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Designing an index of structural vulnerability to climate change

by
Patrick Guillaumont and Catherine Simonet

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Patrick GUILLAUMONT[1] and Catherine SIMONET.[2]

Abstract

This paper proposes an indicator of structural vulnerability to climate change at the country level, likely to be considered as a relevant criterion in the allocation of resources for adaptation between countries. The design of this indicator draws both on the environmental literature and on the United Nations' attempt to measure structural economic vulnerability, through the Economic Vulnerability Index (EVI) for the identification of the Least Developed Countries (LDCs). As an environmental index, the index here proposed relies on components reflecting physical consequences of climate change that can directly affect population welfare and activity, rather than economic consequences. As an index built to be used as an allocation criterion for adaptation resources, this index of vulnerability to climate change refers only to the vulnerability that does not depend on the present will of the country; the "structural vulnerability", distinguished from resilience, usually integrated in vulnerability assessments, but largely depending on policies. The defined index relies on few 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 components are respectively related to the risks of recurrent shocks and the risks of permanent shocks due to climate change, and they refer either to the likely size of the shocks or to the country exposure to these shocks. Provisional results evidence a high heterogeneity among countries in the level of structural vulnerability to climate change, even within a same regional area.

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[1] Email : p.guillaumont@ferdi.fr
Adress : Ferdi, 65 boulevard, F. Mitterrand 63000 Clermont-Ferrand, FRANCE

[2] Email : cat.simonet@gmail.com
Adress : Cerdi, CNRS-Université d'Auvergne, 63 boulevard, F. Mitterrand, 63000 Clermont-Ferrand, FRANCE

Introduction

The recognition of climate change as a dominant issue for world economy and policy, has led to a search of resources for financing mitigation and adaptation. Raising the funds may meet similar problems for mitigation and adaptation, but their allocation should be ruled by different criteria. The creation of the Adaptation Fund by the Parties to the Kyoto Protocol of the UN Framework Convention on Climate Change illustrates the awareness of the international community to mobilize human and monetary resources in order to deal with adaptation problems and the specificity of the adaptation issues. Adaptation is defined by the Intergovernmental Panel on Climate Change (IPCC) in their 4th Assessment report as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007). To meet the adaptation aim, the resources should be allocated according to criteria reflecting the countries' needs of adaptation, as well as their capacity to effectively use the resources to this aim. In that perspective, the country specific vulnerability to climate change could be considered as one of the most relevant criteria for the allocation of the resources between developing countries. An appropriate indicator of vulnerability to climate change available for all the countries concerned is then required for this purpose. In the same way, it has been proposed to consider the economic vulnerability to exogenous shocks as one of the allocation criteria of development assistance, an issue still highly debated (see below).

In 1994, the Barbados Conference on the Sustainable Development of Small Island Developing States asked for "the development of vulnerability indices and other indicators that reflect the status of small island developing countries and integrate ecological fragility and economic vulnerability" (United Nations 1994). While an Economic Vulnerability Index (EVI) has been designed to measure the economic vulnerability of these countries in view of the identification of the Least Developed Countries, there is not yet a consensus on the assessment of environmental fragility, even though it seems to be used for the allocation of adaptation funds. Actually the notion of ecological fragility, sometimes named environmental vulnerability, is referring to many issues. It has indeed been recognised that economic vulnerability and environmental vulnerability are two different concepts, although they partly overlap (Guillaumont 2009a). As noted by the Adaptation Fund website, resources for these two needs cannot be the same: "Helping the most vulnerable countries and elements of societies is thus an increasing challenge and duty for the international community, especially because adaptation to climate change requires significant resources *in addition* to what is already needed to achieve internationally agreed-on development objectives such as the Millennium Development Goals." (Adaptation Fund website)

The aim of this paper is to present an analysis on the vulnerability to climate change likely to lead to a quantitative assessment. As it has been done for the Economic Vulnerability Index (from the development research) this work proposes an original assessment of the vulnerability to climate change focusing on the vulnerability depending only on structural factors. Thus the paper defines a "Structural Vulnerability to

Climate Change Index", relying only on structural factors or factors independent of the present will of the countries.

There is indeed a large amount of literature related to vulnerability to climate change (see for instances, among recent official documents, the *Global Monitoring Report,* World Bank, 2008, chapter 6 and 7, the *World Development Report,* World Bank, 2010, the *Fourth Assessment Report of IPCC*, 2007, the *Climate Action* of UNEP, 2010 the *Report* of the Committee for Development Policy, 2009. However, these works are more focused on various particular aspects of the vulnerability to climate change than on the research for a synthetic index. And when a synthetic assessment is proposed, it considers vulnerability in all its components, including the resilience, i.e. the country's capacity to cope with the shocks resulting from climate change (Brooks et al. 2005 or the Economic Vulnerability Index to Climate Change by Kaly et al. 2004). If resources for adaptation have to be allocated as a function of the vulnerability to climate change, the vulnerability to be considered is the vulnerability that does not depend on the present will of the country, in other words the exogenous or structural vulnerability. A high resilience, as far as its impact on present (and future) policy cannot be a factor of a lower allocation. It is rather a factor of higher effectiveness and could then be a reason for allocating more resources to these more resilient countries, in any case not less, while, as we argue, the more structurally vulnerable countries should receive more resources, *ceteris paribus*. Thus the distinction between structural vulnerability to climate change and resilience to climate change is necessary both for logical and operational reasons.

In the recent political debate about the implications of climate change, the need of an index of vulnerability to climate change has been recognized, noticeably in the United Nations circles and at the Adaptation Fund (UNFCC, 2008a, 2008b, 2008c). However, no recommendation has made clear what kind of index is required. Tentative indices have been proposed by a large number of international or research institutions, for instance by the World Bank in *World Development Report* (2010, p.278), by Adger et al. (2004) and by the International Development Association (IDA, ….) but they all raise problems of definition, databases and uses.

Recognising that an index of structural vulnerability to climate change is needed for the allocation of adaptation resources does not mean that this allocation should not result from a political choice. How such an index is used for allocation, how their various components are weighted and average and what should be the possible other allocation criteria are choices involving a political assessment[3].

As noted above, the index needed should only reflect the structural factors of vulnerability to climate change. Moreover, the index should rely on a few components relevant, reliable, available for the whole set of developing countries and easily understandable, so that the index can be used in a transparent manner. In

[3] The political dimension of the use of vulnerability index has been underlined by Klein (2009) and Hinkel (2011)

the search for such an indicator, it seems useful to refer to two streams of literature. First, the environmental literature offers various definitions and concepts of vulnerability, on which we draw, as far as needed, although we do not include the adaptive capacity and resilience/mitigation in vulnerability, as done in this stream of research. Second, the endeavour to measure a structural economic vulnerability to external and natural shocks as led to building a related indicator, named Economic Vulnerability Index, (EVI) used in particular at the United Nations for the identification of the Least Developed Countries (LDCs) (United Nations CDP 2008, Guillaumont 2009a and Guillaumont 2009b). This index, which refers to the structural vulnerability, indeed includes components related to natural shocks (through “average of homeless due to natural disaster index” and “instability of agricultural production index”). But it is not focused on the long term vulnerability to climate change, and it only captures the likelihood that they re-occur in a near future through the pas recurrent shocks.

The first part of the paper presents the various concepts of vulnerability. It proposes to connect development economics and environmental research, with the aim to build a structural vulnerability to climate change concept and index. The second part discusses the composition of the index and its calculation.

1. What is vulnerability about?

Starting from the main definitions of vulnerability to climate change, this section tries to design the structural vulnerability to climate change. The "vulnerability of systems to climate change" is examined in a fast expanding literature, relying on the various fields of research such as climate science, disaster management and development economics. As recommended by Wam (2009), this part is also a first step towards a "necessary greater synergy between ecologists and economics".

1.1. Overall economic vulnerability versus structural economic vulnerability.

The word 'vulnerability' has been used, with various meanings and by diverse researchers in food security, natural hazards, disaster risk, public health, global environment or climate change (see as a sample of the application of the concept of vulnerability in these various fields: Timmerman 1981; Cutter 1996; UNEP 2002; Turner et al. 2003; Prowse 2003; Blaikie 1994; McCarthy 2001; Guillaumont and Chauvet 2001).In development economics, the notion of vulnerability has been used mainly at the micro level, see for instance Yamano et al. (2005), Dercon et al. (2005). It has also been used at macro level, with the search for measurable and comparable indices (this literature is reviewed in Guillaumont, 2009a and 2009b).

In this macroeconomic context, the vulnerability of a country is taken as "the risk of being harmed by exogenous, generally unforeseen events or shocks" (Guillaumont, 2009a). Relying on a several decades of literature (in particular on export instability), this macro vulnerability is considered as an impediment to growth. The economic vulnerability can be seen as formed by three main components: *shock, exposure and resilience*. Shocks are exogenous and generally unforeseen events (external, such as instability of exports or as natural disasters, such as typhoon, hurricane …). The exposure corresponds to factors upon which the direct impact of shocks depends. The resilience is the capacity to react to shocks. Here, the resilience is considered as a part of the vulnerability (Miller et al. 2010)

Assessments of vulnerability retain all these three components or only one or only two of them. When the three elements are considered, a general or overall vulnerability is assessed. When the size of the exogenous shocks and the extent of exposure to these shocks are the only components considered, the vulnerability considered is essentially a "structural" vulnerability. Indeed resilience, even if it may include some structural elements is mainly related to policy factors. This is the kind of economic vulnerability captured in the economic vulnerability index (EVI) used at the United Nations to identify the Least Developing Countries (LDCs); this index is intended to reflect the potential economic impact of recurrent external and natural shocks and takes into account the main structural factors of the exposure to these shocks in a rather parsimonious and transparent manner (seven indicators) and mainly refers to the components of vulnerability in the low-income countries (see UN CDP web site and Guillaumont 2009a, 2009b). In the same way, this paper tries to design an index of structural vulnerability to climate change, retaining only a small number of indicators related to the size of the climate shocks and to the exposure to these shocks.

1.2. Vulnerability to climate change: can structural vulnerability be identified?

The vulnerability to climate change is designed here as a vulnerability to environmental shocks resulting from climate change. These shocks are physical consequences of climate change. They appear through more droughts, floods, storms as well as the rise of sea level and they are reflected by the change in the mean values of climatic variables (as temperature or rainfall), and related changes in the instability of these variables.

Climate change and vulnerability were always associated.Timmerman (1981) considers the thinking on the vulnerability concept in the heart of the climate change research. He defines vulnerability as "the degree to which a system a system may react adversely to the occurrence of a hazardous event". During this period, the World Meteorological Organization's Climate Program announced the objective: "determining the characteristics of human societies at different levels of development which make them either especially vulnerable or especially resilient to climatic variability or change (p.3)". Liverman in 1990 notes that the concept of vulnerability "has been related or equated to concepts such as resilience, marginality, susceptibility, adaptability, fragility and risk" and proposes a distinction between vulnerability as biophysical condition, and between vulnerability and political economy.

There has been profuse although recent literature on vulnerability to environmental change and more specifically to climate change, and on vulnerability to natural hazards as well, which partly overlaps with the former ones. Not surprisingly, there is no universally accepted definition of vulnerability to climate change (and even a different definition for each IPCC report, as noted by Downing and Patwardhan 2005). A definition of the vulnerability is obviously needed, not only for semantic reasons, but even more to make explicit the theoretical concept. The choice of the definition influences the orientation of the vulnerability analysis (O'Brien et al. 2007). Main references to this environmental vulnerability include Adger (1999), Downing and Patwardhan (2005), H. M Füssel (2007), P. M. Kelly and Adger (2000), O'Brien et al. (2004), Olmos (2001), Ionescu et al. (2009) and, as for the vulnerability to natural hazards, Birkmann (2006a and 2006b), Cardona et al. (2003) or Thywissen (2006). Actually, the definition and then the assessment of vulnerability have met two impediments. Not only the notions have been used with different meanings according the scientific area (Hinkel 2008, Bruckner 2010), but also within each area various conceptual frameworks have been designed, so that, this literature has been qualified as a "Tower of Babel" (Janssen and Ostrom 2006). Facing this "tower" it has been suggested to build a formalized common framework (Ionescu et al. 2009, Hinkel 2008). All these authors agree that the multiplication of frameworks and definitions leads to blur the message drawn from the analyses.

