CEECC Working Paper No. 5

A District Level Climate Change Vulnerability Index of Pakistan

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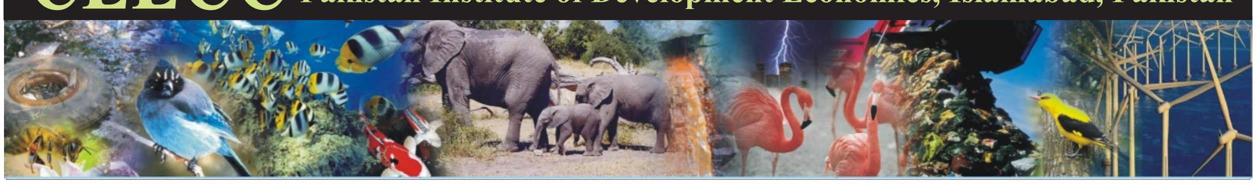

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Designed, composed, and finished at the Publications Division, PIDE.

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ABSTRACT

In the wake of devolution and decentralisation in Pakistan there is a greater need to devise localised vulnerability to climate change indices as an easy reference for both policy-makers and the development sector. While global vulnerability indices are commercially motivated and based on country level data, ranking the degree of vulnerability to climate change across nations represents a 'number' aimed at directing, inter alia, development, disaster and aid efforts among countries. These indices however, fail to highlight sub-national vulnerabilities existing within countries being ranked. Using the IPCC's definitions of vulnerability in the context of climate change as a reference source, this study devises a district level vulnerability to climate change index for 22 districts of Pakistan. The Index shows that there exists a varying degree of vulnerability between districts and a further variation across the rural and urban divide of each district.

1. BACKGROUND

Climate change is often referred to as the greatest externality the world has ever seen Stern (2007). Being a ‘global’ problem, solutions are often assumed to be of a global and collective nature as exemplified by the Kyoto process. Difficulties faced in reaching a universal agreement and its subsequent implementation such as the Kyoto Protocol has led Engel and Saleska (2005) to introduce the term ‘sub-global’ governments that take unilateral action on climate change as an alternative to no action at all. Ostrom (2009) warns that global solutions negotiated at the global level might take too long to take effect if not backed up by efforts at national, regional, and local levels. Advocating a *polycentric* approach to solving the problem of climate change at multiple levels, Ostrom (2009), goes on to say that “While the level of CO2 and other greenhouse gases in the atmosphere may be relatively uniformly distributed at a mega-scale, the impacts of climate change differentially affect regions depending on their geographic location, ecological and economic conditions, prior preparation for extreme events, and past investments” (p. 4).

The difficulty in understanding the extent of the challenge posed by climate change by policy-makers responsible for such agreements is appreciable. Policy-makers often get lost in too much detail hence the need to synthesise information about climate change in a reliable and standardised manner Bättig (2007, cited in OECD, 2002). The need is compounded by the fact that climate change is a strongly debated issue in international politics with thousands of policy-makers involved. One way to meet this need is by indicators and aggregated indices that prove to be an ‘at a glance’ reference of all the scientific jargon associated with climate change. Climate Change Indices can be especially useful in countries where the science of climate change is hardly understood by both governments and the public.

2. THE STUDY’S IMPORTANCE

According to the author of the 18th amendment to the constitution of Pakistan, Senator Raza Rabbani, the devolution of powers to provincial governments is “the most significant restructuring process since 1947”. In April 2012, the functioning and control of a total of 17 ministries was handed over to provincial governments at the end of the third phase of devolution. With the Ministry of Environment being one of the 17 ministries to be handed over to the provinces, the focus of planning and implementation of policies has shifted to a more localised domain, strengthening the need for greater local detail in data evaluation and policy recommendation.

