EXTREME WEATHER, EXTREME PRICES

The costs of feeding a warming world

Farmer Aissata Abdoul Diop, Mauritania March 2012, with dried maize ears. Lack of rain and rising food prices means that people living in the Mauritanian Sahel are at risk of food insecurity

Climate change is making extreme weather – like droughts, floods and heat waves – much more likely. As the 2012 drought in the US shows, extreme weather means extreme food prices. Our failure to slash greenhouse gas emissions presents a future of greater food price volatility, with severe consequences for the precarious lives and livelihoods of people in poverty.

This briefing draws on new research which models the impact of extreme weather on the prices of key international staple crops in 2030. It suggests that existing research, which considers the gradual effects of climate change but does not take account of extreme weather, is significantly underestimating the potential implications of climate change for food prices. This research shows how extreme weather events in a single year could bring about price spikes of comparable magnitude to two decades of long-run price rises. It signals the urgent need for a full stress-testing of the global food system in a warming world.

GROW FOOD. LIFE. PLANET. OXFAM

FOOD PRICES IN A CHANGING CLIMATE

Increased hunger is likely to be one of climate change's most savage impacts on humanity. Greenhouse gas emissions are driving temperature increases, shifting rainfall patterns, and making extreme weather events more likely – like the 2012 drought in the US Midwest – with devastating consequences for agricultural production. Against a backdrop of rising populations and changing diets which will see global food production struggle to keep pace with increasing demand, the food security outlook in a future of unchecked climate change is bleak.

The impact of climate change on food production can already be seen, and will worsen as climate change gathers pace.[1] First, slow-onset changes in mean temperatures and precipitation patterns are putting downward pressure on average global yields.[2] Added to this are crop losses resulting from more frequent and intense extreme weather events.[3]

'Without action at the global level to address climate change, we will see farmers across Africa – and in many other parts of the world, including in America – forced to leave their land. The result will be mass migration, growing food shortages, loss of social cohesion and even political instability.'

Kofi Annan, Former UN Secretary-General

Research to date has focused almost exclusively on the first impact, modelling the extent of long-run average price rises in the absence of price volatility caused by extreme weather. This tells only half the story, but the assessments are nevertheless alarming. Oxfam-commissioned research suggests that the average price of staple foods such as maize could more than double in the next 20 years compared with 2010 trend prices – with up to half of the increase due to changes in average temperatures and rainfall patterns.[4]

More frequent and extreme weather events will compound things further, creating shortages, destabilizing markets, and precipitating food price spikes which will be felt on top of the projected structural price rises.

As 2012's US drought, the most severe in over half a century shows, weather-related shocks, especially in major crop exporting countries, can drive up prices precipitously in the short term. They can also trigger responses among producer and consumer countries, such as an export ban in the case of the Russian drought in 2010, which escalate prices further. The strain that price spikes have put on the global food system in recent years has aggravated political instability and social strife in many parts of the world.[5]

'There are reasons to expect more frequent food price spikes, given that it will be more common to see (weather) conditions that are considered extreme'

David Lobell, Assistant Professor of Environmental Earth System Science, Stanford University.

Such weather and food price extremes could become the new 'normal'. More research is needed to 'stress-test' the global food system: to identify its vulnerabilities and the policy options to increase resilience in a warming world, particularly for the world's poorest consumers and food producers. The research presented in this paper is a first step.

Box 1: Extreme weather and climate change

In March 2012 a special report on extreme weather by the Intergovernmental Panel on Climate Change warned of 'unprecedented extreme weather and climate events' in the future.[6]

The future may already be here. Many parts of the world have seen new records set in the past year alone:

- July 2012 was the USA's hottest month on record, contributing to the warmest 12-month period in the country since records began.
- The UK experienced the heaviest ever rainfall from April to June 2012, and in 2011, the highest ever maximum temperature in October and the warmest November in 100 years.
- In July 2012, China experienced the heaviest ever recorded rainfall to hit Beijing in a 14-hour period.
- June 2012 was the 328th consecutive month with a global temperature above the 20th century average.

Extreme weather has always occurred due to natural variability, but scientists are now able to quantify the extent to which such extreme events have been made more likely by man-made climate change. Recent studies have shown, for example, how global warming more than doubled the chances of the 2003 European heat wave, and made the 2011 Texas drought 20 times more likely. Not all extreme weather events can be attributed to climate change in this way, but pumping emissions into the atmosphere is loading the climate dice and increasing the probability of extreme weather.[7]

FOOD PRICE VOLATILITY HITS POOR PEOPLE HARDEST

Food price spikes are a matter of life and death to many people in developing countries, who spend as much as 75 per cent of their income on food.[8] The FAO estimates that the 2007/08 food price spike contributed to an eight per cent rise in the number of undernourished people in Africa. Price rises in the second half of 2010 caused further turmoil, contributing to an increase in the estimated number of hungry people globally to 925 million.[9]

'Of course I feel hungry. I feel hungry until I become weak. When I'm hungry, if possible, I prepare a broth for myself and my kids – otherwise we drink some water and we sleep'

Adjitti Mahamat, 40, Chad, where 3.6 million people are currently food-insecure due to drought, chronic poverty, and food prices which have increased by up to 30–60 per cent across the Sahel region compared with five-year average prices.

