Climate Change Vulnerability Monitor
Methodology

Introduction

The Climate Change Vulnerability Monitor is an index that provides a country by country assessment of its relative vulnerability to climate change.[1] It uses indicators for three main impacts of climate change on social systems suggested by David Wheeler:[2]

1) Increase in weather-related disasters
2) Sea level rise, and
3) Loss of agricultural productivity.

Obviously, these are not the only impacts of climate change on social systems. However, given our current knowledge they are likely to account for the lion's share of economic losses associated with climate change.

We distinguish between two general approaches to gauge the potential impact of climate change: the first approach employs future projections based on sophisticated modelling to assess future impact; the second approach utilizes historical data to capture past impact (or vulnerability to impact) which is then taken to represent future impact. Each approach has its own benefits and drawbacks. Since we are interested in future risks the first approach seems most appropriate to our purposes. However, climate change impact projections are generally very uncertain and the quality of such projections are difficult to assess. The second approach assumes that history will repeat itself in the future, which might not be the case. There is no single approach which is right in all circumstances. The choice of the approach is often subjective and depends on data availability and quality. In the calculation of the Climate Change Vulnerability Index, both approaches were used to balance the drawbacks.

Below, we describe risk indicators for the climate change impacts and the construction of the index. Formal definitions and data sources for climate change risk indicators are given in Table 1.

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[1] A similar index was developed by the Global Adaptation Institute (GAIN) – the GAIN Index – that incorporates both country vulnerability to and readiness to increase resilience to climate. Source: http://index.gain.org/.
[2] Wheeler, D., "Quantifying Vulnerability to Climate Change: Implications for Adaptation Assistance", Working Paper N°240, January 2011, http://www.cgdev.org/files/1424759_file_Wheeler_Quantifying_Vulnerability_FINAL.pdf.

Weather-related Disasters

Global warming is expected to increase the number of weather-related disasters by intensifying the water cycle. We use the historical approach to construct an indicator for their impact mainly because of availability of historical data for extreme weather events – the EM-DAT International Disaster Database maintained by the Belgian university KU Leuven.[3] More specifically, our risk indicator for extreme weather events is the percentage of the population killed, injured, or homeless as a result of weather-related disasters over the 1990-2009 period. Weather-related disasters include droughts, floods, cold waves, and heat waves. This indicator focuses not on the frequency or severity of weather-related events per se but on the impact of such events on the population. As a result, it combines two aspects: a country's exposure to natural catastrophes and its capacity to deal with them.

Sea Level Rise

Risk indicator for sea level rise uses the percentage of the total population living in areas where the elevation is 5 meters or less.[4] This indicator might not directly translate into the expected risk of sea level rise since it does not take into account the level of infrastructure development and preparedness but it reflects long-term vulnerability of any particular country to the impact of sea level rise (e.g., the Netherlands has a well developed flood control infrastructure, but substantial investments are still needed to address the increasing risks posed by sea level rise).

Agricultural Productivity

To measure the impact of climate change on agriculture, we use the results of the assessment by William Cline for the expected change in agricultural productivity by 2080 for baseline global warming without carbon fertilization.[5,6] The estimates combine the results from crop models developed on the basis of agricultural science and models which use statistical regressions across climate regions of large countries.

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[3] Data from EM-DAT: The OFDA/CRED International Disaster Database of the Belgian Université Catholique de Louvain, as provided by the World Bank. Source: http://www.emdat.be/database and http://data.worldbank.org/indicator/EN.CLC.MDAT.ZS.

[4] Data from the Center for International Earth Science Information Network (CIESIN), Columbia University, PLACE II dataset, as provided by the World Bank. Source: http://data.worldbank.org/indicator/EN.POP.EL5M.ZS.

[5] Cline, W.R., "Chapter 5: Country-Level Agricultural Impact Estimates", in *Global Warming and Agriculture: Impact Estimates by Country*, Washington, D.C.: Center for Global Development and Peterson Institute for International Economics, 2007, http://www.cgdev.org/files/1424759_file_Wheeler_Quantifying_Vulnerability_FINAL.pdf.

[6] Data on agricultural productivity with and without carbon fertilization are essentially identical when they are normalized. Since index calculations involve normalized data, index values are largely not affected by the choice of agricultural dataset. In other words, relative standing of countries in terms of climate change impact on crop productivity does not change whether we consider or not the impact of carbon fertilization.

The importance of agriculture is widely different in various countries. In poor countries agriculture accounts for a much higher share of the total economic output than in rich countries. Therefore, poor countries' vulnerability to changes in agricultural productivity is likely to be higher all other things being equal. To adjust for the economic importance of agriculture we scale (i.e., multiply) the estimates of changes in agricultural productivity by the agriculture value added as a percentage of GDP (for 2010 or latest available).[7]

[7] We use the World Bank's World Development Indicators Database for this variable. Source: http://data.worldbank.org/data-catalog/world-development-indicators.

Table 1. Indicators for Climate Change Impacts

Indicator	Definition	Source	Year(s)
Vulnerability to Weather-related Disasters	Annual average percentage of total population affected as a result of either droughts, floods, or extreme temperature events. Population affected is the number of people injured, left homeless or requiring immediate assistance during a period of emergency resulting from a natural disaster; it can also include displaced or evacuated people. The average percentage of population affected is calculated by dividing the sum of total affected for the period 1990-2009 by the sum of the annual population figures for the period stated.	EM-DAT: The OFDA/CRED International Disaster Database of the Belgian Université Catholique de Louvain, as provided by the World Bank. Source: http://www.emdat.be/database and http://data.worldbank.org/indicator/EN.CLC.MDAT.ZS. The dataset was last updated in August 2012.	1990-2009
Vulnerability to Sea Level Rise	Population living in areas where elevation is below 5 meters as a percentage of total population.	Center for International Earth Science Information Network (CIESIN), Columbia University, PLACE II dataset, as provided by the World Bank. Source: http://data.worldbank.org/indicator/EN.POP.EL5M.ZS.	2000
Vulnerability to Loss of Agricultural Productivity	Preferred estimates of impact of baseline global warming by the 2080s on world agriculture, in % GDP.	Cline, W.R., "Chapter 5: Country-Level Agricultural Impact Estimates", in *Global Warming and Agriculture: Impact Estimates by Country*, Washington, D.C.: Center for Global Development and Peterson Institute for International Economics, 2007.	2080

Climate Change Vulnerability Index

To construct an overall index of vulnerability, we used the following procedure:

1) Individual risk indicators are normalized using the following formula:

$$\hat{x}i = \frac{x_i - x_{min}}{x_{max} - x_{min}};$$

where: x_i – raw value of risk indicator *x* for country *i*;

x_{max} – maximum value of risk indicator *x* for all countries;

x_{min} – minimum value of risk indicator *x* for all countries;

In the case of loss agricultural productivity we also subtract the normalized value from one since we want higher normalized values to correspond to higher vulnerability. The normalization step ensures that all indicators are dimensionless and change on the scale from 0 to 1.

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2) Three risk indicators described above are aggregated into the Climate Change Vulnerability Index using simple average of their normalized values.

The resulting Climate Change Vulnerability Index shows the relative standing of various countries with respect to three major impacts of climate change. It should be noted that the index does not provide a assessment of an absolute impact of climate change on any country, e.g., the expected economic loss.

Two of the risk indicators – impact of weather-related events and impact on agriculture (scaled by the share of agriculture in GDP) – incorporate a country's capacity to deal with climate change impacts (directly or indirectly). Therefore the Climate Change Vulnerability Index also reflects this capacity.