AGRICULTURE

ESTIMATES GLOBAL CLIMATE IMPACT

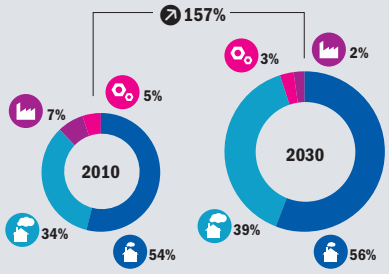
2010 EFFECT TODAY

USD **LOSS** PER YEAR **50 BILLION**

2030 EFFECT TOMORROW

USD **LOSS** PER YEAR **350 BILLION**

ECONOMIC IMPACT



CONFIDENCE **INDICATIVE**

SEVERITY

AFFECTED

INJUSTICE

PRIORITY

MDG EFFECT

- Land-based agriculture is the sector worst affected by climate change, while global demand for food and agricultural products is booming
- Africa is most vulnerable, but several large Asian economies, small islands, and parts of Latin America also suffer
- The worst-affected economies have the highest shares of agricultural workers, so impacts will likely worsen national unemployment
- Adaptation responses abound, but technical solutions are not viable where farmers lack the means to take measures or finance them
- Extreme effects on rural subsistence farmers clearly delays human development, causing new food emergencies

RELATIVE IMPACT

$$$$$$$$$ 2010
80 3

$$$$$$$$$ 2030
84 6

HOTSPOTS

2010 $ 2030

15,000 **INDIA** 100,000

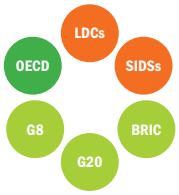
5,500 **CHINA** 55,000

1,500 **PAKISTAN** 15,000

1,250 **THAILAND** 10,000

1,250 **INDONESIA** 9,500

GEOPOLITICAL VULNERABILITY



$ Economic Cost (2010 PPP non-discounted)

Developing Country Low Emitters

Developing Country High Emitters

Developed

Other Industrialized

$ = Losses per 10,000 USD of GDP

Change in relation to overall global population and/or GDP

$ = Millions of USD (2010 PPP non-discounted)

Agriculture was one of the first sectors widely recognized to be heavily affected by climate change (IPCC, 1990; Cline, 1992). Agriculture is one of the most significant and best studied impacts of climate change assessed in the Monitor, and for many, the best known (Nordhaus and Boyer, 1999). Within regions and countries, some will be affected, while others will benefit (Bindi and Olesen, 2011). Climate change will have a particularly serious impact on farmers with limited possibilities for adapting to shifts in climate, e.g., by planting different varieties of plants and implementing new irrigation techniques (Kurukulasuriya et al., 2006; Easterling in Hillel and Rosenzweig (eds.), 2011). Agricultural losses from climate change harm subsistence farmers whose insufficient income or capital reserves prevent them from taking steps to adapt to weather change (IPCC, 2007). In developing countries with economies still heavily reliant on agriculture, the negative effects for this sector are estimated to be severe and widespread (World Bank Data, 2012). The research undertaken as a part of the Monitor's development underscored the importance of empowering vulnerable farmers to generate more value for their products in order to break the vicious spiral of poverty (see in particular the Ghana country study).

CLIMATE MECHANISM

Climate change increases heat stress and evaporation, and aggravates drought (Hansen et al., 2007). While many of these also change in relation to natural weather phenomena such as El Niño, recent evidence suggests a shift to more extreme warm weather conditions (Jung et al., 2010; Hansen et al., 2012). Climate change is altering the pattern of rainfall, which may become more or less abundant or more erratic (Kharin et al., 2007). Rainfall shifts can damage those crops and livestock, which are less suited to the changing weather or susceptible to disease or declining yield. Agricultural losses can be measured when climate deviates from optimal growing conditions, resulting in lower yield per acre (Cline, 2007). Gradual changes can be compounded by more extreme weather, especially large-scale floods (Mueller and Quisumbing, 2011).

