CANADIAN FOODGRAINS BANK

A Primer on Climate Change & Hunger

"A world without hunger"

(Canadian Foodgrains Bank vision)

The lofty goal of ending hunger is one we all are striving to attain in our food aid, food security and nutrition programming. Making progress towards a more food secure world means addressing the serious struggles faced by those we work with, such as degraded soils, lack of seeds, poor access to markets or a harsh climate.

Our local partners in Asia and Africa are increasingly telling us that smallholder farmers have added another challenge to the mix—more flooding, more droughts and more storms linked to climate change.

The likelihood that climate change will lead to a decrease in agricultural yields in developing countries and an increased need for food aid and food security work makes understanding climate change relevant and important for our work. As well, "climate change" is appearing more often in programming proposals. It is likely, in future, that it will also become increasingly important for accessing funding.

This Primer attempts to give a general overview of the current climate change science, including the likely impacts on those we work with, recognizing there are still many uncertainties around climate change, especially related to making future projections.

Introduction to Climate Change

Most of us are awed by the magnificence of creation—from majestic mountains to tiny tadpoles, from the array of flamboyant fish in our oceans to the velvet blackness of the night sky. It is a sense of wonder beautifully expressed in the Psalms: "How many are your works, O Lord! In wisdom you made them all; the earth is full of your creatures. There is the sea, vast and spacious, teeming with creatures beyond number—living things both large and small." (Psalm 104:24-25).

Our atmosphere is also a wonder of creation. The thin layer of gases, tiny water droplets and dust particles that comprise the Earth's atmosphere acts just like a blanket on a cold night. As the sun's energy enters the atmosphere, about one-third of it gets immediately reflected back to space. The rest

is absorbed into the earth's surface, which gives off heat. The atmospheric blanket then prevents some of that warm air from escaping back to space. This natural greenhouse effect keeps our earth at a balmy 30 degrees warmer than it otherwise would be, perfect for life on earth.

However, the amount of greenhouse gases in the atmosphere, including carbon dioxide (CO_2), methane and nitrous oxide, has increased significantly since the start of the Industrial Revolution. By 2005, concentrations of CO_2 had increased by 36 percent since the mid-18th century, far exceeding the natural range over the last 650,000 years.[1]

This has led to a warming of global temperatures. According to the Intergovernmental Panel on Climate Change (IPCC)[2], the temperature increase between 1906 and 2005 was 0.74°C.[3] There is widespread scientific acceptance that this warming can be attributed to human activity, in particular by burning fossil fuels for transportation, heating and electricity, and through land use change.[4]

By the end of the 21st century, global surface temperature is projected to rise between 1.6°C and 6.9°C from pre-Industrial times, depending on various scenarios.[5]

Impact of Climate Change

The effect of warming global temperatures is widespread, including:

- Melting ice cover, snow and permafrost
- Sea level rise
- Increasing variability of weather patterns, especially for precipitation
- Increasingly frequent and severe extreme weather events

[1] Environment Canada (2008) Frequently Asked Questions About the Science of Climate Change: 2008 Update, p. 10

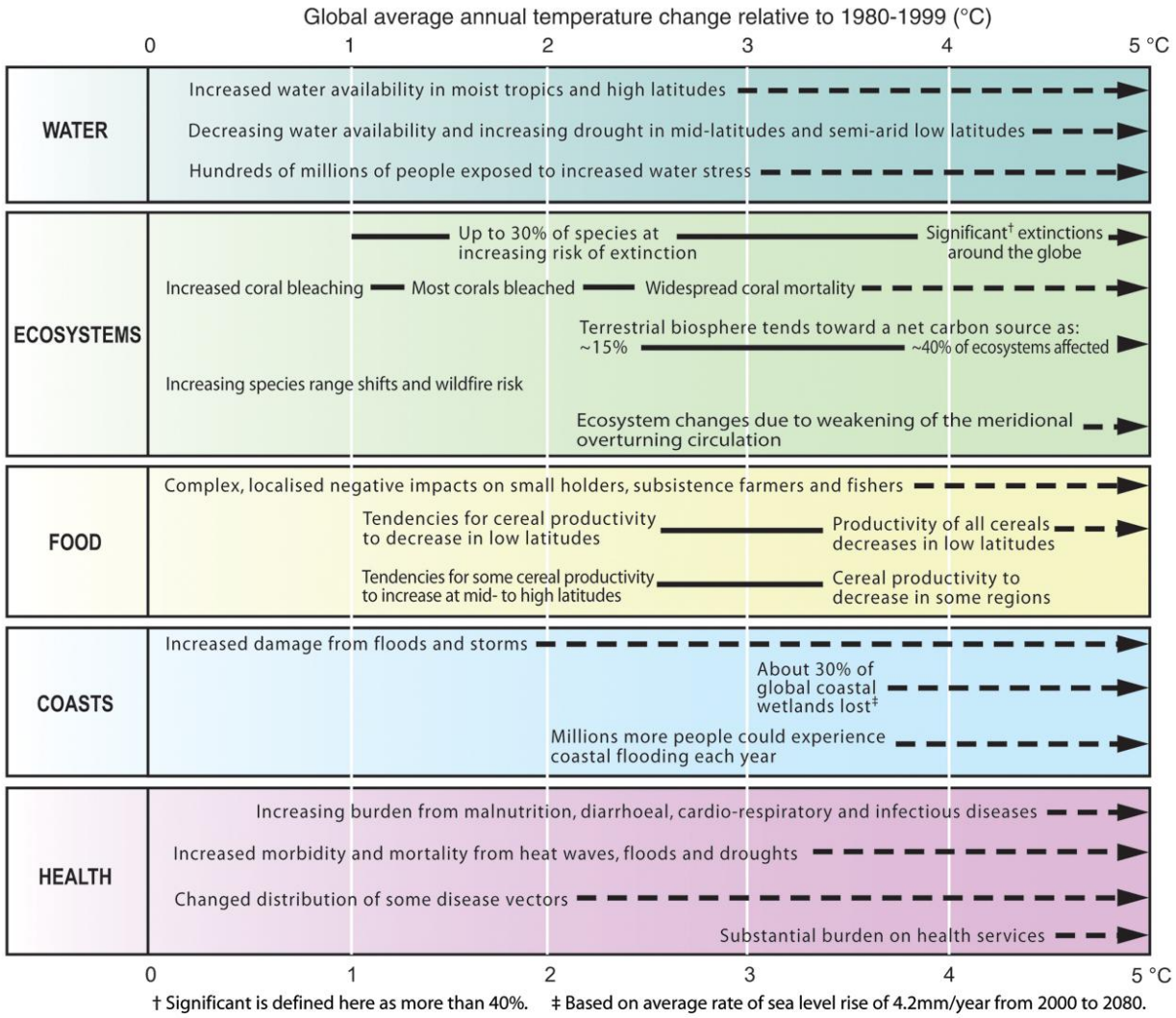
[2] The international scientific body established by the World Meteorological Organization and the UN Environment Programme in 1988 to provide an objective and neutral source of information on climate change. The IPCC releases periodic assessment reports that are reviewed and approved by experts and governments.

