Food insecurity and climate change

Food security in today's climate

Heatwaves became more frequent over the 20th century. In the summer of 2003, Europe experienced a particularly extreme heat event. A record loss of 36 % crop yield for corn occurred in Italy.[1]

In 2010, the Russian drought resulted in wheat yield reductions of 40% in key production areas, and the Pakistan floods resulted in losses of half a million tonnes of wheat. Together with market speculations, these events led to price increases.[2]

Over the past ten years, Category 5 hurricane events have resulted in a 10% average loss of cultivated land in the coastal states of Mexico each year, affecting mostly small farmers who rely primarily on a single crop.[3]

In South Asia, where the most vulnerable people live in the river deltas of Myanmar, Bangladesh, India and Pakistan, population growth has contributed to increased farming in the coastal regions most at risk from flooding and sea-level rise.[4]

Irrigated agricultural land comprises less than one-fifth of all cropped regions but produces 40–45 % of the world's food. Water for irrigation is often extracted from rivers which depend on climatic conditions in distant areas along the river's path.[5]

Over 80% of total agriculture is rain-fed. In Latin America it is close to 90%[6], while in Africa it is 95%.

---

[1] Stott, P.A., Stone, D.A. & Allen, M. R. 2004 Human contribution to the European heatwave of 2003. *Nature* **432**, 610-614. (doi:10.1038/nature03089 et al. 2004)

[2] US Department of Agriculture (2010) 'World Agricultural Production', Bulletin (August 2010) online at: http://www.fas.usda.gov/wap/circular/2010/10-08/productionfull08-10.pdf

[3] **:** SAGARPA (2007) Informe del paso del huracán Dean' http://www.sagarpa.gob.mx/cmdrs/sesiones/2007/7a_sesion/3_huracan_dean.pdf

[4] Webster, P.J. 2008 Myanmar's deadly daffodil. *Nat. Geosci*. **1**, 488-490. (doi:10.1038/ngeo257)

[5] Döll, P. & Siebert, S. 2002 Global modelling of irrigation water requirements. *Water Resour. Res*. **38**. (doi:10.1029/2001WR000355)

Approximately one-sixth of the world's population currently lives in glacier-fed river basins where populations are projected to increase, particularly in areas such as the Indo-Gangetic plain.[7]

Hydrological disasters accounted for 86.7% of economic damage from natural disasters in Africa in 2009. [8]

Climate-related hazards affected over 220 million people on average every year in the period 2000–2009.[9]

It is estimated that, on average, for every United States dollar invested in risk reduction, US$2–4 are returned in terms of avoided or reduced disaster impacts.[10]

---

[6] Wani, S.P., Sreedevi, T. K., Rockstrom, J. and Ramakrishna, Y.S. (2009) 'Rainfed agriculture – Past trends ad future prospects' in Wani S.P., Rockstrom J. and Oweis, T. (eds.) Rainfed agriculture: Unlocking the potential. Oxford: CABI

[7] Stern, N. 2007 *The economics of climate change: the Stern review*. Cambridge, UK: Cambridge University Press.

[8] Vos, F., Rodriguez, J., Below, R. and Guha-Sapir, D. (2010) *Annual Disaster Statistical Review 2009: the numbers and trends.* Brussels: CRED.

[9] Vos, F., Rodriguez, J., Below, R. and Guha-Sapir, D. (2010) *Annual Disaster Statistical Review 2009: the numbers and trends.* Brussels: CRED.

[10] Lal, P.N., Singh, R. and Holland, P. (2009) *Relationship between natural disasters and poverty: A Fiji case study.* SOPAC Miscellaneous Report 678. Suva: SOPAC.

