To What Extent Are African Countries Vulnerable to Climate Change?

Lessons from a New Indicator of Physical Vulnerability to Climate Change

Patrick GUILLAUMONT and Catherine SIMONET
Ferdi and CERDI, CNRS-Université d'Auvergne

November 16th, 2011

Introduction

- Evidence

Growing demand for **an index of vulnerability to climate change**:

- Climate Change is a major issue for world economy and policy
  - creation of the Adaptation Fund by the Parties to the Kyoto Protocol of the UN Framework Convention on Climate Change
  - Intergovernmental Panel on Climate Change (IPCC)
- Need of resources to finance adaptation
- Need of criteria for the allocation of these resources (cf. Adaptation Fund declaration)
- One major relevant criterion may be the country specific vulnerability to climate change
- African Countries
  - High vulnerability to Climate Change
  - Not responsible for Climate Change

  → May have a special interest in the design of such an index

- Aim of the paper

  - To formulate an appropriate index of vulnerability to climate change that could be available for all the countries concerned and likely to be used as a criterion for allocation of adaptation resources

  - To build a ***Physical*** Vulnerability to Climate Change Index (PVCCI) as the Economic Vulnerability Index (EVI) designed at the UN.

  - To examine the vulnerability of African countries to climate change

What is vulnerability about ?

- Overall vs. Structural vulnerability in development economics

  – Countries' vulnerability : the risk of being harmed by exogenous, generally unforeseen events or shocks

  – Three main components of vulnerability :

shock, exposure and resilience

shock: exogenous and often unforeseen factors

exposure : factors on which the direct impact of shocks depends

resilience : capacity to react to the shocks, resilience is mainly related to policy factors

  – Assessments of vulnerability retain all these three components or only two of them

shock+ exposure + resilience = **"overall" vulnerability**

shock + exposure = **"structural" or "physical" vulnerability**

- Vulnerability to climate change
  - Extensive and recent literature on vulnerability to climate change
  - No common framework
  - The framework " shocks/exposure/resilience" not used in these researches but always present

Vulnerability concepts in the light of "shock, exposure and resilience" framework

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

: *continuum of vulnerability concepts*

Assessing vulnerability : existing indices and their limits

- Several indices on Climate Change …
  - Many existing indices related to vulnerability to CC
    - Vulnerability resilience Moss et al (2001)
    - Environmental Sustainability Index Easty et al. (2005)
    - Dimensions of vulnerability Downing et al (1995)
    - Index of Human Insecurity Lonergan et al. (1999)
    - Predictive Indicators of vulnerability Brooks et al. (2005)
    - Global distribution of vulnerability Yohe et al. (2006)
    - EVI CC Kaly et al.(2004)
    - The Index of socioclimatic exposure Diffenbaugh et al. (2007)
    - Climate Change Index (CCI) Baettig et al (2007)
    - National Climate Change Index Giorgi (2006)
  - Lot of studies about these indices: rank comparison, analysis of sensibility, methods

Eriksen and Kelly (2007) ; Füssel (2009) ; Gall (2007) ; Eakin and Luers (2006)

- …present 2 types of problems
  - Usual technical problems
    - scale,
    - aggregation,
    - sensitivity to proxy ,
    - robustness,
    - transparency
  - Specific design problem
    - theoretical background,
    - policy relevance

- Our responses
  - The physical vulnerability index focused on the structural dimension of vulnerability allows us
    - To present an accurate definition and precise components
    - To provide an index only based on exogenous elements
    - To obtain a more synthetic index than the “overall vulnerability indices” but reliable and relevant
  - The country level analysis responds to the need of criteria to guide the allocation of the aid for adaptation (as already discussed for the EVI)
  - The time scale analysis for the PVCCI unlike the EVI, is important, because CC is a medium-long term phenomenon.

    We propose to actualise the index every 5 years.
  - The index is based on the EVI’s aggregation method with bounds, and balanced weighting.