For vulnerable people, sudden and extreme price hikes can be more devastating than gradual long-term rises to which they may have more chance of adjusting. Though the price spike and coping strategies may be short term, the impacts are often felt across generations. An increase in malnutrition can cause stunting and reduce developmental potential in young children.[10] Research by Oxfam on the effects of the 2011 food price crisis documents the coping strategies of people forced to change their diets, sell productive assets, incur debt, withdraw children from school, marry early and to migrate to areas where food might be available.[11]

Price volatility also hits small-scale food producers. Poor farmers may struggle to take advantage of rapid price increases, as they lack the access to credit, land or other inputs they need to expand production. In addition, many small farms are in fact net food consumers, meaning that when prices increase, they are worse off. Finally, volatility makes it hard for poor farmers to invest: because

they do not have access to hedging instruments, they are unable to bear the risk of a future collapse in prices.

Successive droughts in the Sahel and the Horn of Africa expose the hardship of cumulative shocks, which erode resilience and peoples' capacity to recover from one crisis to the next. Niger is today experiencing a food crisis affecting more than five million people, less than two years since the last crisis in 2010, and within the same decade as the 2005 crisis. For developing countries, a future of more frequent and intense extreme weather, reducing food availability and raising prices, means a downward spiral of worsening food insecurity and deepening poverty.

Box 2: Double jeopardy: when food prices go up and purchasing power goes down

When a weather event drives local or regional price spikes, people living in poverty often face a double shock: having to cope with higher prices at a time when the direct effects of the weather may have also depleted their assets, destroyed their crops or stripped them of their livelihood. The 2011 emergency in the Horn of Africa and the 2012 Sahel food crisis show how this toxic mix can bring about hunger on a mass scale. Pastoralists and small-scale subsistence farmers are hit hard in both regions, where the loss of livestock and crops has diminished available food and drastically reduced the value of their assets so that they cannot afford to buy food either. This is shown in the declining terms of trade experienced by pastoralists across the Sahel: in June 2011 in Bandiagara, Mali, a sheep was exchanged for 267 kg of millet; a year later it received only 126 kg.

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'WHAT IF?' SCENARIOS FOR 2030

As the world lurches into a third food price spike in four years, the prospect of a future of more extreme weather calls for stress-testing the global food system under climate change. As a first step, new research commissioned by Oxfam from the Institute of Development Studies investigates how weather extremes induced by climate change might affect food price volatility in the future.[12] The purpose is not to predict the future, but to understand better the kind of food price spikes that could become a common reality in a world of more frequent and intense weather events, and highlight the need for effective policy responses.

The prospect of a future of more extreme weather calls for stress-testing the global food system under climate change.

The research models extreme weather event scenarios in 2030 for sub-Saharan Africa and for each of the main global export regions for rice, maize and wheat. The approach uses the GLOBE Computable General Equilibrium model of the global economy in order to estimate how export and domestic prices for key commodities could be impacted in 2030.[13]

Yield shocks were modelled based on the impacts of historical weather events on yields over the period 1979–2009. For each region the most significant weather-related yield shock was selected, ensuring that it was consistent with projections of how climate change might impact on the region in the future.

What picture do the scenarios paint for future food price rises and volatility?

Extreme weather events in a single year could bring about price spikes of comparable magnitude to two decades of projected long-run price increases.

The baseline modelling indicates that the average price of staple foods could more than double in the next 20 years compared with 2010 trend prices – with up to half of the increase caused by climate change (changing mean temperatures and rainfall patterns).[14] Between 2010 and 2030, average world market export prices:

- For maize could rise by 177%, with up to half the increase due to climate change;
- For wheat could rise by 120%, with around one-third of the increase due to climate change;
- For processed rice could rise by 107%, with around one-third of the increase due to climate change.