[3] IPCC (2007) Climate change 2007: Synthesis Report—Summary for Policymakers, p. 2

[4] Ibid, p. 5

[5] Ibid, p. 8

Fig. 1: Examples of impacts associated with global average temperature change
(Impacts will vary by extent of adaptation, rate of temperature change and socio-economic pathway)



† Significant is defined here as more than 40%. ‡ Based on average rate of sea level rise of 4.2mm/year from 2000 to 2080.

The black lines link impacts; broken-line arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of text indicates the approximate level of warming that is associated with the onset of a given impact.
Source: IPCC (2007) *Climate Change 2007: Synthesis Report—Summary for Policy Makers*

Impact on Agriculture

"Climate change will create a less predictable world."

(World Bank)

Human societies have always had to adapt to changing weather patterns, whether it be by adopting new crop varieties, changing grazing patterns, or finding new lands to cultivate. "But today the speed and intensity of climate change are outpacing the speed of those autonomous actions and threaten the ability of poor smallholders and rural societies to cope," according to the International Fund for Agricultural Development.

While there is still uncertainty about the long-term impacts of climate change, it is expected to negatively impact production in most developing countries. Even an additional 1-2°C will likely reduce yields of major cereal crops. At about a 3°C temperature rise (reached around 2080 if greenhouse gas emissions continue at a high rate) global agricultural productivity could decline 3 percent if higher levels of CO_2 boost crop yields in some parts of the world, and 16 percent if they don't.[6] For the developing world, the impact on agriculture is likely to be even more severe—a 9 percent decline if carbon fertilization takes place, and 21 percent if it doesn't.[7]

The negative impact will likely be greater in countries closest to the equator, because temperatures already tend to be close to crop tolerance levels. Country elevation is also a relevant factor. Countries with higher elevations, such as Uganda, will likely face smaller losses than lower latitude countries.[8]

By 2030 substantial production declines are expected in wheat in South Asia, rice in Southeast Asia and maize in southern Africa, unless farmers are able to adapt to changes. [9]

Land suffering from severe climate or soil constraints in sub-Saharan Africa could increase by 26 million to 60 million hectares by 2080. That represents 9-20 percent of the region's arable land.[10]