To identify the structural vulnerability to climate change, it useful to refer to the three components of the economic vulnerability (size of the shocks, exposure to the shocks, resilience), considering that structural vulnerability is mainly captured through the shock and exposure components, while resilience is more related to policy. We briefly review the literature on vulnerability to climate change in the aim to analyze if it allows us to isolate these structural components of vulnerability to climate change. For the sake of this review, we identify three main approaches in the literature on the vulnerability.

Let us call *chronological approach (ex post/ex ante analysis)* the sequential analysis of the shock comparing the situation before and after the shocks. Elements defining the environment before the shock occurs constitute the context. The consequences and impacts of the shocks are defined and assessed after the shocks occur. Kelly and Adger (2000) adopt this approach by defining the outcomes' end point vulnerability and starting point vulnerability. They define the starting point vulnerability as the body of elements in the environment that makes (ex-ante) the consequences of shocks worse (by a rise in the sensitivity of the environment for instance). This vulnerability is affected by social and economic dynamics, and by political and institutional characteristics. This is the vulnerability related to the context. The end point vulnerability results from the consequences of climate change. It consists of an assessment of the losses of the shocks related to its characteristics and size. The end point vulnerability is a vulnerability associated to scientific studies. The starting point vulnerability is linked to human security framework. O'Brien et al. (2007) uses the similar distinction. The authors deal with an outcome vulnerability and contextual vulnerability whose definitions are closed to the end point and starting point vulnerability of Kelly and Adger (2000).

A matriochkas approach consists of elaborating on an encompassing concept of vulnerability. This approach refers often to different geographic scales (analysis). The aim of this framework is to make the definition of vulnerability gradually more complex following different scales (often geographic). This type of analysis is proposed by Birkmann (2007). The author considers the core of the vulnerability definition as intrinsic vulnerability (vulnerability defined as an internal risk factor). Then he introduces a continuum of definitions of vulnerability from this closest definition to the largest definition: "multi dimensional vulnerability encompassing physical, social, economic, environmental and institutional features" (Birkmann 2006a). A similar analysis lays in the "onion framework" proposed Bogardi and Birkmann (2004).

The social and ecological dichotomy approaches, is a type of framework which finds its roots in the ecological literature. Adger et al. (2004) distinguish a biophysical vulnerability and a social vulnerability. This separation is closed to Brooks (2003) who identifies two kinds of vulnerability to climate change in the literature. The biophysical vulnerability defined by the environmental scientists, in terms of physical (potential) damage caused to a system by a particular climate-related event or hazard (Jones and Boer, 2005; Nicholls et al., 1999). This field of research is based on natural hazard analysis and focuses on the concept of risk. In this context, vulnerability is analyzed in terms of the likelihood of occurrence and impact of weather and climate related events (Nicholls et al., 1999). The second type of vulnerability is defined as the "state that exists within a system before it encounters a hazard event" (Allen, 2003). This is, according to Brooks, the definition of social vulnerability. Social vulnerability of course depends on the biophysical but also includes the set of socio-economic factors that determine people's ability to cope with stress or change (Allen, 2003). Finally, the distinction made by Brooks (2003) led him to aggregate in a unique system the social and biophysical vulnerability (see also Füssel and Klein 2006). This concept must be distinguished from climate hazards assessments. Moreover, in the conceptual framework of "eco-sociological system, the distinction between social and biophysical vulnerability could be discussed (see part 1). Adger (2006) proceeds in the same way: after distinguish two historical mainstreams, entitlements and natural hazards he unites this two streams in a global framework named: "socioecological system".

The IPCC's approach consists of a precise analysis of the IPPC definition of Vulnerability to climate change often used in the vulnerability to climate change analysis. The IPCC's definition is (IPCC 2007b) "*Vulnerability is the degree, to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity".* This definition is closed to the definition presented in first section.[4] The schematic interpretation by Füssel (2010) helps to better understand, what in this definition is about structural vulnerability and what is not. In the figure 1, the sign (+/-) next to factor indicates the direction of influences of this factor on the compound factor below. Here, "social impacts" must be understood as "vulnerability to climate change". This framework is also recognized by the Committee for Development Policy (CDP) of the United Nations (Bruckner 2010).

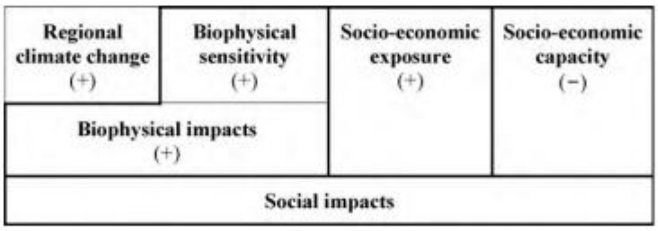

Figure 1: Vulnerability to climate change framework, the reading of IPPC definition by Füssel (2010)

4 The economic analysis (inter-countries studies) exploits all the three dimensions of vulnerability, as the IPCC's vulnerability definition. This example strengthens the fact that economic experiences must be a support to assess vulnerability to climate change.

	Chronological analyses		***"Onion"** or **"Matriochkas"** analysis*	*Dichotomic analyses*				***The 'IPCC' analysis***		
	Kelly and Adger (2000)	*O'Brien et al. (2007)*	*Birkmann (2007)*	*Brooks (2003)*		*Adger (2006)*		*Füssel (2010)*		
SHOCKS	end point vulnerability	outcomes vulnerability	Intrinsic vulnerability	Biophysical Vulnerability	social and biophysical vulnerability	natural disasters	socioecological vulnerability	Regional climate change	Biophysical Impacts	Social Impacts (vulnerability to CC)
EXPOSURE/ SENSITIVITY			Human centred vulnerability					Biophysical sensitivity Socio-economic exposure		
RESILIENCE	starting point vulnerability	contextual vulnerability	Multidimensional vulnerability	Social Vulnerability		Entitlements		Socio economic capacity		

–·– : Continuum of vulnerability concepts

········ : Approximate delimitation

In grey the structural components of vulnerability

Figure 2: Vulnerability frameworks in the light of the Shock, exposure and resilience definition

In any case, referring to the environmental vulnerability to climate change, it shall keep in mind the distinction established about macroeconomic vulnerability among shock, exposure and resilience. This will help us to put aside those components of vulnerability to climate change that are not structural, in other words that depends on, to a large extent, the present policy of countries and makes them more or less resilient to shocks. The frameworks of vulnerability to climate change are plentiful. The will to sum up all the vulnerability dimensions in the framework are laudable. However, the building to a useful indicator forces us to put aside the resilience notions. Indeed this choice is necessary to produce a Simple, Measurable, Accurate, Reliable, and Timely (SMART) indicator.

1.3. Aim of the indicator and preliminary comments.

Existing Indices

The authors of these existing indices point out constantly the growing need of such index (expressed by international community) but also the confusion of frameworks in this recent and boiling area of study. The climate change phenomenon is an object of index as the Climate Change Index of Baettig et al. (2007) or the National Climate Change Index of Diffenbaugh (2007) and Giorgi (2006). The future impact and responsibility to the phenomenon is widely studied (Srinivasan 2010). These indices and studies report the evolution of climate change but don't agree on the areas where the phenomenon is the most severe. More precisely the amount of vulnerability to climate change index exploded in the last years. The aim of the authors is to approach a measure of vulnerability to climate change and to highlight the differential impact of climate change between socio-economic units (state, collectivity). Among these indices we note for instance: the Environmental Sustainable Index (Esty et al. 2005), the Vulnerability-Resilience Indicators (Moss et al. 2001), the Index of Human Insecurity (Lonergan et al. 1999), the Predictive Indicators of Vulnerability (first calculation in Brooks et al. 2005), the Environmental Vulnerability Index to Climate

Change (EVI-CC Kaly 2004) , the IVCC (Barr et al. 2010), The Global Distribution of Vulnerability (Yohe et al. 2006a and 2006b), Social Vulnerability Index (SoVI Cutter et al. 1996), works of Downing et al. (1995) and Buys et al. (2007). However these indices present often the same advantages and weakness than the theoretical frameworks they refer and previously presented. Thus, they capture a global (or "generic", Füssel 2010) vulnerability to climate change and not only a structural vulnerability as we propose. The "generic" vulnerability to climate change indices are subject to a wide literature about their method of calculation and rank. For instance, Füssel (2009) compares works of Yohe (2006), Kaly (2004) and Diffenbaugh (2007). In these papers, after analyzing the existing vulnerability to climate change indices, we note most of the indices are unstable and very sensitive to their proxy, to the aggregation method (Gall 2007, Füssel 2009). Also, the indexes are not comparable even though they refer to the same framework, as noted by Moss et al. 2001, Gall 2007, Füssel 2009, Eriksen and Kelly 2007. Authors also criticize the choice of the geographic scale because national indices are considered not relevant to assess effects of a phenomenon which don't follow borders (Eakin and Luers 2006) or the role of substitutability in the different components in the built of index (Tol and Yohe 2007). The generic indices of vulnerability to climate change are criticized greatly because they present "methodological flaws or severe doubts regarding their validity" (Füssel 2010 for a good review of major lacks of these indices).

The choice of country level

The aim of the index is to help the aid allocation between countries, regarding vulnerability to climate change. Obviously it doesn't analyze the condition of the aid allocation (which must also take into account the population size and poverty level). In order to obtain a better policy use, the choice of scale analysis is the country. The impact of climate change doesn't follow the border. Some effects will affect only a zone in a country, some others will be the same for many countries in a particular region. Although the choice of this scale doesn't embrace the climate change characteristics, it corresponds to feasibility constrains extremely important for using this index. The choice of national scale is mainly confirmed by the aim followed by the index. The index must guide the aid allocation. Thus, even if some authors express the limit of such a type of scale analysis (Eakin and Luers 2006), the choice of the scale is the national level for the same reasons developed by Barr et al. (2010) or Brooks et al. (2005).

Time scale analysis

More than the geographic scale, the time scale is the real question of our indicator. Does it rely on past events or on projection of the future shocks? This question refers to the calculation of an ex-ante or ex-post estimators. It seems possible to rely on scientific forecasting when it is available (as likelihood of sea level rises). The other index can be calculated ex post from the trend calculation of x past years.

The demand for an index of vulnerability to climate change is more important every day. This growing demand leads international institutions and researchers to provide framework and index on the subject. Thus, there is a wide variety of literature on vulnerability to climate change but no common frameworks and definitions. With a precise aim- to guide the allocation of the Adaptation Fund, we propose a framework derived from the development economics science, which allows us to put together all existing frameworks on vulnerability to climate change. This framework provides a new comprehension of the existing frameworks, especially the conception of vulnerability as a global, overall or "generic" (Füssel 2010) element. Based on the split of vulnerability of climate change in three elements: shocks, exposure and resilience, we propose to assess one part of the vulnerability to climate change with an index: the structural vulnerability. This simple index could be a help to guide the allocation funds for adaptation to climate change. The focus on structural vulnerability permits more precision on what is really assessed[5].

2. Possible Components of an Index of Structural Vulnerability to Climate Change.

An examination of the expanding literature on the economic consequences of the climate change leads to make a distinction between two kinds of consequences and related risks: risks of permanent shocks and risks of recurrent shocks. These two categories roughly correspond to the second and the first of the three broad categories of hazard identified by Adger et al. (2004), namely

"Category 1: Discrete recurrent hazards, as transient phenomena such as storms, droughts and extreme rainfall events.

Category 2:Continuous hazards, for example increases in mean temperatures or decreases in mean rainfall occurring over many years or decades desiccation such as that experienced in the Sahel over the final decades of the 20th century (Hulme 1996; Adger and Brooks 2003)."

