 'Workplace Heat Stress, health and Productivity—An Increasing Challenge for Low and Middle-Income Countries During Climate Change,' *Global Health Action* (2009), doi: 10.3402/gha.v2i0.2047.
42. McSweeney, New & Lizcano, 2010. Ibid.
43. P Läderach et al., *Future Climate Scenarios for Viet Nam's Robusta Coffee Growing Areas* (Cali, Colombia: International Center for Tropical Agriculture (CIAT): 2012).
44. J P Dunne et al. 'Reductions in labour capacity from heat stress under climate warming,' *Nature Climate Change* 3 (2013): 563–566.
45. C Caninade et al. 'Impact of climate change on global malaria distribution,' *PNAS*, 111/9 (2014): 3286–3291 (2014).
46. I C Hanigan et al., 'Suicide and drought in New South Wales, Australia, 1970–2007,' *PNAS* 109/35 (2012): 13950–13955.
47. United Nations Framework Convention on Climate Change, *Historic Paris Agreement on Climate Change: 195 Nations Set Path to Keep Temperature Rise Well Below 2 Degrees Celsius*, UNFCCC (12 December 2015) <http://newsroom.unfccc.int/unfccc-newsroom/finale-cop21/>, accessed 10 July 2016.
48. S Mohan, 'The Welfare Gain from Eliminating Coffee Price Volatility: The Case of Indian Coffee Producers,' *Journal of Developing Areas* 48/4 (2014): 57–72.
49. AN Tran et al., *Commodity Prices and Volatility in Response to Anticipated Climate Change* (Milwaukee, USA: Agricultural and Applied Economics Association, 2012).
50. International Coffee Organization, *Sustainability of the coffee sector in Africa* (London: International Coffee Organization, 2015).
51. coffee & climate, 'about c&c' <http://www.coffeeandclimate.org/about-cc.html> accessed 29 June 2016.
52. S Kratz 'Fairtrade Carbon Credits: Supporting smallholders in their fight against climate change,' *Gold Standard* (2015), <http://www.goldstandard.org/blog-item/fairtrade-carbon-credits-supporting-smallholders-their-fight-against-climate-change>, accessed 18 July 2016.
53. H Eakin et al., 'Adaptation in a multi-stressor environment: perceptions and responses to climatic and economic risks by coffee growers in Mesoamerica,' *Environment, Development and Sustainability*, 16(1) (2014), 123–139. doi: 10.1007/s10668-013-9466-9
54. International Coffee Organization, 2015. Ibid.
55. Bunn et al., 2015. Ibid.
56. Schroth et al., 2009. Ibid.
57. H Neuschwander, 'How Does Climate Change Affect Coffee?' *The Specialty Coffee Chronicle* (15 April 2016) <http://www.scaa.org/chronicle/2016/04/15/how-does-climate-change-affect-coffee/>, accessed 8 July 2016.
58. P Läderach et al. 2012. Ibid.
59. Schroth et al., 2009. Ibid.
60. J Avelino, 'Landscape context and scale differentially impact coffee leaf rust, coffee berry borer, and coffee root-knot nematodes,' *Ecological Applications*, 22/2 (2012): 584–596.
61. A Farrag-Thibault, *Climate Change: Implications for Transport* (San Francisco & Cambridge, UK: BSR & University of Cambridge Institute for Sustainability Leadership/Cambridge Judge Business School, 2014), <http://www.bsr.org/reports/BSR-Cambridge-Climate-Change-Implications-for-Transport.pdf>, accessed 10 July 2016.
62. S Lanka, F Naves & Y Fontoura, 'Climate change is causing havoc for global coffee yields,' *The Conversation* (17 April, 2014) <https://theconversation.com/climate-change-is-causing-havoc-for-global-coffee-yields-25685>, accessed 8 July 2016; A D Brenner, 'El Niño and World Primary Commodity Prices: Warm Water or Hot Air?' *The Review of Economics and Statistics* 84/1 (2002): 176–183.
63. K Cooke, 'Climate Change Impacts to Drive Up Coffee Prices,' *Climate News Network* (1 June 2014), <http://ourworld.unu.edu/en/climate-change-impacts-to-drive-up-coffee-prices>, 10 July 2016.
64. F Baarsch et al. *Impacts of Low Aggregate INDCs Ambition: research commissioned by Oxfam*, (Berlin: Climate Analytics, 2015).

Image Credits

- Cover: Sean Hawkey, FECCEG, Guatemala.
- Page 4: Neil Palmer (CIAT)/Flickr licensed under CC BY-SA 2.0.
- Page 5: Neil Palmer (CIAT)/Flickr licensed under CC BY-SA 2.0.
- Page 8: "Nicaraguan Coffee Pickers" by Ingmar Zahorsky/Flickr licensed under CC BY-NC-ND 2.0.
- Page 9: "Nicaraguan Coffee Pickers" by Ingmar Zahorsky/Flickr licensed under CC BY-NC-ND 2.0.

