Climate change will greatly affect what we grow and where we grow it. Bioversity research shows that farmers in Europe and North America stand to gain, whereas farmers in sub-Saharan Africa will lose. Solutions may come from existing diversity, but the wild relatives of crops are also threatened by climate change.

Adapting agriculture to climate change

Wine growers in the UK may well look forward to the new opportunities that a warmer climate will bring, but in other parts of the world the impact of climate change on local growing conditions will have serious consequences for food security and poverty.

Andy Jarvis and Annie Lane, scientists at Bioversity, working with Robert Hijmans at the International Rice Research Institute (IRRI), used sophisticated computer modelling to examine the impact that climate change will have on the cultivation of the world's most important staple and cash crops.

The predictions are bleak: by 2055, more than half of the 23 crops studied—including cereals such as wheat, rye and oats—will lose land suitable for their cultivation. This loss will fall disproportionately on sub-Saharan Africa and the Caribbean, regions of the world that have the least capacity to cope. On the other hand Europe and North America—regions best equipped to manage the impacts of climate change—are predicted to experience the largest gain in land suitable for cultivation (see map).

These results are based on the 'business-as-usual' climate model of the Intergovernmental Panel on Climate Change (IPCC), which assumes that economic growth and greenhouse gas emissions will continue as they are at present. The study focused on crops listed in Annex 1 of the International Treaty on Plant Genetic Resources for Food and Agriculture as well as other staple and cash crops important for food security.

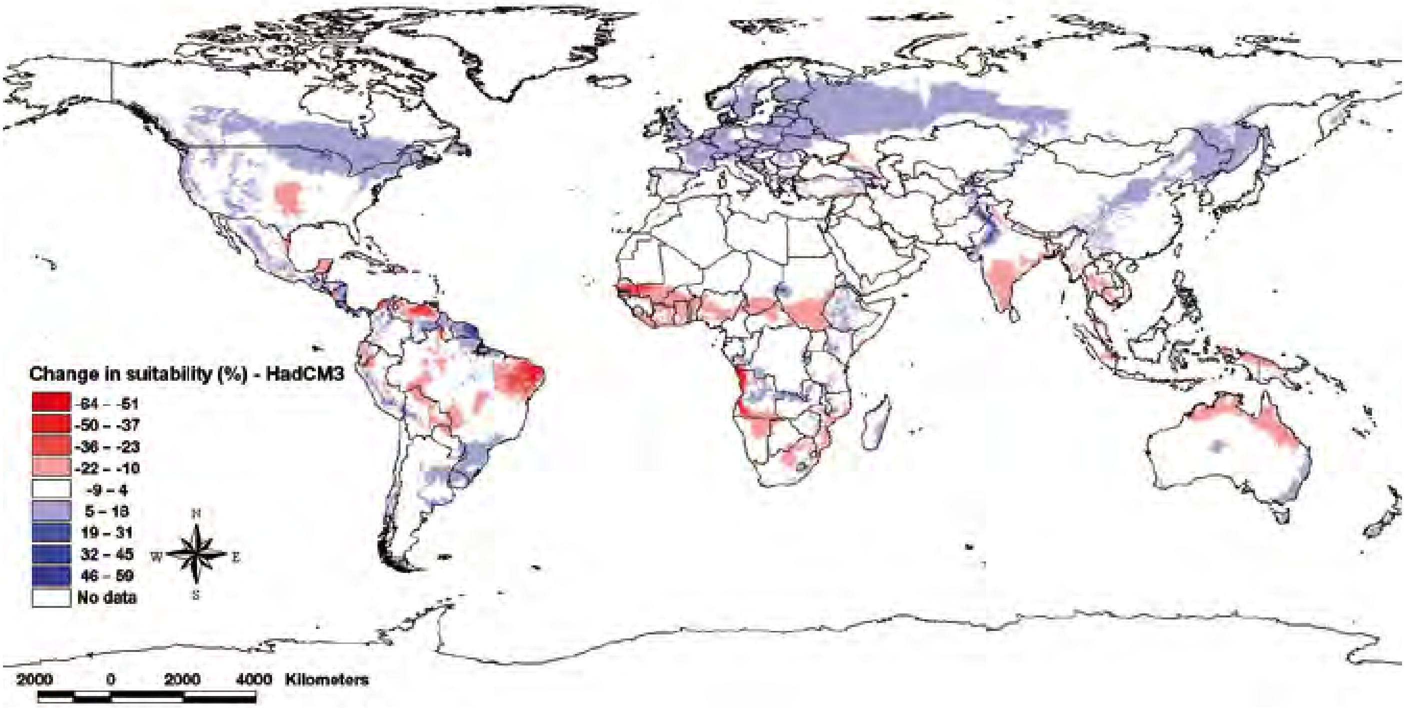
Overall, the area suitable for crop cultivation is projected to increase. For example, the model predicts increases in the area of land suited to pearl millet (31%), sunflower (18%), common millet (16%), chickpea (15%) and soya bean (14%). The problem is that many of the gains occur in regions where these crops are not important for food security. "We predict an increase of

A. Lane/Bioversity International

Wild groundnut, like this one from Bolivia, may be a source of pest and disease resistance for breeding cultivated varieties. Models predict that some 60% of the 51 groundnut species analyzed could become extinct within 50 years as a result of climate change.

