FONDATION POUR LES ÉTUDES ET RECHERCHES SUR LE DÉVELOPPEMENT INTERNATIONAL

Designing an Index of Physical Vulnerability to Climate Change

Patrick Guillaumont
Catherine Simonet

Patrick Guillaumont is President of the Fondation pour les Etudes et Recherches sur le Développement International (Ferdi). He is also Professor Emeritus at the University of Auvergne, member of Cerdi (Centre d'Etudes et de Recherches sur le Développement International) that he founded in 1976, and director of the Revue d'Economie du Développement.

Catherine Simonet is a PhD student at Cerdi.

This is an attempt to build an Index of Physical or Geophysical Vulnerability to Climate Change. It differs from the burgeoning and already rich literature on vulnerability to Climate Change by only considering this part of the vulnerability which does not depend on the present policy, neither on future policy. To this aim it relies only on physical components likely to reflect an impact of climate change, without any use of socioeconomic data. It is an index of *physical vulnerability* to climate change, changing only progressively and slowly.

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policy brief
18
March
2011
note brève

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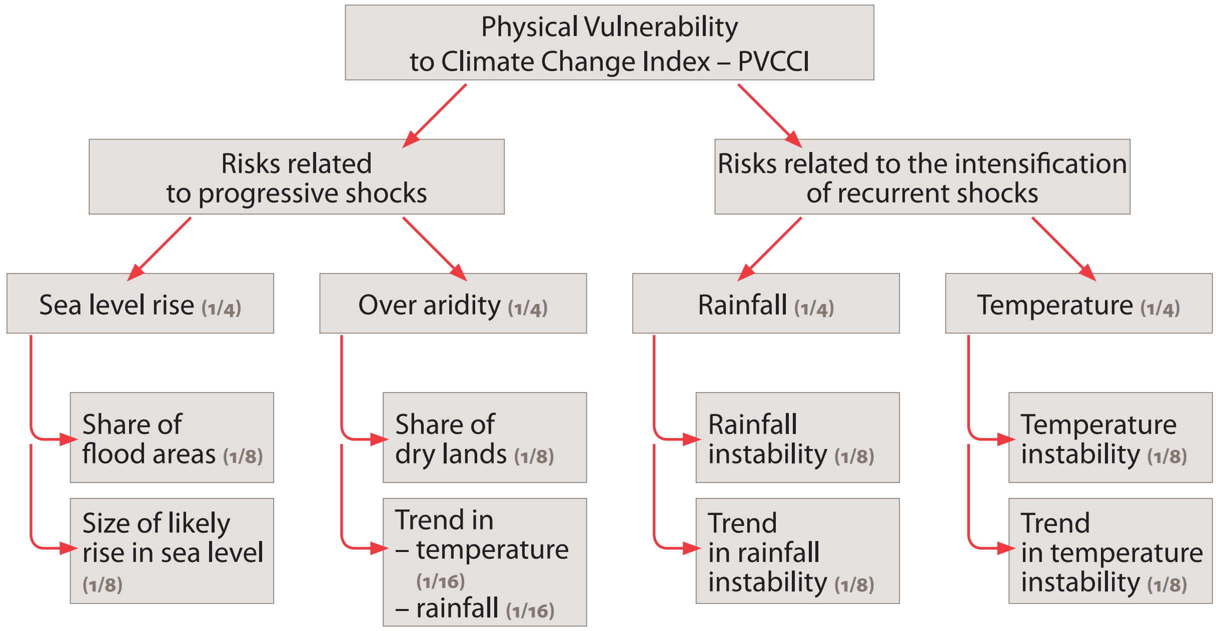
It also differs from other vulnerability indices, both from the more general environmental vulnerability indices, which most often include resilience and policy components, and from the Economic Vulnerability Index (EVI) used by the Committee for Development Policy (CDP) for the identification of the Least Developed Countries (LDCs). The EVI is related only to physical vulnerability (independent from the present will of countries), as the present Physical Vulnerability to Climate Change Index (PVCCI), but it differs from the latter: it covers all kinds of exogenous shocks likely to affect economic growth, it refers to a shorter term horizon and it tries to capture a handicap to economic growth rather than a risk of a change in geophysical conditions.