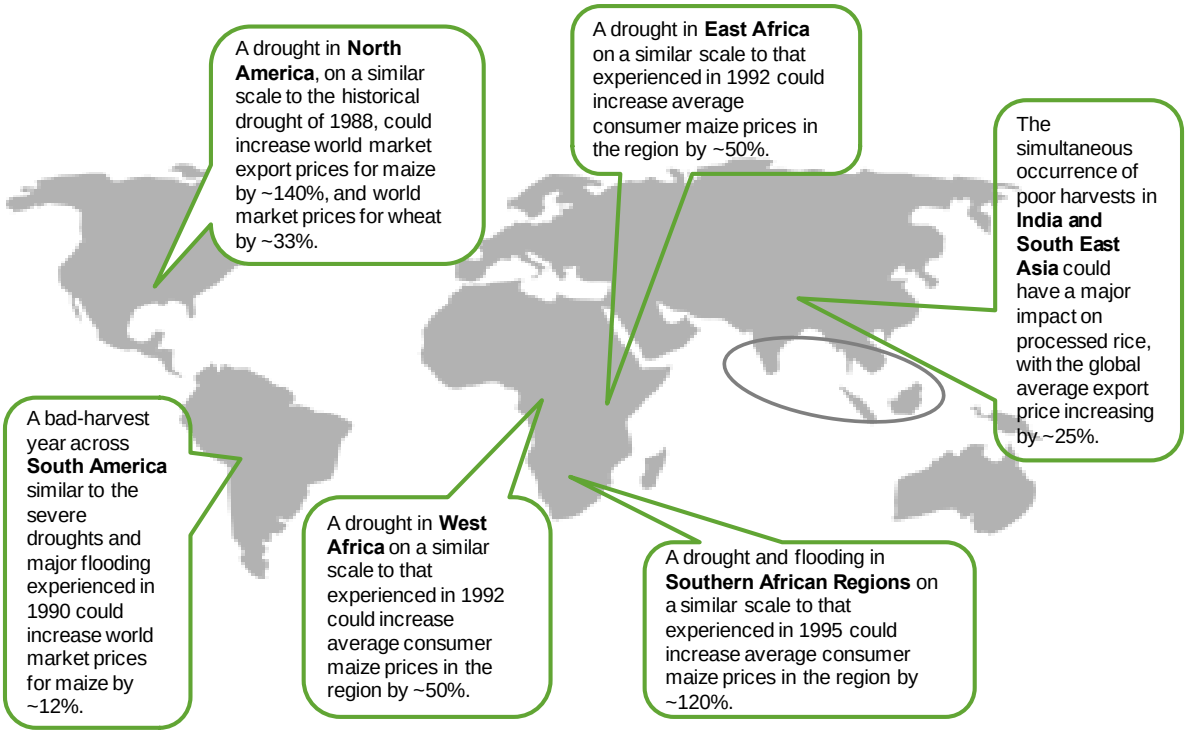
On their own, these structural price rises could spell disaster for many people living in poverty. But on top of this, the modelling also offers a snapshot of how extreme weather events could compound the impact on prices. While prices could double by 2030, the modelling suggests that one or more extreme events in a single year could bring about price spikes of comparable magnitude to two decades of projected long-run price increases.

Short-term price surges can have significantly worse consequences for vulnerable people than gradual price increases, to which they can adjust more easily. But it is the combination of long-term climate impacts and short-term shocks that are likely to be especially devastating.

The modelling suggests that existing research, which considers the gradual effects of climate change but does not take account of extreme weather, may be significantly underestimating the potential implications of climate change for food prices.

The full results of the research can be found at http://www.oxfam.org/en/grow/reports

Figure 1: Modelled price impacts of extreme weather event scenarios in 2030



Best-case scenarios?

While the modelling reveals some dramatic potential impacts, for a number of reasons these are likely to be far from the worst cases.

1. **The price shocks which result from extreme weather events could be compounded by other drivers of food price volatility**, such as crops for biofuels, low food stocks and high oil prices, the impacts of which are not considered in the modelling.
2. **The yield shocks simulated may be conservative for 2030**, because they are based on how weather events affected yields over the period 1979–2009.[15] Extreme events are expected to intensify in the coming decades due to climate change and, if realised in 2030, could exceed historical variability.
3. **The results do not capture the cumulative impact of significant yield shocks becoming more common as climate change gathers pace.** Several harvest failures in the same year, or over consecutive years, could have a devastating cumulative impact on price rises and volatility.
4. **By restricting the time horizon to 2030, the modelling does not explore the impacts of shocks due to the more extreme climate change likely beyond 2030**, when unless far reaching action is taken to curb emissions, climate change is expected to accelerate rapidly.
5. **A number of key escalating factors are not taken into account, such as the possible impacts of perverse government behaviours**. Panic-buying, hoarding, export controls and import subsidies are common reactions to shocks (and even modest price rises) on global food markets, which increase prices further.[16]