Although the third category identified by the author is maybe of high importance, its assessment faces too high obstacles so that we are obliged to keep it aside. This Category 3, to quote it is "Discrete singular hazards, for example shifts in climatic regimes associated with changes in ocean circulation; the paleoclimatic record provides many examples of abrupt climate change events associated with the onset of

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[5] These elements are often linked to the notions of vulnerability in the literature but they are very difficult to quantify. They partly overlap the notions of resilience and their role to guide the aid allocation is controversial. The analysis of vulnerability to climate change undoubtedly meets the usual distinction between adaptation to and mitigation of climate change. Adaptation primarily seeks to moderate the adverse effects of climate change through actions targeted on the vulnerable system by reducing system sensitivity or by reducing the consequent level of damage. The mitigation consists in limiting the number and the magnitude of potential climate hazards due to climate change through reducing the emissions of greenhouse gases, for instance. Both are likely to lower the vulnerability to climate change, but not in the same way. The mitigation has a direct effect on the size of climatic shocks while adaptation may either consist in lowering the exposure to shocks or in enhancing the resilience. Looking for an index to be used for the allocation of resources devoted to adaptation, it seems useful to focus on the structural need for adaptation, namely the structural components of the exposure to climatic shocks. For more information on the relation between mitigation and adaptation see Smit and Wandel (2006), Jones et al. (2007) or Buob and Stephan (2010).

new climatic conditions that prevailed for centuries or millennia (Cullen et al. 2000; Adger and Brooks 2003)."

Actually our aim is, starting from the distinction between the risk of permanent shocks and the risk of recurrent shocks, to identify some reliable indicators that can be used as relevant components of an index of structural vulnerability to climate change. As far is very difficult to assess the final impact of climate change, indicators should rely on intermediary and measurable consequences, estimated either directly or by the means of proxies. Differing from other attempts to assess the vulnerability to climate change, the anticipated consequences of climate change on physical variables are the only elements considered, likely to have an impact on socio-economic variables, but not socio-economic variables. Relying on these physical indicators (see level, rainfall, temperature…) allows one to use objective or neutral data. It avoids reference to indicators partly influenced by policy or resilience factors. Finally, it is no more dependent on the expected impact of climate change on socio-economic variables such as health, agriculture…Consequently; it can be used to assess the link between climate change and these economic variables.

At any rate, the set of the indicators presented below should be considered more illustrative than as an exhaustive set of components. They try to capture the main channel through which climate change is a factor of vulnerability. To be recorded, a good index should be parsimonious, transparent, and focused on the most relevant issues.

2.1. Risks of permanent shocks

The risks of permanent shocks (or continuous hazard) refer to possible persistent consequences of climate change at the country level. The two main kinds of such risks, as identified in the literature, are the rise of sea level and the increasing aridity, possibly leading to desertification.

2.1.1. Rise of sea level: risk and exposure

The vulnerability of a country to the sea level rise corresponds to the risk of this country to be flooded. Its assessment involves making a distinction between the size this shocks (rise of the sea level) and the exposure to this shock (altitude). An assessment of the vulnerability of zones likely to be flooded then depends on the two following components:

- the exposure to sea-level rise depends on the relief, since it influences the liability to flooding, so that the indicator should take into account the distribution of the heights of arable lands or of the population occupied lands;
- the shock could be estimated by the distribution of the likelihood of sea-level rise in t future years.

The combination of the exposure and potential shocks allows one to assess the liability to flooding resulting from the sea level rise.

The measurement of the exposure component does not raise the higher difficulty. Its assessment depends on a good knowledge of the geographical configuration of the country. Indeed a discussion could be opened on the type of area the height of which is considered: should we consider all areas of the country, areas with a minimum population density or arable areas? A more difficult issue arises for the assessment of the risk of sea level, for two reasons: the first one is that there is some degree of uncertainty about the rise of the sea level at a given time horizon, the probability distribution being debated among climate specialists; the second reason is that this probability distribution is changing over time with a rising average level and an increasing dispersion. Let us suppose that we know the probability distribution of the sea level rise for each of the next *x* years, the impact on the percentage of flooded areas should normally be expressed in a present value, using a discount rate. So, a logical indicator would be the present value of the likelihood share of flooded areas over the next *t* years.

$$SLR_i = \int^{t}\int^{j} \frac{h_{ijt}}{(1+r)^t} \times s_{ij}$$

With:

SLR: sea level rise indicator
i, country indicator and *j*, the meters of sea level rise;
h_{ij}, probability that the sea level rises by *j* meters for the *i* country;
and s_{ij}, the part of arable lands below *j* meters in country *i*.
t: number of years from now
r: discount rate

To avoid the use of an arbitrary discount rate, a simplified indicator could be the likelihood of the share of flooded areas in *x* years.

$$SLR_{ix} = \int^{j} h_{ijx} \times s_{ij}$$

2.1.2. Increasing aridity assessed from initial conditions and past trend in temperature and rainfall

The literature on the consequences of climate change underlines the risk of some arid countries (in particular Sahelan countries) to be affected by the rise of temperatures and therefore to be threatened by over-aridity, see for instance (IPCC 2007a). To set up a proxy indicator of this risk we rely on the distinction previously done between the exposure to shocks and the size of shocks.

Proxies of the exposure to the risk of an increasing aridity can be either the actual average level of rainfall in the country or preferably the actual share of dry lands in the country which better fit the risk of desertification. The lower the rainfall level or the higher the dry lands share in a country, the more exposed it is to a long term decrease of rainfall or increase of temperature. As for the size of the (future) shocks, it seems relevant to retain the past trend in the annual average temperature in each country over two or three decades. The hypothesis is that the rise of the average world temperatures will be distributed over countries in the same way it has been so during the last decades. The information on this future distribution thus made available; could be used to assess the risk at the country level. A complementary proxy of this shock measurement can also be found in a decreasing trend of the average rainfall level. It supposes that the past trend in average rainfall is determined by climate change and will go on in each country proportionally to the past trend. At the country level, the permanent shocks resulting from climate change and channelled by a rising trend in temperature or a decreasing trend in rainfall is thus assessed by an extrapolation of recent past trend. As far as more relevant and reliable projections of the temperature and rainfall will become available at this country level it would be possible to use them instead of the linear extrapolation here retained (see for instance the Climate Research Unit data base).

2.2. Risks of recurrent shocks

Climate change can also generate more frequent or more acute natural shocks, such as droughts, typhoons, floods,…(World Bank, 2008) Here again the only considered variables are unambiguously linked to climate: rainfall and temperature. The vulnerability to rainfall and temperature shocks has two main components, corresponding to the previous distinction between exposure and shocks. The first component is related to the frequency of past shocks (that may be link to climate but not to climate change): this frequency during previous years can be taken as a proxy to the exposure. The second main component, more forward-looking, is reflected by the trend in this frequency, supposing that it is determined by climate change and likely to go on in the future. These two components will be considered in the same way for rainfall and temperature.

2.2.1. Average frequency as an indicator of exposure

Because of the heterogeneity of natural shocks (flood, typhoons, droughts, hurricanes, earthquakes…) and their highly unequal intensity and consequences, the Economic Vulnerability Index (EVI) has been built at the United Nations by the Committee for Development policy (CDP), uses indirect and synthetic indicators likely to reflect these heterogeneous and variable shocks. Among the components of the UN Economic Vulnerability Index (EVI) the risks of shocks are assessed “ex-post” by a measure of shock incidence over years. The two related indicators of the EVI are an index measure of the instability of agricultural production (IA) and an index of the percentage of homeless population due to natural disasters[6] (HL). The instability of agriculture production is a square deviation of the agricultural production with regard to its trend. These two indicators are averaged in natural shocks index: NSI= (IA+HL)/2.

Within the EVI this natural shock index, although calculated ex post, is considered as a factor of risk for the future, due to the recurrent nature of the related shocks. The average past level is a proxy for the risk of future shocks, an index of course likely to change over time. It is also considered as capturing handicap to future economic growth.

As for the vulnerability to climate change, the present approach is different. First, the average level of past shocks considered is related to rainfall and temperature, these two variables being clearly linked to climate, while the instability of agriculture production or homelessness can also depends on natural shocks other than climate change. Thus, for this index of exposure to climate change it is possible to have an index which is unambiguously structural, and by no way influenced by policy or resilience factors. It could be the year to year instability of rainfall or temperature, for instance calling R_t the index of rainfall in year t,

$$IR = \sum \frac{\mathrm{R_t} - \widehat{\mathrm{R}}_\mathrm{t}}{\widehat{\mathrm{R}}_\mathrm{t}}$$

with $\hat{R}_t$ the trend level of R_t.

Second, the past average level of shocks is considered as an indicator of the exposure to an increase in the frequency and size of these shocks, captured by a specific index of the size of the shocks as exposed below.

2.2.2. Trend frequency as a proxy of the intensity of future shocks

The risk of recurrent shocks is assessed by a forward-looking manner. It is supposed that the more significantly they have increased in the past, the more they are likely to increase in the future. In other words, if the rainfall and temperature shocks have increased due to climate change, they are likely to still increase. The proxies used will then be the trend in the size of instability.

Thus, the proxy for risk of increasing rainfall shocks will be the (increasing) trend in the absolute (or squared) deviation of the yearly average of rainfall from its own trend, calculated as:

$$\frac{|\mathrm{R_t} - \widehat{\mathrm{R}}_\mathrm{t}|}{\widehat{\mathrm{R}}_\mathrm{t}} = \propto . \mathrm{t} + \beta$$

As α is here the trend in the instability rainfall, it will be possible to estimate the trend in instability temperature (α').

[6] The latter index coming from the Center of Research on Epidemiogical Diseases that also produces other indicators, such as the percentage of population affected by natural disaster.

2.3. Aggregating components

The aggregation of the above components, once they have been expressed as indices on a common scale, raises three main issues.

First, the structure of the index can be presented in two ways. The first one illustrated by the graph below, distinguishes permanent and recurrent shocks, which can be considered as resulting of Climate Change. The permanent shocks cover (i) sea level rise and (ii) the trend in average rainfall and temperature. The recurrent shocks cover (iii) rainfall shocks and (iv) temperature shocks. For each of these four main components an exposure index (in italic) and a shock index have been identified. The second way for presenting the structure of the index, still starting from the distinction between permanent and recurrent shocks is to split up the recurrent ones in two mains components: (a) the average level of rainfall and temperature shocks and (b) the trend in their size. This presentation has been used in tables at the end of the paper.

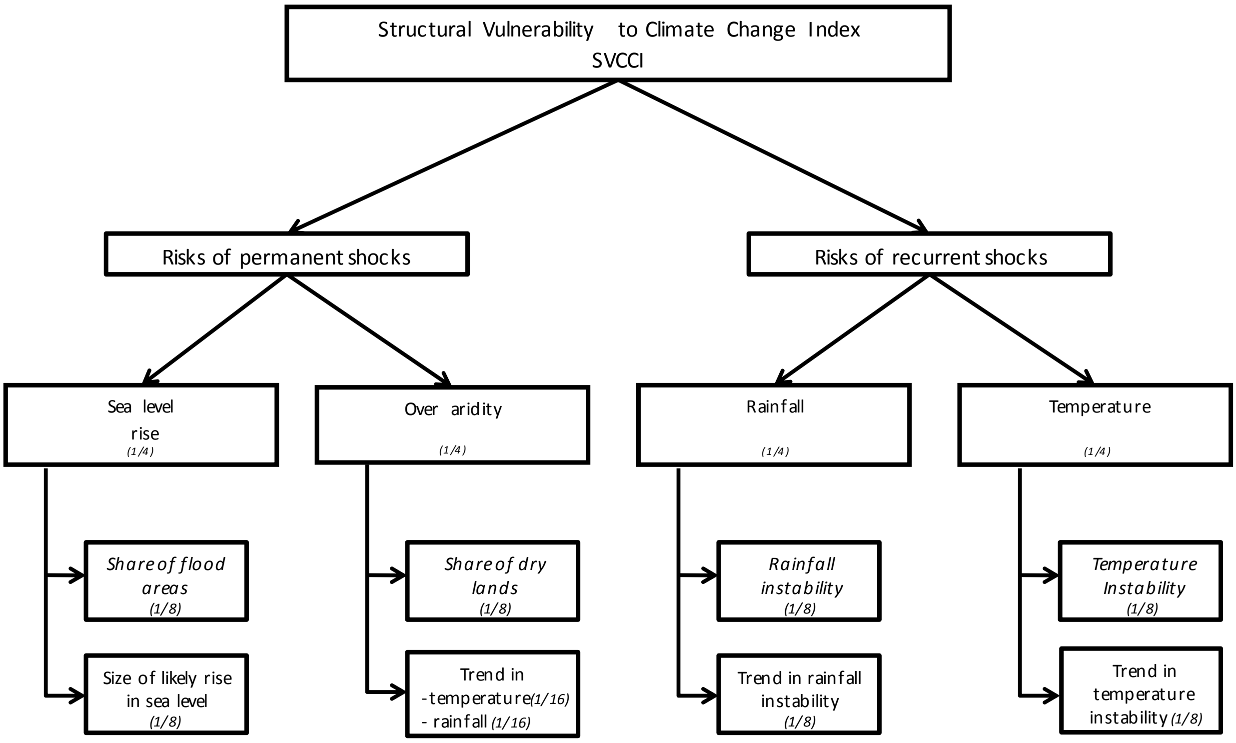
The second issue is related to the weight given to each component. Since we use physical and neutral data, it is not possible to draw weights from estimation of the expected impact on socio-economic variables. Then the simple and usual solution is to give equal weights of the two main categories of shocks (half and half) to the four main components and to the eight sub-components. Giving the measure of each component and sub-component will also allow the researcher to combine the components or to use them separately.