Changes to climate

Mean temperature

Average temperatures are expected to increase across the globe in the coming decades.[11] In mid to high latitudes increasing average temperatures can have a positive impact on crop production, but in seasonally arid and tropical regions the impact is likely to be detrimental.[12]

Mean precipitation

On average an increase in global precipitation is expected, but the regional patterns of rainfall will vary: some areas will have more rainfall, while others will have less. There are high levels of uncertainty about how the pattern of precipitation will change, with little confidence in model projections on a regional scale.[13] Areas that are dependant on seasonal rainfall, such as those that are highly dependent on rain-fed agriculture for food security, are particularly vulnerable.

Extreme events

Recurrent extreme weather events such as droughts, floods and tropical cyclones worsen livelihoods and undermine the capacity of communities to adapt to even moderate shocks. This results in a vicious circle that generates greater poverty and hunger. The impacts on

---

[11] Meehl, G.A. *et al.* 2007 Global climate projections. In *Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (eds S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor & H. L. Miller), pp. 747-846. Cambridge, UK: Cambridge University Press.

[12] Maracchi, G., Sirotenko, O. & Bindi, M. 2005 Impacts of present and future climate variability on agriculture and forestry in the temparate regions: Europe. *Clim. Change* **70**, 117-135. (doi:10.1007/s10584-005-5939-7)

Tuck, G., Glendining, M. J., Smith, P., House, J. I. & Wattenbach, M. 2006 The potential distribution of bio-energy crops in Europe under present and future climate. *Biomass Bioenergy* **30**, 183-197. (doi:10.1016/j.biombioe.2005.11.019)

Olesen, J. E. *et al.* 2007 Uncertainties in projected impacts of climate change on European agrivulture and terrestrial ecosystems based on scenarios from regional climate models. *Clim. Change* **81**, 123-143. (doi:10.1007/s10584-006-9216-1)

Easterling, W. E. *et al*. 2007 Food, fibre and forest products. In *Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (eds M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. v. d. Linden & C. E. Hanson), pp. 273-313. Cambridge, UK: Cambridge University Press.

[13] Meehl, G.A. *et al.* 2007 Global climate projections. In *Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (eds S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor & H. L. Miller), pp. 747-846. Cambridge, UK: Cambridge University Press.

food production of extreme events, such as drought, may cancel out the benefits of the increased temperature and growing season observed in mid to high latitudes.[14]

CO_2 fertilisation

Carbon dioxide (CO_2) concentrations are known to be increasing. However, the effect of CO_2 fertilisation on crop growth is highly uncertain. In particular, there is a severe lack of experimental work in the Tropics exploring this issue. There is some evidence that although CO_2 fertilisation has a positive effect on the yield of certain crops, there may also be a detrimental impact on yield quality[15].

Drought

Meteorological drought (the result of a period of low rainfall) is projected to increase in intensity, frequency and duration[16]. Drought results in agricultural losses, reductions in water quality and availability, and is a major driver of global food insecurity. Droughts are especially devastating in arid and semi-arid areas, reducing the quantity and productivity of crop yields and livestock. Seven hundred million people suffering from hunger already live in semi-arid and arid zones.[17]

Heatwaves

In all cases and in all regions, one in 20-year extreme temperature events are projected to be hotter. Events that are considered extreme today will be more common in the future.[18]

---

[14] Alcamo, J., Dronin, N., Endejan, M., Golubev, G. & Kirilenkoc, A. 2007 A new assessment of climate change impacts on food production shortfalls and water availability in Russia. *Global Environ. Change – Hum. Policy Dimens.* **17**, 429-444. 2007

[15] Sinclair, T. R. et al. 2000 Leaf nitrogen concentration of wheat subjected to elevated CO_2 and either water or N deficits. *Agric. Ecosyst. Environ*. **79**, 53-60. (doi:10.1016/S0167-8809(99)00146-2)

Erda, L., Wei, X., Hui, J. Yinlong, X., Yue, L., Liping, B. and Liyong, X. 2005 Climate change impacts on crop yield and quality with CO_2 fertilisation in China. *Phil Tran Royal Soc B: Biological Sciences.* 360(1463): 2149-2154.

