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Towards an index for Climate Resilient Development

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Executive Summary

The threats posed by climate change are increasingly seen as a major problem for the future of nature and humanity, and significant improvements are needed to set the world on a climate change resilient path to the future.

At global, regional and local level there is an increasing demand from both policy makers and the business sector for understanding relationships between climate change, disaster risk and development as well as metrics and policy options to deal with them. Meeting this demand is fraught with difficulties due to the multitude of objectives/criteria that need to be considered as well as to the interrelated nature of these domains, which are dynamic and evolving over time. Identification of the countries, groups of people, and sectors most seriously threatened by climate change is very urgent. This report reviews the main concepts and metrics used to assess and manage climate change risk within an international context, which considers climate resilient development as a central issue.

Chapter 2 introduces the main issues related to climate resilient development. Climate resilience is indicated as the new context for development. There is an emerging trend, which integrates climate change resilience into development planning and into resources allocation for development.

Chapter 3 gives an overview of the concepts and terminology identifying the main elements of the international debate on vulnerability, adaptation and resilience. However, the debate about standard definitions for most of such key concepts is still open within the international scientific community.

Chapter 4 analyses in depth five climate change indices aiming at measuring all or just a few components of climate change risk with a global coverage. The review highlights that there is no consensus on concepts and metrics for a climate change risk index.

Subsequently a joint analysis of these indices is carried out to verify whether, despite the differences in conceptual framework, we can achieve a common geography of the hot spot areas for climate change risk and vulnerability (chapter 5). Results show a consensus on the relevance of climate change risk in developing countries.

The analysis highlights some open questions and gaps on conceptual frameworks, metrics, and data to build an index for climate resilient development.

The report identifies key issues that will be addressed to build a platform towards an index for climate resilient development:

(i) Climate services and information should be considered as global public good. This requires that such information should be scientifically consistent, transparent, accessible to a vast public and have a global coverage;

(ii) The information provided should be coherent with many policy frameworks such as climate resilient development, low carbon development, and green growth;

(iii) Metrics applied to allocate resources for climate adaptation should be linked to indicators to monitor and evaluate adaptation actions;

(iv) The central role of ecosystem services should be recognised including indicators on ecosystem vulnerability and adaption;

(v) Efforts to build new data sets with global coverage should be implemented.

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1. Introduction

Over the last years a fundamental link between development, climate change, and disaster risk reduction strategies has been recognised (IPCC, 2014). Climate resilient development can be indicate as one of the political priorities at global level.

“Building resilience and reducing death from natural disasters”, and “reducing poverty as result of disasters and impacts of climate change” have been indicated as urgent targets within the context of the international debate on the Post-2015 Development Goals (UN, 2013).

United Nation Framework Convention Climate Change (UNFCCC) commits developed countries to support “developing Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation” (Art.4.4 UNFCCC, 1992).

The Hyogo Framework for Action: Building the Resilience of Nations and Communities to Disaster 2005-2015 supports the integration of disaster risk reduction and adaptation to climate change into sustainable development policies and planning including disaster risks related to climate variability and climate change (UNDSIR; 2013). At global, regional and local level there is an increasing demand from both policy makers and the business sector for understanding relationships between the determinants of climate change risk (hazards, exposure, vulnerability, and adaptation), as well as metrics and policy options to deal with such a risk.

Meeting this demand is fraught with difficulties due to the multitude of objectives/criteria to be considered as well as the interrelated nature of the determinants of climate change, which are dynamic and evolving over time.

Furthermore, a debate with respect to definitions and identification of precise relationships between all the concepts is still open.

This report reviews the main concepts and metrics used to assess and manage climate change risk within an international context, which considers climate resilient development a central issue. Building an index for climate resilient development involves dealing with the scientific and political challenges of climate change, disaster risk and development communities.

Most of the methodological problems are due to the presence of a plurality of frameworks, possible interpretations and the selection of indicators.

A clear definition of political objectives would reduce the vagueness of definitions. This could be a first step to building an index *fit for purpose*.

The report identifies key issues that will be addressed to build a platform towards an index for climate resilient development.

2. Framing the problem

There is scientific evidence that climate is changing and observations of Earth's average surface air temperature indicate evidence of planetary–scale warming (IPCC, 2013, National Academy and Royal Science, 2014).

The latest report of Working Group 1 of the International Panel of Climate Change (IPCC) published in 2013 states "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased" (IPCCC, 2013: p.7).

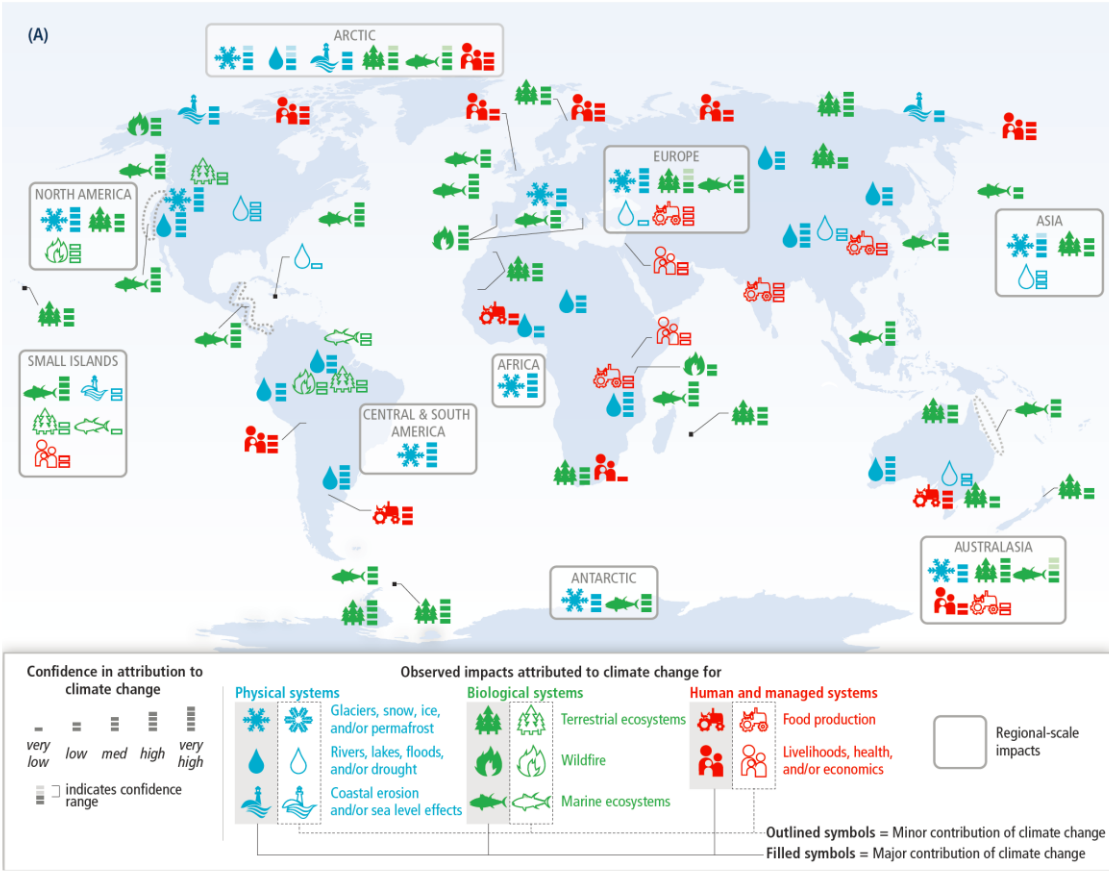
According to IPCC (2013) some events are directly related to climate change, namely, warming ocean, ice loss from glaciers; sea level rise (over the period 1901 to 2010, the global mean sea level rose by 0.19 [0.17 to 0.21] m), change in the global water cycle. Climate change is a fact and some natural events related to climate change have already some impacts in terms of losses and/or damages.

The climate and weather events can affect areas of concern for human society such as ecosystem services categorized as provisioning, regulatory, cultural, and supporting services (National Science 2013).

Changes in climate system can gradually have effects on some species causing loss of biodiversity, and extreme weather events can trigger regional catastrophes with effects on natural ecosystems influencing provision of resources such as water availability.

Figure 1 gives an overview of the observed impacts attributed to climate change for Physical, Biological, Human and managed systems with their geographical distribution.

Figure 1. Global Patterns of observed climate change impacts, at regional, sub-regional, and more local scales.



Source: IPCC, 2014.

It can have direct and indirect economic impacts on some sectors such as agriculture, commercial fisheries sector, ecotourism.

Table 1 summarizes some of the main direct and indirect impacts that a climate change and/or an unexpected event could generate on economy.

Table 1. Examples of direct and indirect impacts

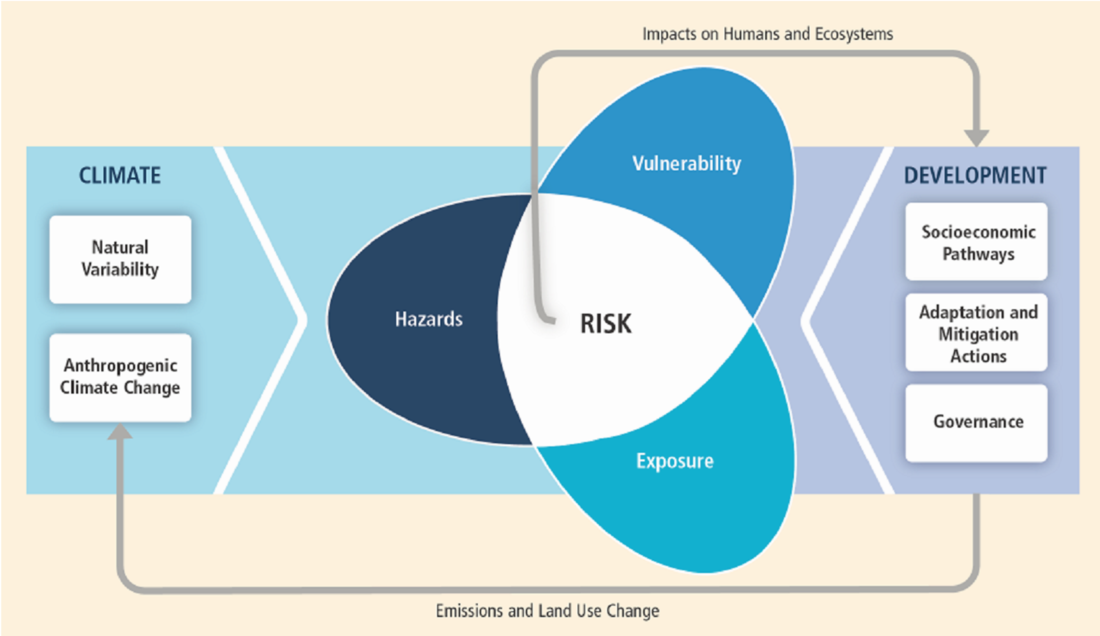
Direct Impacts	Indirect Impacts
Primary direct impacts	***Primary indirect impacts***
Physical damage to buildings and infrastructure	Loss of production due to direct damages
Physical damage to production equipment	Loss of production due to infrastructure disruptions
Physical damage to agricultural land	Loss of production due to supply-chain disruption
Physical damage to raw materials	
Physical damage to products in stock	
Physical damage to semi-finished products	
Secondary direct impacts	***Secondary indirect impacts***
Costs for recovery and reconstruction	Market disturbances (e.g. price variations of complementary and substitute products or raw materials)
Costs for remediation and emergency measures	Damage to company's image
	Decreased competitiveness, in the short term
	Increasing productivity and technological development, in the medium long term
	Economic growth for reconstruction
	Increasing poverty and inequalities

Source: Andreoni, Miola (2014)

All these events and impacts can be transformed into disasters when structural societal inequalities are present, thereby determining their high severity.

According to IPCC (2013, 2014) severity of disasters depends on weather and climate events, but also on exposure and vulnerability, which arises from non-climatic and multidimensional inequalities (Figure 2)

Figure 2. Core concepts of IPCC report Climate Change 2014: Impacts, Adaptation, and Vulnerability.



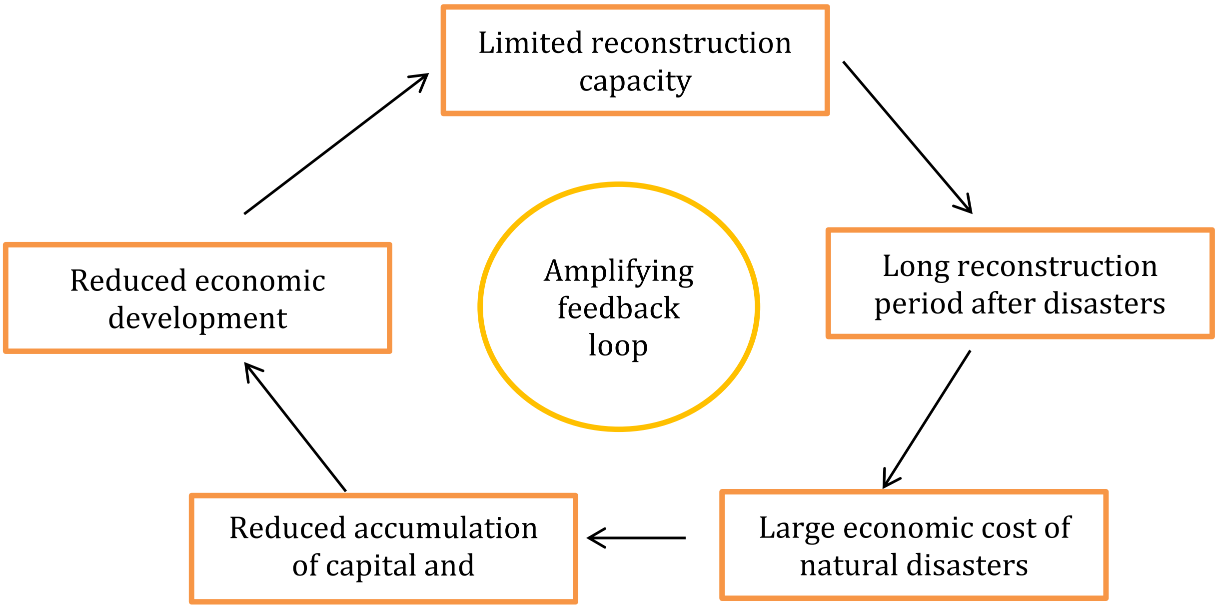
Source: IPCC, 2014

Hence, a fundamental link between development and climate change is clear.

Although the macroeconomic costs of the impacts of climate change are highly uncertain, this is likely to have the potential to threaten development (ADB et al. 2003).

"Natural disasters and climate change related events can increase poverty and inequality. When natural and man-made assets are destroyed in regions with limited capacity of saving, as for example developing countries, the low level of capital accumulation can be a real limit for reconstruction and a determining factor for poverty perpetuation. Estimations provided by Hallegatte et al., 2007 show how reconstruction capacity is a fundamental element to determine the overall impact of natural disasters. When reconstruction capacity is large enough the average GDP impact can be close to zero. On the contrary, when reconstruction capacity is limited the GDP impact can be very large. Rodriguez-Oreggia et al., 2009, used the World Bank's Human Development Index to analysed the impacts generated by natural disasters in Mexico. They found that municipalities affected by unexpected events see an increase in poverty by 1.5% to 3.6%. In Figure 3 some of the main feedback mechanisms existing between disasters and poverty are reported.

Figure 3. Amplifying feedback loop that illustrates how natural disasters could become responsible for macro-level poverty traps



Source: Hallegatte and Przyluski, 2010

From a theoretical perspective, disaster theory supports the idea that economic growth and development are important variables in the management of disaster and in the recovery and adaptation strategies. Empirical evidences also suggest a negative relation between development and disaster. The lower the level of development the higher the magnitude of costs (Albala-Bertrand, 1993; Anbarci et al,. 2005; Kahn, 2005). Based on that, development strategies are considered as an important element to reduce losses and damages for less developed countries (Okonski, 2004)". (Andreoni, Miola, 2014)

Matyas and Pelling (2012) argue a closer relationship between climate change adaptation and disaster risk reduction has shifted the paradigm in development practice. Development is often seen as a disaster risk management issue rather than one of economic growth (Ibidem, 2012).

With regard to the role of multidimensional inequality as driver of impacts and risks of climate change Shepherd et al. (2013) argue that poverty can be considered as one of the major determinants of risks, and economically, socially and politically marginalized people are often the population most vulnerable to climate change and to disasters.

There is an emerging trend, which integrates climate change resilience into development planning and into resources allocation for development.

All these efforts increase the demand for understanding relationships between the determinants of climate change risk (hazards, exposure, vulnerability, and adaptation) as well as metrics and policy options to deal with such a risk.

3. Concepts

One of the major problems in dealing with climate resilient development is that no consensus exists within the international scientific community about standard definitions for most of the key concepts such as vulnerability, resilience and adaptation.

All these are often described as rhetorical concepts since their definitions are characterised by vagueness with their meanings often overlapping (Hinkel, 2011).

According to Jansen and Ostrom (2006) the conceptual state of the art of resilience, adaptation, and vulnerability is a sort of *"Tower of Babel"* due to the distinct communities from which they originated.

A general discussion on concepts and definitions is far from being the objective of this report. However, clear definition of the terminology is a central tool to operationalize such concepts by identifying indicators that will be used to assess climate change risk components.

3.1 Vulnerability

Vulnerability is a central concept in climate change research and policy (Hinckel, 2011). It is mainly indicated as a social concept intrinsically interrelated with exposure, which can be considered as encompassing the spatial and temporal distribution of population and assets.

It has its roots in the study of natural hazards and poverty (Jansen and Ostrom, 2006). Any approach for assessing vulnerability needs to capture the complexity and the various tangible and intangible aspects of vulnerability in its different dimensions (IPCC, 2012; 2014).

According to Fussel (2007) in climate change research two groups of interpretation of vulnerability can be identified: the *end point interpretation* group, and *starting point interpretation group* (Table 2). The first group (*end point)* considers vulnerability as the (expected) net impacts of a given level of global climate change providing relevant information within the context of mitigation and compensation policies, and technical adaptation. In the latest IPCC WGII report (2014) this group of interpretations is defined as outcome vulnerability, which is the "end point of a sequence of analyses beginning with projections of future emission trends, moving on to the development of climate scenarios, and concluding with biophysical impact studies and the identification of adaptive options" (IPCC, 2014b p:19)

On the other hand, the *starting point group considers vulnerability* to be focused on the reduction of internal socio-economic vulnerability to any climatic hazards. This interpretation addresses mainly adaptation policy needs and social development (Fussel, 2007). IPCC WG II defines this approach as contextual vulnerability that is "A present inability to cope with external pressures or changes, such as changing climate conditions. Contextual vulnerability is a characteristic of social and ecological systems generated by multiple factors and processes" (IPCC, 2014b: p.8)

Table 2. Interpretations of vulnerability in climate change

	End-point interpretation	Starting-point interpretation
Root problem	Climate change	Social vulnerability
Policy context	Climate change mitigation, compensation, technical adaptation	Social adaptation, sustainable development
Illustrative policy question	What are the benefits of climate change mitigation?	How can the vulnerability of societies to climatic hazards be reduced?
Illustrative research question	What are the expected net impacts of climate change in different regions?	Why are some groups more affected by climatic hazards than others?
Vulnerability and adaptive capacity	Adaptive capacity determines vulnerability	Vulnerability determines adaptive capacity
Reference for adaptive capacity	Adaptation to future climate change	Adaptation to current climate variability
Starting point of analysis	Scenarios of future climate hazards	Current vulnerability to climatic stimuli
Analytical function	Descriptive, positivist	Explanatory, normative
Main discipline	Natural sciences	Social sciences
Meaning of 'vulnerability'	Expected net damage for a given level of global climate change	Susceptibility to climate change and variability as determined by socioeconomic factors
Qualification according to the terminology from Section 2	Dynamic cross-scale integrated vulnerability [of a particular system] to global climate change	Current internal socioeconomic vulnerability [of a particular social unit] to all climatic stressors
Vulnerability approach	Integrated, risk-hazard	Political economy
Reference	McCarthy et al. (2001)	Adger (1999)

Source: Fussel (2007)

This classification highlights two different perspectives.

