Climate Change and Food Security

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1 Introduction

We live in a highly food insecure world. Although global food supplies are more than adequate, the latest United Nations 'Report on the World Nutrition Situation' estimates that 798 million people were "undernourished" in 1999–2001, up from 780 million in 1995–97 (UN-SCN 2004: 9). In the 46 poorest countries, per capita food production has fallen by 10 per cent in the past 20 years (Fischer *et al.* 2002: 4). Parts of Africa, especially the Horn, have historically been acutely famine-prone – and remain so. HIV/AIDS, civil war and insecurity, and inadequate government and donor support to agriculture are all undermining progress towards the first Millennium Development Goal, of halving extreme poverty and hunger by 2015. The questions that climate change add to this challenging context are: how will climate change impact on global food supplies, and how will its impacts be distributed? Specifically, will climate change increase or reduce the food security risks facing countries and people in different parts of the world?

During the 1990s, a number of projections of world food demand and supplies into the twenty-first century were made, including studies by the UN Food and Agricultural Organisation (Alexandratos 1995), the International Food Policy Research Institute (Pinstrup-Andersen *et al.* 1999), and independent academics (Dyson 1996). The bottom-line conclusion from these models is that global food supplies will match or exceed global food demand for at least the next two to three decades; but three important caveats should be noted. First, following rapid yield increases since the 1950s, production growth is slowing down as the limits of agricultural intensification appear to be approaching – though biotechnology might push back the frontiers. Second, a positive global "storyline" conceals regional disparities that are deeply worrying for already food insecure regions: specifically, food gaps in sub-Saharan Africa are projected to widen as population growth continues to exceed production growth, increasing the need for food imports from surplus producing countries (Maxwell 2001). Third, these models pay little or no attention to climate change.

Environmental determinism has always been an influential strand of the food security discourse. In the 1970s, desertification was invoked as a major threat to livelihoods in Africa. Apocalyptic predictions were made – the Sahara was allegedly advancing by 6 km every year, destroying farmland and pastures – that, with hindsight, have proved unfounded (Nicholson 2001). Also in the 1970s, geographers identified two weather-related "famine belts", one located in the cold northern latitudes from Europe to China, the other girdling the tropics, from the West African Sahel to India (Cox 1981). Cold spells in the former, and droughts in the latter, triggered most famines until relatively recently. Famines have now disappeared from the "cold belt" – though a series of harsh winters brought Mongolia to the brink in 2002 (Siurua and Swift 2002) – but extreme weather events still trigger many humanitarian emergencies in the "hot belt". Nonetheless, the causes of contemporary food crises are recognised as far more complex: if climate, environment and demography received most analytical attention in the past, nowadays failures of national policies and global politics dominate thinking on famine and food insecurity (IDS 2002).

The excessive alarmism of environmental determinists in the past provides no basis for dismissing current concerns about climate change in the future. For one thing, climate modelling is becoming more sophisticated, and the projections for food security in regions that are already vulnerable to hunger and famine are deeply worrying. Achieving food security for all is challenging enough even in the absence of climate change. On the other hand, not all climate change is bad change – or more accurately, climate change

Table 1: Impact of climate change on suitable land for cereals

Region	Reference 1961–1990 (1,000 ha)	1990	Relative to reference 2020	2050	2080
North America	358,202	102	110	121	141
Eastern Europe	124,935	103	101	96	96
Northern Europe	45,462	101	109	113	116
Southern Europe	38,524	98	94	94	91
Western Europe	63,267	100	98	98	97
Russian Federation	243,898	105	124	148	164
Central America & Caribbean	51,505	99	105	109	99
South America	653,060	102	104	105	102
Oceania & Polynesia	115,310	102	102	102	88
Eastern Africa	316,282	99	98	100	96
Middle Africa	254,500	102	104	106	102
Northern Africa	11,782	106	97	62	25
Southern Africa	31,316	88	55	48	54
Western Africa	178,095	99	101	100	96
Western Asia	23,561	105	112	94	101
South-East Asia	97,831	100	98	103	104
South Asia	189,132	101	101	99	97
East Asia & Japan	149,694	102	99	108	110
Central Asia	12,908	111	117	147	153
Developed	993,529	102	110	119	128
Developing	1,965,735	101	101	103	100
World	2,959,264	101	104	108	109

Source: Fischer *et al.* (2002: 64).

is not necessarily bad for all people. This article will argue that the food security implications of climate change need to be carefully disaggregated, and that effective mitigation and adaptation depend as much on political responses as on agricultural consequences.