Most of the Climate Change indices that have been developed so far rely on country-level data. The classic example of who will suffer more damages in case of an extreme event between a poor and a rich farmer may well hold for rich and poor countries as well. Although the rich farmer suffers more damage economically than the poor farmer, the poor farmer has a much weaker ability to bounce back than the rich farmer. Similarly, can country based vulnerability indices accurately predict the amount of damage and the ability of each region *within* a country to bounce back from extreme events given the totally different adaptive capacity and nature of response to extreme events in various locales? Will similar scores on country based vulnerability indices indicate an equal degree of damage, response and bounce-back-ability? With completely different political and social setups in place, the chances that similar scores on country indices mean anything more than an interpretation of country specific data itself are slim. Any assumption that these numbers draw accurate comparisons across nations is misleading.

Aggregating a number of variables into a single index score can be especially useful in the context of climate change:

(i) Due to a lack of complete information because of uncertainties associated with environmental variability, data can be ‘lost in translation’ by over or underemphasising one or more variables and phenomena or their significance.

(ii) An Index can assimilate a large amount of diverse data to produce an ‘at a glance’ reference sheet. Numerous permutations within the index can help highlight most vulnerable areas or the effect of different variables within the index.

(iii) Policy-makers, donors and other stakeholders may not completely comprehend the science of climate change nor understand the relationship of different factors influencing vulnerability to climate change making indices an extremely valuable tool to help them understand the scale of the potential effects.

(iv) An important feature of a climate index is its ability to rank regional differences in vulnerability according to factors such as gender and rural-urban disparities within the same region.

3. AIM OF THE STUDY

The study aims to assess the combined impact of factors that determine the scale of Vulnerability to Climate Change across 22 districts of Pakistan by developing a Vulnerability Index.

4. CONCEPTUAL FRAMEWORK

The IPCC's definition of vulnerability uses the Integrated Assessment Approach (IAA) which considers both Bio-physical and Socio-Economic Vulnerability as well as the Adaptive Capacity of the system. The IAA takes into account interactions and feedbacks between multiple drivers and their impacts linking cross-sectoral interactions across types and scales [IPCC AR-4 (2007)]. This study is based on the IAA that combines indicators from various socio-economic variables as well as biophysical changes within Pakistan. The research makes use of the ability of the IAA to integrate the effects of multi-sectoral variables to assess vulnerability.

According to the IPCC (2001), "social vulnerability describes all the factors that determine the outcome of a hazard event of a given nature and severity" whereas "biophysical vulnerability is a function of hazard and exposure". It follows that the difference between the two types of vulnerabilities is the inclusion of the hazard (to climate change) in biophysical vulnerability and it's exclusion from socioeconomic vulnerability but both incorporating concepts of exposure and sensitivity (to the hazard).

This distinction helps differentiate between the two types of vulnerabilities "by associating hazard with climate variation and sensitivity with social vulnerability" [Brooks (2003)].

Vulnerability can therefore be conceptualised as being a function of Exposure, Sensitivity and Adaptive Capacity.

$$\text{Vulnerability} = f\ (\text{Adaptive Capacity, Sensitivity, Exposure})$$

A system completely immune to any hazards will exhibit zero Vulnerability whereby it's adaptive capacity fully counters all forms of Vulnerabilities, thereby operationalising the above relationship as:

$$\textit{Adaptive Capacity} = (\textit{Bio-Physical Vulnerability}) + (\textit{Socio-Economic Vulnerability})$$

A system exhibiting any degree of Vulnerability can be represented by:

$$\textit{Vulnerability} = (\textit{Bio-Physical Vulnerability} + \textit{Socio-Economic Vulnerability}) - \textit{Adaptive Capacity}$$

5. ISSUES IN MEASURING VULNERABILITY TO CLIMATE CHANGE

Climate change can have varying effects on different sections of the population depending on their socio-economic conditions, their adaptive capacity and well as the influence of bio-physical factors.

(i) The choice of indicators that would adequately quantify vulnerability to climate change remains a challenge. There is no consensus among researchers on the ideal choice of indicators that would result in a universally accepted standard for measuring vulnerability to climate change.