The Physical Vulnerability to Climate Change Index (PVCCI)

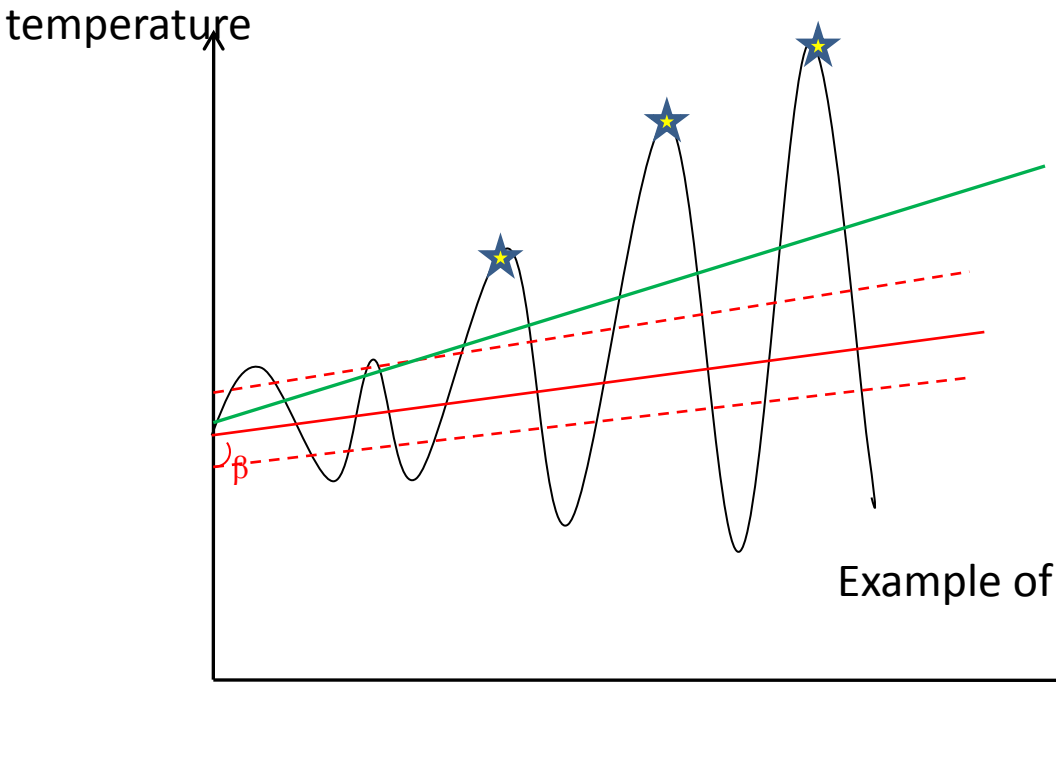
- Possible components of an Index of Physical Vulnerability to Climate Change

  - ***Risk related to progressive shocks***
  - Likely impact of *the rise of sea level (RSLI)* : the vulnerability of zones likely to be flooded depends on
    - the exposure : the distribution of the heights of arable lands : h_{ij}
    - the shock: the distribution of the likelihood of sea-level rise in *t* years: s_{ijt}