Thanks to these features, the PVCCI, set up at the country level, could be used as a criterion for the geographical allocation of the international resources available for the adaptation to climate change. It is a relevant criterion precisely because it doesn„t depend on the present policy (the vulnerability resulting from a poor policy cannot be a reason for a higher allocation), and it only gives an indication of the need for adaptation. By the same way the EVI has been proposed as a possible criterion for the allocation of development assistance. The two indices PCCVI and EVI can then have a complementary role in allocation of international resources as far as these resources are provided from separate windows (Guillaumont 2008 and Guillaumont, Guillaumont Jeanneney and Wagner 2010).

The design of the PVCCI draws both from the environmental literature and from the attempt to measure physical economic vulnerability, as it is done by the Economic Vulnerability Index (UNCDP 2008, Guillaumont 2009a and 2009b). As an environmental index, the index relies on components reflecting the physical consequences of climate change that can directly affect population welfare and activity, rather than an assessment of their long term economic consequences, which would be more debatable. And, as an index of physical vulnerability to climate change, it refers only to the vulnerability that does not depend on the present will of the country.

The index relies on eight components, considered as relevant, reliable, available for the whole set of developing countries and easily understandable, so that the index can be used in a transparent manner. These eight components respectively capture the risks related to progressive or cumulative shocks due to climate change and the risks related to the intensification of recurrent shocks due to it. They reflect both the likely size of the shocks and the country exposure to these shocks.



NB. The boxes corresponding to the two last rows of the graph respectively refer to exposure components (in brown) and to size of the shocks components.

The risks *related to progressive shocks* (or continuous hazard) refer to possible persistent geophysicalconsequences of climate change at the country level. The two main kinds of such risks, as identified in the literature, are a rise of sea level, possibly leading to flood, and an increase of aridity, possibly leading to desertification. The vulnerability of a country to the sea level rise is evidenced by the risk of this country to be flooded. Its assessment involves making a distinction between the likely size of this shock (rise of the sea level) and the exposure to this shock (altitude). The indicator of the risk of increasing aridity and desertification relies on the same distinction between the exposure to shocks and the size of shocks. The exposure can here be proxied by the actual share of dry lands in the country (or the actual average level of rainfall in the country). The higher the share of dry lands (or the lower the rainfall level), the higher is the risk to be affected. As for the size of the shocks, it has appeared relevant to retain the trend in the annual average temperature in each country (over the last decades). A complementary proxy of this shock measurement can also be found in a decreasing trend of the average rainfall level.

The *risks of recurrent shocks* generated by climate change occur through more frequent or more acute natural shocks on rainfall and temperature (such as droughts, typhoons, floods,…). The vulnerability to rainfall and temperature shocks has again two main components, corresponding to the previous distinction between exposure and shocks. The exposure component is related to the size and frequency of the shocks during past years (or the past rainfall and temperature instabilities). The shock component, here capturing a risk of shocks an *increase of the size of the recurrent shocks as a result of climate change*, and is more forward-looking; it is reflected by the trend in the frequency and size of the past trends (or the trends in rainfall and temperature instabilities), supposing that these trends are determined by climate change and are likely to go on in the future. These two components are measured by the same way for rainfall and temperature.

Each of the eight components is normalized following the min-max method. As for averaging, equal weights are given to the two main categories of shocks (half and half), then to the four main components and finally to the eight sub-components. The usual practice is to calculate an arithmetic average. However, any of the main components may be of crucial importance for a country, more or less independently from the level of the other components. It is then relevant to use an averaging method reflecting this limited substitutability between components, by either a quadratic average of the components or by a reversed geometric average (as discussed in Guillaumont, 2009a and 2009b). The companion database gives the measure of each component and sub-component, allowing one to use its own averaging method or to use them separately.