IMPACTS

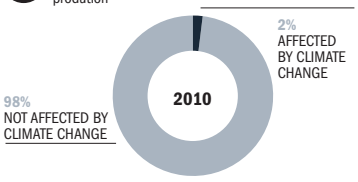
Globally, climate change is already estimated to cause 50 billion dollars a year in agricultural losses, around 90% of which occur in developing countries, since the sector accounts for between just 1–5% of GDP in most developed countries. However, costs are still relatively small in most countries, except for a small handful of the most vulnerable, some of whom are already estimated to lose 1–2% of GDP. Low-income and least developed countries are more vulnerable and suffer the most extreme effects, creating serious concern for food security. Regionally, Sub-Saharan Africa is singled out, Central, East, and West Africa most seriously. Latin America, the Pacific, and parts of Asia also have elevated levels of vulnerability. India and China are currently estimated to suffer the greatest share of the total impact, each with 2010 losses estimated at over 5 billion dollars a year. A small fraction of countries are expected to experience any gains in the agricultural sector in the near future. The scale of effect jumps rapidly over the course of 20 years from less than 0.1% of global income in 2010, more than doubling as a share of global GDP to about 0.2% in 2030, or over 350 billion dollars in yearly losses. However, the rate of increase in damage is declining: as the share of global output in service and industrial sectors grows, agriculture is expected to continue to lose importance—in line with the expansion of industrialization over the next 20 years (OECD, 2012).

THE BROADER CONTEXT

The agricultural sector is also struggling to meet the food demands of growing and wealthier populations (FAOSTAT, 2012; Friedman, 2009). But climate change is preventing the sector from meeting this demand, as indicated by both scientific research and statistical analysis (Cline, 2007). It will also lower the comparative advantage of agriculture-based, lower-income economies, with effects estimated to be especially severe for Africa (Nelson et al., 2009; Tol, 2011). Nevertheless, carbon fertilization—through which high concentrations of CO2 in the atmosphere might improve plant productivity and agricultural outputs—is understood by researchers to outweigh losses due to climate change at least early on (Mendelsohn in Griffin (ed.), 2003). This effect is accounted for in the Carbon section of the Monitor; where large-scale

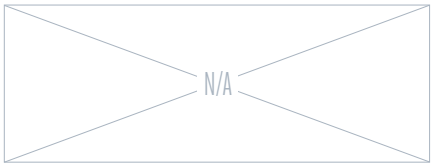
BIGGER PICTURE

Share of total potential agriculture prodution

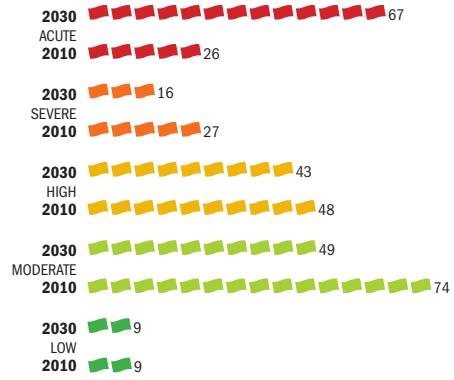


SURGE

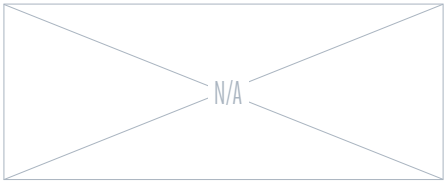
OCCURRENCE



VULNERABILITY SHIFT



PEAK IMPACT



GENDER BIAS

INDICATOR INFORMATION

MODEL: Cline, 2007

EMISSION SCENARIO: Cline, 2007

BASE DATA: FAOSTAT (2012)

= 5 countries (rounded)

Acute Severe High Moderate Low

benefits are estimated by the IPCC to be possible, they never outweigh the costs of climate change estimated here (IPCC, 2007). Recent research has been cautious about the practical realisation of these benefits (Ainsworth et al., 2008; Leaky et al., 2009). A World Bank study recently suggested that a high carbon fertilization effect would reduce adaptation costs by less than 10% (World Bank, 2010).