The scenario results

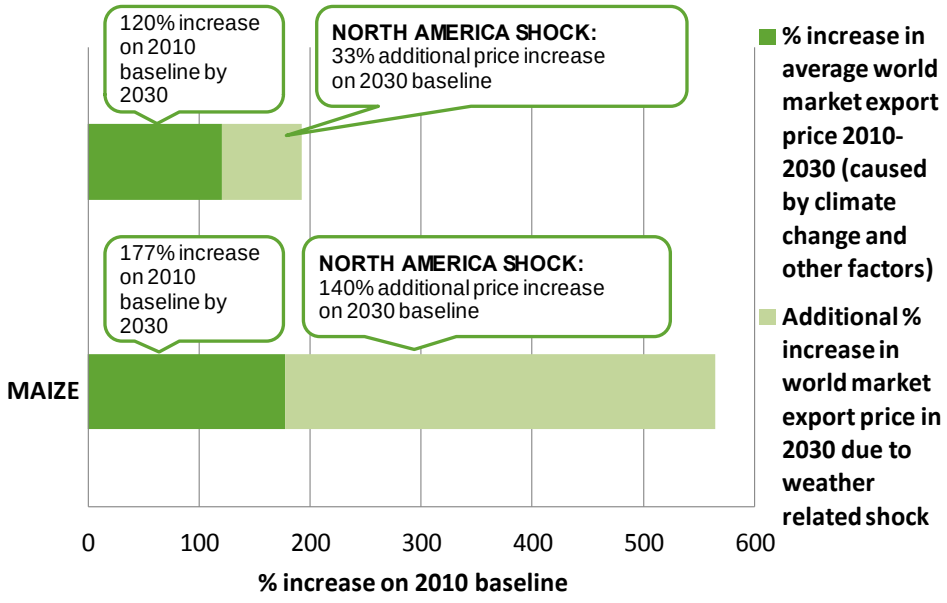
North America shock

This scenario models the impact in 2030 of a drought in North America on a similar scale to the drought of 1988 and indicates that it could have a dramatic temporary impact on world market export prices for maize, which could increase by around 140 per cent, and a strong impact on world market prices for wheat, which could increase by around 33 per cent.

By 2030, the world may be even more vulnerable to the kind of drought witnessed in the US in 2012, as a greater dependence on US exports of wheat and maize combines with a rising incidence of drought.

The modelling suggests that in the coming decades the world may be even more vulnerable to the kind of shock we are witnessing in the US in 2012. Not only do climate projections point to a rising frequency and intensity of drought events in North America over the course of the 21st century,[17] but over the coming decades the world may become even more dependent on the US for wheat and maize than it is today.

Figure 2: Average increases in world market export prices 2010–2030, plus the impact of weather-related shock on price volatility in North America in 2030



North America could remain the largest wheat and maize exporter by 2030, meaning a shock of this magnitude could hit poor import-dependent countries hard. Wheat exports are expected to expand strongly between 2010 and 2030, by which point 57 per cent of worldwide wheat exports and 44 per cent of global maize are predicted to be of North American origin, according to the model. Such a shock to the world's bread basket could well trigger unilateral export controls and import subsidies not captured in this modelling, which would exacerbate prices further. According to the model, by 2030 many developing countries in Central Asia, Central America, North Africa and the Middle East are expected to be dependent on maize and wheat imports and would therefore be hit hard by a shock of this magnitude.

Impacts on domestic prices in many countries could be huge. The model shows a 76 per cent surge in the price of maize in China and 55 per cent in the price of wheat; maize prices in Central America and Andean South America could increase by 80 per cent and 55 per cent respectively; and wheat and maize prices in South East Asia could increase by over 40 per cent.[18]

The current food crisis in Yemen shows what vulnerability to world prices means: high dependence on food imports, including for 90 per cent of its wheat, has left 10 million people hungry and 267,000 children at risk of death from malnutrition.

North Africa and the Middle East would be highly vulnerable to a shock of this magnitude. The model shows domestic prices of maize in the North Africa region rising by 50 per cent, and wheat by nearly 10 per cent.[19] The rising price of wheat has been linked to political instability and the Arab Spring, and it is fair to expect North Africa and parts of the Middle East to remain highly vulnerable to a shock of this size. Wheat is expected to remain a significant part of household food consumption in the region; insufficient potential to expand wheat production means it will continue to be a major wheat importer; and rapid population growth over the coming decades will magnify these pressures.[20]

A drought in the USA in 2030 could mean rocketing domestic prices in import-dependant countries. The modelled shock shows maize prices in Central America surge by 80%.