(ii) Indicators require a method of summation across time and scale, resulting in arithmetic problems regarding different units associated with indicators and time periods for which they are considered.

(iii) Indicators come with a varying degree of importance. Assigning correct weights to each indicator is highly debatable. Once again, no consensus exists on the weights assigned to a variety of indicators used to measure vulnerability to climate change.

(iv) It is not always possible to have data for exactly the same indicators in all the different regions under study especially at sub-national levels.

(v) The choice of indicators is often based on pragmatic choices as pointed out by Carr and Kettle (2009) who state that :

> "*Indicators are often selected based on the availability of existing data or the low cost production of new data sets. Rather than expend resources building new datasets, we often work with the data that are available and then build models to accommodate the data. Working with available data, rather than building new data sets, is more than a pragmatic choice. It is a reflection of power relations that determine what is to be measured, where limited resources need to be directed, and consequently what is seen as legitimate and valuable information. Therefore, the selection of indicators, based on data availability, is a value-laden process*". (p.134)

The choice of indicators for this study was influenced by the availability of data sets. A total of 16 indicators whose data was available for all the different districts under study were chosen as best representatives of factors that influence vulnerability to climate change

6. INDICATORS

The model indicators chosen to quantify each determinant of vulnerability to climate change are taken from the PSLM 2010-11 survey[1] and are divided as follows:

[1] The Pakistan Social and Living Standards Measurement (PSLM) Survey Project was initiated in 2004 and is scheduled to run till 2015. The aim of the survey is to provide Social and Economic data on various indicators of the Millennium Development Goals (MDG) and to help the Government of Pakistan in formulation of policies to eradicate poverty and accelerate development. Pakistan has committed to implementing 16 targets and 37 indicators of the MDG out of which 6 targets and 13 indicators are monitored with the help of PSLM surveys. (http://www.pbs.gov.pk/content/pakistan-social-and-living-standards-measurement)

Table 1

Determinants of Social Vulnerability

Indicator Number	Explanation of Indicator	Assumed Relationship to Vulnerability
S1	Adult Literacy—Population 15 years and older	Education could potentially open up avenues of better employment and greater income decreasing vulnerability
S2	Percentage distribution of population fallen sick or injured during last two weeks before data gathering	A greater percentage of sick people is a burden on relief and emergency efforts increasing vulnerability
S3	Children under 5 suffering from diarrhea in past 30 days	A greater percentage of sick children is indicative of poor health and nutrition conditions increasing vulnerability
S4	Percentage distribution of households by source of drinking water other than tap water	A hazard may affect the chances of access to water supplies that rely on manual collection increasing vulner-ability
S5	Percentage distribution of households by economic perception as of the household as being better than a year before	A household perceived to be less well off than a year earlier would decrease availability of resources and increase vulnerability
S6	Percentage of people living in rented/subsidised/free homes	In an event of a hazard a greater number of people not living in owned houses may increase homeless people thus increasing vulnerability

Table 2

Determinants of Adaptive Capacity

Indicator Number	Explanation of Indicator	Assumed Relationship to Vulnerability
A1	Percentage of children aged 12-23 months that have been immunised	Children not immunised could face disease and lack of opportunities to be immunised in case of a hazard
A2	Percentage distribution of households by material used for roofs other than RCC/Iron/Cement	Living in houses with roofs made of wood/bamboo/mud greatly increases the risk of loss of life in a hazardous event
A3	Percentage distribution of households by fuel type used for cooking other than electricity/gas/oil	Reliance on environmental goods such as wood and crop refuse increases vulnerability in case of non-availability of such goods
A4	Percentage distribution of households by economic perception of the community as not better than last year	The perception the community of not being as well off as earlier would effect the total assets building of the community to counter hazards