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

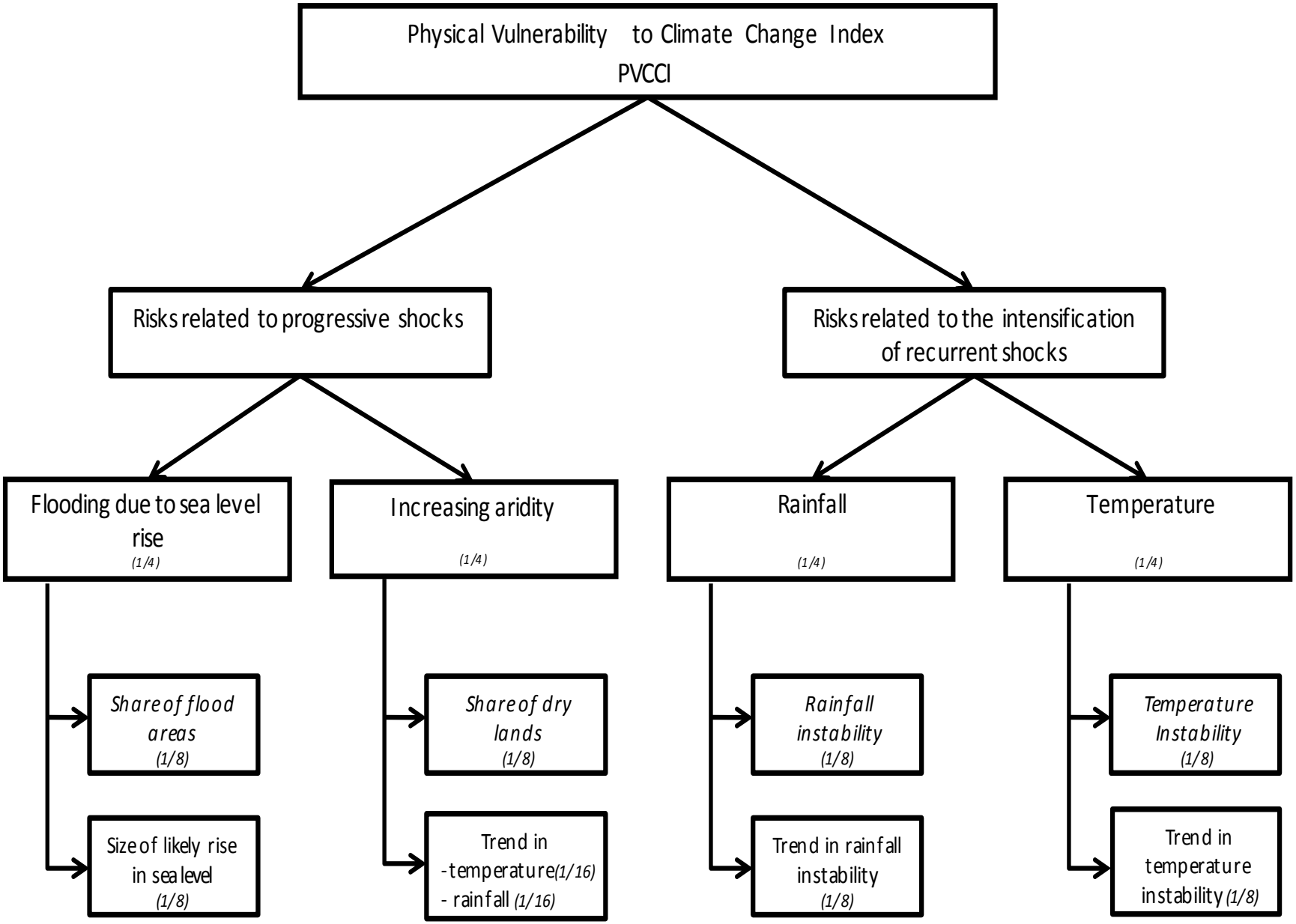
  - *Over-aridity and desertification impact (OADI)* :
    - the exposure: proportion of arid areas
    - the shock : trend value in rainfalls and temperatures (β)

- ***Risks related to intensification of recurrent shocks***
  - *the exposure: average frequency of shocks in rainfalls and temperatures (A)*
  - *the shock : trend in the size of shocks as a proxy of the intensity of future shocks (B)*



(A): number of ★
(B): trend **B**

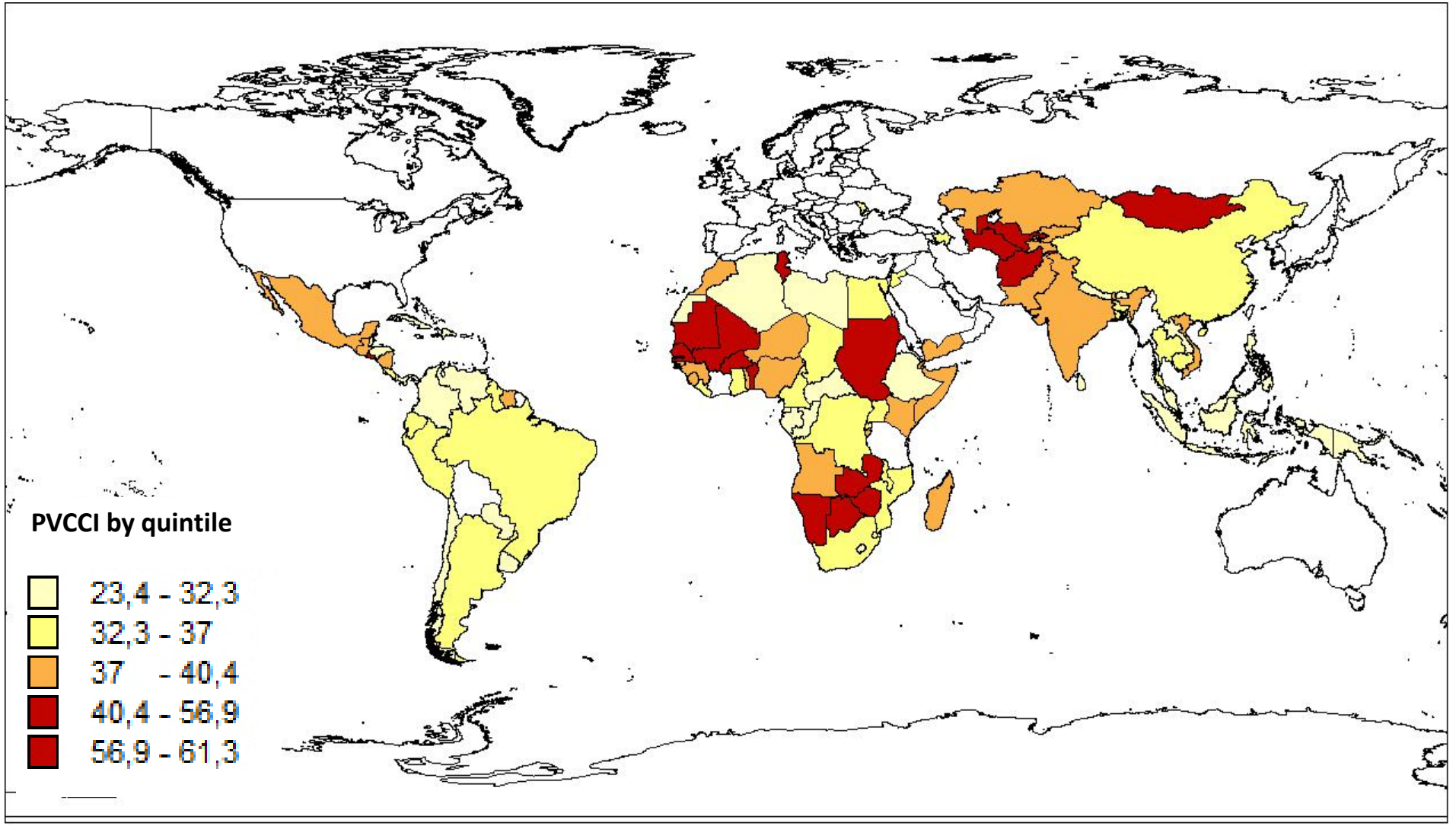
Example of calculation with annual temperature data