2 How will climate change affect agriculture?

The most direct implications of climate change for food security are through its impacts on food production worldwide. The consensus of scientific opinion is that countries in temperate and polar regions will enjoy increased agricultural production, while countries in tropical and subtropical regions are likely to suffer agricultural losses. Overall, the world is expected to gain some 9 per cent of cropland by 2080, almost all of it located in the northern hemisphere. Global food supplies are expected to be "relatively unaffected" by these regional shifts, with higher surpluses in much of the northern hemisphere offsetting deepening deficits in parts of the south (Parry *et al.* 1999: S51).

The good news about global warming is that a northward shift in thermal regimes will open up large tracts of potentially fertile land in the higher latitudes that are presently too cold, and have growing seasons that are too short, for extensive crop cultivation. Regions that will gain most additional agricultural land include the Russian Federation, Central Asia, North America and northern Europe (see Table 1). A related benefit of global warming is that crop yields should improve through "CO_2 fertilisation" (enhanced photosynthesis due to CO_2 enrichment of the atmosphere).

The downside is that global warming could reduce rainfall and shorten growing seasons in the tropics and subtropics to less than the minimum 120 days required by most cereal crops. Most of Africa, especially North Africa and southern Africa, will face losses of arable land, increased water stress and falling cereal yields, intensifying the challenges they face in meeting their food consumption requirements through domestic production. Even with increased fertiliser use, 'it is highly unlikely that the demand for cereals can be met' in these regions (Döös and Shaw 1999: 281). Although other regions (such as Oceania and Polynesia and southern Europe) are also expected to lose arable land, the food security threat posed by climate change is greatest for Africa, where agricultural yields and per capita food production have been steadily declining, and where population growth will double the demand for food, water, and livestock forage in the next 30 years (Davidson *et al.* 2003). Projected losses of cereal production potential in sub-Saharan Africa range from 33 per cent by 2060 (Norse 1994) to 12 per cent by 2080 (Parry *et al.* 1999: S64). Certain countries will be hit more than others. One climate sensitivity analysis of African agriculture concludes that three countries – Chad, Niger and Zambia – will lose 'practically their entire farming sector' by the year 2100 (Mendelsohn *et al.* 2000: 6).

One source of uncertainty in climate modelling is the possible interactions between gradual and abrupt changes, which is important for food security analysis given the acute sensitivity of agriculture to perturbations in the weather. Climate change is not only about global warming; it is also associated with changes in climate variability (e.g. more erratic rainfall), and changes in the frequency and magnitude of extreme weather events (more droughts or floods) (Desanker and Justice 2001). Several models forecast not just higher average temperatures and lower rainfall in semi-arid regions, but an increasing probability of El Niño–Southern Oscillation (ENSO) events, which have already become 'more frequent, persistent and intense since the mid-1970s' (IPCC 2001: 5). This period has coincided with a lengthy dry spell in Sahelian Africa, which has experienced below-average rains since the late 1960s (Nicholson 2001). It is not yet clear whether this is a manifestation of irreversible climate change, or simply a protracted cycle similar to earlier periods of elevated ENSO activity – such as the last third of the nineteenth century, when a series of extreme El Niño and La Niña events (in the 1870s, 1888–91 and 1896–1902) triggered major famines in China, India, Ethiopia, Brazil and elsewhere. What is now clear is that ENSO events have been closely correlated with all weather-related famines in the Horn of Africa for at least the past 200 years (Davis 2001).

Apart from ENSO events, some climate change scenarios foresee imperceptible changes accumulating until thresholds are crossed that cause entire ecosystems to collapse, putting intolerable stress on agro-ecologies and the socio-economic systems that depend on them (Schwartz and Randall 2003). The risk is greatest in areas that are already environmentally marginal and experience regular weather shocks – such as the drought-prone Sahel and Horn of Africa. Mutually reinforcing synergies between slow processes and sudden shocks could precipitate much larger and more frequent harvest collapses than local livelihood systems, national governments and the international humanitarian system can cope with.