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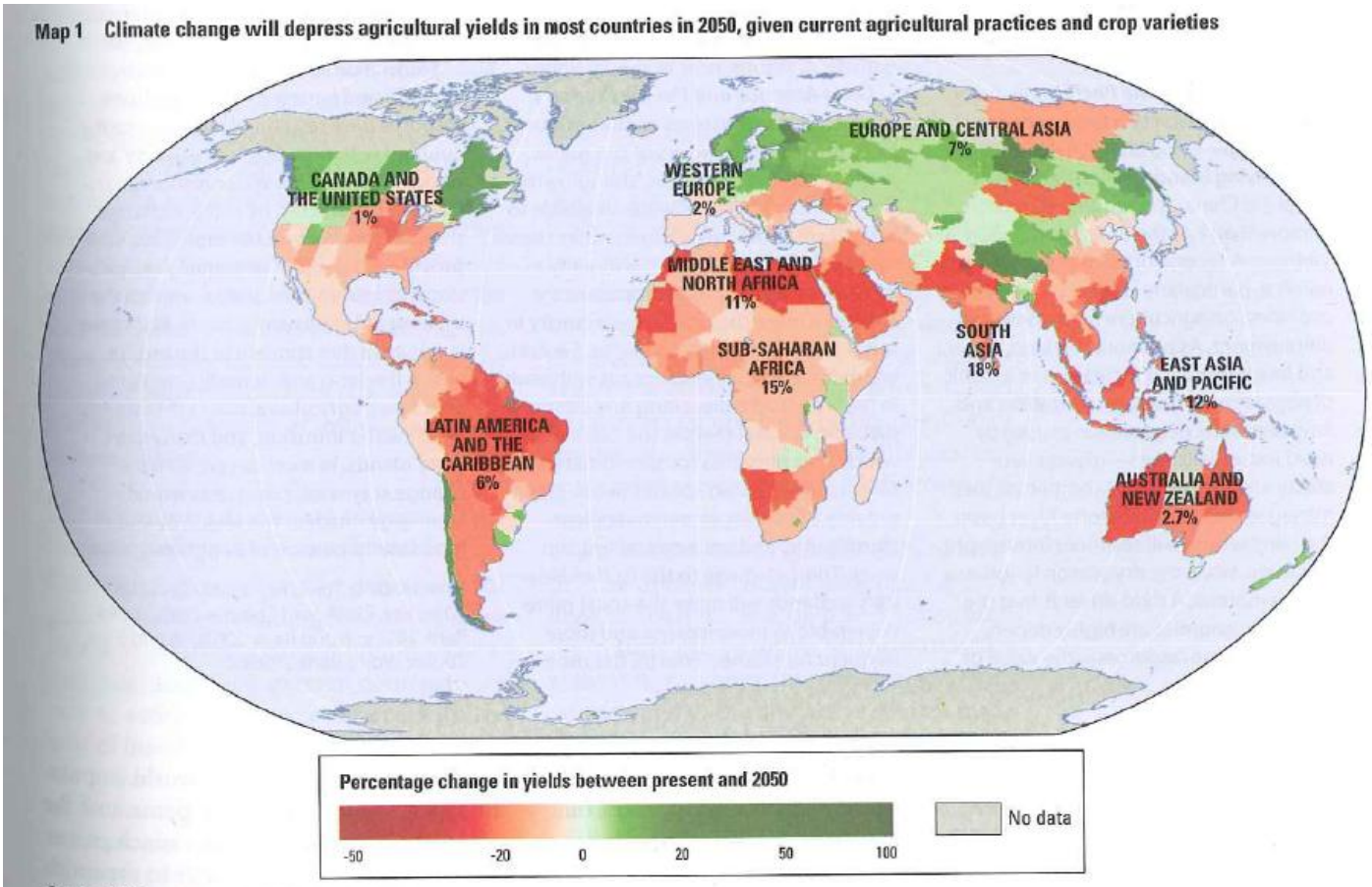
[6] There is scientific debate as to how much (if at all) increased levels of CO_2 in the atmosphere, known as carbon fertilization, will increase plant growth.
[7] World Bank (2010) *World Development Report 2010: Development and Climate Change,* p. 146
[8] Cline, W.R. (2008) "Global Warming and Agriculture" in *Finance and Development* 45 (1): 24, available at http://www.imf.org/external/pubs/ft/fandd/2008/03/pdf/cline.pdf
[9] World Bank (2010) *World Development Report 2010: Development and Climate Change*, p. 146.
[10] Ibid.

Fig. 2: Climate change impacts on agricultural yields by 2050, given current agricultural practices and crop varieties.



Source: World Bank (2010) World Development Report 2010: Development and Climate Change, p. 5