Third, a synthetic index may be needed in particular as we have seen for aid allocation. In that case, the way by which the values' components are averaged is an important issue. The usual practice for averaging such synthetic indices is by arithmetic average (GDI, EVI…). However, one should be aware that any of the main components may be of crucial importance for a country, more or less independently from the level of the other components. In that case it can be relevant to use an averaging method reflecting this limited substitutability between components (as already examined for the EVI in Guillaumont 2009a). It can be obtained by either a quadratic average of the components or by a reversed geometric average (G'), designed in the following way

$$G' = 1 - \sqrt[n]{\prod_{k=1}^{n}(1 - A_k)}$$

For instance, suppose an island with a very large share of area likely to be flooded or an arid country suffering from the most increasing trend the level of temperature. One or the other of these countries is pushed to a higher level of vulnerability by the use of this modified geometric average.

Figure 3: The Structural Vulnerability Index Composition.



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

In the previous presentation, the structural vulnerability index to climate change gathers eight sub-components, according to a unified framework.

3. Calculation of the Index

We calculate the structural vulnerability index since 1950. The index could be actualized and calculated every 5 or 3 years. Here, it is presented by a synthesis for the last 60 years.

3.1 Data bases

The work of Dasgupta and al. (2009) is a reference for the calculation of exposure to rise of sea level. The logical index previously proposed to assess the vulnerability to sea level rise is not currently available. So, we propose an approximation of the index with the index calculated by Dasgupta et al. (2009). We choose the index “part of the population of country affected by a raise of 3 meters of the sea level[7]”.

Rainfall and temperature data come from *Global Air Temperature and Precipitation: Gridded Monthly and Annual Time Series (Version2.01)* interpolated and documented by Cort J. Willmott and Kenji Matsuura (with support from IGES and NASA), University of Delaware. For more information see Legates et al. (1990a 1990b) and Willmott et al. (1995). This is the monthly total precipitation for the years 1900-2008 interpolated to a 0.5 by 0.5 degree grid resolution. We associate each kriging point to a country and then collapse our data to obtain a mean rainfall for each country. Trends are calculated from mean rainfall country data and since 1950 (considering as a period of start of climate change)[8].For this work we could use the Climate Research Unit (CRU) as used by Burke et al. (2009) to assess the role of warming in futures conflicts in Africa. The results are similar but a discussion about this database could be opened.
Trends are calculated on monthly data, before a seasonal adjustment according to:

$$Rj = \alpha + \beta t + \theta j + \mathcal{E}j \qquad \text{for each i country}$$

With

Rj: monthly rainfall data

t : trend

θj : dummy monthly variable

Ɛjt: term or error

[7] We complete the database for 72 countries, in majority landlocked (we assign the null value for these elements). For the other countries we propose an approximation of the index according to the geographic features of the country (altitude, distribution of population). We test the validity of data by some tests of sensitivity (rank correlation).

[8] For countries where kriging points are not exactly in the country (13 countries), we use buffering technique and couple the point closest to the country in the country where data are missing.

For instance, the results of estimation of trend in Benin on rainfall data since 1950 are presented below.

Table 1: Trend in rainfall in Benin

VARIABLES	Rainfall
Trend	-0.0338***
	(0.009)
d2	2.4355
	(1.907)
d3	21.0101***
	(2.525)
d4	68.9388***
	(4.850)
d5	108.6456***
	(5.504)
d6	143.0438***
	(6.051)
d7	198.5777***
	(8.972)
d8	254.7878***
	(9.007)
d9	246.6013***
	(8.841)
d10	100.0894***
	(6.154)
d11	12.1215***
	(3.079)
d12	1.9435
	(1.728)
Constant	34.0590***
	(8.177)
Observations	708
R-squared	0.824

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

If the trend is not significant at the level of 0.1, we assign the null value for this sub-component. In this first version of the index, shocks are calculated as the number of events over two standard deviations of the trend in the temperature or rainfall. Positive and negative shocks are equally taken into account. The trend of the shocks is calculated only on the negative shocks in rainfall data and positive shocks in temperature data. In all these instances, calculation data are seasonally adjusted. All estimations are done with the method of Ordinary Least Squared (OLS), with robust standard error (control for heteroskedasticity).

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). This is the part of dry land considered as the three of the world's six aridity zones—the arid, semi-arid, and dry sub-humid zones—as a percent of the country's total terrestrial area.

Each of components is normalized following the method[9]:

$$\mathrm{CN} = \frac{(C - min_C)}{\mathrm{max_C} - \mathrm{min_C}} * 100$$

With
CN : component normalized
C: value of component

3.2. Aggregation

The first results of the index are summarized in the next table and map. Different methods of aggregations are tested: arithmetic, geometric modified (G'), quadratic means. A Principal Component Analysis (PCA) has been made, to test the choice of weighting in the aggregation.

In the aim to test the sensitivity of results, some rank correlation tests (Spearman and Kendall tau) are executed. The quadratic means and the geometric modified average permit the stress of the value of the index if one of the components has an extreme value (Guillaumont et al., 2010). For the two types of aggregation the rank differences are not significant. The two methods and the arithmetic methods are well correlated. We remark that the choice of equivalent weights is validated by the comparison between the index calculated with equivalent weights' arithmetic mean and the PCA index. Indeed there is no significant difference in rank between the two indices and there correlation is important (0.70 with level of signification of 0.01%)[10].

Finally the arithmetic mean is the simplest method and differences with the other methods are very low so these results are presented (see Appendix).

3.3 Results

Results are summarized in the map below. The index is estimated at the country level, not as regional index and it appears that in a region usually considered as vulnerable or exposed to climate change there can be differences between countries. Country grouping results are presented in the table below, showing the high structural vulnerability to climate change of LDCs, already found to have a high economic vulnerability as evidenced by EVI.

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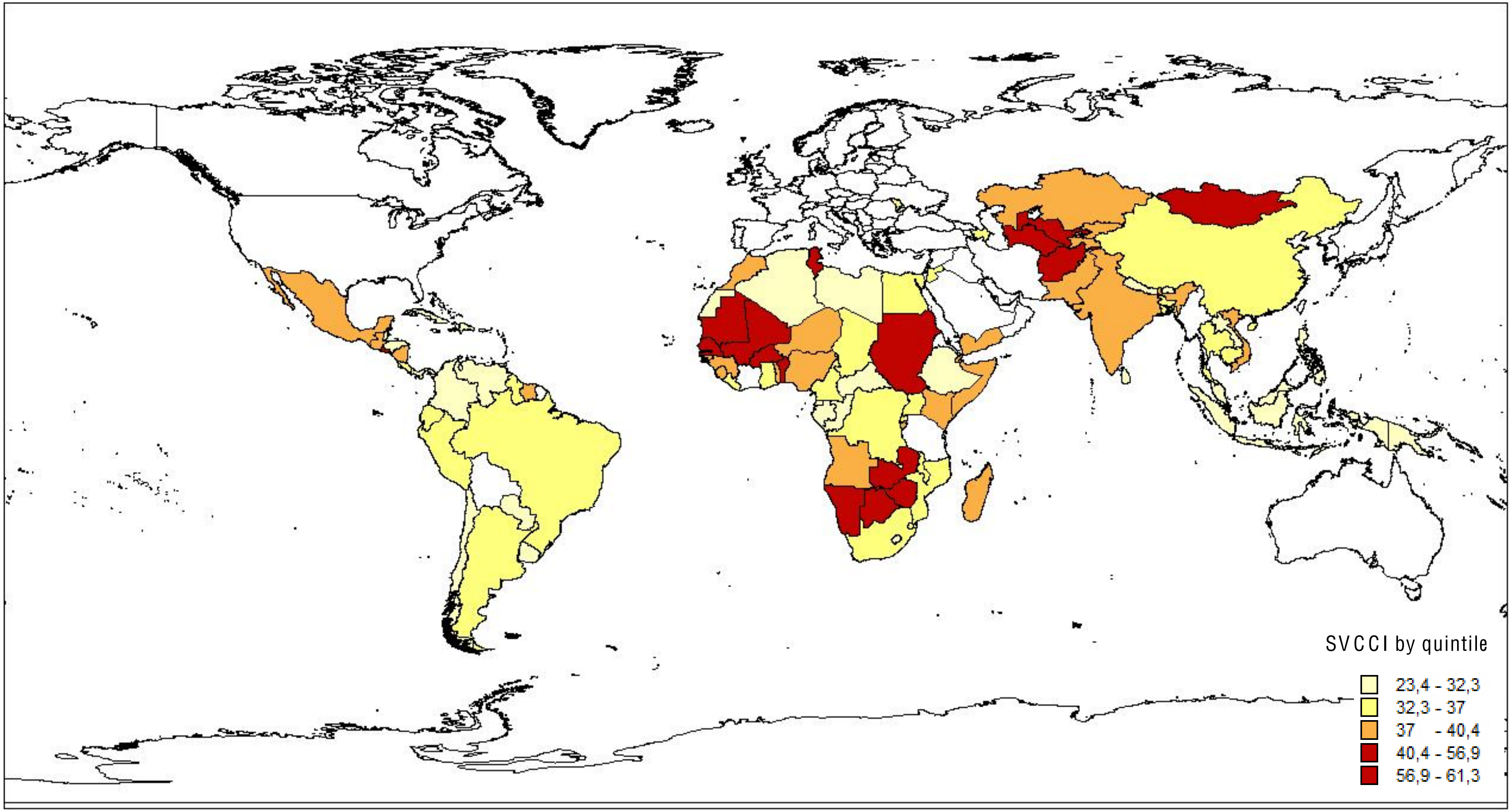
[9] For the component "trend in rainfall", C values are negative. So $\mathrm{CN} = 100 * [1 - \frac{(C - min_C)}{\mathrm{max_C} - \mathrm{min_C}}]$

[10] The same types of comparison of rank are made to test the sensitivity to the proxy.

Figure 4: SVCCI by group of countries

group of countries	number of countries	Mean	Median	Standard Deviation
All Developing countries (DCs)	116	36.43	35.89	6.77
Least Developed Countries (LDCs)	46	38.28	38.38	8.04
All Developing countries non LDCs	72	35.48	34.77	6.30
Low and Lower Middle Income countries	84	37.64	37.21	7.13
Low and LMI countries non LDCs	39	36.66	36.72	5.92
Small Islands Developing States (SIDS)	29	38.00	34.60	9.42
SIDS non LDCs	18	35.98	34.29	7.51
SIDS-LDCs	11	40.19	38.67	11.85
Landlocked Developing Countries (LLDCs)	27	37.14	36.87	6.24
LLDCs non LDCs	11	39.43	40.09	4.96
LLDCs-LDCs	16	35.56	33.52	6.67

Figure 6: Map of SVCCI-Developing countries



Conclusion

This paper presents a first attempt to build a Structural Vulnerability to Climate Change Index (SVCCI). 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 present policy and future policy as well. To this aim it relies only on physical components reflecting a likely impact of climate change, without any use of socioeconomic data. It is an index of structural vulnerability to climate change, changing only progressively and slowly. It differs from other vulnerability indices, both from the more general environmental vulnerability indices, which 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 structural vulnerability (independent from the present will of countries), as the SVCCI, but covers all kinds of exogenous shocks likely to affect economic growth.