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

The Vulnerability to Climate Change Results of the Index

PVCCI in developing countries



Components of PVCCI by group of countries

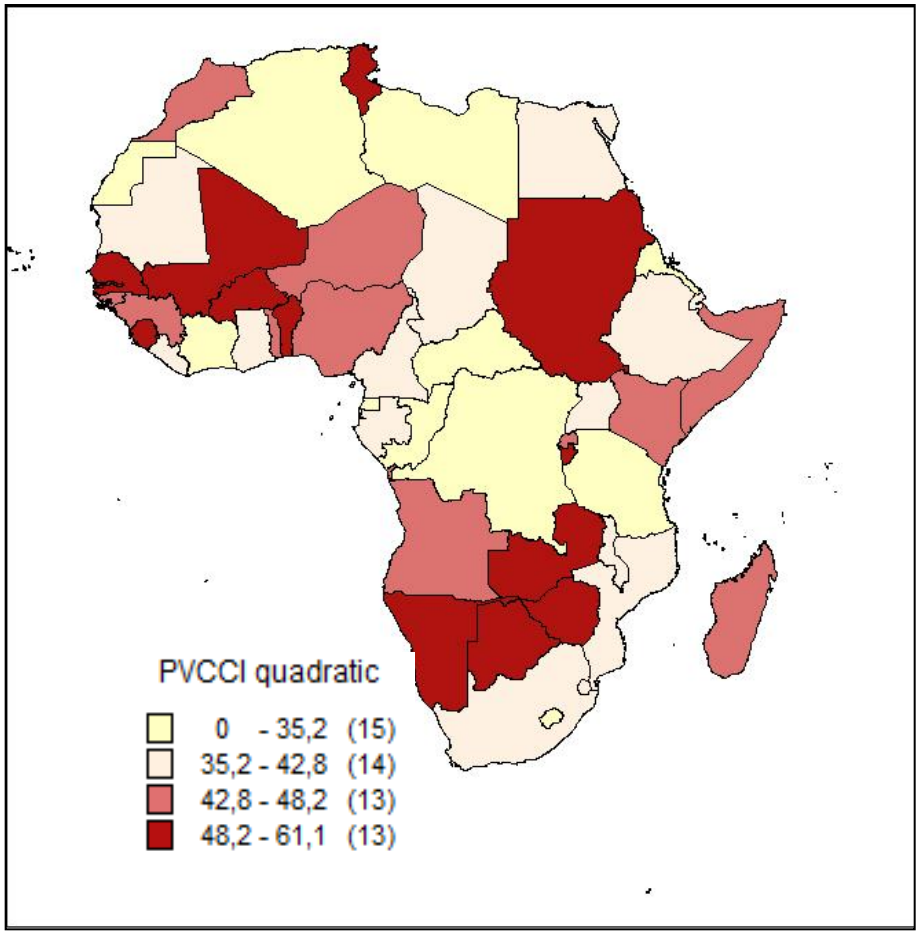
group of countries	PVCCI				PERMANENT SHOCKS				RECURRENT SHOCKS			
	number of countries	Mean	Median	Standard Deviation	number of countries	Mean	Median	Standard Deviation	number of countries	Mean	Median	Standard Deviation
All Developing countries (DCs)	116	36.43	35.89	6.77	116	25.27	22.98	11.60	142	46.72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