Fig. 3: Impacts of climate change on cereal outputs in Africa, 2080

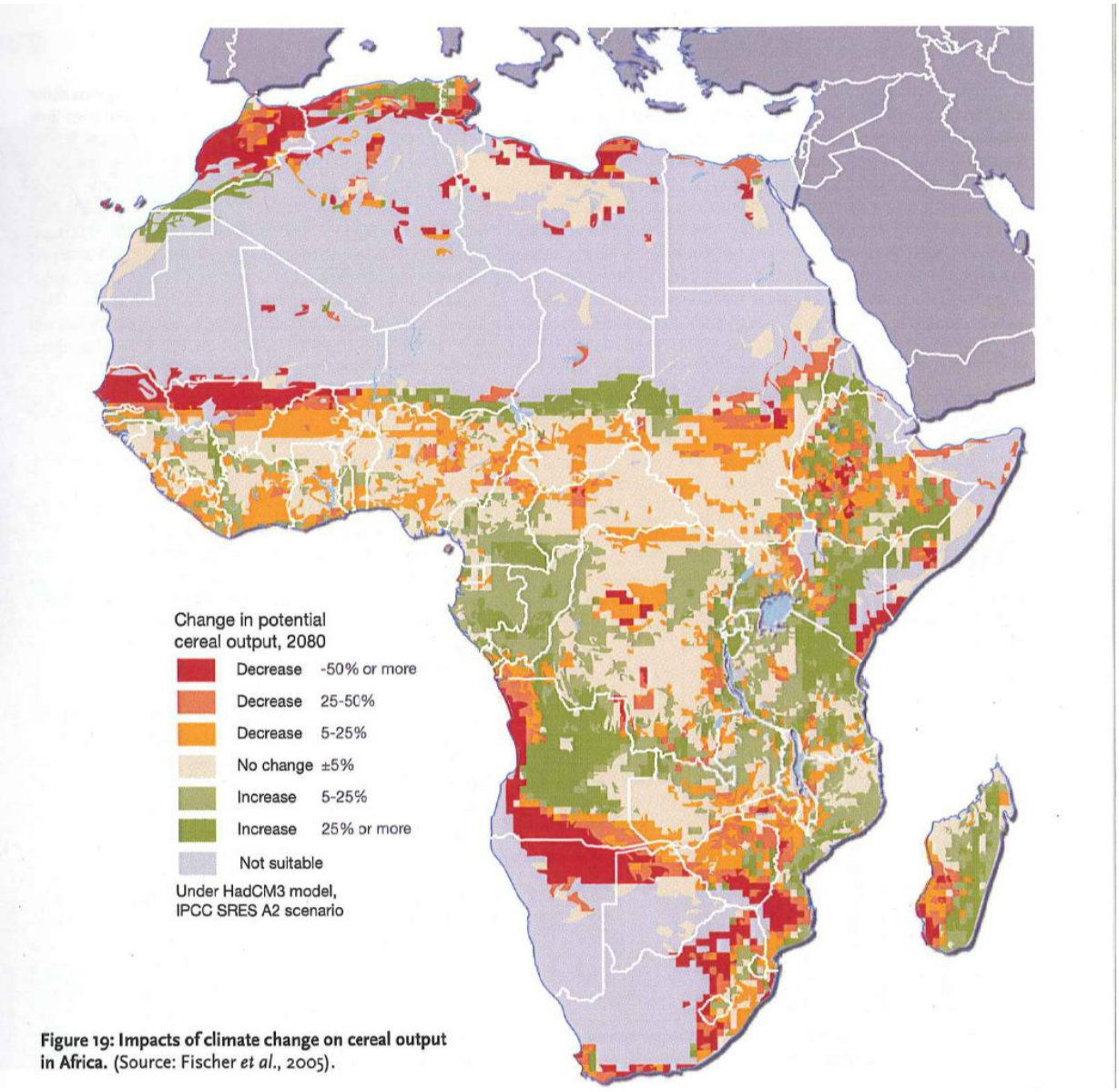


Figure 19: Impacts of climate change on cereal output in Africa. (Source: Fischer *et al.*, 2005).

Source: UNEP (2009) *The Environmental Food Crisis*, p. 47

Impact on Food Security

"There can be no food security without climate security." (Ban Ki-moon, UN Secretary General)

The causes of hunger are complex and interrelated. The International Fund for Agricultural Development refers to climate change as a 'threat multiplier'. Rather than being a specific risk on its own, climate change increases a range of livelihood threats and vulnerabilities.

The World Food Program predicts that by 2050, the number of people at risk of hunger as a result of climate change is likely to be 10 to 20 percent more than without climate change. The number of malnourished children, meanwhile, is expected to rise by 24 million—more than 21 percent higher than without climate change. [11]

Those who are reliant on natural resource base, who live in physically exposed locations and in economically precarious conditions will struggle to adapt. Almost all of this increase in hungry people will be in developing countries, in particular southern and south-eastern Asia and sub-Saharan Africa.

It is in sub-Saharan Africa where the worst impacts are expected to be felt—mainly because many people are already poor, and expected increases in aridity will amplify their vulnerability. The semi-arid regions north and south of the equator are especially vulnerable.

This range of 10 to 20 percent increase in hunger is predicated on a development pathway of high population growth and regional disparity of income. Lower population growth and more equitable distribution of income could decrease these numbers by 5 percent. Strong international action to reduce greenhouse gases and help farmers adapt to climate change would also result in a substantially lower percentage of people at risk of hunger.[12]

A study by German NGOs in 2008 looked at the impact of climate change on the four principles of food security:

- *Availability of food* will likely decrease, due to extreme events, changes to arable land and water, lack of access to crops and animal breeds that are adapted to the change in conditions.
- *Access to food* will likely decrease, due to losses of livelihood assets and loss of income and employment opportunities;
- *Stability of food supply* could be jeopardized, due to food price fluctuations and a higher dependency on imports and food aid;
- *Utilization of food* could be at risk, due to increased human diseases, as well as food safety hazards linked to pests and animal diseases.[13]