The first group is mainly based on a risk hazard approach, whereas the starting point focuses on socio economic factors (Fussel, 2007). This distinction is central to define the political context, which will be more focused on climate change mitigation, compensation and technical adaptation for the end-point/outcome approach. By contrast, the starting point/contextual approach defines a political context driven by social adaptation and sustainable development (Fussel, 2007; IPCC, 2014).

3.2 Adaptation

The IPCC (2014) confirms the focus on risk as in the previous AR4 report (IPCC, 2012) and adopts a risk-based approach, which uses long-term, development-oriented actions that address both intensive and extensive risk around disaster cycles (Mitchell et al, 2013). Within this context adaptation has a central role in managing such a risk. According to IPCC (2014) although natural systems have the potential to adapt through multiple autonomous processes, human adaptation needs intervention to promote particular adjustments or to manage adaptation deficit minimising adverse impacts from existing climate conditions and variability.

Various conceptualizations and terminology exist for adaptation and its relation with vulnerability and resilience. Many schools of thought have applied different approaches to describe these concepts and their relations with the components of climate change risk.

Over the years, a number of additional adaptation approaches have been developed. We will not analyze them in depth, but Table 3 summarizes a number of different frameworks reflecting the diversity of contexts, different views, value systems, interests and perspectives of adaptation researchers and policy makers (Wiese, 2014).

Table 3. Summary of seven analytical frameworks for adaptation

Framing	Focus and emphasis
Livelihoods-based	This approach emphasises the importance of existing social conditions, individual perceptions, local experiences and informal institutions as critical aspects for determining how communities cope with current climate conditions as a starting point for developing appropriate adaptation responses
Impact-analytical	This approach of the IPCC views adaptation as a single (or few) decision(s) that is (are) taken on the basis of projected future impacts, where it is assumed impacts and decisions can be singled out and formally quantified and evaluated using multi-criteria, cost-effectiveness or cost-benefit analyses
Institution-analytical	This framing emphasises the need for horizontal integration of policy to mainstream climate change adaptation considerations into existing policy processes
Decision making under uncertainty	In this framing, the analysis starts with a concrete decision (e.g., raise dikes) based upon all information on the range of possible impacts, rather than with climate scenarios and projections of impacts
Social & institutional process	This framing emphasises how in linked social-ecological systems the outcomes of actions can usually not be predicted as they depend on actions of many agents as well as the social, cultural and natural context. The focal points of analyses thus are institutions (formal and informal rules) that shape the interplay between the actors
Multi-level governance	This framing emphasises how the cross-scale and systemic nature of climate impacts requires understanding and creating multi-level institutions and organisations that promote vertical and horizontal integration
Social learning & adaptive management	In this framing, the complexity and non-determinism of many resource management situations is recognised and adaptive processes of improving management goals, policies and practices through learning are adopted to help bridge the science-policy gap

Source: Wiese (2014)

Increasing efforts have also been made to mainstream adaptation into development policies in line with the central role that adaptation is playing within the global political context of the Parties of UNFCCC.

Nevertheless, the adaptation experiences encompassing countless sectors and different local communities are far from receiving a single classification or from defining a single approach. They can refer to actions addressing drivers of vulnerability, building response capacity, managing climate risk, confronting climate change (Mcgray, et al, 2007).

Most of these experiences raise concerns about the governance challenges. Aid to climate adaptation faces the same issues regarding allocation in the context of developing countries with lack of institutional capacity. Questions of equality, performance, governance and responsibility are very similar in both the development assistance and aid for adaptation literature.

3.3 Resilience

Resilience is often indicated as the ability of an entity or a system to "return to normal functioning quickly following a disturbance" (Prior, Hagmann, 2012: p. 282).

According to Holling (1973), resilience combines persistence, resistance and transformation. This definition introduces the idea of resilience as a pathway that can be reflected into decision making strategies:

1) Resistance of a system or of a component does not require any re-organization since any component remains at the same point of equilibrium and policy strategy is focused on mitigation;
2) Persistence: the system can re-organize its assets and returns to similar equilibrium level. The system is maintained in its status quo;
3) Transformation requires more significant structural changes and pushing the system to a different status quo.

There is an increasing interest in transformation in political, economic and technology systems to facilitate adaptation and sustainable development (transformational adaptation), in particular within the context of the management of the limits of adaptation.

As pointed out before, there is not yet a consensus within the international scientific community about standard definitions for most of the key concepts in the fields of climate change risk. However, we can indicate the key concepts proposed by the IPCC (2014) and summarised in Table 4 as a reference framework.

Table 4. Terminology in climate change. Source: IPCC, 2014.

Climate Change	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use
Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term *hazard* usually refers to climate-related physical events or trends or their physical impacts.
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
Risk	The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard.
Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.
Transformation	A change in the fundamental attributes of natural and human systems. Within this summary, transformation could reflect strengthened, altered, or aligned paradigms, goals, or values towards promoting adaptation for sustainable development, including poverty reduction.
Resilience	The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.

4. Metrics: analysis of some indices assessing climate vulnerability, adaptation and risk

The latest IPCC WG II report (2014) highlights the need for metrics to assess adaptation, vulnerability and risk. However, it states that this is a challenging task and that we are still far from adopting common standards, paradigms or analytical languages (IPCC, 2014 chapter 14; p. 27).

An increasing body of literature has been produced to build metrics for the key determinants of climate change risk, to design index assessing the climate change impacts, vulnerability and risks, to support tools for planning for adaptation, implementing measures and monitoring and evaluating climate adaptation. Nevertheless, no common reference metrics exist for assessing the main components of climate change risk. This is due to many factors such as: the conceptual confusion around the key elements as vulnerability, adaptation and resilience due to different scientific communities that have tried to resolve it (Fussel, 2007); and the vagueness of its definitions and objectives which the international political context dealing with climate change is characterised by (Hinckel, 2011).

This chapter reviews some climate change indices aiming at measuring all or just a few components of climate change risk with a global coverage.

We have selected five indices with open source access. They are: Global Climate change Risk Index (CRI); WorldRiskIndex (WRI); Notre Dame Global Adaptation Index (ND-GAIN); Center for Global Development (CGDev); Climate vulnerability Monitor (DARA).

Our review is based on the analysis of documents, data bases related to them and available on their websites.

We have adopted this approach since we consider climate information for a resilient development a global public good that should be accessible, scientifically consistent, and understandable.

Box 1:Index (Composite indicator), definitions

In general terms, an index (composite indicator) intends to provide an overall assessment of changes of the subject in focus (be it economic, environmental or social conditions), which can be easily interpreted and communicated well to the intended target audience. It is useful in indicating progress on the underlying goals or for benchmarking or policy-making purposes (JRC/OECD, 2008).

According to JRC/OECD (2008) ten main issues should be addresses to build a composite indicator:

1) The theoretical framework. This constitutes the basis for the selection and combination of indicators under a fitness-for-purpose principle. Ideally, the composite indicator, as well as the choice of indicators, reflects fully the aims behind it. Key elements of this framework are: (i) definition of the concept and (ii) the subgroups related to multi-dimensional concepts; (iii) identification of selection criteria.

2) Variables selection. Data is not always available or of high-quality, so it must be accepted that at times ‘second-best’ or 'proxy' indicators have to be used as component indicators. This should be done on the basis of relevance, analytical soundness, measurability, country coverage, and underlying relationships. However, the lack or the scarcity of quantitative data meeting all the above mentioned characteristics can be solved by the use of qualitative data.

3) Imputation of missing data. Consideration should be given to different approaches for imputing missing values using statistical and technical knowledge on environmental themes to be combined. Extreme values should be examined as they can become unintended benchmarks.

4) Multivariate analysis. This will explain the methodological choices and provide insights into the structure of the indicators and the stability of the data set. An exploratory analysis should investigate the overall structure of the indicators, assess the suitability of the data set and explain the methodological choices, e.g. weighting, aggregation.

5) Normalization. This is done to make the indicators comparable. Attention needs to be paid to extreme values as they may influence subsequent steps in the process of building a composite indicator. Skewed data should also be identified and accounted for.

6) Weighting and aggregation. This is done in line with the theoretical framework. Correlation and compensability issues among indicators need to be considered and either corrected for or treated as features of the phenomenon that needs to remain in the analysis.

7) Robustness and sensitivity. By means of these tests it can be decided to exclude certain indicators or use another technique for completing the data sets. Analysis should be undertaken to assess the robustness of the composite indicator in terms of, e.g., the mechanism for including or excluding component indicators, the normalization scheme, the imputation of missing data, the choice of weights and the aggregation method.

8) Links to other variables. Find out about linkages to other composite or aggregate indicators. Attempts should be made to correlate the composite indicator with other published indicators, as well as to identify linkages through regressions

9) Back to the real data. To improve transparency it should be possible to decompose the indicator into underlying values.

10) Presentation and Visualization. Composite indicators can be visualized or presented in a number of different ways, which can influence their interpretation and understanding.

We analyse the main elements of these indices to identify common characteristics, and to define a consensus on what and how to measure for a climate resilient development.

Our final objective is to assess whether these selected indices (or some of them) can provide *"objective comparison of levels of vulnerability between countries"* (Eriksen et al., 2007), and can identify areas for adaptation intervention within the context of Adaptation Initiatives defined by United Nation Framework for Climate Change (UNFCCC). Table 5 summarises the analysed indices. The indices are described using the terminology of their authors. It should be highlighted that even on this aspect there is no consensus. For instance, different terms like component, dimension and axis are used for indicating the group of indicators. Index, indicator, and composite indicator terms are often used as synonyms.

Table 5. Main characteristics of the indices analysed

Index	Author	Objective	Sub-index	Ranking	Geographical coverage /Data
Global Climate change Risk Index (CRI)	Germanwatch (2013)	Quantified impacts of extreme weather events	No sub-index	At top ranking the most affected countries of the last two decades (1993-2012)	MunichRe NatcaService Loss figures from 2012 and 1993 – 2012
World Risk Index (WRI)	UNU-EHS (2013)	Risk as interaction between hazards and vulnerability (comprising susceptibility, coping capacity and adaptive capacity)	1.Exposure; 2.Susceptibility 3.Coping capacities 4.Adaptive capacity	At the top ranking the country with the largest disaster risk worldwide	173 countries/ different data sources
Notre Dame Global Adaptation Index (ND-GAIN)	University of Notre Dame (2013)	Defining a guide to prioritize and measure progress in adapting to climate change and other global forces	1.Vulnerability : 1.1 exposure 1.2 sensitivity 1.3 adaptive capacity 2.Readiness: 2.1 economic 2.2 governance 2.3 social readiness	At the top ranking the most ready country (the most vulnerable country is at the lowest ranking)	177 Countries / 17 years of data (1995-2012)
Center for Global Development (CGDev)	Wheeler (2011)	Quantification of vulnerability to more extreme weather; sea level rise and loss of agriculture productivity for cost effective resources allocation for adaptation	1.Vulnerability to changes in Extreme Weather 2.Vulnerability to Sea level Rise 3.Agriculture Productivity Loss	Ranking is calculated at sub index level. At the top of the risk the country with the highest probability of impact from an extreme weather event, sea level rise.	233 States
Climate vulnerability Monitor (DARA)	DARA (2010)	Measures of Impacts of climate change on human health, weather, human habitat, and economies	1.health impacts 2.weather disasters 3.habitat loss 4.economic stress	No ranking but the country are comparable on the basis of five levels of vulnerability: Acute Severe High Moderate Low	184 countries and 20 Regions /observed and estimated data with different baseline year

4.1. Global Climate Risk Index

The Global Climate Risk index (CRI) of Germanwatch *"analyses to what extent countries have been affected by impacts of weather-related loss events"* (Germanwatch, 2013; p.2). The aim of this index is to indicate the level of exposure and vulnerability to extreme events as a warning for more extreme and more events. In 2006 the first edition of this Index was published setting as prime objective the periodical sensitization of *"the general public and the media to the impacts of extreme weather events, their relation to climate change, and to call for a differentiated discussion about the consequences"* (Germanwatch, 2006; p. 11).

CRI refers to direct impacts (direct losses and fatalities) due to weather-related events (storms, floods, temperature extremes and mass movements). It consists of 4 indicators: number of deaths; number of deaths per 100,000 inhabitants; sum of losses in US$ purchasing power parity (PPP); losses per unit of gross domestic product. The total ranking is an average ranking of countries based on the four indices with the following weighting: *"death toll 1/6, deaths per 100,000 inhabitants 1/3, absolute losses in PPP 1/6, losses per GDP unit 1/3"* (Germanwatch, 2013; p.3). Each indicator is expressed as an average figure for the 20-year period considered.

The latest edition of the index CRI 2014 is based on the loss figures from 2012 and 1993-2012 on the basis MunichRE NatCatservice[1] data and analysis.

The authors clearly stress that the Global Climate Risk index 2014 is a warning sign for the highest ranking countries because these are the ones most impacted by the *"climate variability of the last 20 years"*.

This aspect is evident when we analyse the statistics and correlation of the index as highlighted in the following Tables (6-7).

Indeed, the index has a value different from zero only when a shock resulting in losses or deaths is listed. Over the period 1993-2012 (Table 6) no country experienced any shock but focusing the attention on one year, 2012, (Table 7) the distribution of the indicator appears to be more problematic.

[1] For more information on this data base please see Annex II

Table 6. Climate Risk Index: Statistics and Correlation between components

1993-2012	Overall CRI Score	Death Toll	Deaths per 100000 inhabitants	Losses in million US$ PPP	Losses per GDP in %
Mean	91.21	145.60	0.41	691.72	0.54
Median	87.67	7.30	0.12	50.65	0.13
Standard Deviation	42.68	640.06	1.15	3627.04	1.25
Kurtosis[2]	-0.85	82.94	94.15	87.28	24.05
Skewness	0.24	8.44	8.77	9.13	4.60
Min	10.17	0.00	0.00	0.00	0.00
Country	*Honduras*	*Eq. Guinea +9 countries*	*Eq. Guinea +11 countries*	*Eq. Guinea +4 countries*	*Eq. Guinea +4 countries*
Max	175.50	7135.90	13.51	38827.02	9.07
Country	*Eq. Guinea +3courntries*	*Myanmar*	*Myanmar*	*United States*	*Grenada*
Correlation		-0.30	-0.41	-0.22	-0.35
Ranking Correlation		0.72	0.87	0.77	0.77

Note: 181 countries in the database built following the Germanwatch's report of 2014.

Table 7. Climate Risk Index: Statistics and Correlation between components

2012	Overall CRI Score	Death Toll	Deaths per 100000 inhabitants	Losses in million US$ PPP	Losses per GDP in %
Mean	82.28	36.43	0.17	940.66	0.31
Median	83.50	3.00	0.04	3.39	0.01
Standard Deviation	35.81	107.61	0.40	8705.82	1.67
Kurtosis	-1.15	24.10	29.10	166.27	102.84
Skewness	-0.29	4.71	4.87	12.70	9.57
Min	6.83	0.00	0.00	0.00	0.00
Country	*Haiti*	*Antigua and Barbuda +72*	*Antigua and Barbuda +71*	*Antigua and Barbuda +38*	*Antigua and Barbuda +44*
Max	126.17	719.00	3.28	115603.00	19.57
Country	*Antigua and Barbuda +40*	*China*	*Samoa*	*United States*	*Samoa*
Correlation		-0.46	-0.53	-0.17	-0.31
Ranking correlation		0.83	0.82	0.89	0.89

Note: 183 countries in the database built following the Germanwatch's report of 2014

[2] Kurtosis corresponds to the deviation of the analysed index from the normal distribution. Positive kurtosis indicates a relatively peaked distribution with respect to the Normal one (k=3). Negative kurtosis indicates a relatively flat distribution compared to the Normal.

This unbalanced distribution of the value of the index between countries and the high instability of the index from one year to another is explained by the fact that the index is based on unexpected weather-driven hazards.

Considering this characteristic CRI could be very useful to guide emergency, assistance.

The statistics calculated over the period 1993-2012 can be a good tool to identify the country which has suffered the most during the last 20 years of the weather driven hazards (or the climate variability). By summarizing the extreme events during a period of 20 years, the index calculated over 1993-2012 can be considered as a good index of exposure to natural hazards.

However, the CRI suffers from one important limitation due to data sources. Since it relies essentially on the MunichRE NatCatservice database the index is affected by the limitations of such a database, which is biased by construction towards the more developed countries for two reasons.

Firstly, the database is mainly constructed with insurances reports on losses. These reports exist where the insurances offices are located, therefore an under-representation of developing countries is likely.

Secondly, the component on monetary losses is biased toward countries where infrastructures are more important and costly.

Thirdly, the concepts and terminology used are not clearly defined and if we consider the terminology and concepts as summarised by Table 3, it is evident that there are some inconsistencies between CRI and the international scientific community outcomes on climate change.

The name “Global Climate Risk Index” can mislead the user since a climate risk index should consist of the main components of risk, such as natural hazards, exposure, vulnerability and capacity (adaptive and coping).

On the contrary, CRI provides a ranking of the countries most seriously affected by climate and weather events registered by MunichRE, which is not a transparent source of information and has limitations on geographical coverage.

Finally, the objective of the Global Climate Risk Index (raising awareness of climate change) is a risk communication issue and should be considered as a social and institutional problem addressing risk communication methods and involving many stakeholders.

4.2. World Risk Index

The World Risk index of the United Nations University Institute for Environment and Human Security was published in 2011 and 2012[3]. It was commissioned by the Alliance development works to give the probability with which a country might be affected by a disaster (WR, 2012). The core concept of the WRI is that "*whether a natural events turns into a disaster depends on the strength of the hazard as well as on the vulnerability of the people" (Ibidem, 2012)*.

This concept is translated into an index which consists of 4 components defined as follows: 1) exposure to natural hazards; 2) susceptibility likelihood of suffering harm; 3) coping capacities to reduce negative consequences; and 4) adaptive capacities for long term strategies for societal changes (Ibidem, 2012).

The exposure component consists of indicators on population, built-up area, and infrastructure component, environmental areas being exposed to the effects of one or more natural hazards (earthquakes, cyclones, droughts and floods). Vulnerability is considered as a sum of susceptibility (structural characteristics and framework conditions of a society expressed by public infrastructures, housing conditions, nutrition, poverty and dependencies, economic capacity and income distribution); coping capacity; and adaptive capacity.