3 How will climate change affect food security?

Food security is about adequate access to food, which can be acquired through trade as well as production – production self-sufficiency is not a prerequisite for food security, at either the household or the national level. Most food secure individuals buy the food they eat instead of growing it, and even wealthy countries import some basic consumption commodities. But if the households and countries that stand to lose food production due to climate change are also those that depend most on agriculture and have fewest alternative sources of income, then falling harvests will certainly undermine household and national food security. Many poor countries already experience sizeable cereal gaps every year and significant proportions of their populations are undernourished.

Understanding the full range of climate change impacts on food security therefore requires understanding the implications for prices, incomes and trade, as well as on production. For example, if domestic food production falls, food prices will rise, undermining access to food by everyone who depends on markets for their consumption needs. Moving beyond such broad-brush generalities is more difficult. The impacts of climate change will be highly differentiated across continents, countries and livelihood systems, according to local resource endowments, the nature of agriculture (mechanised or plough-based, irrigated or rain-fed, commercial or subsistence-oriented), urbanisation and economic diversification (agriculture versus industrial and service sectors), and many other environmental and socio-economic variables.

One weakness of many computer models and scenario forecasts is their failure to factor in technological change, adaptive behaviour and political responses to climate change. By isolating climatic effects and holding all other factors constant, many of these simulations generate, in effect, worst case predictions. Recent attempts to integrate the ecological and economic impacts of climate change on the world food system combine climate forecasting with a global general equilibrium model called the Basic Linked System (BLS), which simulates not only climate change impacts on agriculture but also its knock-on effects on other economic sectors, and on international trade (Parry *et al.* 1999; Fischer *et al.* 2002). These studies compare the results of different greenhouse gas emission scenarios from General Circulation Models (GCM)[1] against alternative narrative "storylines" for economic, demographic, social and technological developments in the twenty-first century.

Early applications of climate change to the BLS model generated a wide range of projected outcomes. Chen and Kates (1994) estimated that the number of undernourished people in 2060 could range from 641 million – the BLS reference scenario, assuming no climate change – to as many as 2.1 billion under the most adverse of 12 climate change scenarios. Applying a more sophisticated GCM to the BLS model, Parry *et al.* (1999) concluded that climate change will place an additional 80–125 million people (±10 million) at risk of hunger by the 2080s, of whom 70–80 per cent will be in Africa.

An important initial finding from Fischer *et al.* (2002) is that little progress is foreseen in terms of reducing hunger before 2020 under any of four possible storylines,[2] so targeted programmes will be needed if the Millennium Development Goal of halving hunger by 2015 is to be achieved. Significant progress is however expected after 2020, in the absence of climate change, under three storylines – the exception is storyline A2, which assumes high population growth and low economic growth – and by 2080 hunger is substantially less than it is today. When climate change is introduced to the system, these positive trends are partly reversed and estimates of people at risk of hunger increase under almost all (over 40) simulations. However, the dominant variable is not climate change, but the assumed level of economic growth. For instance, under moderate to high economic growth rates, the three "optimistic" storylines predict a fall in the world's undernourished population, from around 800 million today to between 91 million and 230 million by 2080. Climate change would increase the risk of hunger by between 5 per cent and 26 per cent, depending on which GCM and emission scenarios are simulated, which increases the projected global hungry population to between 99 million and 290 million; still a major improvement on the present.

Only in the "pessimistic" A2 storyline are absolute numbers of hungry people expected to increase during the twenty-first century: without climate change, there would be a slight fall to 768 million by 2080, but climate change adds anything between 50 and 120 million to this figure, so the total could be as high as 888 million in 2080. The authors make no judgement as to which storylines and scenarios are more or less plausible, but conclude their analysis with the observation that climate change will increase the risk of hunger, but that in aggregate terms continued economic growth and a transition to stable population levels could be sufficient to offset this risk: 'hunger – though negatively affected by climate change – would become a much less prevalent phenomenon than it is today' (Fischer *et al.* 2002: 115).