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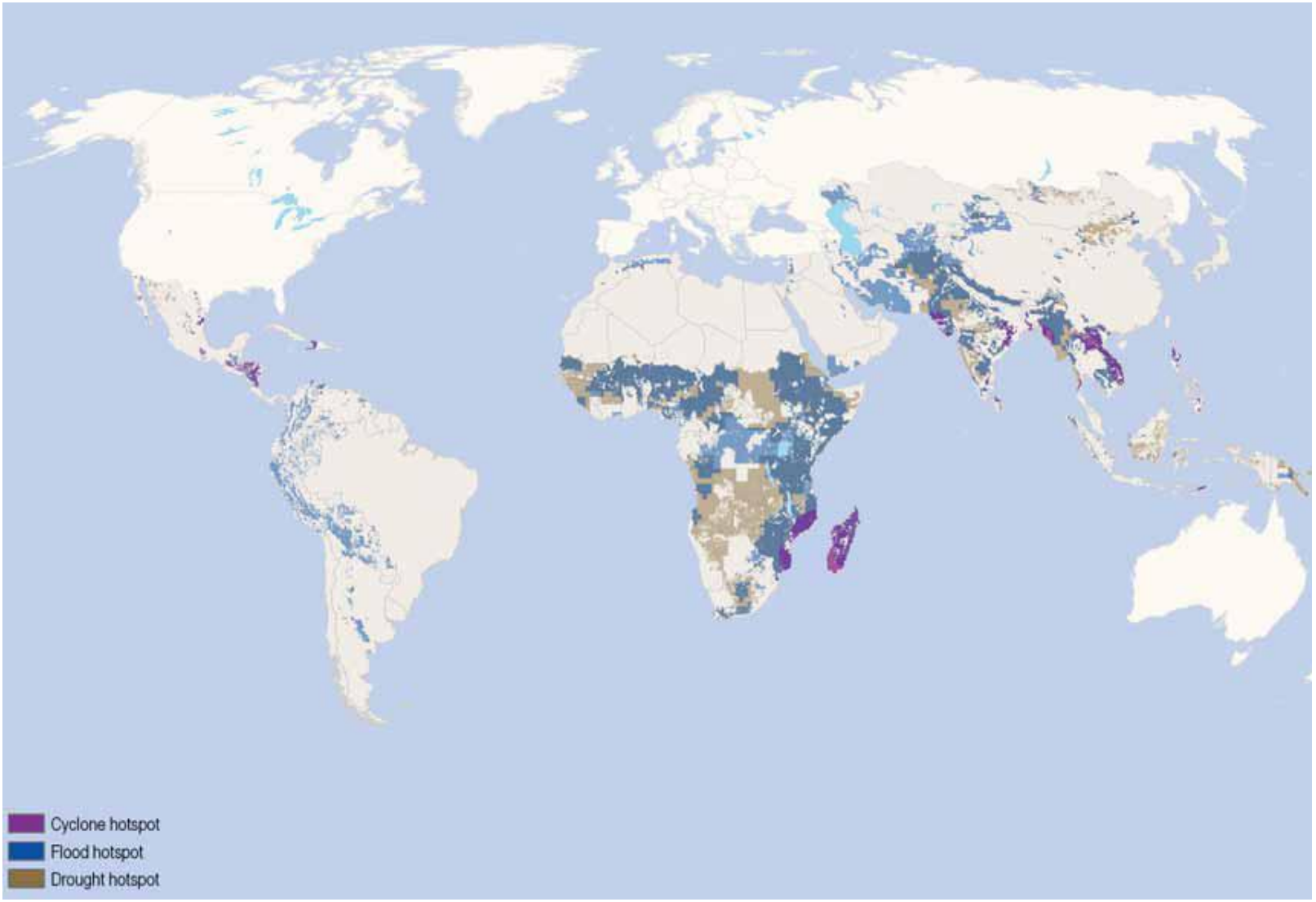
[11] Parry, M, Evans, A. (et al) (2009) *Climate change and hunger: responding to the challenge* (World Food Program), p.4

[12] Ibid., p. 12

[13] Germanwatch, Brot fur die Welt, Diakonie Katastrophenhilfe (2008) *Climate Change, Food Security and the Right to Adequate Food*, p. 126.

While there seems to be a shortage of good analysis on future humanitarian needs, it seems evident that a decrease in food security will be accompanied by an increased demand for food aid. This demand will likely come from both those eking out a minimal living in increasingly harsh conditions and from those displaced, temporarily or permanently, by severe weather events, rising sea levels, or increasing frequency of droughts.

Fig. 4: Hotspots for Three Climate-Related Disasters



Source: OCHA and CARE International (2008) *Humanitarian Implications of Climate Change: Mapping Emerging Trends and Risk Hotspots for Humanitarian Actors*

More maps showing humanitarian risk hotspots available at http://www.reliefweb.int/rw/lib.nsf/db900sid/PANA-7JXCDW/$file/ocha_aug2008.pdf?openelement

Impact on key countries for CFGB programming

Bangladesh

- The predicted sea-level rise will threaten coastal agricultural land particularly in low-lying areas; in more severe scenarios, 18 percent of Bangladesh's land could be inundated (46 percent of Bangladesh's population lives in low-elevation coastal zones)(World Bank, 2010, p 6, 366).
- Studies have shown that the erratic nature of rainfall and temperature has increased and the effects of erratic rainfall and temperature are already being felt in many areas of Bangladesh in terms of agricultural productivity (NAPA, p 8).
- Observed data indicates that the average monsoon (June, July and August) maximum temperatures are rising annually by 0.05°C and monsoon minimum temperatures by 0.03°C (Ibid p 8).
- There is clear evidence of increased saline intrusion in the coastal zones (Ibid p 8).
- One climate model predicts about a 17 percent decline in overall rice production and as much as 61 percent drop in wheat production (NAPA, p 14).
- Another study suggests that overall agricultural output (revenue per hectare) could decrease by 22 percent between 2000 and 2080, but average yields could increase by 9 percent by 2050 (World Bank, 2010, p. 367).

Sources:

- National Adaptation Programme of Action (NAPA): Bangladesh (2005), available at http://unfccc.int/resource/docs/napa/ban01.pdf

- World Bank (2007) *Climate change and South Asia: Rural Lives and Livelihoods of Millions at Risk*, available at http://www.worldbank.org.bd/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/BANGLADESHEXTN/0,,contentMDK:21571064~menuPK:295781~pagePK:141137~piPK:141127~theSitePK:295760,00.html

- World Bank ( ) *Bangladesh: Priorities for Agriculture and Rural Development*, available at http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/EXTSAREGTOPAGRI/0,,contentMDK:20273763~menuPK:548213~pagePK:34004173~piPK:34003707~theSitePK:452766,00.html

- World Bank (2010) *World Development Report 2010: Development and Climate Change*

DR Congo

- The forests in DR Congo cover approximately one million square km and are considered to be one of the largest and most important carbon sinks in the world (UNEP, "Tackling the biggest environment challenge in Africa today").
- The region's forests generate 75-95 percent of rainfall in the Congo River Basin (evapotranspiration) which means any reduction in forest cover will directly impact precipitation and the local climate (WWF).
- Climate change is expected to affect the rainy season: with an increase in rains in the Cuvette region, but a shortening of the rainy season the farther south one goes, especially in the savanna belt where more than 80 percent of the rural population lives (NAPA, p. 12).
- The rainy season in Katanga, for example, could shorten from 7 months to 5 months after 2020 (Ibid).
- Agricultural output (revenue per hectare) could decline by 15 percent between 2000 and 2080 (World Bank, 2010, p. 367).
- Agricultural yields could decrease by 7 percent between 2000 and 2050 (Ibid).