[16] Burke EJ, Brown SJ, Christidis N, 2006. Modelling the recent evolution of global drought and projections for the twenty-first century with the Hadley centre climate model, Journal of Hydrometeorology, Vol: 7, Issue: 5, 1113-1125

Burke EJ, Brown SJ, 2008 Evaluating uncertainties in the projection of future drought. *Journal of Hydrometeorology*. **9**, 2. 292-299

[17] UNDP/EEG and UNCCD (2010) *The Forgotten Billion: MDG Achievement in the Drylands.* New York: UNDP

[18] Clark, R. T., Murphy, J. M., Brown, S. J. 2010 Do global warming targets limit heatwave risk? *Geophys. Res. Let.*, **37**, L17703 (doi:101029/2010GL043898)

Changes in temperature extremes even for short periods can be critical, especially if they coincide with key stages of crop development. [19]

Heavy rainfall and flooding

While uncertain, it appears that there will be more heavy rainfall events as the climate warms.[20] Heavy rainfall leading to flooding can destroy entire crops over wide areas, as well as devastating food stores, assets (such as farming equipment) and agricultural land (due to sedimentation).[21]

Melting Glaciers

Melting glaciers initially increase the amount of water flowing in river systems and enhance the seasonal pattern of flow. Ultimately, however, the loss of glaciers will cause water availability to become more variable from year to year as it will depend on seasonal snow and rainfall, instead of the steady release of stored water from the glacier irrespective of that year's precipitation.[22]

Tropical storms

For many arid regions in the Tropics, a large portion of the annual rain comes from tropical cyclones.[23] However, tropical cyclones also have the potential to devastate a region, causing loss of life and widespread destruction to agricultural crops and lands, infrastructure, and livelihoods.

---

[19] Wollenweber, B., Porter, J. R. & Schellberg, J. 2003 Lack of interaction between extreme high-temperature events at vegetative and reproductive growth stages in wheat. *J. Agron. Crop Sci.* **189**, 142-150. (doi:10.1046/j.1439-037X.2003.00025.x)

Porter, J. R. & Gawith, M. 1999 Temperatures and the growth and development of wheat: a review. *Eur. J. Agron*. **10**, 23-36. (doi:10.1016/S1161-0301(98)00047-1);

Wheeler, T. R., Craufurd, P. Q., Ellis, R. H., Porter, J. R. & Prasad, P. V. V. 2000 Temperature variability and the yield of annual crops. *Agric. Ecosyst. Environ*. **82**, 159-167. (doi:10.1016/S0167-8809(00)00224-3)

[20] Held, I. and Soden, B.J. 2006 Robust responses of the hydrological cycle to global warming. *J Clim.* **19**, 21. 5686-5699.

[21] Falloon, P. D. & Betts, R. 2010 Climate impacts on European agriculture and water management in the context of adaptation and mitigation – the importance of an integrated approach. *Sci. Total Environ*. (doi:10.1016/j.scitotenv.2009.05.002)

[22] Juen, I., Kaser, G. & Georges, C. 2007 Modelling observed and future runoff from a glacierized tropical catchment (Cordillera Blanca, Peru). *Global Planet. Change* **59**, 37-48. (doi:10.1016/j.gloplacha.2006.11.038)

[23] Gray, W.M. 1990 Strong Association between West African Rainfall and US Landfall of Intense Hurricanes', *Science.* **249**, 4974. 1251-1256.

Some studies suggest tropical cyclones may become more intense in the future with stronger winds and heavier precipitation. However, there is a limited consensus among climate models on the regional variation in tropical cyclone frequency.[24]

Sea-level rise

Increases in mean sea-level threaten to inundate agricultural lands and salinise groundwater in the coming decades and centuries. Sea-level rise will also increase the impact of storm surges which can cause great devastation.[25]

Changes in health and nutrition

Climate change has the potential to affect different diseases, including respiratory illness and diarrhoea.[26] Diarrheal disease, acute respiratory infection, measles and meningitis are all major food security and nutrition-related diseases. They result in a reduced ability to absorb nutrients from food and the increased nutritional requirements of sick people. Increasingly poor health in a community also leads to a loss of labour productivity and higher numbers of people dependent on assistance.