Changes in suitability averaged over all crops predicted by the HadCM3 climate change model.

Places shown red become less suitable, while those in blue become more suitable.



Source: Lane A and Jarvis A. 2007. Changes in climate will modify the geography of crop suitability: Agricultural biodiversity can help with adaptation. Journal of SAT Agricultural Research 4(1).

more than 10% in the area suitable for pearl millet in Europe and the Caribbean, where hardly anyone eats the crop, but not for Africa, where pearl millet is currently widely cultivated. That's the problem," Jarvis explained.

The impact of climate change on production depends mainly on the region, the growing season and the temperature thresholds of the crops in question. Thus, the growing period for crops that mature at a given cumulative temperature ('growing degree days') may be shortened as temperatures increase. A shorter growing period may reduce yields. This, combined with major losses predicted in land suitable for the cultivation of staple crops, is why regions such as sub-Saharan Africa will become increasingly vulnerable to food shortages.

The results of the study support the recent call by the IPCC to invest in solutions that will allow countries to

A selection of crops and the predicted areas they will lose or gain under HadCM3 and CCCma, two of the most comprehensive models of climate change.

Most of the losers, for which suitable areas shrink, are cold-weather crops: strawberry, wheat, rye, apple and oats. Among the winners are pearl millet, sunflower, common millet, chickpea and soya bean.

Crop	Species	Change in suitable area, HadCM3 (%)	Change in suitable area, CCCma (%)
Apple	*Malus domestica*	-21.38	-3.42
Chickpea	*Cicer arietinum*	13.91	16.95
Common millet	*Panicum miliaceum*	18.19	14.17
Oat	*Avena sativa*	-21.46	-2.79
Pearl millet	*Pennisetum glaucum*	31.28	31.46
Rye	*Secale cereale*	-25.72	-6.22
Soya bean	*Glycine max*	13.31	13.99
Strawberry	*Fragaria × ananassa*	-39.25	-24.33
Sunflower	*Helianthus annuus*	16.20	19.02
Wheat	*Triticum aestivum*	-30.86	-4.48

adapt to the impacts of climate change. It will be crucial to breed new varieties of crops with improved resistance to abiotic and biotic stresses to minimize the impacts of these climate and other environmental changes, according to Jarvis and Lane. Such new varieties would allow cultivation to continue in areas that would otherwise become unsuitable for the crop, as well as allowing the crop to be grown in new and previously unsuitable areas. The traits that will be needed to develop those new varieties are likely to come from traditional varieties and wild relatives. But another modelling study by Lane and Jarvis in collaboration with colleagues at the International Center for Tropical Agriculture (CIAT) shows that these very genetic resources may themselves be under threat of extinction.

Models of the impact of climate change on wild groundnut, potato and cowpea found that up to 61% of the 51 groundnut species analyzed and 12% of the 108 potato species studied could become extinct within 50 years. Wild cowpea was less affected, with only 4% of the 48 species studied expected to go extinct. It seems certain that, unless protective steps are taken, the impact of climate change on crops and their wild relatives will pose a major threat to the world's food supply. As Lane noted, "Relatively modest climatic changes over the past century have already had a significant impact on the distribution, abundance, phenology and physiology of a wide range of species."

In the case of crop wild relatives, the impact of climate change depends largely on their capacity to adapt to changing conditions or to migrate when their native regions become unsuitable. Wild groundnuts, for example, are particularly vulnerable to climate change because they grow in flat lands and would have to migrate a long way to reach cooler climates. Furthermore, because they bury their seed at the end of an extended flower stem, they can move only about 1 metre per year. On the other hand, species that grow in mountainous regions may be able to migrate to a slightly cooler climate by moving only a short distance up the slope.

The results of these studies point to the urgent need to collect and conserve crop wild relatives in genebanks, on farms and in protected areas, in order to ensure that this precious resource remains available for breeding new varieties of climate-tolerant crops. At the moment crop wild relatives account for only a small portion of the material stored in genebanks worldwide. Lane and Jarvis stress the need for further research into the ability of different wild species to adapt to climate change. This type of information could then be used to identify priority species for conservation.

But the studies also underline another urgent need: to invest in breeding programmes that will improve the tolerance and resistance of major crops to the effects of climate change, another area where developing countries fare worst. Support for plant breeding is inadequate in most countries and especially in countries that need it most. Increased financial support is a necessity but the focus of breeding programmes also has to change. Until recently breeders have concentrated on developing varieties of crops with higher yield and improved resistance to pests and diseases. And yet, according to Jarvis and Lane, abiotic stresses are now the main causes of declining yields. The focus of future breeding efforts will therefore need to be on drought- and heat-resistant varieties to help farmers reduce the losses caused by climate change. "Plant breeders now need to focus on the future as well as the present," conclude Lane and Jarvis.

The answer to global agricultural challenges such as climate change will most likely be found in the rich diversity of crop wild relatives and landraces. Ensuring that these resources remain available to all is the most important thing we can do.

Further information

a.jarvis@cgiar.org