Components are aggregated by the following geometrical formula:

(1) WRI= Exposure *[(Susceptibility) 33%+(Coping capacity)33% + (Adaptive Capacity)33%].

Table 8 summarizes the key statistics of the WRI underlining a very important correlation and overrepresentation of the component "exposure" as suggested by the formula (1).

[3] The 2013 one has been announced but it is not ready yet.

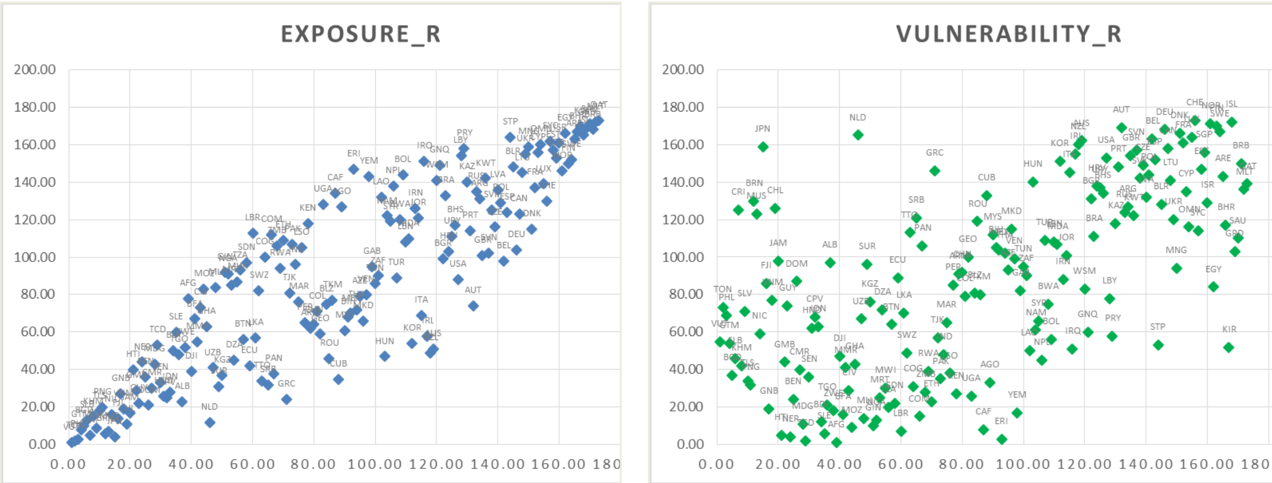
Table 8. World Risk Index: Statistics and Correlation between components

	World Risk Index 2013	Exposure	Vulnerability	Suscept.	Lack of Coping Capacity	Lack of Adaptive Capacity
Mean	7.40	14.73	49.50	31.35	69.79	47.35
Median	6.57	12.34	48.74	27.20	73.97	46.76
Standard Deviation	5.05	9.30	12.98	15.91	14.86	10.44
Kurtosis[2]	8.09	7.88	-1.06	-0.83	-0.76	-0.51
Skewness	2.23	2.45	0.08	0.68	-0.58	0.26
Min Value	0.10	0.28	27.30	9.50	37.63	27.52
Country	*Qatar*	*Qatar*	*Switzerland*	*Qatar*	*Austria*	*Iceland*
Max Value	36.43	63.66	75.41	67.42	93.44	76.11
Country	*Vanuatu*	*Vanuatu*	*Afghanistan*	*Madagascar*	*Afghanistan*	*Afghanistan*
Correlation		**0.92**	0.43	0.37	0.47	0.36
Ranking Correlation		**0.87**	0.63	0.63	0.63	0.55

Note: 174 countries in the database

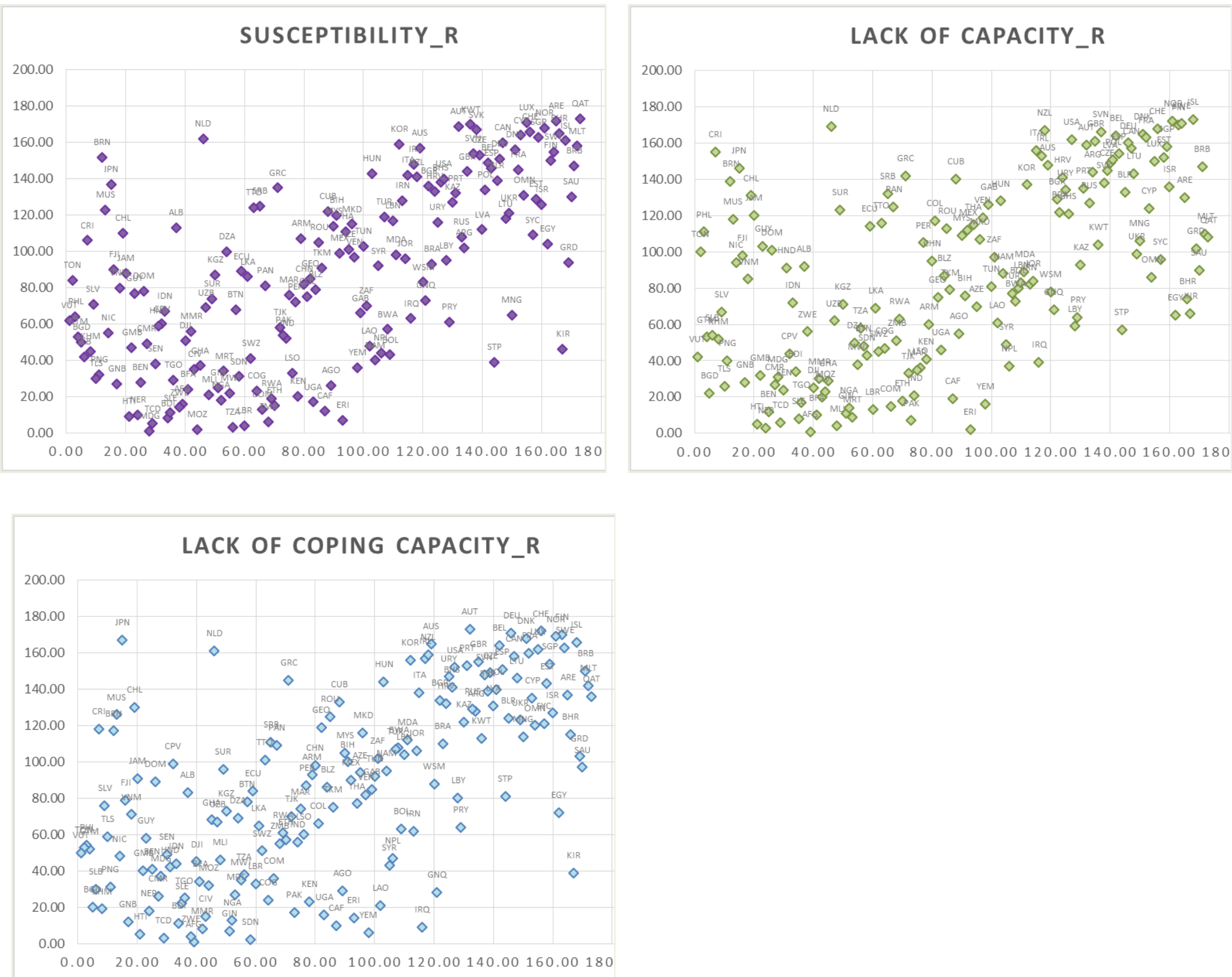
Graphics of the ranking correlation between the index (in y-axis) and each subcomponent (x-axis) confirm an over-representation of the "exposure" indicator (Figure 4).

Figure 4. Ranking correlation between the overall WRI indices (y-axis) and sub-components (x-axis) as indicated in the title



Source: Authors calculations

Figure 5. Ranking correlation between the overall WRI indices (y-axis) and Vulnerability' sub-components (x-axis) as indicated in the title



Source: Authors calculations

The ranking comparison permits to underline the countries having a high overall score in comparison with the other components and vice-versa (Figure 4).
For instance we can note that Japan, the Netherlands and Greece have a very high overall score compared to their vulnerability score (Figure 4).
On the contrary, Yemen, Eritrea or Angola are in the part of the graphic indicating a low level of overall index compared to their vulnerability score and more precisely the lack of capacity and adaptation components. This observation underlines that lack of adapting and coping capacity are less weighted in the index than exposure, which tends to undervalue the overall score of developing countries (Figure 5).

The WRI is easy to interpret and comparable. Its indicators are analytically and statistically robust (the authors provide the results of their sensitivity and factors analysis), reproducible and appropriate in scope. However, as the exposure component includes earthquakes together with storms, floods, droughts and sea level rise, the World Risk Index cannot be considered fit for purpose for indicating the country most vulnerable to climate change. Moreover the filling of missing data according to Templ routine for Robust Imputation of Missing Value in Compositional data (Templ et al. 2006) can be discussed. The routine permits to compare countries with similar characteristics and assign them the same value if data is missing in one country. Some countries (Kiribati, Bahamas, Fiji, Serbia, Tonga) have several data imputed for their indicators, so data in this area represents an average regional situation rather than a specific country exact value.

4.3. The Global Adaptation Index (ND- GAIN)

The Global Adaptation Index is the output of a project of University of Notre Dame[4] to define a guide to prioritize and measure progress in adapting to climate change and other global forces.

Its 2013 edition ranks 177 countries on the basis of 50 indicators over 17 years of data (1995-2010). It consists of two components, Vulnerability axis and Readiness axis.

The vulnerability axis consists of 36 indicators to "capture exposure to climate related hazards, sensitivity to their impacts and the ability to cope with those impacts" (Adaptation Institute, 2011: p. 14). Such indicators are grouped by sectors (water, food, health, human habitat, ecosystem service infrastructure (Coast, Energy, Transport)) under three equal weighted components: exposure, sensitivity and adaptive capacity.

The Readiness axis is based on 14 indicators and defines "the ability of country to absorb investment resources and successfully apply them to reduce climate change vulnerability" (Ibid, 2013, p.7). The indicators are organized into three components with different weights: Economic (50%), Governance (25%), social readiness (25%).

All indicators are scaled up to give a score between 0 and 1. Subsequently, the scores of the components are scaled to a value between 0 and 100. The ranking of countries is based on a final index aggregated by a linear formula:

(2) ND- GaIn score= (Readiness Axis score-Vulnerability axis score +1)*50

The comparison of its two axes is visualized by a ND-GAIN Matrix, which is a scatter plot divided into "four quadrants using the median scores for each of vulnerability and readiness" (ND GAIN Methodology, 2013; p.3). The matrix classifies countries into 4 categories: 1) countries with high vulnerability to climate change and low level of readiness; 2) countries not highly vulnerable, but not ready for investment; 3)

[4] In 2013 the Index moved to the University of Notre Dame. It was formerly housed in the Global Adaption Institute of Washington DC.

countries highly vulnerable but ready to accept adaptation investment; 4) countries with low vulnerability and ready and open for investment.

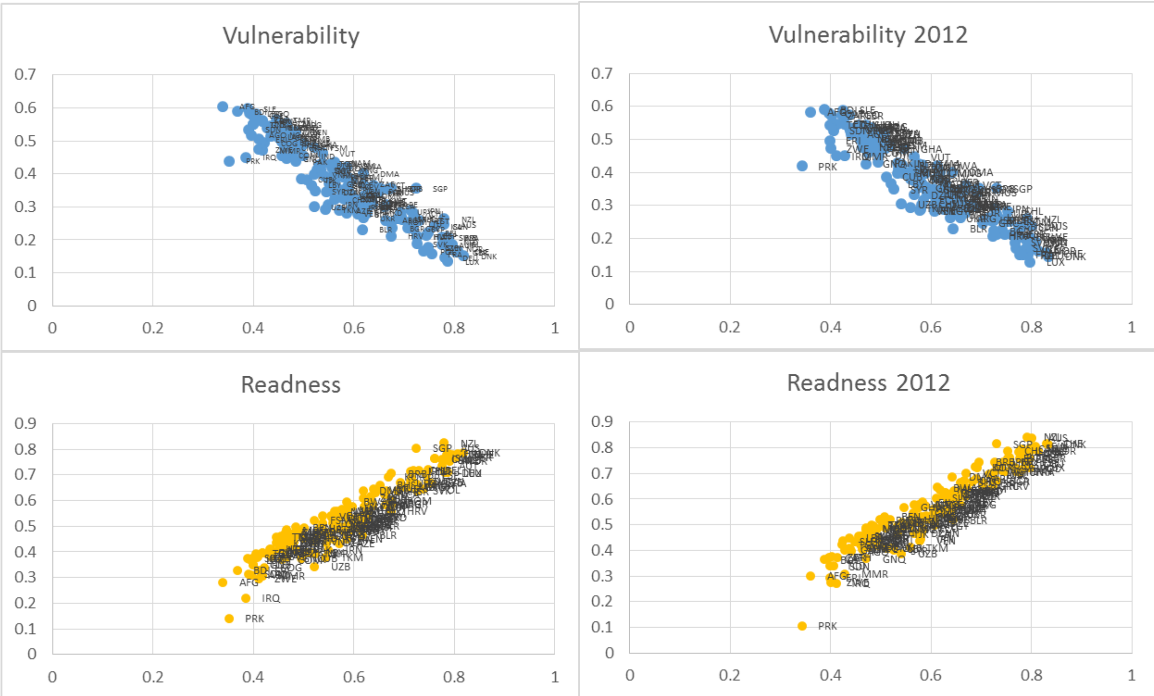
Table 9 and Figure 6 show a negative correlation between the vulnerability component and the Overall Gain Index explained by the formula 2 of aggregation of the index.

Table 9. ND-GAIN Index: Statistics and Correlation between components

	ND-GAIN	Vulnerability	Readness	ND-GAIN 2012	Vulnerability	Readness
Mean	57.80	0.37	0.53	59.92	0.36	0.56
Median	57.80	0.36	0.51	60.45	0.35	0.55
Standard Deviation	11.77	0.12	0.13	11.97	0.12	0.14
Kurtosis[2]	-0.86	-0.98	-0.33	-0.92	-0.94	-0.31
Skewness	0.14	0.09	0.19	0.06	0.08	-0.03
Min Value	33.81	0.14	0.14	34.32	0.13	0.11
Country						
Max Value	81.76	0.60	0.82	83.47	0.59	0.84
Country						
Correlation		-0.93	0.94		-0.93	0.95
Ranking Correlation		-0.92	0.94		-0.92	0.95

All countries present a high correlation of the two components and the Democratic People of Korea clearly appears as an outlier, probably because of the reliability of data in this state.

Figure 6. Plots between overall ND GAIN index (y-axis) and components (Vulnerability and Readiness) for overall period (1993-2012) in column 1 and year 2012 in the second column



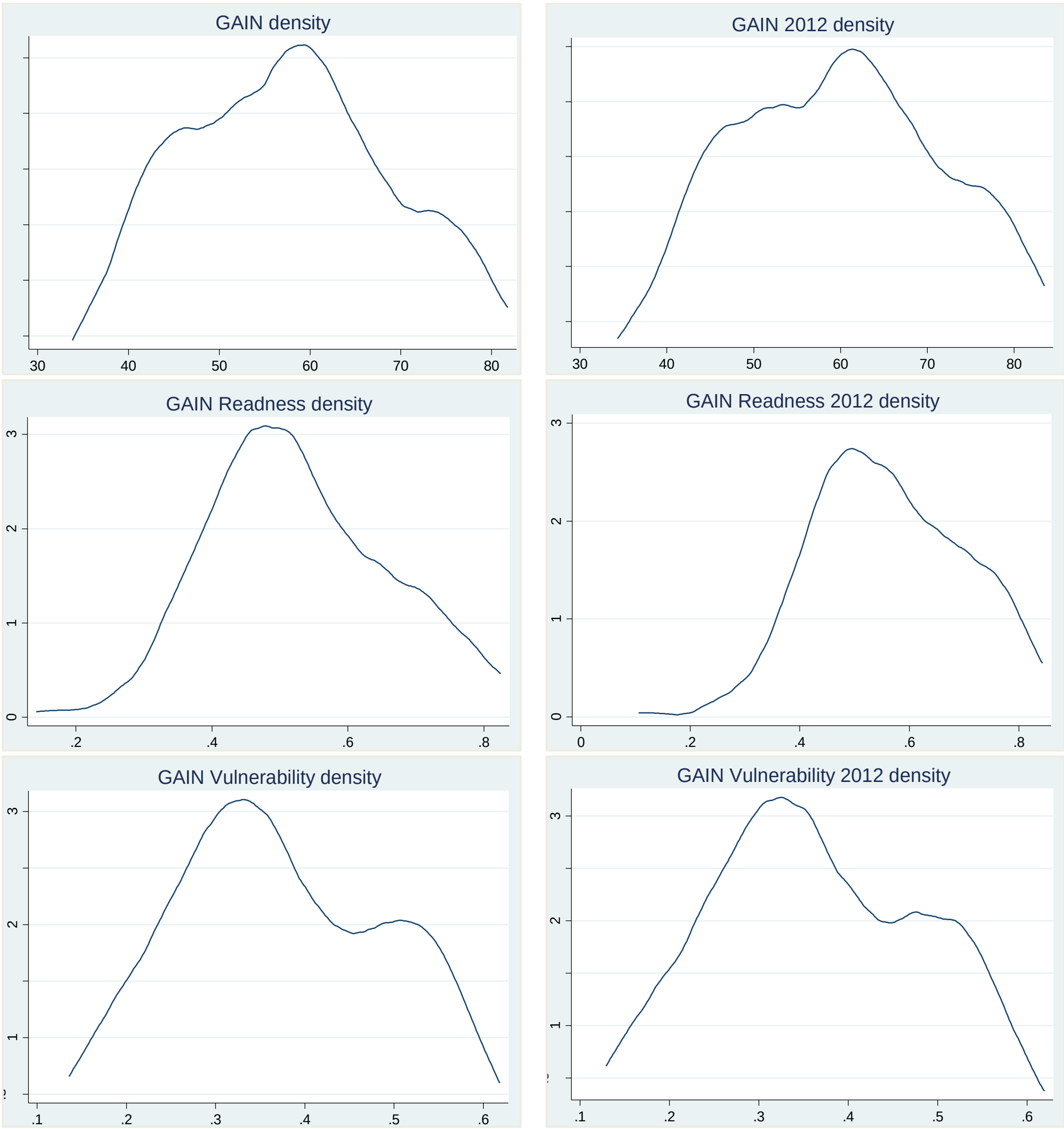
Source: Authors calculations

In the analysis of the distribution of Gain Index and components as showed by Figure 7 some elements can be highlighted.

Firstly, the distribution of the index is not normal and three groups of countries can be identified. Secondly, the distribution of the readiness index is completely asymmetric with high density of countries up to the mean of index but with an important outlier of countries driving the distribution.

Finally, vulnerability components seem to have a bi-modal distribution driving the three groups detected in the overall index distribution.

Figure 7. Distribution of ND Gain Index and Components



Source: Authors calculations

4.4. Quantification of Vulnerability to climate change of the Center of Global Development

In 2011 the Center of Global Development has published a study quantifying vulnerability to climate change by applying country impact indicators for three dimensions: vulnerability to change in extreme weather; vulnerability to sea level rise and loss of agriculture productivity. It is a global analysis applied to 233 States and it is based on the EM-Dat database of natural disasters for the period 1995-2008.