On the other hand, it must be emphasised that global models generate global outcomes; as a rule, impacts are not disaggregated below large regional blocs, and positive trends in some areas can mask negative trends elsewhere. Most forecasts for Africa, for instance, are pessimistic about economic growth prospects for much of the continent, where extreme weather events regularly inflict heavy losses on national GDP. (See Clay *et al.* 2003, on the macro-economic costs of recent droughts and floods in southern Africa.) Amartya Sen (1986) coined the phrase "Malthusian optimism", to describe contexts where adequate aggregate food supplies conceal "entitlement failures" and the risk of famine for certain groups. In the context of climate change, it is important to note that a favourable outcome at the global level does not imply favourable outcomes for all regions and all countries.

A recent simulation for Mali, where average temperatures are predicted to rise by 1°C–2.75°C by the year 2030, finds that the consequent reduced precipitation would increase food insecurity by lowering crop yields for farmers and forage yields for pastoralists. Cereal harvests would fall by 15–19 per cent, causing prices to double. The combined effects of lower production on farming households and higher prices on consumers' access to food raises the 'risk of hunger' in this simulation, from its present baseline of 34 per cent to 64–70 per cent of the Malian population by 2030 (Butt *et al.* 2003: 6).

Unusually, however, the Mali study recognises the dangers of overestimating the impacts of climate change, by assuming that it occurs with no adaptation by affected individuals and societies.[3] Possible agronomic and policy adaptations in Mali include: switching to heat resistant crop cultivars, shifting cultivation from semi-arid to temperate districts, exporting more cotton and importing more cereals, expanding cropland, and modifying land tenure systems. The potential benefits of these adaptations are enormous: losses due to climate change are reduced by one-third if some adaptations are adopted, but if all are adopted the gains more than offset the losses – cereal production actually rises, food prices fall, and the incidence of hunger declines to 21 per cent of the population (Butt *et al.* 2003: 15). This finding suggests that present policies might be generating sub-optimal food security outcomes – great gains in reducing hunger could be achieved if these "no-regrets" adaptations were implemented now, irrespective of future climate change scenarios.[4] But how feasible is it that countries like Mali – chronically poor, with weak institutions and weak infrastructure – can implement the necessary adaptations?

Apart from its impacts on rain-fed agriculture, climate change will affect water resources, marine and freshwater ecosystems, forest products and wildlife, unpredictably and to unquantifiable extents. People who depend on land, livestock, forests, rivers and oceans for their living are at greatest risk of seeing their livelihoods undermined by more extreme or erratic weather. Unfortunately, these groups – farmers, pastoralists, fishers, landless labourers, hunter-gatherers – are already among the most food insecure in the world. Most undernourished Africans, for instance, live in rural areas where their livelihoods derive largely from natural resources and depend critically on favourable weather. More generally, rural residents of poor countries have the lowest levels of food consumption, the highest levels of undernutrition, and are most exposed and most vulnerable to weather-related livelihood shocks.

The current Intergovernmental Panel on Climate Change (IPCC) consensus is that climate change will raise average global temperatures, and 'dry places will get drier while wet places will get wetter' (Alfsen and Skodvin 1998: 17). Water scarcity currently affects some 1.7 billion people, and this number is projected to rise to about 5 billion by 2025. As with the food security impacts of climate change, "water insecurity" will affect people living in the subtropics most severely, due to more erratic rainfall, more frequent droughts and increased evaporation. An integrated approach to water resource management – not just supply-side measures such as rainwater harvesting, storage reservoirs and water recycling, but also demand-side measures such as water use regulation and pricing policies – will become critical to national and household food security in water-stressed regions (Bergkamp *et al.* 2003).

Climate change is only one of many change factors that are either apparent or will emerge as driving forces of global food security in coming decades, and will interact – positively or negatively – with each other. Four factors will be briefly mentioned here. The first is technological change; notably controversial ongoing advances in biotechnology that could transform agricultural practices beyond recognition in the coming decades. Innovative approaches to crop irrigation offer another technological response to reduced and more variable rainfall – only about 2 per cent of Africa's arable land is irrigated – but irrigation is already prohibitively expensive for poor farmers, and will become more costly as water tables fall and drier conditions increase water requirements for crops. Clearly, climate change entails economic losses, and adapting to climate change will incur economic costs. Are national governments and the international community willing and able to make the necessary investments in irrigation and pro-poor agricultural technologies?