---

[24] Meehl, G.A. *et al.* 2007 Global climate projections. In *Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (eds S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor & H. L. Miller), pp. 747-846. Cambridge, UK: Cambridge University Press.

McDonald, R. E., Bleaken, D. G., Cresswell, D. R., Pope, V. D. & Senior, C. A. 2005 Tropical storms: representation and diagnosis in climate models and the impacts of climate change. Clim. Dyn. 25, 19-36. (doi:10.1007/s00382-004-0491-0)

Bengtsson, L., Hodges, K. I., Esch, M., Keenlyside, N., Kornblueh, L., Luo, J. J. & Yamagata, T. 2007. How may tropical cyclones change in a warmer climate? *Tellus* **59**, 539-561.

Gualdi, S., Scoccimarro, E. & Navarra, A. 2008 Changes in tropical cyclone activity due to global warming: results from a high-resolution coupled general circulation model. *J. Clim.* **21**, 5204-5228. (doi:1175/2008JCLI1921.1)

[25] Adams, R.M. (1989) 'Global Climate Change and Agriculture: An Economic Perspective', *American Journal of Agricultural Economics.* 71(5): 1272-1279.

[26] Mao, R. 2009 Climate change is deadly: The health impacts of climate change. In *The health practitioner's guide to climate change: diagnosis and cure* (eds. Griffiths, J., Rao, M., Adshead, F. & Thrope, A.) London, UK; Earthscan.

Confalonieri, U., Menne, B., Akhtar, R., Ebi, K. L., Hauengue, M., Kovats, R. S., Revich, B. & Woodward,, A. 2007 Human Health. In *Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (eds M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. v. d. Linden & C. E. Hanson), pp. 273-313. Cambridge, UK: Cambridge University Press.

Background information

Defining food security and climate change impact

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs, and their food preferences are met for an active and healthy life (World Food Summit, 1996). Analysis of food security should be based on four aspects: (i) food availability; (ii) food access; (iii) food utilisation; and (iv) food stability. Food availability refers to the **physical presence of food** through domestic production, commercial imports and food aid. Food access concerns a **household's** ability to **acquire** adequate amounts of food, through a combination of home production and stocks, purchases, gifts, borrowing and aid. Food utilisation refers to **households'** consumption of the food they have access to and **individuals'** ability to absorb and metabolise the nutrients. Finally, food stability refers to the condition where food is **regularly and periodically** available and affordable so that it contributes to nutritional security.

Some projections suggest that 100–200 million additional people could be at risk of hunger due to climate change by 2050[27]. While such studies produce estimates that are highly uncertain and dependent upon a range of assumptions, they show how climate change could impact all aspects of food security. The overall availability of food is affected by changes in agricultural yields as well as by changes in arable land. Changes in food production, together with other factors, are likely to impact food prices and will affect the ability of poor households to access food. Decreased water availability and quality in some areas are likely to result in increased health and sanitation problems, such as diarrheal disease, which, together with changes in the patterns of vector-borne disease, has the potential to increase malnutrition by negatively affecting food utilisation. Changes in climate and increases in some extreme weather events, such as floods and droughts, will disrupt the stability of the food supply, as well as people's livelihoods, making it more difficult for them to earn a stable income to purchase food.

[27] Parry, M., Evans, A. Rosegrant, M.W. & Wheeler, T. 2009 *Climate Change and Hunger: Responding to the challenge.* Rome, Italy: WFP.