Table 3

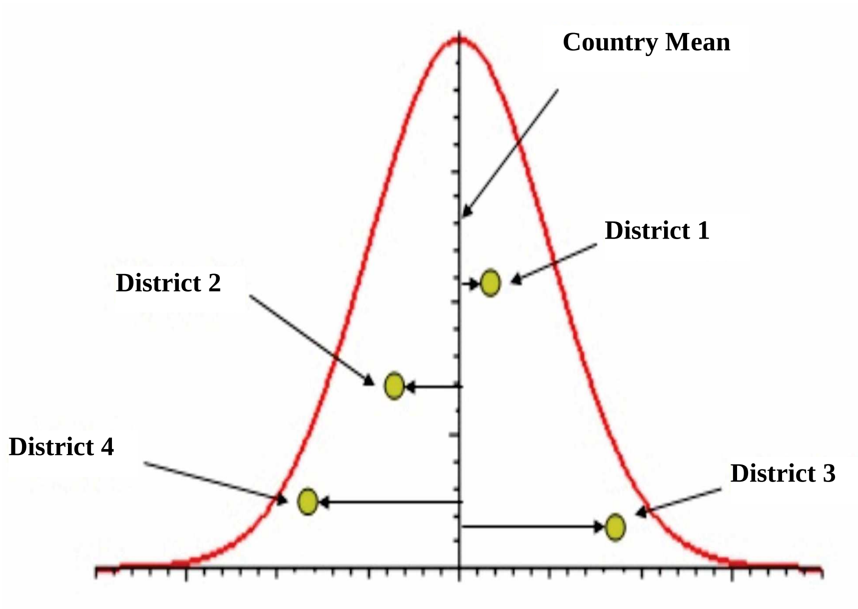
Indicators of Bio-physical Variations

Indicator Number	Explanation of Indicator
C1	Mean June-July-August Precipitation
C2	Mean December-January-February Precipitation
C3	Mean Minimum December-January-February Temperatures
C4	Mean Maximum June-July August Temperatures
C5	Mean Total number of days in a year with Rain

7. METHODOLOGY

The indicators S1, S2, S3, S4, S5, S6, A1, A2, A3, and A4 were developed for the Pakistan Bureau of Statistics' Pakistan Social and Living Standards Measurement survey 2010-11 and used in this study. While calculating vulnerability for 2010, the value for any particular indicator for a district in 2010 was compared with the mean of the same variable for all the districts of Pakistan (country mean) and standard deviation calculated to measure the distance from mean for the district in question w.r.t country mean. A large distance from the mean would imply greater vulnerability. The standard deviations were then normalised from 0 to 1 to arrive at a value representing vulnerability for the district for a particular indicator.

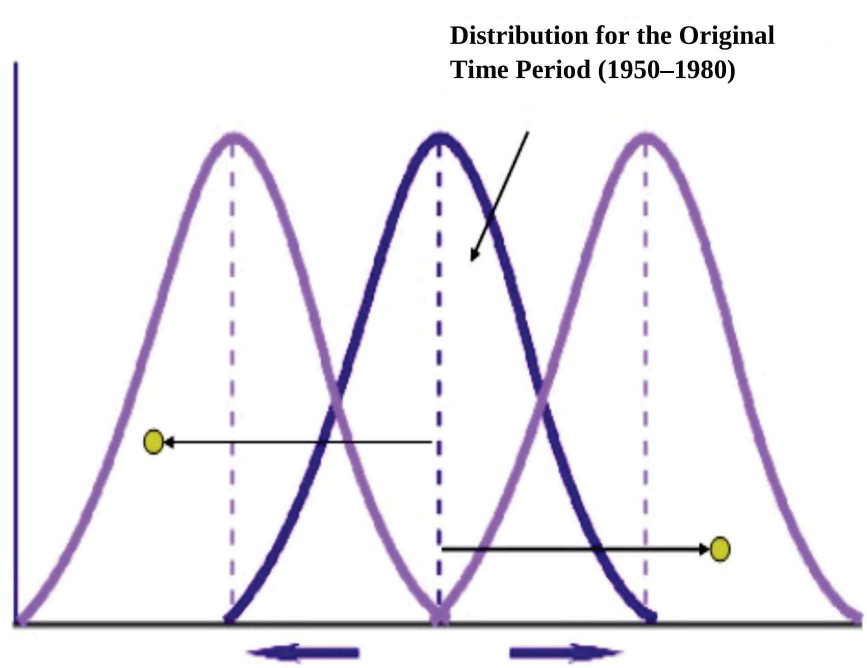
Fig. 1. Distribution for Socio-economic Variables for a Particular Year