The climate impact risk is expressed as "function of radiative forcing from atmospheric accumulation of CO_2" (Wheeler, 2011: p.7).

For the change in extreme weather dimension the function of radiative forcing is incorporated into an equation including population, urban population percentage, information transparency, income per capita and quality of regulation.

As a result 1% increases in atmospheric CO_2 concentration are associated with an increase of about 30% in extreme weather risk.

The analysis provides also an estimation of weather-related risk for 233 countries in 2015 by calculating the impact of change of climate vulnerability (probability of being affected by climate related disasters from 2008-2015).

For the dimension on vulnerability to sea level rise the study includes a specific focus on 192 coastal and small island states estimating risk indices for two years (2008 and 2050).

These impact indicators are integrated within a methodology for designing cost effectiveness of resources allocation for adaptation.

An aggregate climate change index is proposed as a guide to allocation of resources for adaptation. It is:

$$\textbf{(3)}\ D = W + \rho_R R + \rho_A A$$

W= probability for an individual to be affected by weather-related event;

R=probability for an individual to be resident of a coastal area threatened by sea level rise;

A= percentage change in productivity from 2008 to 2050 for an individual employed in agriculture;

ρ_R= population of coastal storm surge zone for sea level rise/national population for extreme weather;

ρ_{A}= rural population/ national population for extreme weather;

4.5. Climate Vulnerability Monitor of DARA

The Climate Vulnerability Monitor has been mandated to DARA (international organization) by the Climate Vulnerability Forum[5] . Its first edition appeared in 2010, the second one in 2012.

The Climate Vulnerability Monitor aims at providing "*a framework for understanding global vulnerability to climate-related concerns*" (DARA, 2012) at global, regional and national scales. Its second edition tries to measure the impacts of two different areas (climate and carbon economy) for today and the near future (climate scenarios in 2030). Each area consists of four sub-indices measuring the effects of climate or carbon economy in terms of: health impacts, habitat changes, industry stress, and environmental disasters.

It combines indicators based on observed data with indicators estimated by models.

The index is a measure of the climate effect (CE) estimated by (i) attributing a climate impact factor to baseline data (indicators express incremental impact of climate change to selected social and economic value) or (ii) by using existing impact factors from complex models. A climate effect of 100 indicates neutral climate effect, above 100 indicates a negative climate effect and below 100 indicates a net gain from the

[5] The Climate Vulnerability Forum is an international cooperation group of developing countries. It was funded in 2009 by the Maldives and involves countries facing high climate vulnerability with a view to seeking a concerted response to climate change. It includes 20 governments and it is currently chaired by Bangladesh.

impact. Sub-index scores are built using a (mean absolute) standard deviation approach, classifying vulnerability in five levels as follows: (i) acute (most vulnerable category); (ii) severe; (iii) high; (iv) moderate; (v) low (least vulnerable category).

It also provides an estimation of the levels of absolute and/or relative loss or gain (impacts) implied by today's or tomorrow's (scenarios in 2013) situation.

The impacts are expressed as additional mortality, additional economic costs and additional persons affected.

The index is calculated for 184 countries grouped in 21 regions. Such regions provide the basis for extrapolations of data for those countries that do not meet the minimum data requirement.

The index provides also information on "multi-dimensional capacity" to address climate change based on the Government effectiveness index of World Bank, the Infrastructure and Human Capital Pillars of the Global Innovation Index.

The Climate Vulnerability Monitor[6] is a very complex information system on climate change impacts that can affect countries at global scale.

The output are realised in a very simple way by grouping countries into 5 levels of Vulnerability and giving effective visualizations of the impacts.

However, its methodology is not clearly described. It cannot be reproduced and it is not possible to appreciate its analytical and statistical robustness.

For instance, the choice of aggregating by category of vulnerability is highly disputable in an index. It allows to group countries and provides a high and clear visibility to the index but also raises the question of thresholds and choice of categorization (number of category and threshold definition).

However, since one of the main function of the DARA index is monitoring change, even though its interpretation is complex, it still gives a broad assessment of international trends in terms of vulnerability.

[6] DARA also published a Risk Reduction Index encompassing climate risks and available on web site.

4.6. Synopsis

In our review we do not identify a consensus on most issues related to the assessment of climate change risk of countries.

This section provides a synopsis of the analysed indices with regard to terminology, indicators.

Natural Hazards

In the analysed indices there is no consensus on which climate and/or weather events should be considered in evaluating climate change risks or to identify the most climate vulnerable countries. In general terms we can list and classify the climate change hazards information and indicators needed for a climate risk index as follows (EuropeAid, 2013):

1) Change in variability and extremes:
    - Rainfall variability, seasonality – droughts, predictability;
    - Changes in peak precipitation intensity (flood risk)
    - Changes in storm activity/behaviour/geographic distribution
    - Heat waves, wild fires, pollution events, etc.
2) Long term changes/trends in average conditions:
    - Warmer, wetter, drier, more saline groundwater
    - Shifts in climatic zones, ecological/species ranges
3) Abrupt /singular changes:
    - Monsoon shifts, circulation changes
    - Landscape &ecosystem transitions
    - Glacial lake outbursts.

Table 10 summarises the different approaches of the analysed indices with regard to the natural hazards indicators comparing the climate and weather events analysed by IPCCC (2013) and the climate extreme events included by the analysed indices.

CRI 2014 of Germanwatch includes the following extreme weather events: storms, floods, temperature extremes and mass movements (heat and cold waves) as defined by the NatCat Service database.

The World Risk Index refers to earthquakes, storms, floods, droughts and sea level rise including an event (earthquake), which does not have any role within weather and climate context.

ND-GAIN index 2013 indicates some estimated indicators for the exposure component: 1) projected proportional change in precipitation; 2) projected change in temperature; 3) estimated impact of future climate change on deaths from disease; 4) frequency of floods per unit area; 5) land and population living less than 10 m above sea level.

CGDev does not list the extreme weather events, which are included for quantifying vulnerability. However, since the index of the Climate Center for Development is based on EM-Dat we assume that this index includes some or all of the events classified as meteorological, hydrological and climatological events by the EM-Dat (for more details see Table 14 of chapter 6). The index includes a specific focus on sea level rise.

DARA vulnerability monitor includes floods, storms and wildfires within the weather disasters. Sea level rise and desertification are included in the habitat loss component.

Table 10. Climate and weather extreme events

IPCC 2013	GCRI (2013)	WRI (2013)	ND-GAIN (2013)	CGDev (2011)	DARA (2012)
warmer and/or fewer cold days and nights over most land areas (1)				Extreme weather events from EM-DAT, but no clear indications on them.	
warmer and/or more frequent hot days and nights over most land areas (1)					
warm spell/heat waves, frequency and/or duration increase over most land areas (2)	temperature extremes (cold and heat waves)	droughts	projected change in temperature		wildfires
heavy precipitation events, increase in the frequency, intensity, and/or amount or heavy precipitation; (3)	Floods	floods	projected proportional change in precipitation frequency of floods per unit area		floods
increase in intensity and/or duration of drought; (4)					desertification
increase in intense tropical cyclone activity; (5)	Storms	storms			storms
increased indices and/or magnitude of extreme sea level rise (6)		sea level rise	land and population living less than 10 m above sea level	Specific focus on sea level rise.	sea level rise
	+mass movements	*+ earthquakes*	*+ estimated impact of future climate change on deaths from disease*		*+ wildfires*

Note: in italic events in the index not included in IPCC 2013, Source: Authors calculations

(1) Very likely;

(2) Medium Confidence on a global scale. Likely in large parts of Europe, Asia and Australia;

(3) likely;

(4) low confidence on a global scale. Likely increased in Mediterranean and West Africa, and likely decreased in central North America and north-west Australia;

(5) low confidence on a global scale, virtually certain in North America since 1970;

(6) likely since 1970 (IPCC, 2013).

Vulnerability

Our analysis has identified confusion on the definition of climate risk and its components like vulnerability. We highlight lack of transparency on the methodology applied to assess vulnerability (such as simulation-model based, participatory and indicator based approaches), and the political reference framework (development, climate change, disaster risk).

For instance, all the analysed indices aim to indicate the most climate vulnerable countries, but for some of them the conceptual framework of their approach on vulnerability is missing.

The World Risk Index considers vulnerability as a sum of susceptibility (described as structural characteristics and framework conditions of a society expressed by public infrastructures, housing conditions, nutrition, poverty and dependencies, economic capacity and income distribution), coping capacity (capacity of society, including governance, to minimize negative impacts) and adaptive capacities (long-term process including structural changes).

Vulnerability is one of the two Axis of the ND-GAIN index including Climate risk (Exposure, and Sensitivity) and adaptive capacity.

In CGDev index vulnerability is expressed as probability to be affected by extreme weather events and sea level rise levels at country and individual levels.

It also includes a specific sub index on loss of agriculture productivity, which indicates probability of agriculture productivity losses by Regions in 2008-2030.

DARA monitor classifies vulnerability in five levels (Acute, Severe, High, Moderate, Low (least vulnerable category) based on estimated impact of climate change on human health, weather, human habitat and economies.

Table 11 summarises the definition of vulnerability for all the indices and for IPCC WGII 2014.

Considering the classification of vulnerability approaches proposed[7] by Fussel (2007) and IPCC WG II (2014), we can classify the analysed indices as follows:

1) End point/outcome Vulnerability: GCDev index and DARA monitor;

2) Starting point/contextual Vulnerability: ND- GAIN; WRI.

We do not classify CRI in any group since it does not indicate their definition of vulnerability.

Table 11. Definition of vulnerability and risk for the analysed indices and IPCC WG II, 2014.

Source	Definition
IPCC, 2014	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
CRI	No clear definition. This index ranks the most affected countries by climate and weather events
WRI	It consists of Susceptibility, coping capacity, and adaptive capacity components aggregated by a linear formula
ND-GAIN	The degree to "which a system is susceptible to, and unable to cope with adverse effects of climate change". It consists of exposure, sensitivity, and adaptive capacity
GCDev	Expressed as probability to be affected by extreme weather events and sea level rise levels at country and individual levels
DARA	Vulnerability is classified in five levels (Acute, Severe, High, Moderate, Low (least vulnerable category) based on estimated impact of climate change on human health, weather, human habitat and economies

[7] See Table 2

Annex I reports the Tables listing the indicators included by the analyzed indices as they are classified. Unfortunately, a comparison of such indicators is not possible because of the fragmented information on the units of these indicators. We can simply classify them on the basis of the name of the indicator.
These tables show one more time the heterogeneity of approaches and methodology to assess climate change risk by indicators.

Conclusions

Our review has highlighted that there is no consensus on concepts and metrics for climate change risk indices. It highlights the various objectives pursued by each index, the various conceptual frameworks and definitions they refer to. The analysis points also the dissonances that result from them.
Our analysis has identified the many weaknesses related to:

1) Conceptual framework. This should constitute the basis for the selection and combination of indicators under a fitness-for-purpose principle. Key elements of this framework are: (i) definition of the concept and (ii) the subgroups related to multi-dimensional concepts; (iii) identification of selection criteria.
   For most of the reviewed indices there is no clear definition of a conceptual framework. The used terminology creates confusion. For instance some indices are defined as climate indices without specific direct links with climate or weather events or variables;
2) Lack of transparency. To improve transparency it should be possible to decompose the indicator into underlying values. This is not possible for some of the analyzed indices. Some indices do not give information on the events analysed or on indicators included. Most indices include information on impacts estimated by different data sources. For instance CRI of Germawatch is based just on NatCaservice. Although this database is a good data source it presents some limitations that should be pointed out by the authors of CRI.

3) Data sets. All the indices aim at providing a comparison across countries on multi-dimensional aspects. However, the level of information and data available at global level is very limited (in terms of quality, coverage data and time span of data). In addition, the quality and coverage of data are also generally very poor in developing countries. This problem is evident in most of the reviewed indices, which are based on observed data, but also on estimations based on complex methodologies (for instance in DARA index).
4) Formula of aggregation. The rank can change on the basis of the formula of aggregation that should be chosen in line with the theoretical and the political frameworks. No consideration about this aspect is included in the analysed indices. It has to be emphasized that a linear approach implies absolute compensability of the components, where a country could still get a good score in the composite indicator by considerably over-performing in one or two themes while underperforming in all the others (JRC/OECD, 2008). For these reasons many practitioners warn against the use of linear aggregation, and propose instead non-compensatory approaches. According to the UN Inter-Agency Task Force on Climate change and Disaster Risk Reduction (2005), the Climate change risk is expressed by a geometrical relationship:

(5) ***Climate change risk = Natural Hazard * Vulnerability / Capacity***

The geometric aggregation followed by the WRI Multiplying indicators for exposure component with those of the vulnerability group captures the fact that the occurrence of a hazard, the exposure to a hazard or the vulnerability to a hazard are each on its own a necessary yet not sufficient condition for having a risk.

Despite these highlighted differences and weakness, all these indices aim at measuring all or just a few components of climate change risk with a global coverage. The next section will investigate what these indices have in common besides their name. Searching for a compromise through various approaches, sections 5 and 6 expose points of agreement between the indices, and they identify whether these indices have a common geography of risk and vulnerability to climate change.

5. Geography of climate change risk and vulnerability

Our review of the core elements of climate change risk identified by the selected indices has highlighted gaps in the analysed indices where important determinants of climate risk have not been captured because of a variety of technical and conceptual reasons.

To complete our analysis we sum up the information provided by the analysed indices to make a joint analysis and to verify whether despite the differences in conceptual framework we can achieve a common geography of the hot spot areas for climate change risk and vulnerability.

In the following statistical analysis we consider the areas of agreement and disagreements of the indicators studied. The main objective is to highlight whether, despite differences in conceptual frameworks and proxies some countries appear particularly vulnerable, regardless of the assessment by these indicators.

We consider WRI, CRI, CGDev and ND- GAIN[8] indices and use a sample of 169 countries for which all indices are available (availability of indices by country is reported in Annex I). The geographical coverage of the indices is not homogeneous, WRI is available for 173 countries while the CGDev's index is available for more than 200 countries and territories. DARA index is not considered as it does not provide any

[8] We don't introduce DARA's indicators because no composite indicator is available. The final data are composed of "a categorization" of the vulnerability (from 0 to 5) and economic and human losses. As explained, the aim of DARA is to monitor the change due to climate between 2010 and 2030 rather than ranking countries. It is therefore not fully relevant to this work.

ranks, but it classifies the countries into 5 groups of vulnerability as described in Chapter 4.5.

Table 12 shows the coverage of the indices by groups of income and geographical areas. Small islands in Pacific, Caribbean and Atlantic areas are the countries where coverage of the indices is most limited.

With regard to groups of income, high-income non-OECD countries and upper income countries have the lowest coverage, which can be explained by the difficulty of sharing data in these countries.

Table 12. Coverage of the indices by groups of income and geographical areas

		Nb of countries	Availability (in percentage)			
			CRI	WRI	ND-GAIN	CGDev
Income status	High Income Non OECD	48	43.75	37.5	35.41	100
	High Income OECD	30	90	90	90	100
	Low Income	45	91.1	88.8	93.3	100
	Lower Middle Income	58	86.2	86.2	87.93	100
	Upper Middle Income	53	81.13	71.69	75.47	100
Geographical group	Andean South America	4	100	100	100	100
	Atlantic Islands	9	33.33	33.33	33.33	100
	Australia NZ	2	100	100	100	100
	Caribbean Islands	27	48.14	29.62	37.04	100
	Central Africa	9	100	88.88	100	100
	Central America	8	100	100	100	100
	China regions	3	66.66	33.33	33.33	100
	Coastal West Africa	12	100	100	100	100
	East Africa	10	90	90	90	100
	Eastern Europe	22	100	95.45	95.45	100
	Indian Ocean Islands	6	66.66	50	66.66	100
	Middle East	14	85.71	92.86	92.86	100
	North Africa	5	100	100	100	100
	North America	3	66.66	66.66	66.66	100
	Northeast Asia	5	80	60	80	100
	Northern South America	8	80	80	80	100
	Pacific Islands	23	30.43	30.43	30.43	100
	Sahelian Africa	5	100	100	100	100
	Southeast Asia	11	100	100	90	100
	Southern Africa	7	100	100	100	100
	Southern Asia	5	100	100	100	100
	Southern South America	4	100	100	100	100
	Western Asia	9	100	100	100	100
	Western Europe	26	73.08	73.08	73.08	100

Note: CGDev'classification of countries, in grey availability of all indexes for all countries of the category

On a common sample of country. We ranked all countries of the sample based on their values for each selected index. Subsequently, we calculated a "mean rank" for each country (average of rank in each index).

We retain the last available version of the indices. Namely, the statistic exercise is done with the ND-GAIN index calculated in 2012, the CGDev 2011 and the World Risk Index in 2013 as these three indices clearly state that they assess climate change risk.

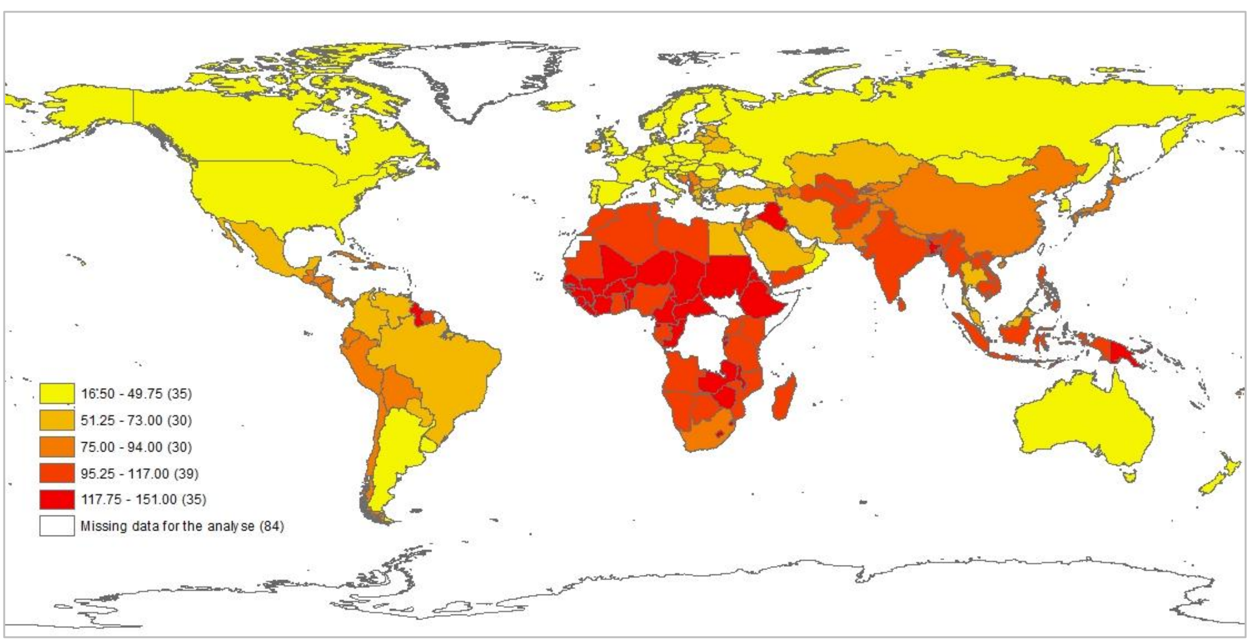
For the Climate Risk index the mean of the period 1993-2012 has been selected *as the CRI report states that the "climate variability of the last 20 years"* can be assessed by the study of the index over a long period (in any case CRI of an individual year cannot be representative of the long term climate change).