The EVI has been proposed as a possible criterion for the allocation of development assistance between countries (Guillaumont, 2008; Guillaumont et al., 2010). By the same way, thanks to its features, the SVCCI could be used as a criterion for the allocation of the international resources available for the adaptation to climate change. It would be relevant criterion precisely because it doesn't depend on the present policy and only gives an indication of the need for adaptation. The two indices EVI and SVCCI can then have a complementary role in the allocation of international resources, as far as these resources are provided from separate windows.

At the end of this paper it should be acknowledging the provided estimations are only tentative and should be refine when more relevant data will be made available in particular for the likely share of population to be affected by sea level rise.

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Appendix 1: SVCCI calculation with different aggregation methods and rank comparison[11]

countries	Arithmetic average		Quadratic average		G' average		Rank difference	Rank difference
	Value	Rank	Value	Rank	Value	Rank	(1-2)	(1-3)
Afghanistan	45.25	135	54.05	138	53.88	138	-3	-3
Algeria	28.63	24	33.40	27	30.56	26	-3	-2
Angola	38.84	105	45.70	110	43.16	108	-5	-3
Antigua and Barbuda	41.01	122	42.19	88	41.94	98	34	24
Argentina	33.32	64	37.90	63	35.41	59	1	5
Austria	24.25	4	28.56	6	25.64	5	-2	-1
Azerbaijan	34.93	76	42.79	94	40.06	89	-18	-13
Bahamas	38.43	102	41.56	82	40.42	93	20	9
Bangladesh	33.12	61	40.40	75	37.57	73	-14	-12
Belgium	35.95	84	36.63	53	36.34	69	31	15
Belize	29.89	36	31.94	20	30.77	28	16	8
Benin	45.62	137	50.65	128	49.54	127	9	10
Bhutan	26.19	15	31.50	18	28.19	15	-3	0
Bosnia and Herzegovina	24.88	8	29.48	8	26.47	8	0	0
Botswana	47.60	139	56.69	139	57.76	140	0	-1
Brazil	36.15	85	42.48	90	40.03	87	-5	-2
Brunei Darussalam	25.37	10	30.58	16	27.26	12	-6	-2
Burkina Faso	45.46	136	53.63	137	52.66	136	-1	0
Burundi	40.05	116	49.00	125	47.74	124	-9	-8
Cambodia	34.87	75	40.42	76	37.99	75	-1	0
Cameroon	32.97	60	38.97	70	35.94	64	-10	-4
Cape Verde	29.85	35	35.16	37	32.10	33	-2	2
Central African Republic	30.18	40	35.45	39	32.42	38	1	2
Chad	33.15	62	40.58	78	37.33	72	-16	-10
Chile	31.07	44	36.03	47	33.19	43	-3	1
China	36.40	86	40.61	79	38.54	80	7	6
Colombia	28.02	20	32.42	25	29.69	22	-5	-2
Comoros	35.73	81	45.32	107	43.50	111	-26	-30
Congo	29.12	29	34.94	36	31.63	31	-7	-2
Congo. The Dem. Rep. of the	32.32	56	39.01	71	35.78	63	-15	-7
Costa Rica	33.25	63	41.42	81	38.73	81	-18	-18
Cuba	31.09	45	36.58	52	33.69	49	-7	-4
Cyprus	36.78	89	42.51	91	40.34	92	-2	-3
Czech Republic	26.04	13	30.15	15	27.41	13	-2	0
Denmark	51.80	141	59.12	143	100.00	143	-2	-2
Djibouti	38.62	103	43.12	96	41.63	97	7	6
Dominican Republic	30.15	39	34.71	33	32.04	32	6	7
Ecuador	36.72	88	41.90	84	39.54	84	4	4
Egypt	35.27	78	36.94	56	36.20	68	22	10
El Salvador	44.74	134	53.17	136	52.65	135	-2	-1

[11] The SVCCI calculation resumed in this first appendix is calculated following various methods of aggregation, only for countries where data are available for all components. That is why some countries (mainly developed countries) are not available in this appendix but presented in the second. The sea level rise is the element the most restrictive (for which data in developed countries are not available).

countries	Arithmetic average		Quadratic average		G' average		Rank difference	Rank difference
	Value	Rank	Value	Rank	Value	Rank	(1-2)	(1-3)
Equatorial Guinea	28.78	26	34.13	30	31.03	29	-4	-3
Ethiopia	31.73	51	37.21	58	34.25	52	-7	-1
Fiji	30.32	41	34.74	34	32.26	36	7	5
French Guiana	31.94	53	37.57	61	35.39	58	-8	-5
French Polynesia	33.60	69	42.04	86	39.44	83	-17	-14
Gabon	31.55	49	37.25	59	34.28	54	-10	-5
Gambia	52.31	143	56.69	140	57.48	139	3	4
Ghana	33.69	70	41.96	85	38.48	79	-15	-9
Greece	33.49	68	38.89	69	36.05	65	-1	3
Grenada	38.98	106	40.38	74	40.03	88	32	18
Guadeloupe	28.42	22	32.77	26	30.28	25	-4	-3
Guatemala	37.96	100	46.61	115	45.06	119	-15	-19
Guinea	39.27	108	45.04	106	42.96	106	2	2
Guinea-Bissau	38.67	104	44.43	102	42.53	101	2	3
Guyana	34.60	74	35.78	45	35.20	57	29	17
Haiti	28.88	27	33.47	28	30.70	27	-1	0
Honduras	31.17	46	36.35	49	33.48	45	-3	1
Hungary	27.77	18	32.28	23	29.43	21	-5	-3
India	40.00	115	45.86	112	43.44	109	3	6
Indonesia	31.31	48	35.77	44	33.39	44	4	4
Iran. Islamic Republic of	40.30	119	47.47	121	45.49	120	-2	-1
Ireland	27.93	19	29.72	10	28.64	17	9	2
Jamaica	32.55	58	37.07	57	34.60	56	1	2
Jordan	35.59	80	41.25	80	38.43	78	0	2
Kazakhstan	40.09	117	50.62	127	51.79	134	-10	-17
Kenya	39.34	109	45.52	109	42.87	105	0	4
Kiribati	50.16	140	58.29	141	100.00	143	-1	-3
Korea. Democratic Peo. Rep. of	33.39	65	39.51	72	36.70	70	-7	-5
Korea. Republic of	29.84	34	35.91	46	32.64	40	-12	-6
Kuwait	35.14	77	42.14	87	39.67	85	-10	-8
Kyrgyzstan	37.36	95	45.00	105	42.59	103	-10	-8
Lao People's Democratic Republic	28.89	28	36.04	48	32.15	35	-20	-7
Lesotho	26.38	16	32.23	21	28.64	16	-5	0
Liberia	35.36	79	40.56	77	38.39	77	2	2
Libyan Arab Jamahiriya	31.89	52	35.72	43	33.65	48	9	4
Luxembourg	23.26	1	27.27	2	24.49	2	-1	-1
Macedonia. The Former Yugoslav Republic	27.67	17	32.24	22	29.36	19	-5	-2
Madagascar	40.37	120	47.28	119	44.97	118	1	2
Malawi	33.89	71	40.03	73	37.10	71	-2	0
Malaysia	25.53	11	30.10	13	27.24	11	-2	0
Maldives	56.91	145	62.77	145	100.00	143	0	2
Mali	44.45	132	51.74	133	49.73	129	-1	3
Marshall Islands	61.28	146	66.05	146	100.00	143	0	3
Mauritania	41.44	124	43.12	95	42.52	100	29	24
Mayotte	45.92	138	49.73	126	50.44	131	12	7
Mexico	37.03	92	42.60	93	40.07	90	-1	2
Micronesia. Fed. Sts.	33.43	67	33.72	29	33.58	47	38	20
Moldova. Republic of	36.87	90	45.45	108	43.47	110	-18	-20

countries	Arithmetic average		Quadratic average		G' average		Rank difference	Rank difference
	Value	Rank	Value	Rank	Value	Rank	(1-2)	(1-3)
Mongolia	44.02	130	51.80	134	49.92	130	-4	0
Morocco	37.65	98	44.93	104	43.05	107	-6	-9
Mozambique	36.99	91	42.53	92	40.14	91	-1	0
Namibia	52.73	144	61.07	144	60.94	142	0	2
Nepal	31.05	43	37.72	62	34.32	55	-19	-12
New Caledonia	25.68	12	29.69	9	27.19	10	3	2
New Zealand	23.66	3	28.46	5	25.23	3	-2	0
Nicaragua	37.81	99	44.80	103	42.40	99	-4	0
Niger	39.84	113	46.30	113	43.72	112	0	1
Nigeria	37.63	97	43.87	100	41.13	94	-3	3
Oman	24.33	5	27.34	3	25.27	4	2	1
Pakistan	39.65	112	46.35	114	44.01	113	-2	-1
Palau	41.44	125	43.17	97	42.74	104	28	21
Panama	30.08	38	35.64	42	32.65	41	-4	-3
Papua New Guinea	29.30	31	34.69	32	31.57	30	-1	1
Paraguay	31.57	50	36.58	51	33.71	50	-1	0
Peru	35.91	83	42.44	89	39.77	86	-6	-3
Philippines	30.00	37	34.83	35	32.15	34	2	3
Puerto Rico	28.14	21	31.25	17	29.38	20	4	1
Qatar	28.71	25	32.29	24	30.19	23	1	2
Rwanda	36.64	87	45.75	111	44.11	114	-24	-27
Saint Vincent and the Grenadines	28.56	23	30.14	14	29.18	18	9	5
Samoa	26.16	14	30.02	12	27.62	14	2	0
Sao Tome and Principe	40.17	118	46.72	118	44.22	116	0	2
Saudi Arabia	32.01	54	35.54	41	33.54	46	13	8
Senegal	52.22	142	58.91	142	59.46	141	0	1
Seychelles	34.47	73	36.50	50	35.51	61	23	12
Sierra Leone	40.38	121	48.23	122	47.01	123	-1	-2
Slovakia	25.16	9	29.72	11	26.72	9	-2	0
Solomon Islands	29.80	32	35.52	40	32.35	37	-8	-5
Somalia	39.61	110	46.62	116	44.27	117	-6	-7
South Africa	35.88	82	41.85	83	39.05	82	-1	0
Sri Lanka	30.97	42	35.27	38	32.82	42	4	0
St. Kitts and Nevis	34.11	72	37.49	60	36.10	67	12	5
Sudan	44.14	131	51.10	130	48.93	126	1	5
Suriname	37.11	94	38.63	66	37.93	74	28	20
Swaziland	32.54	57	38.54	65	35.48	60	-8	-3
Switzerland	24.55	6	28.94	7	26.01	7	-1	-1
Taiwan. Province of China	31.18	47	34.17	31	32.48	39	16	8
Tajikistan	39.94	114	46.72	117	44.14	115	-3	-1
Thailand	33.43	66	38.47	64	36.08	66	2	0
Timor-Leste	44.51	133	53.16	135	52.87	137	-2	-4
Togo	38.14	101	43.60	98	41.23	95	3	6
Tonga	39.61	111	43.67	99	42.55	102	12	9
Tunisia	41.41	123	48.62	124	48.83	125	-1	-2
Turkmenistan	41.97	127	51.01	129	50.77	132	-2	-5
Tuvalu	61.28	146	66.05	146	100.00	143	0	3
Uganda	32.59	59	38.75	67	35.73	62	-8	-3

countries	Arithmetic average		Quadratic average		G' average		Rank difference	Rank difference
	Value	Rank	Value	Rank	Value	Rank	(1-2)	(1-3)
United Arab Emirates	29.13	30	31.70	19	30.20	24	11	6
Uruguay	24.73	7	27.98	4	25.85	6	3	1
Uzbekistan	42.54	128	51.63	132	51.61	133	-4	-5
Vanuatu	29.82	33	36.91	55	33.94	51	-22	-18
Venezuela	32.22	55	36.79	54	34.27	53	1	2
Viet Nam	37.05	93	38.83	68	38.15	76	25	17
Western Sahara	23.42	2	26.94	1	24.46	1	1	1
Yemen	37.55	96	43.99	101	41.53	96	-5	0
Zambia	43.26	129	51.48	131	49.55	128	-2	1
Zimbabwe	41.69	126	48.45	123	45.98	122	3	4