Pakistan experiences four seasons with the majority of rains coming in the monsoon season from June to August. This is also a period of extreme heat with maximum temperatures recorded in these months. Pakistan also experiences cold winters accompanied by rain from December to February. Historical lows have been recorded during these months. Yearly means for all the bio-physical indicators would have averaged out shifts in extreme values therefore to capture a relevant movement of mean for both sets of extreme temperatures as well as precipitation variations over time, two periods from June to August and December to February were considered.

According to the World Meteorological Organisation the 'classical time' period taken to calculate climate variations is 30 years. After the creation of Pakistan in 1947, the climate data was recorded for different regions. This research analysed climate data for the period 1950-1980 and means calculated for this period. The variation in climate readings in any particular district for any of the climate indicators for 2010 was calculated by comparing the 2010 reading with the mean of the period 1950-1980 for the same indicator. Distances from the mean would indicate the magnitude of vulnerability, implying thereby that the further away a reading is from the historical mean the greater the vulnerability. The standard deviations were normalised on a scale of 0 to 1.

Fig. 2. Changes in Distribution for a Single District from the Period 1950-80 to Other Periods



8. DATA SOURCES

The data sources for this study include:

(i) Pakistan Social and Living Standards Measurement (PSLM) 2010-11.
(ii) The Pakistan Meteorological Department.

9. AREA OF STUDY

The study considered 22 districts of Pakistan covering all the provinces with meteorological observatories situated in each of these districts. The complete list of districts is as under:

Table 4

List of Districts under Study

Province	District
Punjab	Bahawalnagar
	Bahawalpur
	Faisalabad
	Jhelum
	Lahore
	Multan
	Sialkot
Sindh	Badin
	Hyderabad
	Karachi
	Nawabshah
	Jacobabad
KPK	Abbottabad
	Dir
	D. I. Khan
	Nowshera
Balochistan	Gwadar
	Kalat
	Pajgur
	Sibbi
	Zhob
Northern Areas	Chitral

10. ANALYSIS AND CONCLUSIONS

A detailed analysis is carried out comparing all the districts under study on the basis of Aggregate, Rural, Urban and a combination of factors.

The analysis begins with a relative ranking of all the districts based on Urban, Rural and Total Vulnerability.

10.1. Total Vulnerability to Climate Change – 2010

Table 5

Rural, Urban and Aggregate Vulnerability Ranking

	Urban Ranking		Rural Ranking		Total Ranking	
Rank	District	Score	District	Score	District	Score
01	Panjgur	686	Chitral	880	Chitral	900
02	Zhob	660	Badin	797	Zhob	781
03	Chitral	656	Karachi	753	Badin	752
04	Gawadar	539	Gawadar	677	Gawadar	679
05	Karachi	465	Zhob	668	Panjgur	661
06	Kalat	433	Kalat	625	Kalat	648
07	Badin	422	Lower Dir	620	Lower Dir	647
08	D. I. Khan	357	Bahawalpur	595	Karachi	555
09	Lower Dir	347	Nawabshah	574	D. I. Khan	509
10	Bahawalpur	338	Sibbi	553	Bahawalpur	507
11	Nawabshah	332	Panjgur	539	Sibbi	492
12	Bahawalnagar	315	Hyderabad	534	Nawabshah	490
13	Jacobabad	299	Jacobabad	532	Jacobabad	468
14	Sibbi	256	D. I. Khan	494	Abbottabad	461
15	Nowshera	234	Faisalabad	494	Bahawalnagar	450
16	Faisalabad	214	Bahawalnagar	468	Faisalabad	376
17	Multan	188	Multan	465	Jhelum	365
18	Jhelum	144	Abbottabad	435	Multan	347
19	Hyderabad	70	Jhelum	396	Nowshera	332
20	Sialkot	65	Nowshera	337	Sialkot	263
21	Abbottabad	57	Sialkot	274	Hyderabad	228
22	Lahore	18	Lahore	270	Lahore	180

