

TROUBLE BREWING

BEHIND THE SCENES

New Kew research highlights just how vulnerable wild coffee species are in our changing climate, with potentially far-reaching consequences, as **Aaron Davis** explains

‘Coffee is not dead, but it’s losing its wild side’, ‘Is climate change killing coffee?’ and ‘A jolt for coffee lovers: arabica beans doomed to extinction?’ These are just a small selection of the numerous headlines that followed the recent release of a research article authored by Kew and Ethiopian scientists on the influence of climate change on wild arabica coffee. In the days after the release of the article, the story went viral, spreading like wildfire across the internet and trending on Twitter, as people shared the news with each other across the world. So, what is all the fuss about, and should we be concerned about the future of our coffee? The problem seems very real when you look at some basic information about coffee.

The main species used in the production of coffee is arabica (*Coffea arabica*), which provides 70 per cent of the world’s marketable crop, and is the one we consume in our homes and coffee shops when we drink ‘real’ ground coffee. The remaining 30 per cent of coffee production is from robusta (*Coffea canephora*), which has a strong, rather harsh taste and around twice the caffeine content of arabica. Robusta





Left: From South Sudan's Boma Plateau, you can look across to the highlands of south-west Ethiopia, the main stronghold of wild arabica coffee forests

Below: Kew's Aaron Davis (right) and Sarada Krishnan (of Denver Botanic Gardens) in South Sudan studying wild arabica coffee with Sudanese university students

is widely used in instant coffee and in some countries is added to arabica to make an espresso blend. It provides body and a fuller flavour, as well as improving the 'crema' – the cream-like foam that settles on the top of a freshly made coffee.

It has been found that the productivity of arabica is tightly linked to climate. Arabica is usually grown at between 18°C and 21°C, or up to 24°C. Above 25°C, productivity falls and beverage quality suffers. Continuous exposure to temperatures as high as 30°C leads to stress in arabica plants, slowing growth, influencing flowering and fruiting, and increasing the incidence and severity of pests and diseases. In regions with an average annual temperature below 18°C, the occurrence of frosts, even if sporadic, may devastate the economic success of the crop. The relationship between climate and agricultural production is further complicated because temperature and other environmental factors (particularly rainfall) influence the growth and development of the plants in different ways during the various growth stages of each year's coffee crop.

Wild (or naturally occurring) arabica plants are only found in the humid forests of south-west and southern Ethiopia, and the Boma Plateau in south-eastern South Sudan, mostly

between 1,000 m and 2,000 m above sea level, where they experience rather cool tropical conditions. It is these wild storehouses of genetic material that need to be protected if the future of plantation coffee is to be assured – they hold the critical genetic variability that could be essential for the long-term survival of plantation arabica. Indeed, the history



The history of coffee cultivation is punctuated with the use of wild coffee resources

of coffee cultivation is punctuated with the use of wild coffee genetic resources to tackle all sorts of issues and crises caused by diseases, pests and climate.

Couple the environmental sensitivity of both wild and plantation arabica with accelerated climate change, and it seems obvious that there are problems ahead. Whatever our thoughts on the causes, speed and predictions of climate change, recorded temperatures alone indicate cause for concern. The average temperature increase in Ethiopia, between 1960 and 2006, was 0.28°C per decade, or 1.3°C over 46 years. Ethiopia is not only the stronghold for wild arabica plants, but also the number one producer of coffee in Africa, and home to many other important wild relatives of crops.

It seems that the influence of climate change on coffee production is already evident. Reports from coffee farmers and other industry stakeholders throughout the coffee-growing areas of the world already claim that climate change is negatively influencing coffee production. This particularly appears to be the case where coffee is being grown in less than ideal conditions.

Despite these concerns, there has been very little detailed research on the influence of climate change on coffee. In the paper published by Kew and the Ethiopian Environment and Coffee Forest Forum (ECFF), the first objective was to better understand the potential risks of accelerated climate change on wild arabica populations in Ethiopia and South Sudan, and then to gain an insight into what needs to be done in order to reduce negative consequences. The computer modelling, some of which was new to this field of science, was completed by Kew's Geographic Information Science (GIS) team. Using two types of analysis, they found that the predicted impact of climate change on wild arabica would be extremely negative. In a 'locality analysis', the most favourable outcome was a 65 per cent reduction in the number of recorded suitable sites for

the existence of wild coffee plants, and, at worst, a 99.7 per cent reduction by 2080. By 'suitable sites' we mean those that have the right combination of temperature and rainfall to allow a species to survive.

Loss of such optimum conditions places plants under severe environmental stress, leading to a high risk of extinction. In a worst-case scenario, arabica coffee could be extinct in the wild by 2080. This is worrying enough in itself, but overall the predictions are regarded as conservative, mainly because the modelling doesn't factor in the large-scale deforestation that has occurred in the highland forests of Ethiopia and South Sudan. Other factors, such as pests and diseases, changes in flowering times, and perhaps a reduction in the number of birds (which disperse coffee seeds), are also not included in the modelling, and these could have a compounding negative impact.