Appendix 2: SVCCI Components

Countries	Sea level rise	Trend in temperature	Trend in rainfall	Share of dry lands	Rainfall instability	Temperature instability	Trend in rainfall instability	Trend in temperature instability	Sea Level rise		Over Aridity		Rainfall shocks		Temperature shocks	
									Value	Rank	Value	Rank	Value	Rank	Value	Rank
Afghanistan	0.00	74.12	66.42	94.00	76.56	34.71	32.37	54.08	0.00	1	82.14	185	54.47	180	44.39	79
Albania		17.90	77.42	0.00	46.88	35.54	22.96	54.08			23.83	22	34.92	53	44.81	86
Algeria	1.28	45.73	67.18	20.90	23.44	39.67	31.97	54.08	1.28	77	38.68	112	27.70	16	46.87	116
Angola	0.67	35.41	71.62	19.30	87.50	40.50	39.22	69.32	0.67	69	36.41	104	63.36	196	54.91	158
Antigua and Barbuda	40.93	59.22	80.97	0.00	29.69	39.67	32.37	74.42	40.93	147	35.05	93	31.03	30	57.05	163
Argentina	2.39	19.60	63.74	52.80	57.81	34.71	30.75	44.00	2.39	91	47.24	136	44.28	126	39.35	20
Armenia		28.82	69.60	98.10	39.06	42.15	30.81	54.08			73.66	177	34.94	58	48.11	126
Australia		18.09	66.42	85.70	68.75	33.88	32.37	54.08			63.98	161	50.56	161	43.98	67
Austria	0.00	26.96	66.42	0.00	40.63	23.14	29.45	54.08	0.00	1	23.35	20	35.04	59	38.61	15
Azerbaijan	0.00	35.46	71.18	83.80	28.13	30.58	29.53	54.08	0.00	1	68.56	169	28.83	21	42.33	47
Bahamas	14.07	38.83	66.42	27.40	50.00	62.81	32.37	54.08	14.07	136	40.01	117	41.18	107	58.44	175
Bangladesh	5.25	5.48	66.42	0.00	75.00	34.71	54.71	54.08	5.25	111	17.97	5	64.85	198	44.39	79
Belarus	0.00	61.56	66.42		54.69	32.23	32.37	54.08	0.00	1			43.53	120	43.15	57
Belgium	40.93	51.28	66.42	0.00	28.13	35.54	29.10	54.08	40.93	147	29.43	65	28.61	18	44.81	86
Belize	13.60	34.38	66.42	0.00	46.88	33.88	32.37	48.37	13.60	135	25.20	32	39.62	94	41.13	37
Benin	9.28	27.16	72.03	87.50	73.44	45.45	32.37	58.06	9.28	125	68.55	168	52.90	170	51.76	149
Bhutan	0.00	10.27	75.55	0.00	64.06	38.02	10.44	54.08	0.00	1	21.46	13	37.25	72	46.05	105
Bolivia	0.00	23.61	66.42		43.75	43.80	32.37	54.08	0.00	1			38.06	79	48.94	137
Bosnia and Herzegovina	0.00	43.56	70.09	0.00	21.88	33.88	32.37	54.08	0.00	1	28.41	60	27.12	11	43.98	67
Botswana	0.00	73.34	70.91	100.00	64.06	53.72	36.82	54.08	0.00	1	86.06	187	50.44	159	53.90	156
Brazil	2.11	45.26	66.42	15.30	53.13	68.60	32.37	59.78	2.11	87	35.57	99	42.75	117	64.19	181
Brunei Darussalam	0.95	4.69	66.42	0.00	39.06	29.75	42.59	54.08	0.95	73	17.78	3	40.83	105	41.91	40
Bulgaria		0.00	66.42	53.10	21.88	34.71	32.37	54.08			43.15	125	27.12	11	44.39	79
Burkina Faso	0.00	38.75	75.13	100.00	65.63	46.28	40.77	54.08	0.00	1	78.47	179	53.20	175	50.18	145
Burundi	0.00	61.98	70.04	0.00	62.50	72.73	35.62	83.57	0.00	1	33.00	81	49.06	155	78.15	199
Cambodia	5.29	32.42	75.03	0.00	70.31	46.28	43.99	54.08	5.29	113	26.86	47	57.15	185	50.18	145
Cameroon	0.42	14.73	77.81	13.00	67.19	28.93	39.28	68.30	0.42	58	29.63	67	53.23	176	48.61	133
Canada		55.08	66.42	15.80	42.19	36.36	32.37	54.08			38.27	110	37.28	73	45.22	95
Cape Verde	0.17	14.82	66.42	15.40	56.25	37.19	34.94	54.08	0.17	43	28.01	55	45.60	136	45.63	100
Cayman Islands		59.74	82.29	0.00	37.50	22.31	37.97	54.08			35.51	97	37.73	78	38.20	11
Central African Republic	0.00	4.30	74.32	20.10	57.81	28.93	36.17	59.10	0.00	1	29.70	68	46.99	143	44.01	76
Chad	0.00	42.69	69.42	68.20	9.38	47.11	39.11	45.39	0.00	1	62.13	157	24.24	5	46.25	110

Countries	Sea level rise	Trend in temperature	Trend in rainfall	Share of dry lands	Rainfall instability	Temperature instability	Trend in rainfall instability	Trend in temperature instability	Sea Level rise		Over Aridity		Rainfall shocks		Temperature shocks	
									Value	Rank	Value	Rank	Value	Rank	Value	Rank
Chile	0.52	23.50	69.25	21.00	59.38	38.02	28.64	54.08	0.52	64	33.69	86	44.01	125	46.05	105
China	5.30	47.55	66.42	34.00	59.38	43.80	32.37	54.08	5.30	114	45.49	134	45.87	137	48.94	137
Colombia	1.22	13.14	66.42	17.40	50.00	28.10	32.37	54.08	1.22	76	28.59	62	41.18	107	41.09	31
Comoros	0.20	74.86	87.93	0.00	50.00	100.00	0.00	54.08	0.20	47	40.70	119	25.00	7	77.04	197
Congo	0.45	15.30	74.58	0.10	56.25	33.88	35.78	61.16	0.45	59	22.52	17	46.01	139	47.52	122
Congo. The Dem. Rep. of the	0.07	31.05	71.98	0.40	54.69	58.68	35.76	57.39	0.07	40	25.96	37	45.22	135	58.03	172
Cook Islands	40.93	61.35	66.42		54.69	52.07	32.37	54.08	40.93	147			43.53	120	53.07	154
Costa Rica	0.48	65.82	66.42	0.00	26.56	85.95	32.37	54.08	0.48	60	33.06	82	29.47	22	70.01	190
Côte d'Ivoire	2.60	14.63	79.20		70.31	35.54	32.37	54.08	2.60	94			51.34	163	44.81	86
Croatia		32.05	72.92	0.00	3.13	28.10	32.37	54.08			26.24	42	17.75	2	41.09	31
Cuba	2.16	6.92	75.24	11.00	65.63	32.23	40.36	54.08	2.16	89	26.04	39	52.99	173	43.15	57
Cyprus	4.00	13.84	69.33	85.50	48.44	21.49	35.18	54.08	4.00	103	63.54	160	41.81	114	37.78	8
Czech Republic	0.00	32.42	66.42	12.80	40.63	19.01	32.37	54.08	0.00	1	31.11	75	36.50	67	36.54	7
Denmark	100.00	36.57	71.81	0.00	39.06	34.71	32.37	54.08	100.00	152	27.10	51	35.72	62	44.39	79
Djibouti	10.85	36.12	66.42	73.40	29.69	34.71	35.58	62.63	10.85	130	62.34	158	32.63	44	48.67	134
Dominican Republic	1.45	53.42	72.19	4.70	39.06	34.71	38.21	58.78	1.45	79	33.75	87	38.64	88	46.74	115
Ecuador	3.45	25.81	61.51	63.40	71.88	21.49	32.37	54.08	3.45	102	53.53	144	52.12	165	37.78	8
Egypt	19.86	42.16	65.79	7.80	50.00	43.80	32.81	54.08	19.86	138	30.89	73	41.40	112	48.94	137
El Salvador	0.50	89.46	90.25	0.00	56.25	100.00	49.95	60.87	0.50	61	44.93	132	53.10	174	80.43	200
Equatorial Guinea	0.63	17.35	84.68	0.00	37.50	28.10	41.43	70.92	0.63	68	25.51	34	39.47	92	49.51	140
Eritrea		17.15	66.42	83.00	79.69	23.14	35.99	62.04			62.39	159	57.84	187	42.59	50
Estonia		71.89	66.42	0.00	37.50	39.67	35.52	54.08			34.58	90	36.51	68	46.87	116
Ethiopia	0.51	23.28	66.42	57.70	29.69	43.80	32.37	44.44	0.51	63	51.28	139	31.03	30	44.12	78
Falkland Islands (Malvinas)	32.80	7.97	64.08		50.00	21.49	32.37	54.08	32.80	140			41.18	107	37.78	8
Fiji	4.00	28.02	82.24	0.00	50.00	42.98	32.37	54.08	4.00	103	27.57	54	41.18	107	48.53	130
Finland		49.22	64.44	0.00	46.88	33.88	34.89	54.08			28.42	61	40.88	106	43.98	67
France		40.95	66.42	0.30	20.31	24.79	32.37	54.08			26.99	49	26.34	9	39.44	21
French Guiana	9.53	23.51	66.42	0.00	32.81	57.02	32.37	69.27	9.53	128	22.48	16	32.59	41	63.15	178
French Polynesia	0.20	51.57	66.42	0.00	45.31	95.87	21.46	46.75	0.20	47	29.50	66	33.39	49	71.31	192
French Southern Territories		39.37	80.03	0.00	18.75	33.88	27.12	63.50			29.85	69	22.93	3	48.69	135
Gabon	2.13	19.94	79.01	0.00	60.94	32.23	40.17	65.32	2.13	88	24.74	29	50.55	160	48.77	136
Gambia	18.63	38.23	86.37	97.30	53.13	57.85	56.59	54.08	18.63	137	79.80	180	54.86	181	55.96	160
Georgia		34.51	72.28	33.70	48.44	24.79	29.31	54.08			43.55	126	38.87	91	39.44	21
Germany		46.68	66.42	5.00	29.69	26.45	32.37	72.87			30.78	72	31.03	30	49.66	141