Mexico and Central America are also likely to be at high risk. The modelled price increase is of comparable magnitude to the global price spike in maize between 2006 and 2008, which was a major driver of the rocketing tortilla prices in Mexico that prompted 'tortilla riots' when 70,000 people took to the streets.[21]

In 2030, Mexico and Central America are still expected to be heavily reliant on maize imports and therefore highly vulnerable to a shock of this degree.[22]

Shocks in sub-Saharan Africa

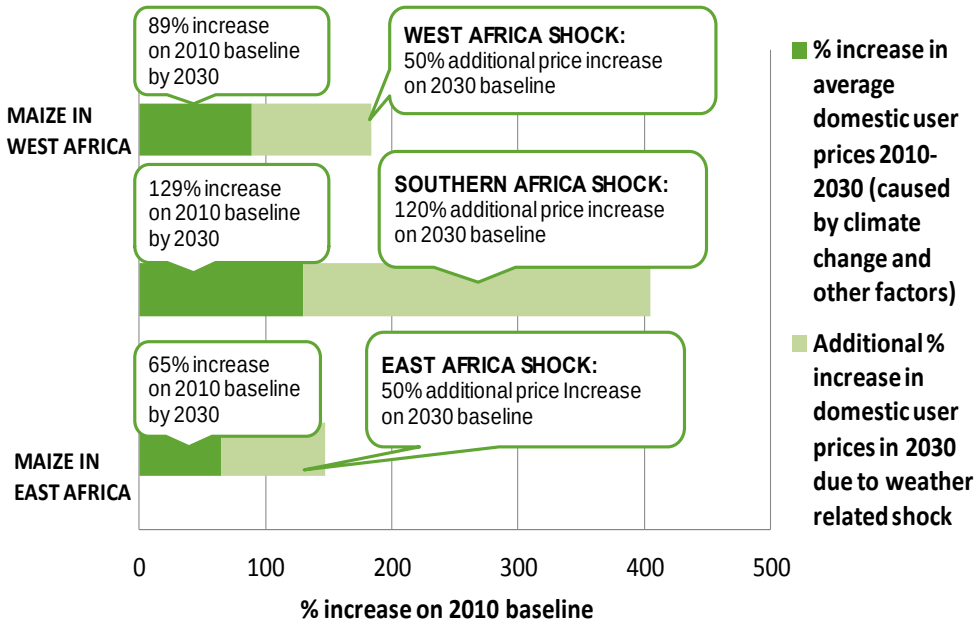
A drought in East Africa in 2030 on a similar scale to that experienced in 1992 could increase average consumer prices for maize and other coarse grains in the region by around 50 per cent.

Drought and flooding in Southern Africa in 2030 on a similar scale to that experienced in 1995 could increase average consumer prices for maize and other coarse grains in the region by around 120 per cent.

A drought in West Africa in 2030 on a similar scale to that experienced in 1992 could increase average consumer prices for maize and other coarse grains in the region by around 50 per cent.

These events are consistent with climate projections for sub-Saharan Africa, which tend to suggest a rising risk of drought and extreme precipitation events over the course of the 21st century.[23] They underline the significant risk extreme weather events in the region pose for the price of maize and other coarse grains such as sorghum and millet, which are key staples for households across the region.

Figure 3: Increase in average domestic-user prices for sub-Saharan Africa, 2010–2030, plus price-volatility impact of weather-related shocks



In these scenarios 'maize' also includes other coarse grains such as millet and sorgum

The impact on prices of extreme weather events in sub-Saharan Africa is likely to be more devastating than price spikes on global markets. Because sub-Saharan Africa is expected to remain dependent on locally and regionally produced crops for food and livelihoods, international shocks (such as the North America scenario explored above) are likely to pose less of a threat than local events – though they could still have significant impacts. By 2030 over 95 per cent of the maize and other coarse grains consumed in sub-Saharan Africa is likely to come from the region itself.[24] As a result, weather-related shocks could

By 2030, 95% of maize and other coarse grains consumed in sub-Saharan Africa could come from the region itself, meaning that local climatic shocks are likely to have dramatic impacts on local production, prices, and ultimately on levels of consumption.

have a devastating impact on local production, prices and ultimately on levels of consumption of staple crops like maize and other coarse grains. For example, the modelled shock in Southern Africa shows that direct consumption of maize and other coarse grains could fall by as much as 54 per cent – a massive blow to the food security of the poorest consumers – while consumption of all processed foods (including maize-based and other products) falls by four per cent.[25]