VULNERABILITIES AND WIDER OUTCOMES

Underscoring the vulnerability of developing countries, especially the least developed, is the significance at the national level of the size and composition of the agricultural sector in terms of output and workforce. One of the few advantages that small-scale farmers have over large commercial operators is the ability to adjust crop varieties or experiment more readily with different crops. Agricultural companies that practice large-scale mono-cropping may suffer correspondingly large losses, if climate conditions shifted to the disadvantage of the chosen crops (Brondizio and Moran, 2008). Countries that rely heavily on just one or two cash crops face similar concerns, as is highlighted in the Ghana country study in this report. Poor environmental protection also increases vulnerability, such as when biodiversity losses inhibit resistance to invasive species (Castree et al. (eds.), 2009). In general, rainfed-only agriculture is much more vulnerable than irrigated land (Kurukulasuriya et al., 2006). Communities reliant on subsistence farming are dangerously vulnerable, as global warming accelerates; the World Health Organization has estimated climate change to be a major driver of contemporary malnutrition (WHO, 2004). These health effects are measured in the Health Impact section of the Monitor.

Climate change is a major risk for food insecurity, since a number of the world's food-insecure regions are expected to experience the most severe climate shocks (Lobell et al., 2008). Indeed, climate effects on agriculture harm development, since they diminish the disposable incomes of communities already struggling to achieve gains (UNDP, 2007). They also drive the seasonal rural-urban migration of young adults, as shown by the Ghana country study.

RESPONSES

The vast literature on the impact of climate change on agriculture cannot be summarized here. All societies are understood to be "adaptive," but communities differ considerably in this capacity (Adger et al., 2003; Dixon et al., 2003). Response options vary widely, including from large-scale or micro irrigation infrastructure, to index-based weather insurance, new/hybrid seeds, and education/rural extension programmes. The involvement of local communities in the design of adaptation measures is advised, so that initiatives are feasible and practical (Smit and Wandel, 2006). The Monitor's country studies emphasize that where farmers cannot afford to take measures, efforts should focus on increasing capacity for investment and enabling local products to access more lucrative global supply chains and markets. Farmers with growing incomes could make better use of parallel extension schemes that offer appropriate adaptation options. Development plans that promote biodiversity and crop and livestock diversification will also lower vulnerability to plant and animal disease. Macroeconomic risks can only be offset by ensuring steady growth of less sensitive industrial and service sectors.

THE INDICATOR

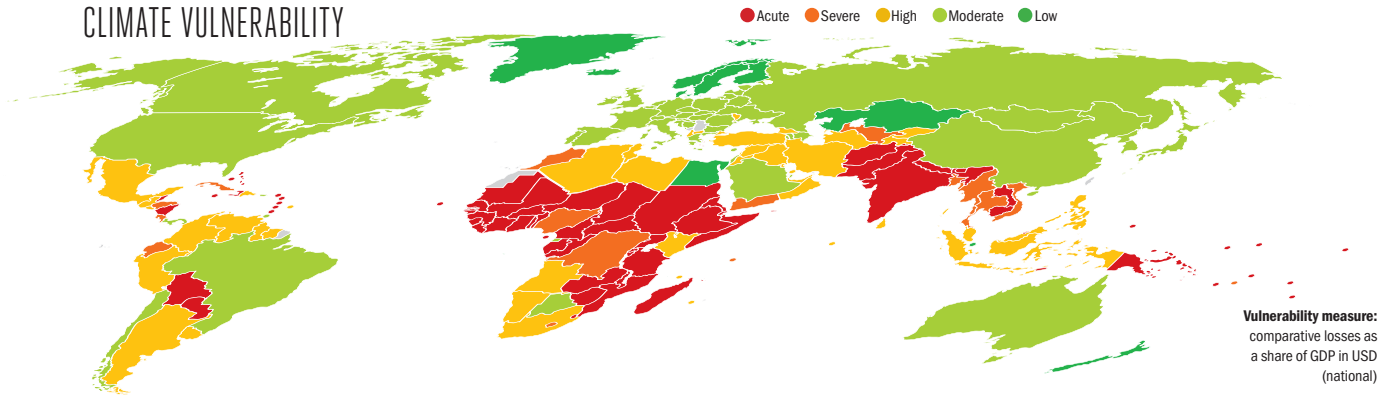
This Indicator relies on a recent and comprehensive global review of agricultural impacts of climate change that combines a wealth of experience from a range of methods and models (Cline, 2007). The difficulties in predicting rainfall accurately make some regions more uncertain about agriculture outcomes. Carbon fertilization or other effects related to atmospheric pollutants are not considered here. The Monitor accounts for the effect under Agriculture in the Carbon section of this report.