A mean rank of these four indices for the year indicated above has been calculated and is presented in Map 1.

In such a map, countries are grouped into 5 categories by means of the Jenks methodology, which consists of minimizing the intra-variance group.

The map highlights some hotspot areas concentrated in Africa and Asia.

Map 1. Mean Rank of the four indices

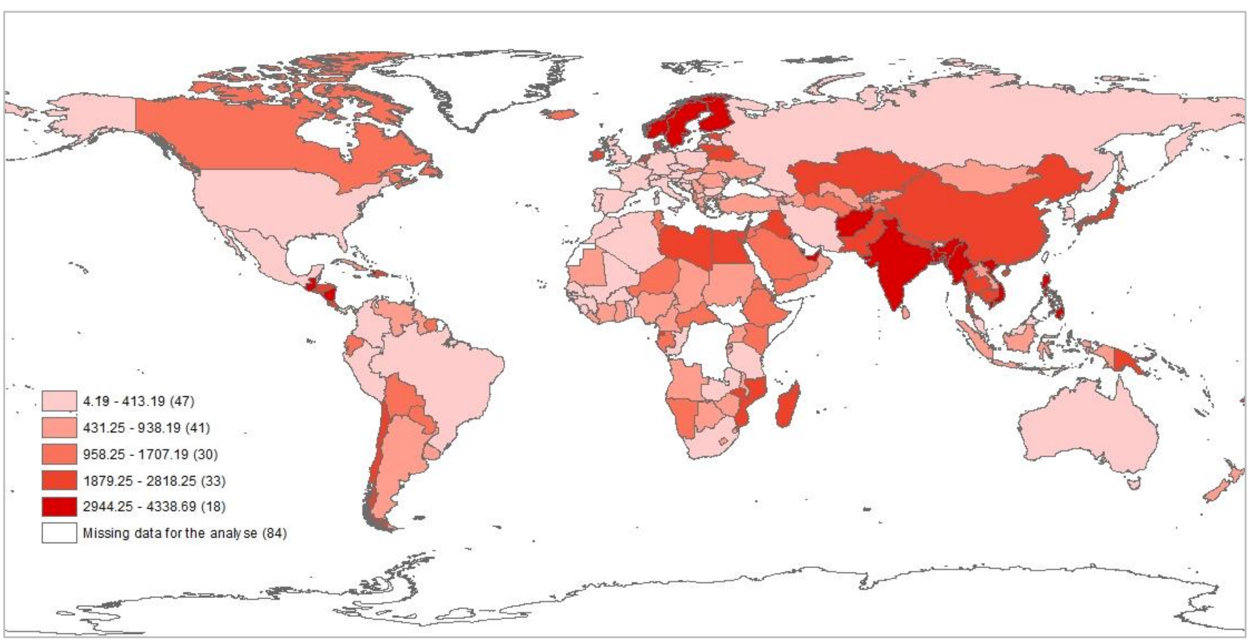


Source: authors' calculation. In brackets, number of countries in the category

We applied the same methodology to calculate the variance in ranking (Map 2).

This calculation aims to provide an overview of the area where the vulnerability ranking is the same between indices and where there is disagreement on the ranking of the country between indices. A high variance in ranking indicates an important disagreement between the indices about the place of a given country compared to the other in terms of climate change risk. Calculating the variance of rank per each country permits to identify the "switching country", i.e., country for which there is no consensus on the ranking (heterogeneous rank depending of the index). The results presented in Map 2 confirm that Africa is a hot spot area as variance in most African countries is under the median of the variances of the rest of the countries (excluding Mozambique and Madagascar). Thus, African countries present a high rank of climate change risk compared to other countries and this observation is common to all the indices examined. In Asia, by contrast, variance in ranking is very high showing that there is no consensus for this area. High variance is also evident for Caribbean and North European countries.

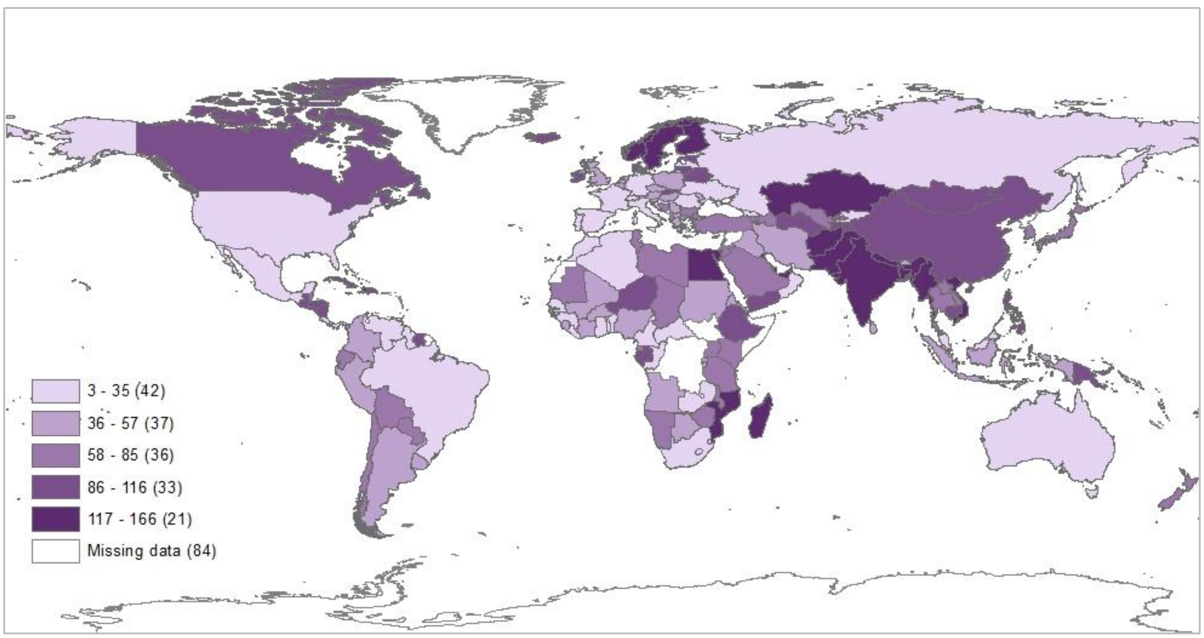
Map 2. Variance Rank of the four indices



Source: authors' calculation. In brackets, number of countries in the category

As the variance in ranking presented in Map 2 has been calculated on 4 indices we complete our analysis by providing additional statistics on the difference in ranking between the highest and the lowest for each country. Results are presented in Map 3. The analysis provides very similar results as the number of indices used to calculate the variance are low. The Jenks classification changes slightly. The categories and countries, like Libya and Iraq, seem less "switching" in the Map 3. Obviously these changes are not really significant.

Map 3. Highest Difference in ranking of the four indices



Source: authors' calculation. In brackets, number of countries in the category

The 10 countries presenting the highest variance are: Bangladesh, Barbados, Finland, Haiti, Malta, Myanmar, Norway, Philippines, Qatar, Singapore. As we can observe in the next table (Table 13), this high volatility between components is mainly due to the ranking of the Climate Risk Index which is completely different from the others.

In developing countries, the value of the CRI'index is very low compared to the other, because MunichRE NatCatservice database is not relevant in these countries. On the contrary the CRI index is extremely high in Nordic developed countries where insurance penetration is very high and hence MunichRE NatCatservice database is abundantly fed.

For this reason we reproduce the statistics exercise without the CRI index.

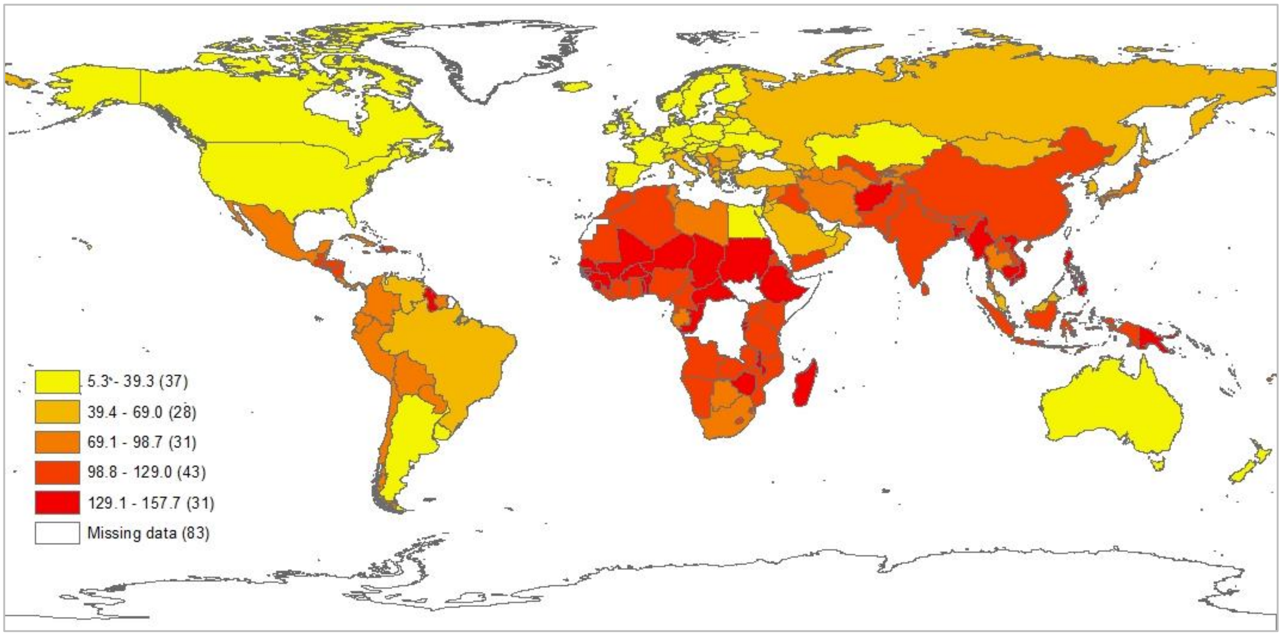
Table 13. Countries for which variance of vulnerability components is very important between indices

Country	GAIN	GAIN Rank	CRI	CRI Rank	WRI	WRI Rank	CGD	CGD Rank	Mean Rank	Var	rank MAX	rank MIN
Bangladesh	47.26	139	19.67	**5**	19.81	**165**	53.37	162	103	4914	165	5
Barbados	69.62	41	137.5	146	1.16	**3**	38.28	**147**	63.33	3657	147	3
Finland	80.80	4	154.2	**154**	2.28	9	6.417	**3**	55.67	4838	154	3
Haiti	44.92	152	16.83	**3**	11.88	150	34.68	139	101.6	4868	152	3
Malta	71.93	37	144.8	**150**	0.61	**2**	0.71	10	63	3988	150	2
Myanmar	42.87	**158**	11.83	**2**	9.1	129	47.30	157	96.33	4589	158	2
Norway	81.28	3	134.2	**143**	2.35	11	-3.715	4	52.33	4120	143	3
Philippines	57.45	102	31.17	**7**	27.52	167	30.35	124	92	4316	167	7
Qatar	66.79	46	175.5	**168**	0.1	**1**	3.989	36	71.67	4977	168	1
Singapore	73.12	30	168.5	**164**	2.49	12	0.568	**9**	68.67	4598	164	9

We retain the latest available version of the indices. Namely, the statistic exercise is done with the GAIN index calculated in 2012, the CGDev 2011 and the World Risk Index in 2013 as these three indices clearly state that they assess climate change risk.

The Map 4 shows the mean rank of the three indices. It highlights the same hot spot areas of the Map 1. Namely, Africa and Asia.

Map 4. Mean Rank of the three indices

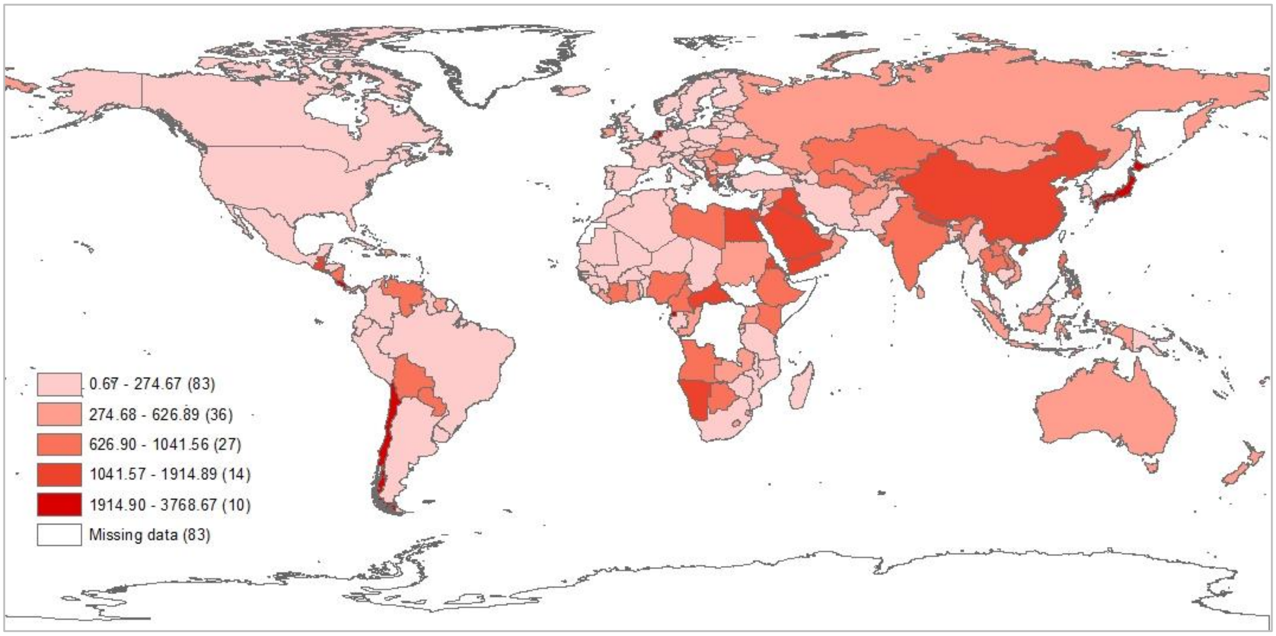


Source: authors' calculation. In brackets, number of countries in the category

Deleting the data base CRI, virtually nothing changes, the location of hotspots as was done in the first part of the analysis is roughly the same. While Map 4 is very similar to Map 1, the former, however, is more "stable" in the sense that the variances among countries have considerably decreased with the removal of the base CRI.

Map 5 appears completely different from Map 2 since only Asian countries remain significant switching countries.

Map 5. Variance Rank of the three indices



Source: authors' calculation. In brackets, number of countries in the category

The analysis has been restricted to the comparison of the vulnerability components as defined in each index. These are:

- Vulnerability component of GAIN index in 2012
- the CGDev 2011 vulnerability component
- Vulnerability component of WRI in 2013[9]

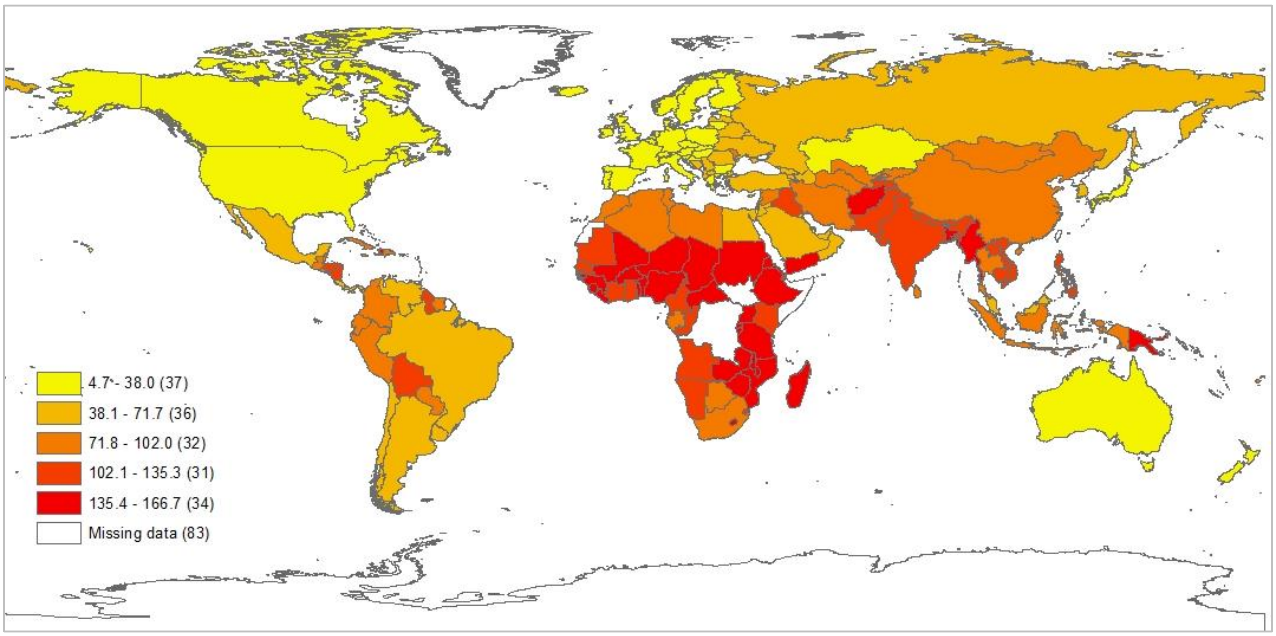
Map 6 shows the mean rank of vulnerability components. Results of Map 7 confirm hotspots vulnerability in developing countries compared to developed countries. European countries, United States and Australia are the least vulnerable countries.

Between developing countries results are in contrast and differ from the analysis of the overall climate risk indices. The hotspots in Asia seem less important as the

[9] We reduce the second part of the work to these three elements because they clearly aimed to address and assess vulnerability.

vulnerability of African countries remains very high. Comparisons with the analysis on overall indices seem to underline that the highest level of African countries as hotspots of Climate risk are mainly driven by the high climate change vulnerability of these countries, which is less the case for Asian and South American countries.