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Ghana	2.19	31.30	73.02	66.20	0.00	60.33	32.37	54.08	2.19	90	59.18	152	16.18	1	57.20	168
Greece	0.20	0.00	70.19	45.20	71.88	28.93	32.37	54.08	0.20	47	40.15	118	52.12	165	41.50	38
Greenland		63.77	65.54	0.00	37.50	37.19	32.37	54.08			32.33	77	34.93	54	45.63	100
Grenada	32.80	59.22	80.97	0.00	29.69	39.67	32.37	74.42	32.80	140	35.05	93	31.03	30	57.05	163
Guadeloupe	4.00	40.49	80.75	0.00	26.56	38.84	32.37	60.99	4.00	103	30.31	71	29.47	22	49.92	144
Guatemala	0.15	76.78	77.21	0.00	45.31	99.17	27.79	54.08	0.15	41	38.50	111	36.55	69	76.63	195
Guinea	4.61	32.46	85.61	14.10	59.38	64.46	47.83	60.14	4.61	110	36.57	105	53.60	178	62.30	177
Guinea-Bissau	5.95	35.38	88.40	5.90	71.88	34.71	58.27	64.85	5.95	118	33.90	88	65.07	199	49.78	143
Guyana	34.25	13.51	66.42	0.00	57.81	26.45	23.17	60.93	34.25	145	19.98	9	40.49	102	43.69	64
Haiti	0.84	54.07	74.63	2.60	37.50	22.31	32.37	70.20	0.84	72	33.48	85	34.93	54	46.26	111
Honduras	0.57	50.60	86.60	0.00	40.63	47.93	37.00	54.08	0.57	66	34.30	89	38.81	89	51.01	148
Hungary	0.00	0.00	66.42	46.40	29.69	26.45	32.37	54.08	0.00	1	39.80	116	31.03	30	40.26	26
Iceland	0.20	17.68	66.42		26.56	27.27	32.37	54.08	0.20	47			29.47	22	40.68	27
India	1.63	19.81	66.42	59.80	84.38	42.98	32.37	54.08	1.63	82	51.46	140	58.37	189	48.53	130
Indonesia	5.25	7.21	93.92	2.80	60.94	29.75	39.19	56.75	5.25	112	26.68	45	50.06	157	43.25	61
Iran. Islamic Republic of	1.09	33.35	69.08	90.30	62.50	29.75	32.37	54.08	1.09	74	70.76	173	47.43	145	41.91	40
Iraq		24.85	67.81	99.90	35.94	29.75	32.37	69.73			73.12	176	34.15	50	49.74	142
Ireland	13.33	33.19	66.42	0.00	32.81	37.19	32.37	44.59	13.33	131	24.90	31	32.59	41	40.89	30
Israel		0.00	69.33	69.20	62.50	34.71	32.37	43.44			51.93	142	47.43	145	39.07	19
Italy		36.89	70.31	20.60	48.44	27.27	32.37	54.08			37.10	107	40.40	100	40.68	27
Jamaica	2.86	43.69	66.42	31.20	39.06	38.84	32.37	58.15	2.86	98	43.13	124	35.72	62	48.50	129
Japan		21.89	70.94	0.00	65.63	29.75	32.37	54.08			23.21	18	49.00	153	41.91	40
Jersey		37.01	66.42		43.75	33.88	32.37	54.08					38.06	79	43.98	67
Jordan	0.00	0.00	67.79	72.40	60.94	32.23	31.15	54.08	0.00	1	53.15	143	46.04	140	43.15	57
Kazakstan	0.00	78.81	67.79	99.20	31.25	31.40	31.51	54.08	0.00	1	86.25	188	31.38	37	42.74	51
Kenya	0.15	26.10	66.42	68.00	62.50	51.24	32.37	54.08	0.15	42	57.13	150	47.43	145	52.66	152
Kiribati	100.00	12.38	100.00	0.00	21.88	29.75	32.37	61.13	100.00	152	28.09	57	27.12	11	45.44	97
Korea. Democratic Peo. Rep. of	2.06	47.11	66.42	0.00	85.94	33.88	32.37	54.08	2.06	86	28.38	59	59.15	190	43.98	67
Korea. Republic of	1.68	22.40	60.61	0.00	71.88	35.54	32.37	54.08	1.68	83	20.75	10	52.12	165	44.81	86
Kuwait	1.57	20.21	64.22	92.30	40.63	30.58	33.54	38.75	1.57	81	67.26	167	37.08	71	34.67	4
Kyrgyzstan	0.00	100.00	69.62	54.50	35.94	37.19	32.37	54.08	0.00	1	69.66	171	34.15	50	45.63	100
Lao People's Dem. Republic	0.00	0.00	66.42	0.00	73.44	38.02	32.37	54.08	0.00	1	16.60	2	52.90	170	46.05	105
Latvia		64.50	66.42	0.00	39.06	35.54	34.85	54.08			32.73	79	36.95	70	44.81	86
Lebanon		31.95	72.43	59.40	71.88	35.54	40.26	54.08			55.80	148	56.07	183	44.81	86

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Lesotho	0.00	0.00	71.77	0.00	54.69	26.45	32.37	61.61	0.00	1	17.94	4	43.53	120	44.03	77
Liberia	7.26	24.80	82.47	0.00	65.63	59.50	32.37	57.25	7.26	122	26.82	46	49.00	153	58.38	174
Libyan Arab Jamahiriya	6.30	63.14	66.42	22.70	28.13	40.50	32.37	54.08	6.30	120	43.74	127	30.25	27	47.29	119
Lithuania		63.01	66.42	0.00	43.75	34.71	32.37	54.08			32.36	78	38.06	79	44.39	79
Luxembourg	0.00	36.49	66.42	0.00	25.00	23.14	32.37	54.08	0.00	1	25.73	36	28.68	19	38.61	15
Macedonia	0.00	0.00	68.86	36.70	34.38	33.06	28.69	54.08	0.00	1	35.56	98	31.53	38	43.57	62
Madagascar	1.53	35.32	66.42	23.10	85.94	73.55	32.37	54.08	1.53	80	36.99	106	59.15	190	63.82	180
Malawi	0.00	63.77	74.79	0.00	75.00	31.40	41.35	54.08	0.00	1	34.64	91	58.17	188	42.74	51
Malaysia	3.23	9.94	66.42	0.00	35.94	37.19	32.37	54.08	3.23	100	19.09	8	34.15	50	45.63	100
Maldives	100.00	46.15	66.42	0.00	60.94	47.93	32.37	57.75	100.00	152	28.14	58	46.65	142	52.84	153
Mali	0.00	47.04	71.09	80.20	75.00	49.59	37.70	54.08	0.00	1	69.63	170	56.35	184	51.83	150
Marshall Islands	100.00	59.76	84.89	0.00	56.25	33.88	32.37	95.39	100.00	152	36.16	101	44.31	127	64.64	184
Mauritania	21.31	46.90	69.56	45.60	54.69	42.15	34.12	54.08	21.31	139	51.92	141	44.41	132	48.11	126
Mauritius		22.03	66.42	0.00	59.38	39.67	32.37	50.51			22.11	14	45.87	137	45.09	93
Mayotte	40.93	74.86	87.93	0.00	50.00	100.00	0.00	54.08	40.93	147	40.70	119	25.00	7	77.04	197
Mexico	1.77	21.76	66.42	69.20	64.06	28.93	32.37	54.08	1.77	84	56.64	149	48.22	150	41.50	38
Micronesia. Fed. Sts.	32.80	38.13	88.56	0.00	43.75	0.00	37.39	57.36	32.80	140	31.67	76	40.57	103	28.68	2
Moldova. Republic of	0.00	32.11	66.42	99.90	31.25	28.10	32.37	54.08	0.00	1	74.58	178	31.81	39	41.09	31
Mongolia	0.00	85.25	67.19	65.10	92.19	32.23	32.37	54.08	0.00	1	70.66	172	62.28	194	43.15	57
Montenegro		14.11	79.17		67.19	28.10	32.37	54.08					49.78	156	41.09	31
Morocco	2.48	33.22	69.41	92.30	42.19	23.97	32.37	54.08	2.48	92	71.81	174	37.28	73	39.02	18
Mozambique	2.70	35.35	74.20	37.60	81.25	25.62	37.21	54.08	2.70	95	46.19	135	59.23	192	39.85	23
Myanmar	6.18	19.81	72.52		100.00	31.40	39.23	54.08	6.18	119			69.62	201	42.74	51
Namibia	0.82	75.02	70.04	90.80	90.63	69.42	36.57	60.25	0.82	71	81.67	183	63.60	197	64.84	187
Nepal	0.00	8.03	66.42	9.40	84.38	27.27	27.21	62.92	0.00	1	23.31	19	55.79	182	45.10	94
Netherlands		48.28	66.42	0.00	42.19	42.98	32.37	65.71			28.68	63	37.28	73	54.34	157
New Caledonia	4.00	19.82	77.36	1.20	40.63	38.02	14.91	54.08	4.00	103	24.90	30	27.77	17	46.05	105
New Zealand	0.20	0.00	72.81	0.00	43.75	22.31	32.37	54.08	0.20	47	18.20	6	38.06	79	38.20	11
Nicaragua	0.58	72.14	83.19	0.00	56.25	86.78	32.37	48.24	0.58	67	38.83	113	44.31	127	67.51	189
Niger	0.00	52.60	69.08	62.10	64.06	52.07	36.12	43.57	0.00	1	61.47	156	50.09	158	47.82	125
Nigeria	0.19	34.42	71.49	58.20	46.88	48.76	32.37	61.49	0.19	46	55.58	147	39.62	94	55.12	159
Norway		35.82	66.42	0.00	43.75	42.98	26.95	54.08			25.56	35	35.35	60	48.53	130
Oman	3.28	20.78	66.42	13.90	26.56	23.97	32.37	47.71	3.28	101	28.75	64	29.47	22	35.84	5
Pakistan	0.71	33.52	66.42	82.60	56.25	40.50	32.37	54.08	0.71	70	66.28	166	44.31	127	47.29	119

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Palau	40.93	31.70	66.42	0.00	42.19	54.55	41.11	62.78	40.93	147	24.53	27	41.65	113	58.66	176
Panama	1.89	32.51	66.42	0.00	43.75	52.07	37.48	54.08	1.89	85	24.73	28	40.62	104	53.07	154
Papua New Guinea	0.27	20.39	83.04	0.50	43.75	35.54	42.75	59.59	0.27	55	26.11	40	43.25	119	47.56	123
Paraguay	0.00	0.00	66.42	55.20	42.19	35.54	32.37	54.08	0.00	1	44.20	128	37.28	73	44.81	86
Peru	0.51	30.60	62.59	36.80	43.75	65.29	32.37	61.46	0.51	62	41.70	121	38.06	79	63.38	179
Philippines	4.05	19.24	74.78	0.00	53.13	28.10	43.86	59.79	4.05	109	23.51	21	48.49	151	43.95	66
Poland		52.09	66.42	19.30	45.31	37.19	32.37	54.08			39.28	115	38.84	90	45.63	100
Portugal		25.58	72.79	29.30	48.44	22.31	37.86	54.08			39.24	114	43.15	118	38.20	11
Puerto Rico	7.60	33.98	66.42	0.30	39.06	33.88	32.37	54.08	7.60	123	25.25	33	35.72	62	43.98	67
Qatar	5.92	43.67	66.42	0.00	37.50	38.84	32.37	54.08	5.92	117	27.52	53	34.93	54	46.46	112
Romania		17.81	72.27	38.40	25.00	29.75	32.37	54.08			41.72	122	28.68	19	41.91	40
Russian Federation		66.93	66.42	21.80	43.75	42.98	33.00	72.84			44.24	129	38.37	86	57.91	169
Rwanda	0.00	58.01	66.42	0.00	40.63	73.55	36.30	80.42	0.00	1	31.11	74	38.46	87	76.99	196
St Vincent and the Grenadines	13.33	22.80	86.12	0.00	42.19	26.45	32.37	46.38	13.33	131	27.23	52	37.28	73	36.41	6
Samoa	4.00	12.38	100.00	0.00	21.88	29.75	32.37	61.13	4.00	103	28.09	56	27.12	11	45.44	97
Sao Tome and Principe	0.17	7.98	81.31	54.90	65.63	32.23	60.83	62.77	0.17	43	49.77	138	63.23	195	47.50	121
Saudi Arabia	5.51	37.87	66.42	23.70	53.13	28.10	33.93	54.08	5.51	115	37.92	109	43.53	124	41.09	31
Senegal	9.37	53.66	79.04	94.10	53.13	81.82	44.01	59.60	9.37	127	80.22	182	48.57	152	70.71	191
Serbia	0.00	0.00	69.01		26.56	25.62	27.74	54.08	0.00	1			27.15	15	39.85	23
Seychelles	32.80	0.00	62.80	0.00	67.19	30.58	26.95	54.08	32.80	140	15.70	1	47.07	144	42.33	47
Sierra Leone	2.75	42.05	97.36	0.00	23.44	93.39	71.95	59.04	2.75	96	34.85	92	47.70	149	76.22	194
Slovakia	0.00	28.74	66.42	0.10	39.06	28.10	32.37	54.08	0.00	1	23.84	23	35.72	62	41.09	31
Slovenia		30.01	74.88	0.00	40.63	22.31	38.57	54.08			26.22	41	39.60	93	38.20	11
Solomon Islands	0.20	13.58	93.97	0.00	46.88	47.93	32.37	57.01	0.20	47	26.89	48	39.62	94	52.47	151
Somalia	1.37	35.26	66.42	79.90	35.94	42.15	34.99	70.31	1.37	78	65.37	163	35.46	61	56.23	162
South Africa	0.18	26.45	70.12	66.20	46.88	38.84	32.37	54.08	0.18	45	57.24	151	39.62	94	46.46	112
S. Georgia and Sandwich		33.68	0.00		15.63	22.31	100.00	90.12					57.81	186	56.22	161
Spain		52.31	68.78	69.10	57.81	31.40	32.37	54.08			64.82	162	45.09	133	42.74	51
Sri Lanka	3.02	18.00	66.42	24.40	48.44	35.54	32.37	58.79	3.02	99	33.31	83	40.40	100	47.16	118
St. Kitts and Nevis	13.33	59.22	80.97	0.00	29.69	39.67	32.37	74.42	13.33	131	35.05	93	31.03	30	57.05	163
Sudan	0.32	63.83	66.42	66.80	68.75	61.98	35.71	54.08	0.32	56	65.96	165	52.23	168	58.03	171
Suriname	40.93	8.33	66.42	0.00	57.81	28.10	32.37	59.37	40.93	146	18.69	7	45.09	133	43.73	65
Svalbard		0.00	66.42		20.31	43.80	29.21	0.00					24.76	6	21.90	1
Swaziland	0.00	49.38	72.61	49.00	32.81	34.71	28.71	54.08	0.00	1	55.00	145	30.76	29	44.39	79