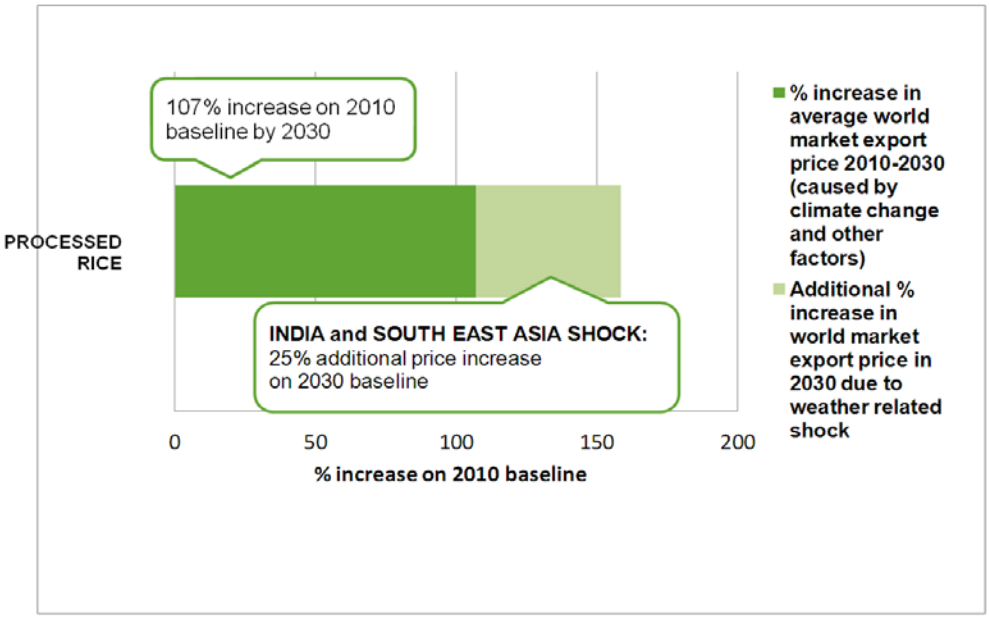
Other key staples in the region would also be hard hit. Due to a lack of research on the impacts of climate change on the production of local non-grain staples such as cassava, the model is unable to estimate price changes for these crops. These 'orphan crops' are generally marginalized within research and agricultural R&D more widely, despite the numbers of people who depend on them for their food and for their livelihoods. However, we can assume that harvests would be greatly affected, with severe consequences for the most vulnerable people.

India and South East Asia shock

This scenario models the simultaneous occurrence of poor harvests in India and South East Asia and indicates that it could lead to an increase in 2030 in the global average export price of processed rice of around 25 per cent.[26]

The yield reductions modelled are on a similar scale to those caused by the nationwide Indian drought of 1979 and the extensive flooding across South East Asia in 1980.[27] These events are consistent with future climate projections for these regions, which point to a rising frequency of droughts over the course of the 21st century in India and a significant increase in the frequency of extremely wet seasons in South East Asia, associated with an increase in the risk of floods in humid monsoon regions.[28]

Figure 4: Average increases in world market export prices 2010–2030, plus price-volatility impact of weather-related shock in India and South East Asia in 2030



By 2030, India and South East Asia could account for nearly half of global food exports for processed rice. The model indicates that 15 per cent of processed rice could come from India and 40 per cent from South East Asia by 2030, which is why a major supply shock of this nature could impact significantly on global markets.[29]

Rice import dependent counties could be hard hit. According to the model, by 2030 a number of developing countries in Central Asia, West Africa and elsewhere are expected to be rice-import dependent by 2030 and could therefore be adversely affected by a global price increase.[30] For example, the modelling suggests that average domestic market prices for rice in Sub-Saharan Africa could increase by 6 to 43 per cent, with Nigeria – currently the most populous country in Africa where rice is a key staple – the hardest hit.[31]

As modelled, a simultaneous shock in India and South East Asia in 2030 could see domestic market rice prices in Nigeria, currently Africa's most populous country, rocket by 43%.

A price spike for rice on this scale could trigger a collapse in confidence. In 2007/08 it was not a shock in rice yields that caused global prices to escalate to record levels, but initial concerns about wheat.[32] Over the course of six months, world market prices for Thai '100%B' rice tripled, from $335 per ton to over $1000 per ton, reaching the highest level ever recorded in nominal terms.[33] Recent experience suggests that the rice price shock in this scenario could precipitate a crisis of similar proportions. Rice is particularly vulnerable to price shocks: it is thinly traded, which leaves the market subject to large price fluctuations from relatively small supply changes;[34] production is concentrated geographically; and rice is of significant political importance, meaning governments are quick to impose trade restrictions.[35]

BUILDING A RESILIENT FOOD SYSTEM

The research set out in this paper is a first attempt to look at how food prices might be affected by climate-induced weather extremes if we do not act now to reduce emissions. It shows the urgent need for a full stress-testing of our fragile and dysfunctional food system in a warming world.

'It has not been properly recognized yet that we are dealing with a food system here. There is a whole chain that is also going to be affected by climate change,'

Professor Dr John Porter, University of Copenhagen

None of the scenarios presented in this research are inevitable. It is within our power to address our broken food system and strengthen its resilience, especially for the poorest consumers and food producers.

Reversing decades of under-investment in small scale, sustainable and resilient agriculture in developing countries can boost regional productivity, helping it keep pace with rising populations. Scaling up community-based disaster preparedness globally is vital to reducing vulnerability and building people's capacity to cope when weather shocks strike. Scaling up community-based, national and regionally coordinated food reserves, and social protection schemes, can help the most vulnerable people to cope with recurrent shocks.

Climate change could lead to a permanent increase in yield variability and excessive food price volatility, however, which could leave many poor countries with potentially insuperable food security challenges. The urgency of immediate action to cut emissions and to facilitate and fund adaptation could not be starker.