Map 6. Mean Rank of vulnerabilities components

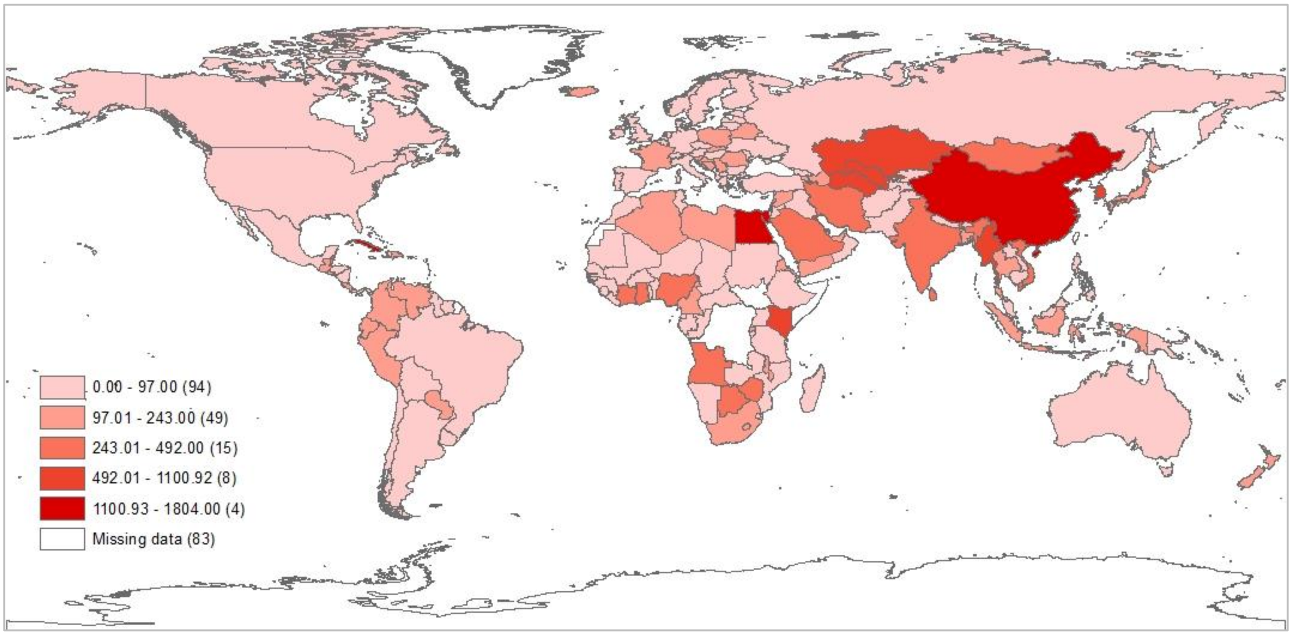


Source: authors' calculation. In brackets, number of countries in the category

As previously observed, the variance in ranking of vulnerability components has been calculated and confirms the results of variance of ranking between overall indices (Map 5). Obviously variance is less important for vulnerability components than for the overall indices. Consensus on the identification of vulnerable countries to climate change is more important as it is a sub-component of overall climate risk indices.

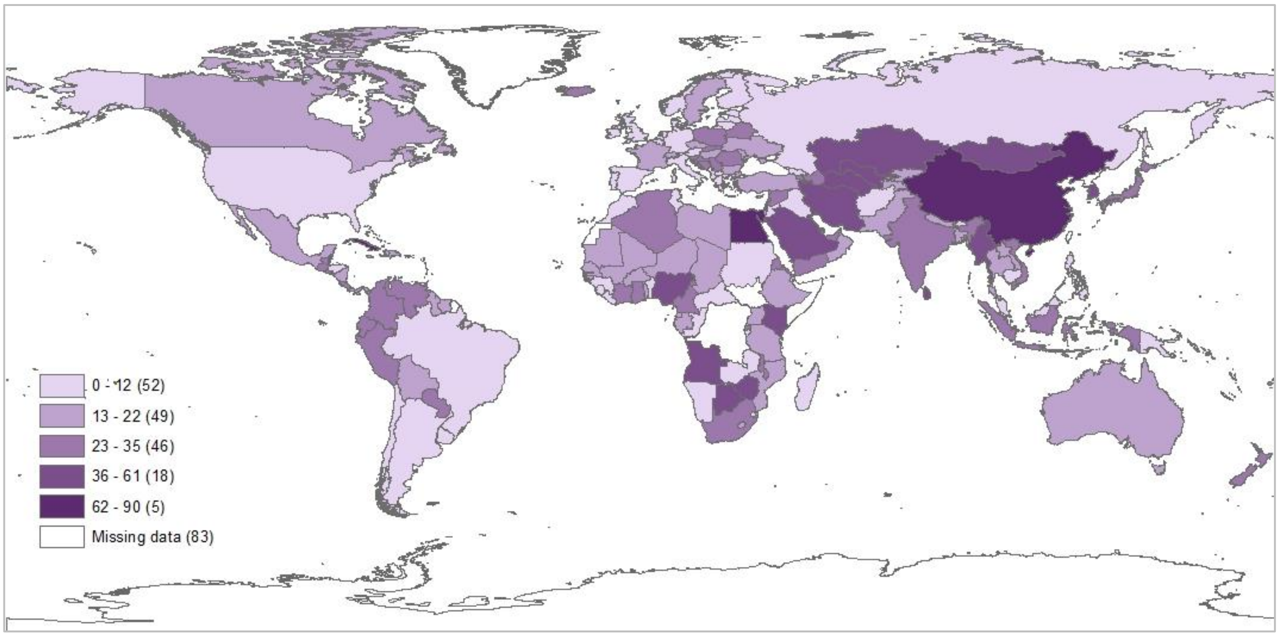
Map7 and Map 8 underlines and confirms less consensus for Central Asian Countries China vulnerability to climate level appears also debatable.

Map 7. Variance in vulnerability components



Source: authors' calculation. In brackets, number of countries in the category

Map 8. Highest Difference in ranking of the vulnerability components of indices



The identification of climate change risk and vulnerability geography brings together the studied indices. Although they differ in the definitions, indicators, methodologies or frameworks they refer to, the exercise allows to find "points of agreement" of these indicators.

Maps show a consensus on the relevance of climate change risk in developing countries. Particularly African countries are exposed to climate change risk and they appear especially vulnerable to climate change. On the opposite side of the spectrum, Latin American and Asian countries have a high level of risk to climate change, but the agreement on the level of vulnerability to Climate Change in these countries is on average less unanimous between the analysed indices.

6. Components analysis of indices

In this section we analyse the correlation between the different sub-components of each index. This statistical analysis completes the one done in section 5 as it details the points of consensus at sub-component level.

The correlations calculated are a ranking correlation by calculation of Spearman coefficient (Table 15) and a simple correlation analysis (Table 14). Stars indicate a level 0.01 of significativity. High significant correlation (with values up to 0.8) is marked red. Grey areas indicate the intra correlation between sub-components of the same indices.

On the intra-index correlations, we can see an important complementarity between the sub-components of the WRI index as the two components: exposure and vulnerability are correlated significantly but with a low level of correlation. WRI sub-components of vulnerability are highly correlated. In the same time, CGDev sub-components are not correlated at all. This part complete and confirm the chapter on each index.

We note that the correlation between CRI component and CGDev component is mainly due to the use of loss databases in the two sub-components of the indices. These components try to capture the same concept of loss they didn't refer to the same datasets, results suggest a correlation between the two datasets of losses used (EM-DAT of CGDev index and Munich RE for CRI index).

Table 14. Simple correlation between indices' components

		GAIN		CRI				WRI					CGD		
		Vuln	Read	dr	dpi	Imp	lpg	expo	vuln	scus	lcc	lac	scdi	acdi	wcdi
GAIN	Vuln	1													
	Read	**-0.78***	1												
CRI	dr	0.007	-0.141	1											
	dpi	0.026	-0.11	**0.789***	1										
	Imp	-0.141	0.081	**0.222***	-0.004	1									
	lpg	0.153	-0.147	0.0907	**0.298***	0.034	1								
WRI	expo	0.1513	-0.028	0.010	0.078	-0.009	0.133	1							
	vuln	**0.928***	**-0.87***	0.039	0.048	-0.114	0.133	0.112	1						
	scus	**0.906***	**-0.75***	-0.004	0.0158	-0.101	0.088	0.0791	**0.943***	1					
	lcc	**0.856***	**-0.90***	0.0672	0.084	-0.106	0.172	0.1722	**0.948***	**0.810***	1				
	lac	**0.867***	**-0.83***	0.0567	0.0356	-0.119	0.111	0.0536	**0.948***	**0.844***	**0.879***	1			
CGD	scdi	0.011	0.044	0.020	0.058	-0.033	**0.25***	0.094	-0.070	-0.114	-0.039	-0.033	1		
	acdi	**0.610***	**-0.54***	0.031	0.061	-0.133	0.056	0.027	**0.567***	**0.511***	**0.591***	**0.496***	0.063	1	
	wcdi	0.045	-0.125	**0.361***	0.023	**0.569***	0.069	0.079	0.082	0.059	0.10	0.0723	0.015	-0.028	1

The important correlation between GAIN and WRI sub-components need to be underlined. The two indices don't seem to capture the same concept but the correlation between vulnerability component of WRI and the both two components of GAIN (vulnerability and Readness) is important. Going in details, we can see that the sub-components of these two indices relies on indicators very similar.

Table 15. Spearman correlation between indices' components

		GAIN		CRI				WRI					CGD		
		Vuln	Read	dr	dpi	Imp	Ipg	expo	vuln	scus	Lcc	lac	scdi	acdi	wcdi
GAIN	Vuln	1													
	Read	**-0.79***	1												
CRI	dr	-0.099	-0.01	1											
	dpi	-0.091	0.09	**0.72***	1										
	Imp	**-0.38***	**0.27***	**0.77***	**0.50***	1									
	Ipg	0.19	-0.122	**0.30***	**0.48***	**0.51***	1								
WRI	expo	0.241*	-0.14	**0.20***	**0.22***	0.1357	**0.35***	1							
	vuln	**0.92***	**-0.87***	-0.003	-0.056	-0.32*	**0.21***	**0.25***	1						
	scus	**0.90***	**-0.81***	0.04	-0.02	-0.27*	**0.24***	**0.278***	**0.96***	1					
	lcc	**0.88***	**-0.90***	0.03	-0.03	-0.27*	**0.22***	**0.274***	**0.97***	**0.90***	1				
	lac	**0.86***	**-0.84***	-0.05	-0.11	**-0.34***	0.155	0.186	**0.95***	**0.86***	**0.90***	1			
CGD	scdi	-0.03	0.114	-0.096	0.031	-0.065	-0.118	0.152	-0.13	-0.16	-0.09	-0.12	1		
	acdi	**0.63***	**-0.52***	-0.15	-0.10	**-0.31***	0.048	0.097	**0.58***	**0.55***	**0.56***	**0.51***	0.05	1	
	wcdi	**0.47***	**-0.37***	**0.44***	**0.33***	**0.35***	**0.57***	**0.36***	**0.45***	**0.52***	**0.47***	**0.34***	-0.049	**0.30***	1

The correlation of sub-component underlines the high ambiguity in the concept, definition and vocabulary used. The name of subcomponent, which does not seem to refer to the same framework and concepts, use similar indicators. And in contrary, very similar indicators do not appear in the same sub-component group.

Testing these results some indicators showing similarities in their name (or concept) have been selected and compared from WRI and GAIN indices because these two indices presents high correlation between their sub components (Table 15).

Table 16 shows the results of this comparison. Although name, target population, scale are very analogous they are not classified into the same sub-component. For instance, the indicator *"population exposed to sea level rise and living above 5 meters"* is classified as an indicators of vulnerability axis (sensitivity group) in GAIN index. This indicator is classified as indicator of exposure component of WRI index.

This result seems to indicate that there is a sort of agreement on which indicators should be included into an index for climate change risk and development. The main problem remains how to classify them. This aspect is related to the confusion on the definition of conceptual framework, which is not a rhetorical exercise.

Table 16. Comparison of indicators, examples from WRI and GAIN indices

GAIN						WRI						Comparison		
Components	**VULN**	EXPO	SENS	CAP	**READ**	**Components**	**VULN**	SCUSC	LCC	LAC	**EXPO**	**Name**	**target pop**	**Scale**
Population living less than 5 m above sea-level (%)	x		x			Population exposed to sea level rise (possible from 1m to 6m)					x	x	x	x
Land less than 5 m above sea-level (%)	x	x												
Population with access to improved water supply (%)	x			x		Population with access to an improved water source	x	x				x	x	x
% Population with access to improved sanitation	x			x		Population with access to improved sanitation facilities	x	x				x	x	x
Children under 5 suffering from malnutrition (%)	x			x		Percentage of population undernourished	x	x				x		
Food import dependency (%)	x		x			Dependency Ratio	x	x				x		
Health workers per capita	x		x			Number of hospital beds per 10,000 persons	x	x	x					
						Number of physicians per 10,000 people	x		x					
Health expenditure derived from external resources (%)	x		x			Private per capita expenditure on health (percentage of total health expenditure)	x	x		x		x		
						Per capita expenditure on health government	x	x		x				
Longevity	x			x		Life expectancy at birth by country	x	x		x		x		
Projected proportional change in precipitation	x	x				Physical exposure to earthquakes, cyclones, floods and droughts	x	x						
Projected change in temperature (deg C)	x	x												
Frequency of floods per unit area (index based on observed floods)	x	x												
Internal and external freshwater water extracted for all uses (%)	x		x			Ecosystem vitality: Water effects on ecosystems	x			x				
						Water Quality Index (WQI)								
						The Water Stress Index (WATSTR)								
						Water scarcity index (WSI).								
Biome threat	x	x				Ecosystem vitality: Biodiversity & Habitat:	x			x			x	
						Biome protection (PACOV)								
Protected biomes	x			x		Marine Protected Areas (MPAs)								
						Critical habitat protection (AZE)								
Agric Capacity (index based on access to farm mechanization, fertilizers and irrigation)	x			x		Ecosystem vitality: Agriculture: agricultural water intensity (AGWAT)	x			x			x	
						pesticide regulation (AGPEST)								
						agriculture subsidies (AGSUB)								

7. Conclusion and way to forward

At global, regional and local level there is an increasing demand from both policy makers and the business sector for understanding relationships between climate change, disaster risk and development as well as metrics and policy options to deal with them. Meeting this demand is fraught with difficulties due to the multitude of objectives/criteria that need to be considered as well as to the interrelated nature of these areas, which are dynamic and evolving over time. A debate with respect to definitions and identification of precise relationships between the key components of climate change risk (vulnerability, resilience, adaptive capacity) is still open.

However, although these components are often described as rhetorical concepts as they are characterised by vagueness and their meanings often overlap (Hinkel, 2011), political commitments to deal with climate adaptation are a fundamental objective of the global climate policy agenda (such as Adaptation Fund, National Adaptation Plan of Action).

In a world of limited resources available to deal with climate change impacts, identification of the countries, groups of people and areas most seriously threatened by the phenomenon for policy actions is very urgent.

Achieving this political objective requires scientific support, which should provide "objective comparison of levels of vulnerability between countries". Over the last years an increasing body of literature has been produced to build metrics on the key components of climate change risk, to design indices assessing the climate change impacts, vulnerability, resilience and adaptive capacity, to support tools for planning for adaptation, implementing measures and monitoring and evaluating climate adaptation (UNFCCC, 2013). The latest IPCC WGII report states that "Vulnerability indicators define, quantify, and weigh aspects of vulnerability across regional units, but methods of constructing indices are subjective, often lack transparency, and can be difficult to interpret. There are conflicting views on the choice of adaptation metrics, given differing values placed on needs and outcomes, many of which cannot be captured in a comparable way by metrics" (IPCC, 2014; p. 12).

The results of our analysis are coherent with this conclusion. Indeed, our analysis of five climate change risk indices has highlighted some open questions on conceptual frameworks, metrics, and data, but at the same time it has identified a sort of geography for the climate change risk and vulnerability to climate change.

Moreover, our statistical review of the selected indices shows a sort of agreement on which indicators should be included into an index for climate change risk and development. The main problem remains how to classify them. This aspect is related to the confusion on the definition of conceptual framework, which is not a rhetorical exercise as pointed out above.

At the end of our analysis we can identify some key issues that should be integrated into an index for climate resilient development:

1) **Climate services and information as global public good.** This requires that that such information should be scientifically consistent, transparent, accessible to a vast public, and having a global coverage;
2) **A conceptual framework for a climate resilient development should :**
    a. **Integrate Mitigation and Adaptation**. According to IPCC WGII (2014) Climate resilient pathways are development trajectories of combined mitigation and adaptation to realize the goal of sustainable development (Chapter 20; page 5). Within this context mitigation and adaptation are not alternative. Mitigations actions contribute to sustainable development by contributing to the reduction of future rate and magnitude of climate change. Moreover, technological and institutional changes reducing net GHG emissions interact with development. This means that an index for climate resilient development should include metrics for mitigation action.
    b. **Identify coherence between the frameworks of climate resilient development, low carbon development, green growth and green economy.** As pointed out for mitigation and adaptation, all the above

mentioned policy objectives have strong overlapping that should be visible into supporting analytical tools such as an index.

3) **Ecosystem services.** Climate change adaptation is often seen as an issue of economic growth without capturing the complexity of climate change risk, which affects socioeconomic elements and the natural resources as well. Information on climate vulnerability of ecosystem services, and on the role of natural resources for adaptation actions should be highlighted.
4) **Links between metrics and concepts applied to allocate resources for climate adaptation and indicators to monitor and evaluate adaptation actions**;
5) **Data sets.** A key issue highlighted by our analysis is the general concern about the quality, coverage and time span of data, particularly since the most vulnerable populations are often in developing countries with the least reliable information. This lack of data gives a fragmented picture of the key components of climate change risk and its geography. International efforts for building up new data bases (including those on losses) should be supported.

Although we consider these key issues, and those highlighted in this report, as really urgent and relevant, integrating all them into a single index is really difficult.

For this reason, we propose the construction of a scientific platform organizing indicators, concepts and possible formulas of aggregation with a global coverage for climate resilient development.

Such a platform, which is proposed as an interface between science and policy in the domain of climate change risk, disaster risk management for humanitarian aid and development should provide transparent, objective, reliable, accurate, and open source information on the natural hazards related to climate change, vulnerability, adaptive capacity, mitigation, and resilience. It should propose indicators and formulas of aggregation. The aim of such a platform is not just to provide information needed to rank countries and allocate resources, but also to provide supporting tools coherent with many frameworks such as the climate resilient development, low carbon development, green growth and green economy ones**.** It will be up to the users to select indicators and mathematical formula for building their own composite indicators consistent with their political objective.

This could be a first step to building an index *fit for purpose*.