The average Rural Vulnerability stands at 554 compared to an average Urban Vulnerability of 322 an increase of 72 percent. The difference can be mainly attributed to the difference in adaptive capacities rather than socio-economic vulnerability. Rural socio-economic vulnerability stands at 396 compared to 347.7 for Urban vulnerability an increase of 13.9 percent whereas Rural adaptive capacity measured only 233.5 against Urban adaptive capacity of 413.3 a deficit of 77 percent that translates into the total vulnerability difference of rural and urban areas.

The ranking suggests that larger urban areas like Lahore and Karachi offer much better socio-economic conditions as well as adaptive capacities than the rural areas of these districts.

Table 6

Rural and Urban Ranking of Districts with Large Cities

District	Urban Vulnerability	Rural Vulnerability
Lahore	18	270
Karachi	465	753
Faisalabad	214	494
Multan	188	465
Hyderabad	70	534

10.2. Provincial Vulnerability

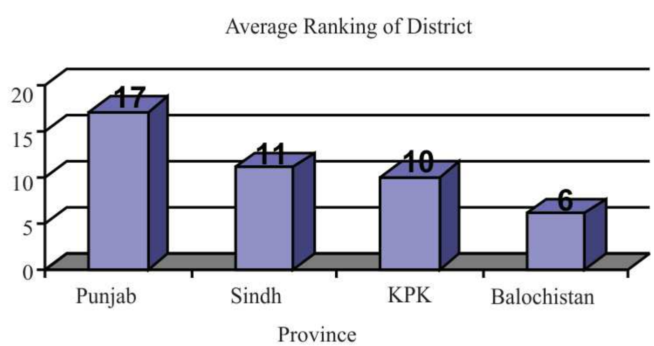
Table 7

Provincial Urban and Rural Vulnerability with Urban-Rural Differential

Province	Urban Vulnerability	Rural Vulnerability	Difference
Punjab	352.4	396.5	12.5%
Sindh	361.1	438.9	21.5%
KPK and Chitral	282.1	339.4	20.3%
Balochistan	393.4	409.2	4%

Balochistan showed only a 4 percent difference in vulnerability possibly pointing to the fact that the difference in socio-economic development between Rural and Urban areas was almost negligible. Similarly, Sindh and KPK show a larger disparity between Rural and Urban vulnerabilities hence larger disparities between Rural and Urban socio-economic development. Punjab showed a relatively modest difference of 12.5 percent. Balochistan is seen to be the most vulnerable province based on total vulnerability as 4 of the 6 most vulnerable districts were from Balochistan.

Fig. 3. Average Ranking of Vulnerability by Province



10.3. Indicators Affecting Rural and Urban Vulnerability

Table 8

Contribution of Socio-economic Indicators towards Urban and Rural Vulnerability

	S1	S2	S3	S4	S5	S6
Percent Contribution to Urban Vulnerability	16.66	3.52	6.96	23.00	39.65	10.22
bution to Rural Vulnerability	24.56	3.05	5.87	27.15	36.55	2.83

Table 9

Contribution of Bio-Physical Indicators towards Urban and Rural Vulnerability

	A1	A2	A3	A4
Percent Contribution to Urban Adaptive Capacity	29.03	23.44	37.29	10.24
Percent Contribution to Rural Adaptive Capacity	58.3	13.26	14.39	14.05

One of the biggest contributors to the lack of adequate adaptive capacities in urban areas is the reliance on environmental goods such as wood and crop refuse increasing vulnerability in case of non-availability of such goods as reflected in the indictor A3 that measures the reliance on fuel other than electricity and gas.

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