ESTIMATES COUNTRY-LEVEL IMPACT

COUNTRY	2010 ($)	2030 ($)
ACUTE		
Afghanistan	85	700
Antigua and Barbuda	5	45
Bahamas	45	350
Belize	10	75
Benin	90	600
Bhutan	10	100
Bolivia	150	1,250
Brunei	75	650
Burkina Faso	70	450
Burundi	60	400
Cambodia	100	1,500
Cameroon	200	1,250
Cape Verde	5	45
Central African Republic	50	350
Chad	60	400
Congo	50	350
Cote d'Ivoire	150	900
Djibouti	10	70
Dominica	5	25
Eritrea	15	85
Ethiopia	450	3,000
Gabon	300	2,000
Gambia	15	100
Ghana	200	1,500
Grenada	5	35
Guinea	150	900
Guinea-Bissau	15	100
Haiti	35	300
India	15,000	100,000
Jamaica	250	2,000
Kiribati	1	20
Laos	90	1,000
Liberia	15	100
Madagascar	100	800
Malawi	150	1,000
Mali	150	1,000
Marshall Islands	1	15
Mauritania	40	250
Micronesia	5	30
Mozambique	100	800
Nepal	150	1,250
Nicaragua	55	450
Niger	65	450
Pakistan	1,500	15,000
Palau	1	10
Papua New Guinea	45	350
Paraguay	150	1,250
Rwanda	100	750
Saint Lucia	5	50
Saint Vincent	5	30
Samoa	5	30
Sao Tome and Principe	1	15
Senegal	250	1,750
Sierra Leone	30	200
Solomon Islands	5	60
Somalia	35	250
Sudan/South Sudan	650	5,000
Swaziland	15	100
Tanzania	350	2,500
Timor-Leste	10	80
Togo	55	400
Tonga	5	25
Tuvalu		1
Uganda	150	1,000
Vanuatu	5	40
Zambia	85	600
Zimbabwe	75	500
SEVERE		
Bangladesh	650	5,500
Costa Rica	100	850
Cuba	250	2,000
DR Congo	60	400
Ecuador	200	1,500
Fiji	10	75
Honduras	75	600
Lesotho	10	55
Morocco	400	3,000
Myanmar	200	1,500
Nigeria	900	6,250
Seychelles	5	30
Thailand	1,250	10,000
Uzbekistan	200	1,500
Vietnam	550	6,000
Yemen	100	800
HIGH		
Albania	15	100
Algeria	300	2,250
Angola	150	1,000
Argentina	550	4,500
Bahrain	25	200
Barbados	5	45
Colombia	300	2,500
Comoros	1	5
Dominican Republic	150	1,000
El Salvador	60	500