By 2030, climate change could cost corn-belt farmers in the US up to $4.1bn annually.

Developed countries must now deliver on their promises of climate change

adaptation finance to the poorest. They must capitalize the Green Climate Fund, which – if properly operationalized – can channel resources to those on the front lines of climate change. Adaptation will be needed in developed countries too, given that some of the world's main exporting regions are highly vulnerable. By 2030, climate change could cost corn-belt farmers in the USA up to $4.1bn annually.[36]

Fighting hunger means cutting emissions, and fast.

But while adaptation will help address the long-term productivity impacts of climate change, extreme events that have the potential to wipe out harvests will be harder to forestall. Ultimately, our food system cannot cope with unmitigated climate change. The 2011 yearly global average of greenhouse gas emissions was the highest yet. As emissions continue to climb, extreme weather in the US and elsewhere provides a glimpse of our future food system in a warming world. Our planet is heading for average global warming of 2.5–5°C this century. It is time to face up to and act on the implications this holds for levels of hunger and malnutrition among the most vulnerable people on our planet.

The simulation results set out in this issue brief are based on the research report ***Extreme Weather Events and Crop Price Spikes in a Changing Climate: Illustrative Global Simulation Scenarios*** written by Dirk Willenbockel of the Institute of Development Studies. The full report can be downloaded from Oxfam's website: http://www.oxfam.org/en/grow/reports

NOTES

[1] Research by Stanford University indicates that global yields of maize and wheat may have declined by 3.8 and 5.5% over the past three decades due to climate change. See D. Lobell *et al.* (2011) *Climate trends and global crop production since 1980.*

[2] *Ibid.*

But it should be noted that the impact on agriculture will be mixed (some positives and many negatives). Analysis indicates that the negatives are likely to outweigh any benefit resulting from changing agro-ecological conditions in some parts of the world.

[3] IPCC (2012) *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.* A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change, Field et al.

[4] D. Willenbockel (2011) 'Exploring Food Price Scenarios Towards 2030 with a Global Multi-Region Model', Oxfam Research Report, http://oxf.am/448

Analysis by the FAO, IFPRI and others also indicate temperature increases and changing precipitation patterns are expected to contribute to a structural increase in average food prices.

[5] Statistical analysis by the IMF found increases in international food prices lead to increasing risk of riots and civil conflict in low income countries:

http://www.imf.org/external/pubs/ft/wp/2011/wp1162.pdf

Analysis of international food prices and political instability indicates a food price threshold above which protests become more likely:

http://arxiv.org/abs/1108.2455

[6] IPCC (2012) *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.* A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change, Field et al.

[7] http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-12-00021.1 ; http://www.washingtonpost.com/opinions/climate-change-is-here--and-worse-than-we-thought/2012/08/03/6ae604c2-dd90-11e1-8e43-4a3c4375504a_story.html

[8] Ivanic and Martin (2008) '*The Implications of Higher Global Food Prices for Poverty in Low-Income Countries*', World Bank Policy Research Working Papers.

For more on how food price volatility can be a matter of life and death for poor people see: M. Herman *et al* (2011), *Not a game: Speculation vs. Food security*, Oxfam Issue Briefing, http://oxf.am/4RL

[9] http://www.fao.org/news/story/en/item/92495/icode/

[10] Comton *et al* (2010) *Impact of the global food crisis on the poor: what is the evidence?* Overseas Development Institute.

[11] N. Hossain and D. Green (2011) 'Living on a Spike: How is the 2011 food price crisis affecting poor people?' Oxfam Research Report, http://oxf.am/4TZ

[12] The Institute of Development Studies is based at the University of Sussex, UK

[13] Details of the GLOBE model and assumptions underpinning the research are set out in the full research report, D. Willenbockel (2012) 'Extreme Weather Events and Crop Price Spikes in a Changing Climate: Illustrative Global Simulation Scenarios', Oxfam Research Report – see http://www.oxfam.org/en/grow/reports

[14] The model seeks to project long-term food price trends, insulated from the impact of volatility, like the food price spikes of 2007/8 and 2010/11. It takes the most comprehensive dataset available from 2004 and combines this with a series of assumptions about population growth and agricultural productivity, and models what could happen to food prices between 2010 and 2030 if these assumptions are accurate. The reason modelled rather than actual prices are used is because food prices can fluctuate within a given year, and comparing long-run projections for 2030 with temporary observed price peaks in 2010 would result in misleading conclusions about the direction of the long-term crop price trends.

[15] With the exception of the India–South East Asia scenario, which combines bad harvests of two different (adjacent) years. See footnote 24.

[16] Beyond their immediate impact on yields, extreme weather events can trigger market panic, which drives prices even higher. For a good analysis, see K. Ward, *et al.*, 'Wheat's Up', HSBC Global Research, 9 August 2010.