Sources

- UNEP (2007) "UNEP Mission to the DR Congo," available at http://www.unep.org/grasp/docs/UNEP_report_DRC_mission.pdf

- UNEP "Tackling the biggest environment challenge in Africa today" available at http://www.unep.org/grasp/docs/UNEP_cbdCOP_290508_English.pdf

- World Bank (2010) *World Development Report 2010: Development and Climate Change*

- WWF "Climate change in the green heart of Africa," available at http://www.panda.org/what_we_do/where_we_work/congo_basin_forests/problems/climate_change/

Ethiopia

- Over the past 55 years, Ethiopia has seen an average warming trend of approximately .37°C every 10 years (NAPA).
- Average annual temperature between 1961-1990 was 23.08°C; average annual temperature between 2017-2099 is projected to be 26.92°C (World Bank, Ethiopia: Climate risk fact sheet).
- Precipitation projections are more uncertain than temperature and considerable regional variations exist (Ibid).
- Ethiopia is extremely vulnerable to drought. It is the biggest climate-related natural hazard for the country (NAPA, p 36).
- Agriculturally, smallholder rain-fed farmers and pastoralists are found to be the most vulnerable and the arid, semi-arid and dry sub-humid parts are most affected by drought (NAPA, p 29).
- Potential impacts of climate variability in agriculture include a shortening period of maturity in crops, decreasing yields and livestock feed availability (lower yields because crops that speed through their development produce less grain in the process) (Ibid, p 30).
- Agricultural output (revenue per hectare) could decrease by 31 percent between 2000 and 2080, while yields could actually increase by 0.5 percent between 2000 and 2050 (World Bank, 2010, p. 367).
- Malaria is expected to expand into highland areas, due to climate change (Ibid).

Sources:

- CEEPA (2006) "Climate change and African agriculture," available at http://www.ceepa.co.za/docs/POLICY%20NOTE%2025.pdf

- Deressa & Hassan (2009) "Economic impact of climate change on crop production in Ethiopia: Evidence from cross-section measures" in *Journal of African Economies* (18:4), pp 529-554, available at http://jae.oxfordjournals.org/cgi/content/full/ejp002

- Deressa et al. (2008) "Measuring Ethiopian farmers' vulnerability to climate change across regional states" (IFPRI Policy Brief), available at http://www.ifpri.org/sites/default/files/publications/rb15_05.pdf

- ICIPE (2010) "Pioneering research proposes a 'return-to-past' in coffee farming," available at http://www.icipe.org/icipe-study-predicts-climate-change-impact-on-coffee-berry-borer

- National Adaptation Programme of Action (NAPA): Ethiopia (2007), available at http://unfccc.int/resource/docs/napa/eth01.pdf

- World Bank (2009) "Ethiopia at a glance," available at http://devdata.worldbank.org/AAG/eth_aag.pdf

- World Bank ( ) "Ethiopia: Climate risk factsheet," available at http://siteresources.worldbank.org/INTAFRICA/Resources/Ethiopia_Country_Note.pdf

- World Bank (2010) *World Development Report 2010: Development and Climate Change*

India

- Climate change models project at increase in temperatures between 2.5°C and 5°C by the end of the 21st century, with greater warming in northern India (V&A Programme, 2009, p. 11).
- Precipitation is expected to increase for all parts of India, except for Punjab, Rajasthan and Tamil Nadu (Ibid, p. 12).
- Arid and semi-arid regions and coastal areas are the most vulnerable to climate change (Ibid).
- Generally, more extremes are expected in both temperatures and precipitation (Ibid). (More specifics on regional variations in V&A Programme report.)
- Yields of major crops in India are projected to drop by 4.5 to 9 percent by 2040, even with short-term adaptations (World Bank, 2010, p 40).
- By 2080, agricultural output (revenue per hectare) is projected to fall by 38 percent (from 2000), while yields are projected to decrease by 12 percent by 2050 (World Bank, 2010, p. 367).
- In southern India, in particular, agriculture will be severely impacted. Temperatures are already high, and an increase in temperature will surpass crop tolerance levels (World Bank, 2007).
- Northern India, too, could see a substantial drop in crop yields, due to increased rainfall combined with higher temperatures (Ibid).

Sources:

- V&A Programme (2009) *Vulnerability and Adaptation Experiences from Rajasthan and Andhra Pradesh*, SDC V&A Programme, India, available at http://www.intercooperation.org.in/images/Climate%20Change%20-%20Introduction%20to%20V&A%20Case%20studies.pdf
- World Bank (2007), Climate change and South Asia: Rural Lives and Livelihoods of Millions at Risk, available at http://www.worldbank.org.bd/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/BANGLADESHEXTN/0,,contentMDK:21571064~menuPK:295781~pagePK:141137~piPK:141127~theSitePK:295760,00.html
- World Bank (2010) *World Development Report 2010: Development and Climate Change*, p. 40