- A high average level of vulnerability to climate change in Africa

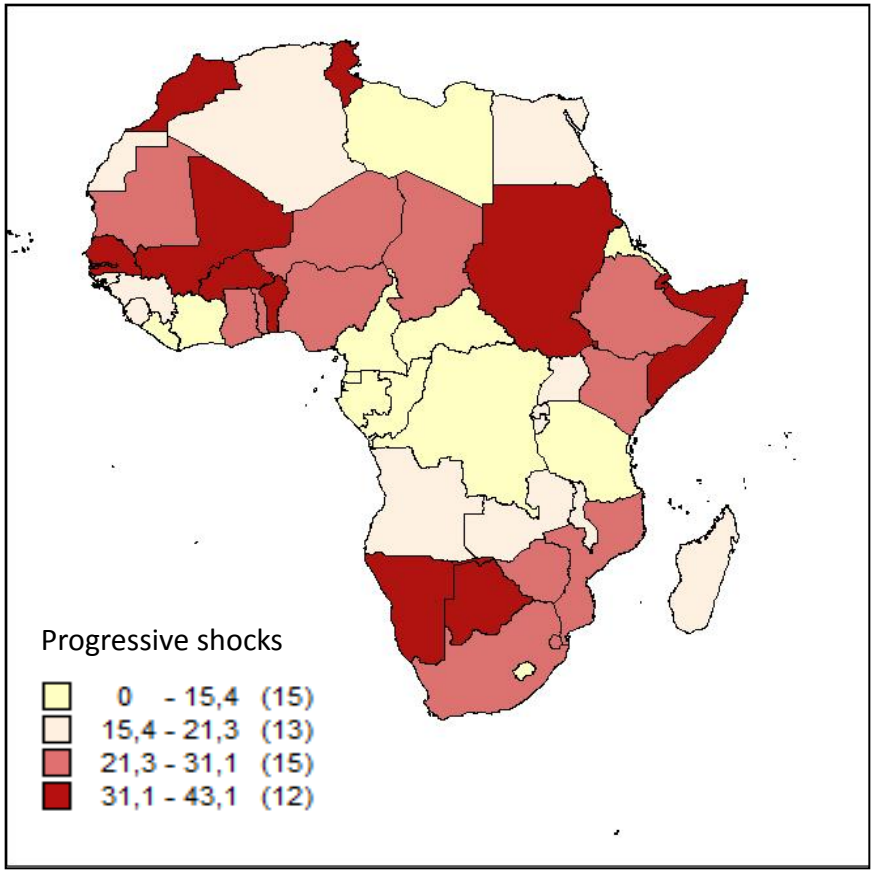
group of countries	PVCCI				PROGRESSIVE SHOCKS				RECURRENT SHOCKS			
	number of countries	Mean	Median	Standard Deviation	number of countries	Mean	Median	Standard Deviation	number of countries	Mean	Median	Standard Deviation
All Developing Countries (DCs)	116	35,96	35,81	6,74	116	24,33	21,53	11,60	142	46.72	45.75	7.48
African Developing Countries	43	37,97	37,63	5,87	43	24,64	23, 37	9,32	47	51,07	50,92	7,18
Least Developed Countries (LDCs)	46	37,93	37,38	7,83	46	24,92	18,80	14,22	49	51.03	51.02	7.58
African LDCs	30	38,11	38,14	5,72	30	23,63	20,09	9,29	32	52,44	52,01	7,14
Low and LMI Countries non LDCs	84	37,25	36,84	7,16	84	25,53	22,37	13,00	95	48.54	48.92	7.50
African Low and LMI Countries	37	37,61	37,65	5,49	37	23,84	21,77	8,86	40	51,25	50,97	7,27