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Sweden		31.03	66.42	0.00	34.38	38.02	32.37	54.08			24.36	24	33.37	45	46.05	105
Switzerland	0.00	37.74	66.42	0.00	28.13	29.75	32.37	54.08	0.00	1	26.04	38	30.25	27	41.91	40
Syrian Arab Republic		22.44	71.48	98.10	42.19	30.58	34.10	54.08			72.53	175	38.14	85	42.33	47
Taiwan. Province of China	8.12	41.08	92.26	0.00	43.75	36.36	32.37	54.08	8.12	124	33.33	84	38.06	79	45.22	95
Tajikistan	0.00	94.26	67.98	39.90	50.00	33.06	32.37	83.10	0.00	1	60.51	155	41.18	107	58.08	173
Tanzania. United Republic of	0.36	24.37	66.42		73.44	42.15	32.37	54.08	0.36	57			52.90	170	48.11	126
Thailand	6.53	9.16	74.93	6.80	67.19	46.28	37.96	54.08	6.53	121	24.42	25	52.57	169	50.18	145
Timor-Leste	0.20	83.03	96.60	0.00	60.94	90.08	41.88	72.97	0.20	47	44.91	131	51.41	164	81.53	201
Togo	2.79	27.77	72.46	33.60	75.00	55.37	26.53	58.91	2.79	97	41.86	123	50.77	162	57.14	167
Tonga	13.33	59.76	84.89	0.00	56.25	33.88	32.37	95.39	13.33	131	36.16	101	44.31	127	64.64	184
Trinidad and Tobago		22.77	74.63	4.20	34.38	43.80	32.37	47.22			26.45	44	33.37	45	45.51	99
Tunisia	9.35	65.12	68.16	93.70	34.38	31.40	32.37	54.08	9.35	126	80.17	181	33.37	45	42.74	51
Turkey		0.00	66.42	77.20	62.50	33.88	32.37	54.08			55.20	146	47.43	145	43.98	67
Turkmenistan	0.00	61.32	66.42	100.00	51.56	33.88	32.37	54.08	0.00	1	81.93	184	41.97	115	43.98	67
Turks and Caicos Islands		39.30	66.42	0.00	17.19	31.40	35.67	54.08			26.43	43	26.43	10	42.74	51
Tuvalu	100.00	59.76	84.89	0.00	56.25	33.88	32.37	95.39	100.00	152	36.16	101	44.31	127	64.64	184
Uganda	0.00	32.37	66.42	16.20	46.88	51.24	32.37	64.68	0.00	1	32.80	80	39.62	94	57.96	170
Ukraine		42.14	66.42	65.40	34.38	29.75	32.37	54.08			59.84	153	33.37	45	41.91	40
United Arab Emirates	10.81	31.47	66.42	0.00	50.00	33.88	34.58	43.99	10.81	129	24.47	26	42.29	116	38.94	17
United Kingdom		23.49	66.42	0.00	32.81	34.71	32.37	54.08			22.48	15	32.59	41	44.39	79
United States		32.02	66.42	41.20	37.50	41.32	32.37	54.08			45.21	133	34.93	54	47.70	124
Uruguay	5.59	16.94	66.42	0.00	31.25	27.27	32.37	54.08	5.59	116	20.84	11	31.81	39	40.68	27
Uzbekistan	0.00	65.64	66.42	99.30	54.69	33.88	32.37	54.08	0.00	1	82.66	186	43.53	120	43.98	67
Vanuatu	4.00	41.81	66.42	0.00	32.81	74.38	15.16	54.08	4.00	103	27.06	50	23.99	4	64.23	182
Venezuela	2.50	30.09	66.42	49.20	39.06	29.75	32.37	54.08	2.50	93	48.73	137	35.72	62	41.91	40
Viet Nam	34.13	10.75	72.97	0.00	64.06	25.62	42.54	54.08	34.13	144	20.93	12	53.30	177	39.85	23
Virgin Islands. U.S.		59.22	80.97	0.00	29.69	39.67	32.37	74.42			35.05	93	31.03	30	57.05	163
West Bank		0.00	70.03	96.00	70.31	33.06	38.23	54.08			65.51	164	54.27	179	43.57	62
Western Sahara	0.53	22.58	67.14	15.10	26.56	27.27	32.37	40.14	0.53	65	29.98	70	29.47	22	33.71	3
Yemen	1.22	50.39	67.80	30.30	45.31	28.93	34.31	100.00	1.22	75	44.70	130	39.81	99	64.46	183
Zambia	0.00	46.42	70.74	16.30	95.31	66.94	42.63	66.34	0.00	1	37.44	108	68.97	200	66.64	188
Zimbabwe	0.00	34.36	71.68	67.30	81.25	31.40	38.52	62.07	0.00	1	60.16	154	59.88	193	46.74	114

Appendix 3: Components of SCCVI by group of countries

group of countries	SCCVI number of countries	SCCVI Mean	SCCVI Median	SCCVI Standard Deviation	PERMANENT SHOCKS number of countries	PERMANENT SHOCKS Mean	PERMANENT SHOCKS Median	PERMANENT SHOCKS Standard Deviation	RECURRENT SHOCKS number of countries	RECURRENT SHOCKS Mean	RECURRENT SHOCKS Median	RECURRENT SHOCKS Standard Deviation
All Developing countries (DCs)	116	36.43	35.89	6.77	116	25.27	22.98	11.60	142	46.72	45.75	7.48
Least Developed Countries (LDCs)	46	38.28	38.38	8.04	46	25.62	20.19	14.62	49	51.03	51.02	7.58
All Developing countries non LDCs	72	35.48	34.77	6.30	72	25.47	24.92	10.49	95	44.56	44.60	6.40
Low and Lower Middle Income countries	84	37.64	37.21	7.13	84	26.32	23.70	13.00	95	48.54	48.92	7.50
Low and LMI countries non LDCs	39	36.66	36.72	5.92	39	26.80	26.57	10.95	47	45.85	45.40	6.42
Small Islands Developing States (SIDS)	29	38.00	34.60	9.42	29	28.47	24.19	16.66	31	46.41	44.86	6.85
SIDS non LDCs	18	35.98	34.29	7.51	18	26.63	24.50	12.73	20	45.04	44.56	4.73
SIDS-LDCs	11	40.19	38.67	11.85	11	31.49	20.45	22.04	11	48.89	49.75	9.37
Landlocked Developing Countries (LLDCs)	27	37.14	36.87	6.24	27	26.93	30.08	11.55	29	47.02	48.79	8.12
LLDCs non LDCs	11	39.43	40.09	4.96	11	35.03	35.33	6.94	13	43.64	42.97	6.41
LLDCs-LDCs	16	35.56	33.52	6.67	16	21.36	16.91	10.86	16	49.76	49.45	8.50

group of countries	PERMANENT SHOCKS number of countries	PERMANENT SHOCKS Mean	PERMANENT SHOCKS Median	PERMANENT SHOCKS Standard Deviation	Sea level rise number of countries	Sea level rise Mean	Sea level rise Median	Sea level rise Standard Deviation	Over aridity number of countries	Over aridity Mean	Over aridity Median	Over aridity Standard Deviation
All Developing countries (DCs)	116	25.27	22.98	11.60	122	7.17	1.15	17.49	135	43.31	37.97	18.54
Least Developed Countries (LDCs)	46	25.62	20.19	14.62	48	7.50	0.67	18.33	47	42.50	36.41	18.48
All Developing countries non LDCs	72	25.47	24.92	10.49	76	7.20	1.37	15.48	89	43.46	38.83	18.57
Low and Lower Middle Income countries	84	26.32	23.70	13.00	88	8.27	0.62	21.38	91	45.64	40.70	19.00
Low and LM Income countries non LDCs	39	26.80	26.57	10.95	41	8.19	0.63	21.27	45	48.48	45.49	19.28
Small Islands Developing States (SIDS)	29	28.47	24.19	16.66	29	25.39	13.33	33.58	31	31.08	28.14	7.81
SIDS non LDCs	18	26.63	24.50	12.73	18	23.37	13.83	24.69	20	29.32	27.79	7.38
SIDS-LDCs	11	31.49	20.45	22.04	11	28.69	4.00	45.84	11	34.29	33.48	7.87
Landlocked Developing Countries (LLDCs)	27	26.93	30.08	11.55	28	0.02	0.00	0.10	27	53.37	60.16	22.54
LLDCs non LDCs	11	35.03	35.33	6.94	12	0.00	0.00	0.00	11	68.91	70.66	12.89
LLDCs-LDCs	16	21.36	16.91	10.86	16	0.03	0.00	0.13	16	42.69	33.82	21.71

group of countries	number of countries	RECURENT SHOCKS			Rainfall shocks			Temperature shocks		
		Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
All Developing countries (DCs)	142	46.72	45.75	7.48	43.31	43.39	10.77	50.13	46.60	10.07
Least Developed Countries (LDCs)	49	51.03	51.02	7.58	47.74	49.06	11.91	54.32	50.18	10.90
All Developing countries non LDCs	95	44.56	44.60	6.40	41.00	40.62	9.28	48.11	45.09	8.97
Low and Lower Middle Income countries	95	48.54	48.92	7.50	45.71	45.60	10.73	51.37	48.11	10.71
Low and LM Income countries non LDCs	47	45.85	45.40	6.42	43.45	43.25	8.86	48.26	45.63	9.55
Small Islands Developing States (SIDS)	31	46.41	44.86	6.85	40.72	41.18	9.75	52.10	48.50	10.97
SIDS non LDCs	20	45.04	44.56	4.73	40.70	41.18	5.90	49.39	47.15	8.94
SIDS-LDCs	11	48.89	49.75	9.37	40.77	39.62	14.81	57.02	52.47	12.95
Landlocked Developing Countries (LLDCs)	29	47.02	48.79	8.12	44.57	43.53	11.37	49.47	46.05	9.61
LLDCs non LDCs	13	43.64	42.97	6.41	40.95	38.06	10.78	46.33	44.39	4.91
LLDCs-LDCs	16	49.76	49.45	8.50	47.51	49.57	11.31	52.02	46.15	11.73