This is all very worrying, but there are opportunities for action that will help to preserve arabica in the wild. The Kew and ECFF study forms the basis for developing strategies to promote the survival of arabica in its natural environment. It identifies a number of core sites in Ethiopia that, if protected, might be able to sustain wild populations of arabica throughout this century, serving as long-term storehouses for coffee genetic resources. The study also identifies populations that require

Destruction of the forests where wild arabica coffee grows threatens the genetic diversity of many plant species, including coffee



For premium-quality coffee, only the red coffee 'cherries' are picked, as shown here in Rwanda



Photos: World Coffee Research

immediate conservation action, such as those in South Sudan, which could be gone by 2020. For these critical populations, the study recommends urgent collection and storage in seed banks and in living plant collections in botanic gardens.

All indications are that the impact of climate change on arabica coffee production in Ethiopia's plantations will also be negative, as forest coffee (semi-domesticated) and many plantations occur in the same areas as wild arabica. Optimum cultivation conditions are likely to become increasingly difficult to achieve in many other coffee-growing areas around the world, leading to a reduction in productivity, along with increased and intensified management, such as the use of irrigation and pest and disease control. In some areas, diminishing financial returns, or even crop failure, might render production unsustainable.

This leads to an obvious question: what can be done to save arabica production over the coming decades? Various mitigation and adaptation measures have been suggested to maintain harvest levels, including the use of shade trees to reduce air temperatures within plantations, mulching to limit soil-water loss, irrigation or increased irrigation, and the use and development of drought- or temperature-tolerant cultivars. Shade planting and mulching have merit, although these are already practised in many coffee-growing areas. Irrigation certainly makes a huge difference to the success and productivity of many coffee plantations, although this is only viable in the long term if there is a plentiful supply of water, and one that is not required for other purposes.

As part of an adaptation strategy, perhaps climatically tolerant coffee cultivars may hold promise. It has also been suggested that the relocation of coffee plantations to higher, cooler, wetter ground could be part of the solution. There are, however, complications with relocation, including the availability of land and the costs versus benefits of moving coffee farms. In many areas there is simply no land available at higher altitudes, or if it is available it is being used for other purposes. It seems that a holistic approach is required, although ultimately we need to tackle the causes of climate change as well as the consequences.

There are suggestions that we should just give up on coffee and start drinking another beverage. But the issue is not just

Right: Shade plantations can mitigate the adverse effects of climate change by reducing air and soil temperatures

about the impact on our daily habits and preferences. It has been estimated that about 100 million people around the world depend on coffee for their livelihoods. Approximately 70 countries produce coffee, from the Americas to Australasia and the Pacific. It seems hard to believe, but coffee is the second most traded commodity after oil, and the world's most important agricultural commodity. In 2009, when some 93.4 million (60 kg) bags were shipped, coffee accounted for exports worth an estimated US\$ 15.4 billion. Coffee plays a crucial role in the economies of several tropical countries, accounting for a significant proportion of tax income and GDP.



So, is the coffee industry in dire crisis due to climate change? Well, not yet. However, there are some serious problems on the horizon. Despite recent dips and plateaus, demand for arabica coffee remains strong and on an upward trajectory, especially with markets developing in Asia and Africa. The high demand for arabica, in combination with other factors (commodity trading dynamics, poor harvests, transport costs, etc), has led to sky-high increases in coffee prices. Can current levels of arabica production and quality be maintained, let alone increased, in a world under the influence of accelerated climate change?

It is difficult to say what will happen. In the past, the coffee industry has weathered crises on similar scales, but it has always had one eminently powerful ally: the storehouse of coffee genetic diversity supplied by Mother Nature in the wild forests of Africa. These natural resources, and especially those in the highland forests of Ethiopia, are going to require careful and appropriate protection from natural and human-induced pressures alike.

Future work by the Kew and ECFF team will include detailed on-the-ground surveys of wild coffee forests in Ethiopia, in order to test and refine their computer modelling. Such work will help to give local conservation organisations the resources they need to save a wild plant that provides hope for the livelihoods of millions of people and pleasure to even more.

- Aaron Davis is Kew's expert in wild coffee species – he has discovered more than 20 new species of coffee in recent years
- » Part of this study was funded by the Bentham-Moxon Trust. Fieldwork in South Sudan was supported by the USAID-funded JGMUST Project and World Coffee Research

▶ Watch the film – smell the coffee plants

You can find out more in an exclusive film by Aaron Davis about his research, on the Kew magazine app (see p8). This also provides easy links to more information about coffee and the journal in which this paper was published.

This summer, in the Princess of Wales Conservatory, you'll be able to visit a mini coffee plantation and an accompanying display about coffee, where you can learn the latest about this research.