Hunger and Climate Vulnerability Index

The Hunger and Climate Vulnerability Index — the base layer of this map — is work in progress to illustrate the complex interactions between food security and climate change. The analysis is based on the definition of vulnerability to climate change from the Intergovernmental Panel on Climate Change. In this case, vulnerability is defined as the relationship between the degree of climate stress on populations (exposure), the degree of responsiveness to stress (sensitivity) and the ability of populations to adjust to the climatic changes (adaptive capacity). Indicators are selected based on their relevance to food security through rigorous statistical analysis. A total of 17 indicators have been chosen for exposure (demographics, climate-related hazard frequency and intensity), sensitivity (agricultural and environmental profiles) and adaptive capacity (socio-economics, infrastructure and governance).

Uncertainty and evidence-based planning

Climate scientists are confident that the climate is changing and they concur on some of the ways it is changing, such as increasing global average temperature. However, the details of what this means on a regional scale and the impacts of those changes on other systems, such as agriculture or markets, are more complex. This uncertainty means that we cannot talk about the future in definite terms, but instead must use the language of risk. Understanding the risk of particular events occurring, along with the potential consequences of those events, helps to keep decision-makers fully informed of the range of impacts that could occur.

Despite uncertainties in the climate science, it is vital that food security planning decisions are based on the available evidence. Improving resilience and reducing risk are the best ways to approach adaptation to climate change. Basing decisions on input from experts who understand the twin complexities of the climate system and food security reduces the likelihood of investment in misguided adaptation measures.

Climate change and variability

When we talk about climate change, scientists usually mean change in the long-term trend in climate, generally over decades and centuries. This can include long-term changes or trends in the average climate (such as annual average temperature) and changes or trends in extremes (such as the frequency of intense rainfall). However, people experience climate as individual weather events, which naturally fluctuate from year to year. In addition to natural variation, climate change will mean a shift in the patterns of weather events over the long-term. The changes in climate described on this poster apply to the coming decades and are largely the result of greenhouse gases already emitted into the atmosphere so cannot be avoided. The magnitude of these changes to our climate in the second half of the century will depend on how successful policies are at reducing greenhouse gas emissions.

Next steps

Although some regions could benefit in the shorter term, in others climate change may offset any gains in food security from economic and social development. Planning for these changes is even more of a challenge due to uncertainties in our understanding of the climate impacts on food security. This uncertainty is caused by a number of factors: the first is that climate science itself is uncertain, which means that information must be treated with caution according to the level of detail it contains. Some broad features of the climate are well understood, but what may happen at a local level is far more complicated to determine. There is also a lack of understanding of how crops respond to changes in weather and climate. Finally, to understand food security it is essential to analyse the effects of climate change in terms of socio-economic interactions and development, which are difficult to anticipate.

Despite the level of uncertainty, it is possible to make robust plans with adequate advice. There is much that scientists do know about the climate and many tools and research options that allow useful information to be extrapolated from climate model experiments. Expert interpretation of research by climate scientists and careful integration of this information with food security expertise are essential.

A fundamental challenge is the lack of integration across disciplines: generally, modelling studies have simplified food security as food *availability* without explicitly addressing the issues of food access, stability and utilisation. It is important to evaluate climate science together with information about socio-economics and human vulnerability. This will require a more systematic integration of climate science with analyses of food security vulnerability to begin to develop a clearer understanding of the impacts of climate change on hunger at the global, national and regional levels.

Food security policies should also be flexible, focusing on reducing risks, building capacity at different levels, and enhancing resilience. In this way, it will be possible to manage risk, adapt to a range of different outcomes, and act despite the uncertainty.

The Climate and Hunger Vulnerability Index presented here is a small, first step to addressing the issue of integration. By combining the expertise of climate scientists and food security analysts in applying and extending the concept of the Index, there is the opportunity to develop a working tool for planners. This would enable decision-makers to access the best available information about climate change and food security for their region, to build resilience and reduce the risk of future hunger.