Kenya

- Mean annual temperature has increased by 1°C since 1960. A further increase of 2.8°C is projected for 2060 and 4°C by 2100 (Harding and Devisscher, 2009, p. 20).
- The unpredictability of the rains means farmers struggle to determine the best planting time (FIAN, 2010).
- Drought incidence has quadrupled within the Mandera region of Kenya (a dry area in northern Kenya) in the last 25 years (Christian Aid, p 2).
- Approximately 500,000 people in Mandera have been forced to abandon pastoralism due to climatic conditions (Ibid).
- As a result of the last drought 60 per cent of pastoralists needed outside assistance to recover due to large scale losses of cattle, camels, and goats (Ibid).
- Kenya has very low availability of good water making it highly vulnerable to climate variability, from both floods and droughts (Mogaka et al, p 7).
- Climate change is expected to exacerbate water shortages in areas where water is already scarce; other areas, however, may see increases in precipitation (Harding and Devisscher, 2009, p. 22).
- Agricultural output (revenue per hectare) could decrease by 5 percent between 2000 and 2080, while yield could actually increase 6 percent by 2050 (World Bank, 2010, p. 367).

Sources:

- Christian Care ( ) *Life on the edge of climate change: the plight of pastoralists in Northern Kenya*, available at http://www.reliefweb.int/rw/RWFiles2006.nsf/FilesByRWDocUNIDFileName/LTIO-6VHRL6-christianaid-ken-13nov.pdf/$File/christianaid-ken-13nov.pdf
- FIAN International and RAPDA (2010) *Kenya's Hunger Crisis: The result of right to food violations,* available at http://www.fian.org/resources/documents/others/kenyas-hunger-crisis-the-result-of-right-to-food-violations/pdf
- Mogaka, H. and Gichere, S. et al (2006) *Climate variability and water resources degradation in Kenya: improving water resources development* (World Bank Working Paper No 69), available at http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2006/01/10/000090341_20060110161654/Rendered/PDF/348540KE0Clima101OFFICIAL0USE0ONLY1.pdf
- IISD (2008) *Preparing for climate change in Kenya,* available at http://www.iisd.org/pdf/2008/preparing_for_climate.pdf
- World Bank (2010) *World Development Report 2010: Development and Climate Change*

Liberia

- Liberia could face a 33 percent decrease in agricultural output by the 2080s from a 2003 baseline (not counting any positive effects of carbon fertilization) (Keane et al, p 4).
- Soil fertility is low to medium. There are four major soil types in Liberia and they all have low moisture retention capacity (Wiles, p 2).
- Increased weather variability has made it increasingly difficult to identify the optimal planting time; the Northwest and Central regions of Liberia, in particular, have had lower cereal yields relative to the baseline conditions as a result of poor soil moisture (NAPA, p 4).
- Changes in precipitation have resulted in more pests, weeds, and animal disease in the 'near-term' and this is expected to contribute to the extinction of species, narrowing of the genetic pool and the promotion of pest development (Ibid).
- Fish represent the main source of animal protein in the Liberian diet and over 20,000 workers earn their living from fishing activities. It is estimated that the effects of changing water temperatures combined with changing rainfall patterns are negatively affecting fishing stocks through declining levels of certain species. Additionally, destruction of wetland habitats (mangrove swamps) have also negatively affected the fisheries (Ibid).
- Rising sea levels will affect ground water by increasing levels of salinization, making it undrinkable and unsuitable for agriculture, thus resulting in food and water insecurity (IRIN).

Sources:

- IRIN (2008) "West Africa: coastline to be submerged by 2099," available at http://www.irinnews.org/Report.aspx?ReportId=79986

- Keane, J., Page, S. et al (2009) *Climate Change and Developing Country Agriculture: An Overview of Expected Impacts, Adaptation and Mitigation Challenges, and Funding Requirements* (ICTSD–IPC Platform on Climate Change, Agriculture and Trade, Issue Brief No.2), available at http://www.agritrade.org/documents/JKEANEweb_FINAL.pdf

- National Adaptation Programme of Action (NAPA): Liberia (2008), available at http://unfccc.int/resource/docs/napa/lbr01.pdf

- Wiles Sr, D.L. (2005) *Coastal Zone vulnerability and adaptation to climate change in Liberia*, available at http://unfccc.int/files/national_reports/non-annex_i_natcom/meetings/application/pdf/20050419wiles.pdf

Malawi

- More than half a million people live in the Lower Shire Valley making them particularly vulnerable to droughts and floods. Over the last 10 years the Shire Valley has experienced some of the worst droughts (1991/92) and floods (2000/01) in memory (NAPA, p 2)
- Smallholder farmers have reported the following changes in weather patterns: shortened growing seasons due to changing rainfall patterns and higher temperatures and increased frequency of floods and droughts (reduced periods between crises lowers farmers' capacity to recover) (ActionAid, p 4)
- The shortened growing season has forced farmers to grow more expensive short-season hybrid maize varieties (Ibid)
- Increased incidence of malaria and cholera is forcing women to tend the sick rather than their fields (Ibid)
- Climate change threatens economic growth and development in Malawi. Approximately 65 percent of the population lives below the poverty line, making it very difficult for many Malawians to adapt to extreme weather events, especially droughts and floods (NAPA, p xii).
- Malawi could face a 31 percent reduction in agricultural output (revenue per hectare) between 2000 and 2080, and a 3 percent decrease in agricultural yield by 2050 (World Bank, 2010, p. 367).