Data are obtained from the works of Dasgupta and al. (2009) for the calculation of exposure to rise of sea level. Rainfall and temperature data come from Global Air Temperature and Precipitation: Gridded Monthly and Annual Time Series (Version 2.01, Cort J. Willmott and Kenji Matsuura, University of Delaware). Data of the exposure of dry lands come from the World Resources Institute (1999) and the United Nations Environment Program/Global Resource Information Database (UNEP/GRID 1991).

The PVCCI has been calculated on the basis of data covering the last 60 years (since 1950) for 146 developing countries and territories. Provisional results evidence a high heterogeneity among countries in the level of physical vulnerability to climate change, even within a same regional area. Country grouping results are presented in the Table below, showing the high physical vulnerability to climate change of the LDCs, already found to have a high economic vulnerability, as evidenced by EVI.

Table: SCCVI, by group of countries (arithmetic average, quadraticaverage, geometric modified mean of the components).

Group of countries	number of countries	PCCVI arithmetic mean			PCCVI quadratic mean			PCCVI geometric modified mean		
		Mean	*Median*	*Standard Deviation*	*Mean*	*Median*	*Standard Deviation*	*Mean*	*Median*	*Standard Deviation*
All Developing countries (DCs)	116	36,43	35,89	6,77	42,25	41,64	7,63	41,22	38,89	12,24
Least Developed Countries (LDCs)	46	38,28	38,38	8,04	44,68	44,21	8,35	45,11	42,53	16,56
All Developing countries non LDCs	72	35,48	34,77	6,30	40,91	39,24	7,30	39,41	38,04	10,29
Low and Lower Middle Income countries	84	37,64	37,21	7,13	43,72	43,63	7,75	43,48	41,58	14,51
Low and LMI countries non LDCs	39	36,66	36,72	5,92	42,35	41,90	6,92	41,24	38,54	11,43
Small Islands Developing States (SIDS)	29	38	34,60	9,42	42	37,49	10,07	46	36,10	22,82
SIDS non LDCs	18	35,98	34,29	7,51	39,11	36,83	7,54	39,61	35,36	15,59
SIDS-LDCs	11	40,19	38,67	11,85	46,61	45,32	12,20	55,25	43,50	29,63
Landlocked Developing Countries (LLDCs)	27	37,14	36,87	6,24	44,51	45,75	7,33	42,45	43,72	8,51
LLDCs non LDCs	11	39,43	40,09	4,96	47,30	48,45	6,08	45,88	45,98	7,40
LLDCs-LDCs	16	35,56	33,52	6,67	42,59	40,31	7,67	40,10	37,22	8,63

The method and results have been presented in details in:

- **Guillaumont P.** and **Simonet C.** (2011), "Designing an index of physical vulnerability to climate change", *Ferdi Working Paper N°I 09*

Other references

- Committee for Development Policy and Department of Social and Economic Affairs (2008), *Handbook on the Least developed Country Category: Inclusion, Graduation, and Special Measures*, United Nations.
- **Guillaumont P.** (2008), Adapting Aid Allocation Criteria to Development Goals, An Essay for the UN Development Cooperation Forum, *Ferdi Working Paper, P 1*, May.
- **Guillaumont P.** (2009a), *Caught in the Trap: Identifying the Least Developed Countries*, Paris: Economica.
- **Guillaumont P.** (2009b), An Economic Vulnerability Index: Its Design and Use for International Development Policy, *Oxford Development Studies*, 37:3, pp. 193-228.
- **Guillaumont P.**, **S. Guillaumont Jeanneney** and **L. Wagner** (2010), How to take into account vulnerability in aid allocation criteria and lack of human capital as well; improving the performance based allocation, *Ferdi Working Paper P 13*, October.

→ In the case you use the data from the companion database: please quote the reference paper and "*Data available on the FERDI website:* www.ferdi.fr"

Contact cat.simonet@gmail.com
or michael.goujon@u-clermont1.fr

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Contact
www.ferdi.fr
contact@ferdi.fr
+33 (0)4 73 17 75 30

policy brief
18
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