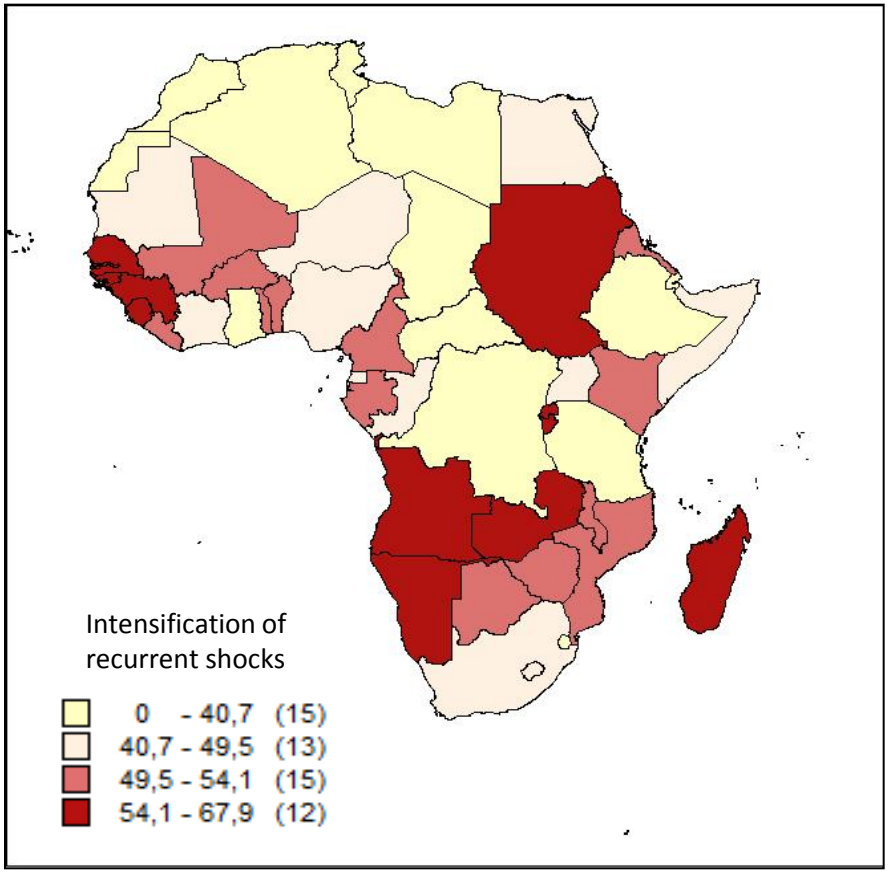
  - Sub-Sahara African countries evidence a higher average PVCCI than other DCs
    - level of the risk associated to progressive shocks index is a result of two opposed effects
      - a low impact of the sea level rise in Africa
      - component “increasing aridity” more important for African DCs and the trend in temperature is more increasing in Africa
    - difference between DCs and African DCs is important and non ambiguous for the impact of the increasing recurrent shocks

- Heterogeneous levels, heterogeneous kinds of vulnerability among African countries



- most vulnerable African countries Namibia, Senegal, Botswana, Gambia, Burkina Faso, Mali, Zambia, Sudan, Benin and Burundi
- Five main regions
  - the three most vulnerable sub-regions: West Africa, a group of Eastern Africa countries and Southern Africa (not including South Africa),
  - lower vulnerability than the rest of continent, a group of Central Africa countries and North Africa.





- Level of vulnerability to progressive shocks, is at the highest level in the world for some African countries: Botswana, Chad, Comoros and Mali
- As for the “risk of intensification of recurrent shock”, this component, on average high for African countries, also exhibits significant differences between African countries . Most vulnerable countries : Zambia, Namibia, Burundi, Sierra Leone, Madagascar, Senegal

Conclusion

- We proposed a Physical Vulnerability to Climate Change index which permits
  - Focused only on the structural/physical dimension of vulnerability
  - Relying on a assessment of the main physical trends linked to Climate Change (shocks)
  - Taking into account the initial conditions specific to each country (exposure)

- PVCCI for African Countries
  - higher vulnerability for African countries than for the other developing countries
  - significant heterogeneity among African countries
  - Five main regions
  - Ten most vulnerable African countries Namibia, Senegal, Botswana, Gambia, Burkina Faso, Mali, Zambia, Sudan, Benin and Burundi

- Policy use
  - An index likely to be relevant for resources allocation
  - To detect various profiles of vulnerability to climate change and so help to design appropriate adaptation policies