Sources:

- ActionAid (2006) *Climate change and smallholder farmers in Malawi*, available at http://www.actionaid.org.uk/doc_lib/malawi_climate_change_report.pdf
- Nangoma, E. (2007) *National Adaptation Strategy to Climate Change Impacts: A Case Study of Malawi* (Human Development Report 2007/2008), available at http://hdr.undp.org/en/reports/global/hdr2007-2008/papers/Nangoma_Everhart_Malawi.pdf
- National Adaptation Programmes of Action (NAPA): Malawi (2006), available at http://unfccc.int/resource/docs/napa/mwi01.pdf
- World Bank (2010) *World Development Report 2010: Development and Climate Change*

Nicaragua

- Projected increases in temperature are as follows: 0.9°C on the Pacific side and 0.8°C on the Caribbean side by 2010, 2.1°C (Pacific) and 1.9°C (Caribbean) by 2050 and by 3.7°C (Pacific) and 3.3°C (Caribbean) by 2100, according to the most pessimistic scenario (World Bank, p. 2).
- Projected decreases in average annual precipitation: from 8.4 percent (2010) to 36.6 percent (2100) on the Pacific side and from 8.2 percent (2010) to 35.7 percent (2100) on the Caribbean side, according to the most pessimistic scenario. Most significant precipitation changes are expected to occur in the regions of the country that are already relatively dry such as the northern municipalities of Chinandega and Leon (Ibid).
- According to the Global Climate Risk Index (1997-2006) Nicaragua ranked second in the world in both human and economic impacts (Ibid).
- In 2008, Nicaragua lost 50 percent of its national coffee harvest due to extreme weather (Cafédirect).
- Coffee crops tend to grow in only a very limited subtropical climatic range and therefore are particularly sensitive to climatic changes (Ibid).
- Coffee has an upper temperature limit after which yields dramatically decrease which has been forcing growers to increasingly higher altitudes (Ibid).

Sources

- Cafédirect (2009) *Climate change already hitting world coffee and tea farmers hard: Three-year initiative shows adaptation is imperative but solutions are obtainable*, available at http://www.cafedirect.co.uk/pdf/press/2009_October_12_CLIMATE_CHANGE_ALREADY_HITTING_WORLD_COFFEE_&_TEA_FARMERS_HARD.pdf

- World Bank (2008) *Climate Change Aspects in Agriculture: Nicaragua Country Note*, available at http://siteresources.worldbank.org/INTLAC/Resources/257803-1235077152356/Country_Note_Nicaragua.pdf

Sudan

- Limited water resources, low soil fertility, and drought are common, creating conditions for high vulnerability to climate shocks (NAPA, p 1).
- One of the most important climate risks for Sudan is chronic drought, threatening the existing cultivation of about 12 million hectares of rain-fed mechanized farming and 6.6 million hectares of traditional rain-fed lands (NAPA, p 3).
- An estimated 50-200 km expansion of desert has occurred since rainfall and vegetation records have been kept (1930s). This has not been directly attributed to climate change but demonstrates a trend (UNDP).
- Remaining semi-desert and low rainfall savannah which represents 25 percent of Sudan's agricultural land are at "considerable" risk of further desertification (UNDP).
- Agricultural output (revenue per hectare) could decrease by 56 percent from 2000 to 2080 (World Bank 2010, p. 367)
- Agricultural yields could fall by 7 percent from 2000 to 2050 (World Bank 2010, p. 367).

Sources:

- National Adaptation Programme of Action (NAPA): Sudan (2007), available at http://unfccc.int/resource/docs/napa/sdn01.pdf
- Oxfam International (2008) *Climate Wrongs and Human Rights: Putting people at the heart of climate change policy*, available at http://www.oxfam.ca/sites/default/files/climate-wrongs-and-human-rights.pdf
- Sudan's First National Communications under the United Nations Framework Convention on Climate Change (2003), available at http://unfccc.int/resource/docs/natc/sudnc1.pdf
- UNDP Sudan (2003) Overview of National Adaptation Program of Action for Climate Change, available at http://www.sd.undp.org/projects/en1.htm
- World Bank (2010) *World Development Report 2010: Development and Climate Change*

Zimbabwe

- Sub-Saharan Africa, including Zimbabwe, is particularly vulnerable to climate change and climate variability. High temperatures and low, erratic precipitation already reduce yields in the region. Increased heat stress from high temperatures and drought related to climate change will make farmers even more vulnerable to disaster, increased poverty and food insecurity (Kurukulasuriya, et al, 2007)
- A 2007 World Bank study found that net farm revenues in Zimbabwe are affected negatively by increases in temperature and positively by increases in precipitation (Mano and Nhemachena, 2007).
- The onset of the critical rainy season has been getting later in Zimbabwe (the period examined was 1979-2001) (Tadross et al, 2005).
- Maize is particularly vulnerable to climate change as it does not yield well under arid conditions. Prolonged high temperatures and periods of drought are expected to severely reduce maize production in many parts of Zimbabwe (Collier et al, 2008).
- General agricultural output (revenue per hectare) could decrease by 38 percent between 2000 and 2080. By 2050, yields could fall by 11 percent (World Bank, 2010, p. 367).
- These projected yield losses pose serious risks. Although agriculture in Zimbabwe only contributes 19 percent of the gross domestic product, over 70 percent of Zimbabweans depend on agriculture for their livelihoods. A decline in production will severely impact the subsistence and social security of people (Venema and Cisse, eds, 2004).

Sources:

- Collier, P., Conway, G. and Venables, T. (2008) 'Climate Change and Africa' in *Oxford Review of Economic Policy* 24 (2): 337-353
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July 2010