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Annex I - Lists of indicators

Table AI-1. Indicators for Exposure

ND-GAIN 2013	WRI	CRI	DARA	CfD
Projected change in precipitation	Percentage of expected average annual population exposed to droughts	NA	NA	NA
	Percentage of expected average annual population exposed to floods			
Land less than 10 m above sea-level	Percentage of expected average annual population exposed SLR			
Projected change in temperature	Percentage of expected average annual population exposed to earthquakes			
Projected change in agricultural yield	Percentage of expected average annual population exposed to storms and cyclones			
Coefficient of variation in crop yields				
Estimated impact of future climate change on deaths from disease				
Mortality due to communicable (infectious) diseases				
Urban concentration in largest city				
Urban risk				
Projected biome threat				
Dependency on natural capital				
Population with access to reliable electricity				
Frequency of floods per unit area				

Note: Up to black line comparable element, down to the black line non comparable components

Table AI-2. Indicators for Susceptibility and Sensitivity

ND-GAIN	WRI	CRI	DARA	CfD
Internal and external freshwater extracted for all uses	Share of the population without access to an improved water source	NA	NA	NA
Food import dependency	Share of population undernourished			
Urban population living in slums	Share of the population living in slums, proportion of semi-solid and fragile dwellings			
Mortality among under 5 yr.-olds due to water-borne diseases	Share of population without access to improved sanitation			
Health workers per capita	Dependency ratio (share of under 15 and over 65 years olds in relation to the working population)			
Health expenditure derived from external resource	Extreme poverty population living with USD 1.25 per day or less (purchase power parity)			
Population living in rural areas	Gini Index			
Excess urban growth	Gross domestic product per capita (purchasing power parity)			
Ecological Footprint				
Threatened species				
Population living less than 10 m above sea-level				
Energy at risk				
Roads paved				

Note: Up to black line comparable element, down to the black line non comparable components

Table AI-3. Indicators for Adaptive Capacity

ND-GAIN	WRI	CRI	DARA	CfD
Agricultural capacity fertilizer consumption, machinery, and % irrigation)(Low)	Agriculture management	NA	NA	NA
Population with access to improved sanitation	Combined gross enrollment ratio			
Population with access to improved water supply	Adult literacy rate per country			
Children under 5 suffering from malnutrition	Share of female representatives in the national parliament			
Longevity	Water resources			
Maternal mortality	Biodiversity and habitat protection			
Value lost due to electrical outages	Forest management			
Quality of trade and transport infrastructure	Gender parity in primary, secondary and tertiary education			
Protected biomass	Projects and strategies to adapt to natural hazards and climate change			
International Environmental Conventions	Public health expenditure			
	Life expectancy at birth			
	Private Health expenditure			

Note: Up to black line comparable element, down to the black line non comparable components

Table AI-4. Indicators for Coping capacity

ND-GAIN	WRI	CRI	DARA	CfD
IEF Business freedom	Corruption Perception Index	NA	NA	NA
IEF Trade freedom	Good Governance (Failed States Index)			
IEF Fiscal Freedom	National Disaster risk management policy according to report to the United Nations			
IEF Government Spending	Number of physicians per 10,000 inhabitants			
IEF Monetary Freedom	Number of hospital beds per 10,000 inhabitants			
IEF Investment Freedom	Neighbors, family and self help			
IEF Financial Freedom	Insurances			
Work Governance Indicators (WGI) Voice & Accountability	Share of population without access to improved sanitation			
WGI Political Stability & Non-Violence	Share of the population without access to an improved water source			
WGI Control of Corruption	Share of the population living in slums, proportion of semi-solid and fragile dwellings			
Tertiary Education	Share of population undernourished			
IEF Labor Freedom	Dependency ratio (share of under 15 and over 65 years olds in relation to the working population)			
Mobiles per 100 persons	extreme poverty population living with USD 1.25 per day or less (purchase power parity)			
WGI Rule of Law	Gross domestic product per capita (purchasing power parity)			
	Gini Index			
	Adult literacy rate per country			
	Combined Gross Enrollment Ratio			
	Gender Parity in primary, secondary and tertiary education			
	Share of female representatives in the National Parliament			
	Water resources			
	Biodiversity and habitat protection			
	Forest management			
	Agriculture management			
	Projects and strategies to adapt to natural hazards and climate change			
	Public health expenditure			
	Life expectancy at birth			
	Private Health expenditure			

Table AI-5. Indicators for Vulnerability

GAIN	WRI	CRI	DARA	CFDev
Population with access to improved water supply	Corruption Perception Index	Death toll	Excess deaths per capita due to climate change malnutrition	
Population with access to improved sanitation	Good Governance (**Failed** States Index)	Deaths per 100.000 inhabitants	Excess deaths per capita due to climate change Malaria	NA
Agricultural capacity fertilizer consumption, machinery, and % irrigation (Low)	National Disaster risk management policy according to report to the United Nations	Losses in million US $ purchasing power parity	Excess deaths per capita due to climate change Diarrhea	
Children under 5 suffering from malnutrition	Number of physicians per 10,000 inhabitants	Losses per GDP %	Denque	
Longevity	Number of hospital beds per 10,000 inhabitants		Excess deaths per capita due to climate change Cardiovascular diseases	
Maternal mortality	Neighbors, family and self help		Excess deaths per capita due to climate change Respiratory diseases	
Value lost due to electrical outages	Insurances (life insurances excluded)		Excess deaths due to climate change per capita	
Quality of trade and transport infrastructure	Share of population without access to improved sanitation		Excess deaths due to storms, floods, and wildfires due to climate change per capita	
Protected biomes	Share of the population without access to an improved water source		Excess deaths due to storms, floods, and wildfires due to climate change per GDP	
International Environmental Conventions	Share of the population living in slums, proportion of semi-solid and fragile dwellings		People at risk due to climate change - induced desertification	

GAIN	WRI	CRI	DARA	CFDev
Internal and external freshwater extracted for all uses	Share of population undernourished		Cost per GDP due to climate change	
Mortality among under 5 yr.-olds due to water-borne diseases	Dependency ratio (share of under 15 and over 65 years olds in relation to the working population)		Economic loss per GDP due to Climate change	
Population living in rural areas	extreme poverty population living with USD 1.25 per day or less (purchase power parity)		Excess damage costs relative to GDP due to floods	
Food import dependency	Gross **domestic** product per capita (purchasing power parity)		Excess damage costs relative to GDP due to storms	
Health workers per capita	Gini Index		Excess damage costs relative to GDP due to climate change for wildfires	
Health expenditure derived from external resource	Adult literacy rate per country		Excess damage costs relative to GDP due to floods	
Urban population living in Slums	Combined Gross Enrlolment Ratio		Excess damage costs relative to GDP due to natural disasters	
Excess urban growth	Gender Parity in primary, secondary and tertiary education		Excess population per capita at risk due to climate change in climatic zone: dry, steppe, vegetation type	
Ecological Footprint	Share of female **representatives** in the National Parliament		Excess population per capita at risk due to climate change in climatic zone: dry, steppe, vegetation type, subtropical desert with average temperature> 18° C	
Threatened species	Water resources		Excess population per capita at risk due to climate change in climatic zone: dry, steppe, vegetation type, cool dry climate middle latitude	

GAIN	WRI	CRI	DARA	CFDev
			deserts	
Population living less than 10 m above sea-level	Biodiversity and habitat protection		Excess population per capita at risk due to climate change in climatic zone: dry, steppe, vegetation type, subtropical desert with average temperature< 18° C	
Energy at risk	Forest managment		Tidal basin nourishment costs relative to GDP	
Roads paved	Agriculture management		Baech nourishment costs relative to GDP	
Projected change in precipitation	Projects and strategies to adapt to natural hazards and **climate change**		Land loss costs relative to GDP	
Projected change in temperature	Public health expendicture		Migration costs relative to GDP	
Projected change in agricultural (cereal) yield	Life expentancy at birh		River dike costs relative to GDP	
Coefficient of variation in cereal crop yields	Private Health expenditure		River flood costs relative to GDP	
Estimated impact of future climate change on deaths from disease			Salinity intrusion costs relative to GDP	
Mortality due to communicable (infectious) diseases			Sea dike costs relative to GDP	
Urban concentration in largest city			Sea flood costs relative to GDP	
Urban Risk			Wetland nourishment costs relative to GDP	
Projected Biome Threat			Costs relative to GDP due to effect on water	

GAIN	WRI	CRI	DARA	CFDev
Dependency on natural capital			Costs relative to GDP due to effect on agriculture	
Land less than 10 m above sea-level			Costs relative to GDP due to effect on ecosystem/biodiversity	
Population with access to reliable electricity			Change in fishery exports relative to GDP due to effect of fisheries.	
Frequency of floods per unit area				

Annex II - The Main Data sets on natural disasters used by the analysed indices

A climate risk index should make a comparison across countries on multi-dimensional aspects and it should be based on reliable global studies.

As pointed out previously, the level of information and data available at global level is very limited. In addition, the quality and coverage of data are also generally very poor in developing countries. This means that the picture that can be defined by a global index may not be very detailed. Numerous international databases on natural disasters and impacts exist from various sources.

This section provides an analysis of three of data sets used by the analysed indices, EM-Dat, MunichRE and SwissRE. This description aims at highlighting the general concern about the quality, coverage and time span of data, in particular in developing countries with the least reliable information

1. EM-Dat database: Critical analysis

The EM-Dat database was developed in 1988 and is maintained by the WHO collaborating Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the *Université catholique de Louvain* (Belgium).

The database contains data on the date and impact of natural and technological disasters in the world from 1900 to the present. Its main objective is *"to provide an evidence-base to humanitarian and development actors at national and international levels"*, the base can also constitute an objective basis for vulnerability assessment and priority setting.

EM-Dat provides free access to data by country, disaster profile or timeframe. It is updated on a daily basis. Once a month after validation of the entries, systematically reviewed for redundancy, inconsistencies and incompleteness, new data are made available without restriction on the website. The interface is user friendly and provides various analyses, maps and related documents for research using outputs of the database.

The database is built from various sources, including UN agencies (UNEP, OCHA, WFP, and FAO), non-governmental organizations (IFRC), insurance companies, research institutes and the media. Priority is given to data from UN agencies, followed by OFDA governments and the International Federation of Red Cross and Red Crescent Societies.

CRED defines a disaster as "*a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering*"[10]. EM-Dat distinguishes between two generic categories for disasters (natural and technological). The natural disaster category is divided into 5 sub-groups, which in turn cover 12 disaster types and more than 30 sub-types[11]. Table AII-1 gives a detailed description of the type of events and their classification.

[10] Glossary CRED EM-Dat : http://www.emdat.be/glossary/9

[11] See http://www.emdat.be/classification for the complete classification and definitions and Box 1.

Table AII-1. Type of the events, EM-Dat Classification for natural disaster

Disaster Sub-Group	Disaster Main Type	Disaster Sub-Type	Disaster Sub-sub Type
Geophysical	Earthquake	Ground Shaking	
		Tsunami	
	Volcano	Volcanic eruption	
	Mass Movement (dry)	Rockfall	
		Avalanche	Snow avalanche
			Debris avalanche
		Landslide	Mudslide
			Lahar-Debris flow
		Subsidence	Sudden subsidence
			Long-lasting sundidence
Meteorological	Storm	Tropical Storm	
		Extra-Tropical cyclone	
		Local/Convective Storm	Thunderstorm Lightening
			Orographic storm (Strong winds)
			Snowstorm Blizzar
			Sandstorm Dust storm
			Generic (severe) Storm
			Tornado
Hydrological	Flood	General river flood	
		Flash flood	
		Storm surge/coastal flood	
	Mass Movement (wet)	Rockfall	
	Landslide	Debris flow	
		Debris avalanche	
	Avalanche	Snow avalanche	
		Debris avalanche	
	Subsidence	Sudden subsidence	
		Long-lasting subsidence	
Climatological	Extreme Temperature	Heat Wave	
		Cold Wave	Frost
		Extreme Winter Conditions	Snow Pressure
			Icing
			Freecing Rain Debris avalanche
	Drought	Drought	
	Wild fire	Forest Fire	
		Land fires	
Biological	Epidemic	Viral Infectious Diseases	
		Bacterial Infectious Diseases	
		Parasitic Infectious Diseases	
		Fungal Infectious Diseases	
		Prion Infectious Diseases	
		Insect infestation	Grasshoper
			Locust
			Worms
		Animal Stampede	

Source: EM-DAT website

A disaster is included in EM-Dat if it satisfies one or more of the following criteria based on the declarations of the sources previously cited: (i) 10 or more people killed;
(ii) 100 or more people affected; (iii) a declaration of a state of emergency; (iv) a call for international assistance. Information for each disaster include: dates: start and end date[12], disaster type, name of the event, localization of the event: country,

[12] The event start date has been used as the disaster reference date

region …[13], number of people reported killed, injured, homeless and affected, and estimates of infrastructure and economic damages.

The units used for the size of the events are Richter scale for earthquakes, maximum wind speed (km/h) for storms, Celsius Degrees for extreme temperatures and km^2 affected for floods, droughts and wildfires.

Box 1: Definition of "*number of people affected injured…*"

In EM-Dat, the number of *people killed* include those confirmed dead and those missing and presumed dead.
People affected are those requiring immediate assistance during a period of emergency (e.g. requiring basic survival assistance such as food, water, shelter, sanitation and immediate medical help): "People requiring immediate assistance during a period of emergency, i.e. requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance. Appearance of a significant number of cases of an infectious disease introduced in a region or a population that is usually free from that disease"[14].
People reported injured or homeless are aggregated with those affected to produce the *total number of people affected*.
The number of victims is equal to the sum of persons reported killed and the total number of persons reported affected.

Source: based on EM-Dat website

The damages are provided in US $ in the value of the year of occurrence[15]. A deflation of these values is necessary to use the economic information of the data base.

The registered data of damages correspond to the value of the immediate damages, the direct consequences on the economy (crop losses, destruction of infrastructures etc.). The indirect consequences (loss in growth, unemployment…) are usually not taken into account.

[13] If a disaster occurred in several countries, the disaster event will result in several country-level disasters

[14] We can note that this very broad definition is ambiguous

[15] Exchange rate used "the one at the date the disaster happens"

1.1 Limits

Several points have to be highlighted with regard to the EM-Dat , especially for developing countries.

1. **Declaration of the events**: Data are "declared data". This aspect constitutes a non-objective assessment. Governments could overestimate the consequences of a natural disaster in order to increase aid or media visibility.
2. **Definition**: A fundamental difference in the definitions of disaster events and effects exists since a lack of standardization of the terminology used in this field complicates comparisons of data (Velasquez 2002). Even if this point has been particularly improved for EM-Dat, the classification of disaster types and sub-categories not balanced could be problematic, depending on the use of the data.
3. **Geographic Scales**: The scale aggregation problems must be underlined (Tschoegl 2006):
    a. On one hand, disaggregating a global (international) effect of large scale disaster is very difficult and may lead to overestimating the impacts of the event.
    b. On the other hand, EM-Dat maintains a global and national observation level, at these scales, smaller scale disasters could be "invisible".
4. **Date**: The date of occurrence of an event is not homogenously reported. Events are recorded as falling within a range while others report a specific date (Tschoegl 2006).
5. **Discrepancies**: Data are not considered to be homogenous temporally and geographically (Tschoegl 2006, Le Saout 2010).
    a. Quality of data is less good prior to the creation of the database (1988). Most of the econometric analyses based on EM-Dat begin in 1980, the ones prior to this date being considered not homogeneous. A positive trend can be identified in the data registered, especially for developing countries.

b. Since countries have not the same tools and capacities to react and assess damages, important discrepancies in the declarations between developed and developing countries could occur. For instance developing country database must rely on one source of information due to the lack of data at the same time that developed countries can compare various data sources.

6. **Censored data**: Because the database relies on "declared" information, a "0" in EM-Dat may have two meanings: no disasters occurred OR the data is not available (has not been declared). Le Saout (2010) showed that the rate of non-response is important in EM-Dat database. He suggests that a possible selection bias should be systematically analysed. In his study Le Saout finds that the probability of non-response is reduced for developed countries and large scale disasters. Moreover the probability of non-response is linked with the probability of non-response to the "number of dead people" variable. In order to have robust results to non-response, observations must be considered as censored.
7. **Threshold:** Finally Le Saout (2010) underlined the threshold problem. Data rely on fixed thresholds of affected and killed people, even though population has grown since 1900. After computing a standardized threshold, the author finds that less than 10% of the disasters impacts will be excluded in recent years (1980-2005). Moreover, the author underlines that there is no threshold on damage for the inclusion in the database. "One event with high damage but with only few killed and no need for international assistance will not be included". For instance the author compares data on tropical cyclones on EM-Dat for the USA and data from the NOAA (National Oceanic and Atmospheric Administration), and notices that tropical storms and small hurricanes are always excluded from EM-Dat. Before 1980 there are 133 observations from NOAA and only 37 from EM-Dat[16].

[16] CRED has also compared the three main global databases, EM-DAT, Nathan and Sigma (Guha-Sapir, Below, The quality and accuracy of disaster data, 2004) and found significant discrepancies between them.

2. MunichRE database

In 1974MunichRE has built its historical natural hazard archive, NatCat, by compiling and collecting worldwide data on natural events. It was built to satisfy one of the basic needs of the insurance sector: reliable loss information to assess risk (in this case natural hazards).

The database contains data on the date and impact (losses) of natural disasters in the world (excluding technological disasters, which is one major difference from EM-Dat). The entries cover the period from 79AD to the present.

Currently more than 32,000 events are included in the database.

The oldest registered event relates to the eruption of Mount Vesuvio in 0079. For the period from 0079 to 1899, 1,340 natural catastrophes are registered.

These datasets cannot be used for trend analyses because they are incomplete (available only for certain regions or types of events).

From 1980 until today all loss events are claimed to be covered. The dataset for the period from 1980 onward is considered complete and it allows trend analyses and statistics at various levels (continent, national…).

For some countries (USA, Germany…) records have been complete since 1970 and can be used from this date. Around 800 new entries are added every year (see Box 1).

Table AII-2. Number of events registered per periods in the database

Year	Number of events
0079 - 999	40
1000 - 1499	200
1500 - 1899	1 100
1900 - 1949	1 300
1950 - 1979	3 000
1980 - 2012	27 000

Source: MunichRE' web site

Events are entered on a country and event level including number of people killed/affected, economic losses, and scientific data (wind speed, magnitude, and geocoding).

The database is built from various sources: insurance agencies, Lloyds, UN agencies, world weather services (NOAA, National Huricance Center), governments, NGOs, national meteorological services but also news agencies (press and media: Spiegel, Times, NBC…).

In 2007,MunichRE (NatCat), CRED (EM-Dat) and SwissRE[17] (Sigma) have defined a common terminology and hierarchy of natural hazards with the United Nations Development Programme (UNDP, DesInventar), the Asian Disaster Reduction Centre and the International Strategy for Disaster Reduction (ISDR). Natural hazards are divided into four main hazard groups: Geophysical events, Meteorological events, Hydrological events, Climatological events.

These hazard groups are divided into 9 event families, which are broken down into 26 Sub-perils (see Table AII-3).

[17] No information on this point from Swiss Re'web site. Gall (2013, p….) states : "As a result, the group has recently completed the harmonization of hazard types though only EM-Dat, Swiss Re, MunichRE and select national disaster loss databases have implemented this common standard"

Table AII-3. Type of the events, MunichRE Classification for natural disasters

Disaster Sub-Group	Disaster Main Type	Sub-Perils
Geophysical	Earthquake	Ground Shaking Fire Following Tsunami
	Volcanic eruption	Volcanic eruption
	Mass Movement Dry	Rockfall Landslide Subsidence
Meteorological	Storm	Tropical Storm Extra-Tropical cyclone Local Storm Convective Storm
Hydrological	Flood	General flood Flash flood Storm surge Glacial lake outburst flood
	Mass Movement Wet	Subsidence Avalanche Landslide
Climatological	Extreme Temperature	Heat Wave Cold Wave/Frost Extreme Winter Conditions
	Drought	Drought
	Wild fire	Forest Fire Brush Fire Bush Fire Grassland Fire

Source: MunichRE website

The database provides: (i) dates: start and end date; (ii) disaster type; (iii) name of the event; (iv) country of the event and GIS references; (v) number of people reported killed, injured, homeless and affected; (vi) Economic losses.