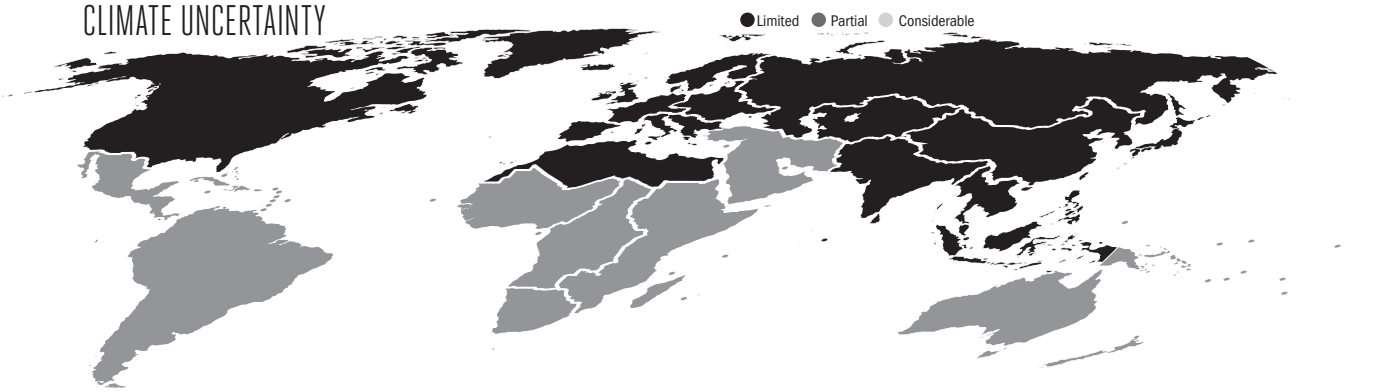
($) Additional economic costs due to climate change (million USD PPP) - yearly average

CLIMATE VULNERABILITY



Vulnerability measure: comparative losses as a share of GDP in USD (national)

CLIMATE UNCERTAINTY



COUNTRY	2010	2030
Georgia	15	100
Guatemala	100	850
Guyana	5	55
Indonesia	1,250	9,500
Iran	1,250	8,750
Iraq	150	1,000
Jordan	20	150
Kenya	60	400
Kuwait	95	750
Kyrgyzstan	15	100
Lebanon	70	550
Libya	150	1,000
Macedonia	15	100
Malaysia	500	4,000
Maldives	1	25
Mauritius	25	200
Mexico	1,250	7,750
Moldova	15	90
Namibia	10	80
Oman	60	500
Peru	250	2,000
Philippines	550	4,500
South Africa	550	3,750
Sri Lanka	100	900
Suriname	5	35
Syria	90	700
Tajikistan	15	100
Tunisia	150	1,000
Turkey	1,250	3,000
Turkmenistan	40	300
United Arab Emirates	200	1,500
Uruguay	30	250
Venezuela	350	2,750
MODERATE		
Armenia	5	45
Australia	450	1,000
Austria	15	35
Azerbaijan	25	200
Belarus	55	400
Belgium	35	85
Bosnia and Herzegovina	10	90
Botswana	1	10
Brazil	900	6,750
Bulgaria	40	250
Canada	35	80
Chile	150	800
China	5,500	55,000
Croatia	25	150
Cyprus	1	1
Czech Republic	25	100
Equatorial Guinea	5	50
Estonia	5	20
France	300	700
Germany	90	200
Greece	200	450
Hungary	30	150
Ireland	1	5
Israel	80	450
Italy	300	650
Japan	450	1,000
Latvia	5	30
Lithuania	15	100
Luxembourg		1
Malta		1
Mongolia	1	15
Netherlands	50	100
North Korea	10	100
Panama	20	150
Poland	90	500
Portugal	65	150
Qatar	1	10
Romania	100	800
Russia	400	2,750
Saudi Arabia	100	950
Slovakia	10	50
Slovenia	5	30
South Korea	550	3,250
Spain	350	850
Switzerland	10	25
Trinidad and Tobago	10	75
Ukraine	150	1,250
United Kingdom	60	150
United States	1,000	2,500
LOW		
Denmark	-25	-60
Egypt	-350	-2,750
Finland	-15	-35
Iceland		-1
Kazakhstan	-55	-400
New Zealand	-5	-10
Norway	-5	-15
Singapore		
Sweden	-20	-40