[17] See sections 2.1.2 and 2.2.2 in the full research report – see D. Willenbockel (2012), *op. cit.*

[18] See Figures 5.2 and 5.3 in D. Willenbockel (2012), *op. cit.* which show that in most cases these countries and regions are projected to import significant amounts of wheat / maize in the 2030 baseline.

[19] Wheat prices follow maize prices, so wheat would be expected to rise further.

[20] For example, in North Africa population growth could rise by one-third in the next 20 years. See Table A.4 Population Growth in D. Willenbockel (2012), *op. cit*.

And for a summary of projected grain imports in the Middle East see 'Arab Grain Imports Rising Rapidly' http://www.earth-policy.org/data_highlights/2012/highlights28

[21]The maize price spike was caused by multiple factors including biofuel production, low food stocks and increasing oil prices. The unrest experienced in Mexico is covered in *''Tortilla riots' give foretaste of food challenge*, October 12, 2010, *Financial Times*

[22] See Fig.5.3 in D. Willenbockel (2012), *op. cit.* – which indicates that Central America as a whole (including Mexico) is expected to remain a significant net importer of maize.

[23] See sections 2.1.2 and 2.2.2 in D. Willenbockel (2012), *op. cit*.

[24] See table Table A.7 in D. Willenbockel (2012), *op. cit*.

[25] The 54% decline is likely to hit poor households hardest, including rural subsistence farmers in the region whose share of direct consumption of grains (through milling and further processing at home) will be far higher than the region-wide 3.6% average assumed in the modelling. See tables 5.9 and A.1 in D. Willenbockel (2012), *op. cit.*

[26] The historically observed yield shocks for the India–South East Asia scenario have occurred in different (adjacent) years, while the simulation analysis assumes hypothetically that shocks of the observed magnitudes occur simultaneously across both regions in the same year. A partial justification for this assumption is given by the fact that the historical annual rice yield deviations from trend over the period 1979 to 2009 for India and Other East Asia are significantly positively correlated (correlation coefficient 0.37). We are not, however, suggesting that this historically observed correlation will be rising in the future as a result of climate change. The purpose of this exploratory 'what if 'scenario is to illustrate the potential impacts of the simultaneous occurrence of multiple stressors for the case of the two main rice-exporting regions.

[27] In 1980, EM-DAT database reports a conjunction of regional floods in Indonesia, the Philippines, Thailand and Vietnam, but also a drought in the Philippines. Centre for Research on the Epidemiology of Disasters at the Catholic University of Louvain (www.emdat.be – accessed February 2012).

[28] See sections 2.1.2 and 2.2.2 in D. Willenbockel (2012), *op. cit*.

[29]See Table 5.3 in D. Willenbockel (2012), *op. cit*.

[30] See Figure 5.4 in D. Willenbockel (2012), *op. cit.*

[31] See Figure 5.13 in D. Willenbockel (2012), *op. cit.*

[32] The global rice price spike in 2008 was initially triggered by concern in India over wheat availability, which then led to an Indian export ban on rice and fed into panicked hoarding and export bans elsewhere. Indeed, it was not a bad harvest that led a collapse in confidence, but initial concerns about wheat that led to the chaos: 'Fears of shortages spread and a cumulative price spiral started that fed on the fear itself, C.P. Timmer (2008) *Causes of High Food Prices*, ADB Economics Working Paper No 128, p16.

[33] D. Dawe and T. Slayton 'The World Rice Market Crisis of 2007–2008' in *The Rice Crisis: Markets Policy and Food Security* p15.

[34] 'Thinly traded' means a relatively small proportion of overall global production is traded, which makes prices more volatile because a small change in demand can greatly affect the price.

[35] Governments play a large role in the international trade for rice that does take place. For further explanation of the points set out here on why rice is vulnerable to escalating prices see: C.P. Timmer (2008) *op. cit.*

[36] The US Department for Agriculture forecast recently – see G. Meyer 'Drought and Climate Scepticism in the Corn Belt', *Financial Times*, 15 August 2012.

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This paper was written by Tracy Carty. Oxfam acknowledges the assistance of Tim Gore, Dirk Willenbockel, David Waskow, Rob Bailey, Gonzalo Fanjul, Rob Nash, Thierry Kesteloot, Debbie Hillier and Ruth Kelly in its production. It is part of a series of papers written to inform public debate on development and humanitarian policy issues.

For further information on the issues raised in this paper please e-mail advocacy@oxfaminternational.org

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The information in this publication is correct at the time of going to press.

Published by Oxfam GB for Oxfam International under ISBN 978-1-78077-154-0 in September 2012.
Oxfam GB, Oxfam House, John Smith Drive, Cowley, Oxford, OX4 2JY, UK.

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