MunichRE also proposed a classification of the data depending on their catastrophe classes based on the economic losses and the criteria set by the insurance company as described by Table AII-4.

Table AII-4. Classes of events

Catastrophe class		Overall losses				
		Loss profile	1980s*	1990s*	2000 – 2008*	**and/or fatalities**
0	Natural event	No property damage				none
1	Small-scale loss event	Small-scale property damage				1-9
2	Moderate loss event	Moderate property and structural damage				> 10
3	Severe catastrophe	Severe property, infrastructure and structural damage	US$ >25m	US$ > 40m	US$ > 50m	> 20
4	Major catastrophe	Major property, infrastructure and structural damage	US$ > 85m	US$ > 160m	US$ > 200m	> 100
5	Devastating catastrophe	Devastating losses within the affected region	US$ > 275m	US$ > 400m	US$ > 500m	> 500
6	Great natural catastrophe „GREAT disaster“	Region's ability to help itself clearly overtaxed, inter regional/international assistance necessary, thousands of fatalities and/or hundreds of thousands homeless, substantial economic losses (UN definition). Insured losses reach exceptional orders of magnitude.				

Source: MunichRE website

The database is partially accessible to the public (secondary data on statistics, aggregations, graph, maps…), most primary data is available only to MunichRE clients.

Most limitations are the same as those listed for the CRED data base in section 6.1, for instance, definitions, discrepancies and thresholds.
Moreover, NatCa Service provides less data for areas with lower insurance coverage (Tschoegl 2006) due to its dependence on calculating insured losses.

3. SwissRE database

The Swiss REinsurance Company maintains the Sigma database comprising natural disasters and made-man events recorded from 1970 to the present with around 300 new events introduced per year. The database is narrower than EM-Dat and CatNat, with only 7000 entries.

This lower number of events compared to the other existing database is probably due to the stringent inclusion criteria applied to create a new entry in the database [18]:

1. *Causalities criteria*, the event must lead at least to one of the following 3 thresholds: (i) Number of deaths ≥ 20; (ii) Number of injured people ≥50; (iii) Number of homeless people ≥2000
2. *Total losses criteria*, the event must cause at least 91.1 million US$ of losses;
3. *Declared insured losses*: at least one of the following 3 thresholds has to be attained: (i) Maritime disasters >US$ 18.3 million; (ii) Aviation disasters >US$ 36.7 million; (iii) Other losses > US$ 45.5 million

Events are entered on a country (classified by International Monetary Fund conventions) and event level with the following information: (1) technical characteristics (magnitude for earthquakes…); (2) number of victims (dead, missing, severely injured, and homeless[19]), and (3) economic losses and damages (insured and uninsured) if the insurance penetration in the region is sufficient to provide statistics.

Sources of information declared by SwissRE are newspapers, direct insurance and reinsurance periodicals, specialist publications, reports from insurers and reinsurers.

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[18] Criteria, in 2012

[19] Note that “affected” people are not reported. Tschoegl (2006) and Guha-Sapir (2002) underlined also the lack of a clear definition of “homeless” people, leading to under-estimation for some events

SwissRE doesn't provide free access to the data. Access to the information is restricted to SwissRE clients. Due to this lack of free access, the classification of events and definitions are very complex to discuss.

The damages are quantified in US $ in the value of the year of occurrence[20]. Losses are determined using year-end exchange rate and are adjusted for inflation. A deflation of these values is necessary to use the economic information of the data base. The methodology to make comparisons is also provided on the SwissRE'web site. As for EM-Dat it seems that the registered data of damages correspond with the value of the immediate damages, the direct consequences on the economy (crop losses, destruction of infrastructures …). The indirect consequences (loss in growth, unemployment…) are not systematically introduced (but some adjustment of previously published losses is possible).

The database is seriously limited by the insurance penetration in the country. Moreover, we can highlight almost the same limitations pointed out for CRED and MunichRe databases.

[20] Using the end of year exchange rate (which is different to EM-Dat)

Annex III - Data sets indices availability

Table AIII-1. Indices availability by country

iso3	country	income status (IMF classification)	CRI	WRI	WRI vuln.	WRI exp.	WRI susc.	WRI lack of adapt. cap.	WRI lack of cop. cap.	GAIN	GAIN vuln.	CGDev	Data Availability (4 indices)
AFG	Afghanistan	Low Income	X	X	X	X	X	X	X	X	X	X	4
ALB	Albania	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
DZA	Algeria	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
ASM	American Samoa	Upper Middle Income										X	1
ADO	Andorra	High Income Non OECD										X	1
AGO	Angola	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
AIA	Anguilla	Upper Middle Income										X	1
ATG	Antigua and Barbuda	High Income Non OECD	X								X	X	2
ARG	Argentina	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
ARM	Armenia	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
ABW	Aruba	High Income Non OECD										X	1
AUS	Australia	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
AUT	Austria	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
AZE	Azerbaijan	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
BHS	Bahamas, The	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
BHR	Bahrain	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
BGD	Bangladesh	Low Income	X	X	X	X	X	X	X	X	X	X	4
BRB	Barbados	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
BLR	Belarus	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
BEL	Belgium	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
BLZ	Belize	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
BEN	Benin	Low Income	X	X	X	X	X	X	X	X	X	X	4
BMU	Bermuda	High Income Non OECD										X	1
BTN	Bhutan	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
BOL	Bolivia	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
BIH	Bosnia and Herzegovina	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4

iso3	country	income status (IMF classification)	CRI	WRI	WRI vuln.	WRI exp.	WRI susc.	WRI lack of adapt. cap.	WRI lack of cop. cap.	GAIN	GAIN vuln.	CGDev	Data Availability (4 indices)
BWA	Botswana	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
BRA	Brazil	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
VGB	British Virgin Islands	High Income Non OECD										X	1
BRN	Brunei Darussalam	High Income Non OECD	X	X	X	X	X	X	X		X	X	3
BGR	Bulgaria	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
BFA	Burkina Faso	Low Income	X	X	X	X	X	X	X	X	X	X	4
BDI	Burundi	Low Income	X	X	X	X	X	X	X	X	X	X	4
KHM	Cambodia	Low Income	X	X	X	X	X	X	X	X	X	X	4
CMR	Cameroon	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
CAN	Canada	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
CPV	Cape Verde	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
CYM	Cayman Islands	High Income Non OECD										X	1
CAF	Central African Republic	Low Income	X	X	X	X	X	X	X	X	X	X	4
TCD	Chad	Low Income	X	X	X	X	X	X	X	X	X	X	4
CHL	Chile	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
CHN	China	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
COL	Colombia	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
COM	Comoros	Low Income	X	X	X	X	X	X	X	X	X	X	4
ZAR	Congo, Dem. Rep.	Low Income	X							X	X	X	3
COG	Congo, Rep.	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
COK	Cook Islands	Upper Middle Income										X	1
CRI	Costa Rica	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
CIV	Cote d'Ivoire	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
HRV	Croatia	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
CUB	Cuba	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
CYP	Cyprus	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
CZE	Czech Republic	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
DNK	Denmark	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
DJI	Djibouti	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
DMA	Dominica	Upper Middle Income	X							X	X	X	3
DOM	Dominican Republic	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4

iso3	country	income status (IMF classification)	CRI	WRI	WRI vuln.	WRI exp.	WRI susc.	WRI lack of adapt. cap.	WRI lack of cop. cap.	GAIN	GAIN vuln.	CGDev	Data Availability (4 indices)
ECU	Ecuador	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
EGY	Egypt, Arab Rep.	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
SLV	El Salvador	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
GNQ	Equatorial Guinea	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
ERI	Eritrea	Low Income	X	X	X	X	X	X	X	X	X	X	4
EST	Estonia	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
ETH	Ethiopia	Low Income	X	X	X	X	X	X	X	X	X	X	4
FRO	Faeroe Islands	High Income Non OECD										X	1
FLK	Falkland Islands	High Income Non OECD										X	1
FJI	Fiji	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
FIN	Finland	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
FRA	France	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
GUF	French Guians	High Income Non OECD										X	1
PYF	French Polynesia	High Income Non OECD										X	1
GAB	Gabon	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
GMB	Gambia, The	Low Income	X	X	X	X	X	X	X	X	X	X	4
GEO	Georgia	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
DEU	Germany	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
GHA	Ghana	Low Income	X	X	X	X	X	X	X	X	X	X	4
GIB	Gibraltar	High Income OECD										X	1
GRC	Greece	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
GRL	Greenland	High Income Non OECD										X	1
GRD	Grenada	Upper Middle Income	X	X	X	X	X	X	X		X	X	3
GLP	Guadeloupe	Upper Middle Income										X	1
GUM	Guam	High Income Non OECD										X	1
GTM	Guatemala	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
GGY	Guernsey	High Income OECD										X	1
GIN	Guinea	Low Income	X	X	X	X	X	X	X	X	X	X	4
GNB	Guinea-Bissau	Low Income	X	X	X	X	X	X	X	X	X	X	4
GUY	Guyana	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
HTI	Haiti	Low Income	X	X	X	X	X	X	X	X	X	X	4

iso3	country	income status (IMF classification)	CRI	WRI	WRI vuln.	WRI exp.	WRI susc.	WRI lack of adapt. cap.	WRI lack of cop. cap.	GAIN	GAIN vuln.	CGDev	Data Availability (4 indices)
HND	Honduras	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
HKG	Hong Kong SAR, China	High Income Non OECD	X									X	2
HUN	Hungary	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
ISL	Iceland	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
IND	India	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
IDN	Indonesia	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
IRN	Iran, Islamic Rep.	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
IRQ	Iraq	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
IRL	Ireland	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
IMY	Isle of Man	High Income Non OECD										X	1
ISR	Israel	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
ITA	Italy	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
JAM	Jamaica	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
JPN	Japan	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
JEY	Jersey	High Income OECD										X	1
JOR	Jordan	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
KAZ	Kazakhstan	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
KEN	Kenya	Low Income	X	X	X	X	X	X	X	X	X	X	4
KIR	Kiribati	Lower Middle Income	X	X	X	X	X	X	X			X	3
PRK	Korea, Dem. Rep.	Low Income								X	X	X	2
KOR	Korea, Rep.	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
KWT	Kuwait	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
KGZ	Kyrgyz Republic	Low Income	X	X	X	X	X	X	X	X	X	X	4
LAO	Lao PDR	Low Income	X	X	X	X	X	X	X	X	X	X	4
LVA	Latvia	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
LBN	Lebanon	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
LSO	Lesotho	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
LBR	Liberia	Low Income	X	X	X	X	X	X	X	X	X	X	4
LBY	Libya	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
LIE	Liechtenstein	High Income Non OECD										X	1
LTU	Lithuania	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4

iso3	country	income status (IMF classification)	CRI	WRI	WRI vuln.	WRI exp.	WRI susc.	WRI lack of adapt. cap.	WRI lack of cop. cap.	GAIN	GAIN vuln.	CGDev	Data Availability (4 indices)
LUX	Luxembourg	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
MAC	Macao SAR, China	High Income Non OECD										X	1
MKD	Macedonia, FYR	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
MDG	Madagascar	Low Income	X	X	X	X	X	X	X	X	X	X	4
MWI	Malawi	Low Income	X	X	X	X	X	X	X	X	X	X	4
MYS	Malaysia	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
MDV	Maldives	Lower Middle Income	X							X	X	X	3
MLI	Mali	Low Income	X	X	X	X	X	X	X	X	X	X	4
MLT	Malta	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
MHL	Marshall Islands	Lower Middle Income										X	1
MTQ	Martinique	Upper Middle Income										X	1
MRT	Mauritania	Low Income	X	X	X	X	X	X	X	X	X	X	4
MUS	Mauritius	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
MYT	Mayotte	Upper Middle Income										X	1
MEX	Mexico	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
FSM	Micronesia, Fed. Sts.	Lower Middle Income								X	X	X	2
MDA	Moldova	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
MCO	Monaco	High Income Non OECD									X	X	1
MNG	Mongolia	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
MNE	Montenegro	Upper Middle Income	X									X	2
MSR	Montserrat	Lower Middle Income										X	1
MAR	Morocco	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
MOZ	Mozambique	Low Income	X	X	X	X	X	X	X	X	X	X	4
MMR	Myanmar	Low Income	X	X	X	X	X	X	X	X	X	X	4
NAM	Namibia	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
NRU	Nauru	Low Income										X	1
NPL	Nepal	Low Income	X	X	X	X	X	X	X	X	X	X	4
NLD	Netherlands	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
ANT	Netherlands Antilles	High Income Non OECD										X	1
NCL	New Caledonia	High Income Non OECD										X	1
NZL	New Zealand	High Income OECD	X	X	X	X	X	X	X	X	X	X	4

iso3	country	income status (IMF classification)	CRI	WRI	WRI vuln.	WRI exp.	WRI susc.	WRI lack of adapt. cap.	WRI lack of cop. cap.	GAIN	GAIN vuln.	CGDev	Data Availability (4 indices)
NIC	Nicaragua	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
NER	Niger	Low Income	X	X	X	X	X	X	X	X	X	X	4
NGA	Nigeria	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
NIU	Niue	Upper Middle Income										X	1
NFK	Norfolk Island	High Income Non OECD										X	1
MNP	Northern Mariana Islands	High Income Non OECD										X	1
NOR	Norway	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
OMN	Oman	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
PAK	Pakistan	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
PLW	Palau	Upper Middle Income										X	1
PAN	Panama	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
PNG	Papua New Guinea	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
PRY	Paraguay	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
PER	Peru	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
PHL	Philippines	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
PCN	Pitcairn	High Income Non OECD										X	1
POL	Poland	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
PRT	Portugal	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
PRI	Puerto Rico	High Income Non OECD										X	1
QAT	Qatar	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
REU	Reunion	Upper Middle Income										X	1
ROM	Romania	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
RUS	Russian Federation	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
RWA	Rwanda	Low Income	X	X	X	X	X	X	X	X	X	X	4
BLM	Saint Barthelemy	High Income Non OECD										X	1
MAF	Saint Martin	High Income Non OECD										X	1
WSM	Samoa	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
SMR	San Marino	High Income Non OECD										X	1
STP	Sao Tome and Principe	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
SAU	Saudi Arabia	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
SEN	Senegal	Low Income	X	X	X	X	X	X	X	X	X	X	4

iso3	country	income status (IMF classification)	CRI	WRI	WRI vuln.	WRI exp.	WRI susc.	WRI lack of adapt. cap.	WRI lack of cop. cap.	GAIN	GAIN vuln.	CGDev	Data Availability (4 indices)
SRB	Serbia	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
SYC	Seychelles	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
SLE	Sierra Leone	Low Income	X	X	X	X	X	X	X	X	X	X	4
SGP	Singapore	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
SVK	Slovak Republic	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
SVN	Slovenia	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
SLB	Solomon Islands	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
SOM	Somalia	Low Income									X	X	1
ZAF	South Africa	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
ESP	Spain	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
LKA	Sri Lanka	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
SHN	St. Helena	Lower Middle Income										X	1
KNA	St. Kitts and Nevis	Upper Middle Income	X								X	X	2
LCA	St. Lucia	Upper Middle Income	X							X	X	X	3
SPM	St. Pierre and Miquelon	Upper Middle Income										X	1
VCT	St. Vincent and the G.	Upper Middle Income	X							X	X	X	3
SDN	Sudan	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
SUR	Suriname	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
SJM	Svalbard and Jan Mayen	High Income Non OECD										X	1
SWZ	Swaziland	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
SWE	Sweden	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
CHE	Switzerland	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
SYR	Syrian Arab Republic	Lower Middle Income		X	X	X	X	X	X	X	X	X	3
TWN	Taiwan (China)	High Income Non OECD	X									X	2
TJK	Tajikistan	Low Income	X	X	X	X	X	X	X	X	X	X	4
TZA	Tanzania	Low Income	X	X	X	X	X	X	X	X	X	X	4
THA	Thailand	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
TMP	Timor-Leste	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
TGO	Togo	Low Income	X	X	X	X	X	X	X	X	X	X	4
TKL	Tokelau	Low Income										X	1
TON	Tonga	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4

iso3	country	income status (IMF classification)	CRI	WRI	WRI vuln.	WRI exp.	WRI susc.	WRI lack of adapt. cap.	WRI lack of cop. cap.	GAIN	GAIN vuln.	CGDev	Data Availability (4 indices)
TTO	Trinidad and Tobago	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
TUN	Tunisia	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
TUR	Turkey	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
TKM	Turkmenistan	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
TCA	Turks and Caicos Islands	High Income Non OECD										X	1
TUV	Tuvalu	Lower Middle Income										X	1
UGA	Uganda	Low Income	X	X	X	X	X	X	X	X	X	X	4
UKR	Ukraine	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
ARE	United Arab Emirates	High Income Non OECD	X	X	X	X	X	X	X	X	X	X	4
GBR	United Kingdom	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
USA	United States	High Income OECD	X	X	X	X	X	X	X	X	X	X	4
URY	Uruguay	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
UZB	Uzbekistan	Low Income	X	X	X	X	X	X	X	X	X	X	4
VUT	Vanuatu	Lower Middle Income	X	X	X	X	X	X	X	X	X	X	4
VEN	Venezuela, RB	Upper Middle Income	X	X	X	X	X	X	X	X	X	X	4
VNM	Vietnam	Low Income	X	X	X	X	X	X	X	X	X	X	4
VIR	Virgin Islands (U.S.)	High Income Non OECD										X	1
WLF	Wallis and Futuna	Lower Middle Income										X	1
WBG	West Bank and Gaza	Lower Middle Income										X	1
YEM	Yemen, Rep.	Low Income	X	X	X	X	X	X	X	X	X	X	4
ZMB	Zambia	Low Income	X	X	X	X	X	X	X	X	X	X	4
ZWE	Zimbabwe	Low Income	X	X	X	X	X	X	X	X	X	X	4

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Title: Concepts and Metrics for Climate Change Risk and Development - Towards an index for Climate Resilient Development

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Abstract

The threats posed by climate change are increasingly seen as a major problem for the future of nature and humanity, and significant improvements are needed to set the world on a climate change resilient path to the future. At global, regional and local level there is an increasing demand from both policy makers and the business sector for understanding relationships between the determinants of climate change risk (hazards, exposure, vulnerability, and adaptation) as well as metrics and policy options to deal with such a risk. Meeting this demand is fraught with difficulties due to the multitude of objectives/criteria to be considered as well as the interrelated nature of the determinants of climate change, which are dynamic and evolving over time. A fundamental link between development strategies, climate adaptation planning, and disaster risk reduction has been recognized, but not characterized. In this context, climate resilient development can be indicated as one of the political priorities at global level.
This report reviews the main concepts and metrics used to assess and manage climate change risk within an international context, which considers climate resilient development a central issue.
It analyses in depth five climate change indices aiming at measuring all or just a few components of climate change risk with a global coverage. The review highlights that there is no consensus on concepts and metrics for a climate change risk index.
A joint analysis of these indices identifies a common geography of the hot spot areas for climate change risk and vulnerability. Results show a consensus on the relevance of climate change risk in developing countries.
The report highlights some open questions and gaps on conceptual frameworks, metrics, and data to build an index for climate resilient development. It identifies key issues that will be addressed to build a platform towards an index for climate resilient development .

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