Second, urbanisation is a process generally associated with reduced vulnerability to food insecurity, and rural–urban migration is proceeding with some rapidity. In Africa, where the urban population rose from 23 per cent in 1980 to 34 per cent by 1999 (World Bank 2000: 277), climate change could trigger accelerated urbanisation. But successful urban-based development (rather than just an "urbanisation of rural poverty") is usually associated with a structural transformation of the national economy that involves a shift away from climate-dependent livelihoods. This transformation is imperative in food insecure countries dominated by subsistence-oriented agriculture – all the more so where climate change superimposes an additional dimension of vulnerability – but where will viable alternative livelihoods come from in these countries? Third, the rise to global prominence of the "war on terror" since September 2001 is reshaping geopolitical alliances and interests in fundamental but still unforeseeable ways, and is illustrative of how rapidly new change factors can emerge that transform previous priorities and public spending choices. Will climate change generate even a fraction of this political attention and resource allocation?

Finally, climate change could be "politically stratifying" at the global level. Losers from climate change could find themselves increasingly marginalised and eventually abandoned by wealthier "winners", which might abrogate responsibility for global poverty and withdraw behind bureaucratic fortresses designed to restrict in-migration from affected countries. Shortages of food and water 'could potentially destabilise the geo-political environment [and] could contribute materially to an increasingly disorderly and potentially violent world' (Schwartz and Randall 2003: 2; see also Rogers, this *Bulletin*). One epicentre of this instability could be chronically food deficit and water-stressed regions such as the Sahel and Horn of Africa, where tensions over access to the Nile already contribute to the long-running conflict between north and south Sudan.

4 What can be done?

Although climate change will result in more extreme weather events, which are difficult to predict locally and could result in large-scale ecological shocks and surprises, it will also cause slower changes to established weather patterns. In this respect, climate change offers time and opportunities for mitigation and adaptation: risk reduction, risk management and risk coping. In this context, risk reduction is best achieved by reducing greenhouse gas emissions, and the UN Framework Convention on Climate Change and the Kyoto Protocol are important (though imperfect) global policy instruments in this effort. Risk management includes reducing exposure to climate change (e.g. diversifying livelihood systems away from those that depend directly on natural resources), or reducing sensitivity to climate change (e.g. focusing agricultural research on drought-tolerant crops). Risk coping mechanisms (such as out-migration of people displaced by rising sea levels from low-lying areas of Bangladesh and Egypt) would be adopted once the worst effects of climate change are apparent, but would indicate a failure to mitigate these effects.

The people who will be worst affected are unlikely to be passive victims of climate change. Most already live in marginal environments and face weather variability, against which they have developed livelihood strategies that are resilient against all but the most severe or protracted shocks (see the contributions by Leach and Leach and by Scoones, this *Bulletin*). Pastoralism, for instance, is not a lifestyle choice; it is the only livelihood system that makes survival possible in many arid environments. Seasonal and long-term migration are already common responses to food insecurity, and will certainly be deployed in response to future climate change. Farm-level adaptations could include: diversifying towards climatically optimal crop and livestock varieties, adjusting land use and cropping patterns, intensifying fertiliser application, investing in irrigation and improving water management practices (Mathur *et al.* 2004). Many of these adjustments will require pro-active support by national governments and the international community – increased public investment in agricultural research to offset falling crop yields, incentives and subsidies to promote the adoption of improved seeds and technologies, provision of "weather insurance" to poor farmers, and strategic planning that anticipates the worst consequences of climate change rather than reactive "disaster management" after the event (see contributions by Burton and Yohe and by Hamilton, this *Bulletin*, on insurance).

Thus, individual responses are not enough. Collective action is needed at every level, from affected communities to institutions of global governance. Part of the global effort to address climate change must be to assist "at risk" groups in strengthening their coping mechanisms, or better still, reducing their exposure and sensitivity to climate change. Assistance provided to some poor countries under the Global Environment Fund to develop National Adaptation Programmes of Action is one (limited) step in this direction (Adger *et al.* 2003), and is discussed in more detail in this *Bulletin* by Huq and Reid and by Greene.

As with all policy arenas, the extent to which climate change is taken seriously and effectively addressed, depends primarily on political will. This raises the question of "political adaptation" to climate change. Political responses must be formulated at national, regional and global levels. In many poor countries, national capacity to cope with acute and chronic food insecurity is limited due to resource constraints, skewed policy priorities and political unaccountability. Regional solutions are implausible within Africa, as most of the continent will be adversely affected by climate change. So the dependence of low-income countries on concessionary finance and international assistance is likely to increase, assuming no positive movement in economic and demographic trends. (Higher economic growth rates would reduce poverty and hunger and increase the import capacity of food deficit countries, while falling fertility rates would decelerate the rise in food consumption requirements.)

At the global level, mobilising forces for action could include enlightened self-interest (e.g. fears by wealthier countries of large-scale in-migration of displaced people from poorer countries), peer pressure from the international community (such as a perception that climate change is undermining agreed targets for global poverty reduction), and altruism (the humanitarian imperative). As noted above, the agricultural potential of large surplus producers like Western Europe, the USA and Canada is projected to rise thanks to climate change (though intensifying public pressure to reduce agricultural subsidies could alter this equation), so food supplies should be adequate to support increased demand for food aid. However, whether the political willingness to transfer food surpluses to "hungry" populations abroad will continue indefinitely is yet another unpredictable variable.

5 Conclusion

In terms of food security, climate change is likely to be globally stratifying, because its worst impacts will fall disproportionately on those countries, livelihood systems and "at risk" populations that are already poor and food insecure, for three reasons. First, tropical and subtropical countries that are currently hot, dry and drought-prone will become hotter, drier and more drought-prone. Second, the livelihoods of the poor in these countries are dominated by farming or pastoralism, and these sectors will be worst hit by climate change. Third, limited livelihood diversification at household level, and a narrow economic base at national level, leave these families and countries with few options if the agricultural sector is undermined, so their adaptive capacity is extremely limited. By contrast, wealthier countries will lose least from climate change, have more resources to cope with impacts and may even benefit in terms of increased agricultural production potential.

The linkages from climate change to social impacts are difficult to model, given the central but unpredictable role of human agency in affecting outcomes. Nonetheless, it seems likely that the prevalence and depth of hunger will deteriorate in those countries and population groups where food insecurity is already significant. There is a risk that mutually reinforcing synergies between slow processes and sudden shocks caused by climate change, when added to existing vulnerabilities and institutional weaknesses, could precipitate much larger and longer term poverty traps than local livelihood systems, national governments and the international humanitarian system seem capable of coping with. To minimise such risks, a range of mitigation and adaptation strategies can be implemented at the local and national levels that will offset some of these anticipated consequences; many being "no regrets" measures that should be implemented anyway, if chronic food insecurity is to be seriously addressed. However, international action will also be required to support the losers from climate change, since 'the people who will be exposed to the worst of the impacts are the ones least able to cope with the associated risks' (Adger *et al.* 2003: 180). Because of these differentiated food security impacts, it follows that climate change is not just a technical matter; it is a global political issue requiring global political solutions.

Notes

1. The GCMs used by Fischer *et al.* (2002) were developed by the Hadley Centre for Climate Prediction and Research (HadCM3); the Commonwealth Scientific and Industrial Research Organisation (CSIRO); the Canadian Centre for Climate Modelling and Analysis (CCCMA); and the National Center for Atmospheric Research (NCAR).
2. Storyline A1, for example, anticipates a 'future world of very rapid economic growth, low population growth, and rapid introduction of new and more efficient technology', while storyline B2 anticipates a more heterogeneous world 'in which the emphasis is on local solutions to economic, social, and environmental sustainability' (Fischer *et al.* 2002: 34–6).
3. Responses to climate change can take two forms: *mitigation*, or reducing the magnitude of climate change (e.g. by reducing greenhouse gas emissions); and *adaptation*, or reducing the negative impacts of climate change.
4. The phrase "no-regrets" adaptation describes 'measures that would be justified even in the absence of climate change' (Mathur *et al.* 2004: 24).

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