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How Much More Are the Poor Exposed to Natural Disasters? Global and Regional Measurement

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Abstract

This paper proposes a simple indicator to measure the exposure to natural disasters of the poor and non-poor segments of the population. The measure can be useful to assess global and regional trends in exposure to natural hazards and poverty. Globally, using data referring to the early 2000s, poor people are two times more exposed to natural disasters than non-poor people. Exposure varies across regions: according to this measure, poor people in East Asia and the Pacific are most exposed to natural disasters, followed by those in South Asia and Sub-Saharan Africa. The change of the exposure measure over time is decomposed into two factors: a pure exposure change and a concentration component. The results shows that the total net increase of exposure between the 1970s and the early 2000s is driven significantly by the increased concentration of the poor in disaster-prone areas (26%), while the contribution of that factor stays very small for the non-poor (6%).

Keywords: Natural disaster, Poverty, Exposure.

JEL Classification: Q54, Q56, I32.

1. Introduction

Large natural disasters are observed worldwide and their impact on human wellbeing receives much attention. Many scholars and policy makers have argued that the economic costs of natural disasters are disproportionately large for poor people in developing countries. The risks and vulnerabilities seem skewed towards the world's poorest people (UNDP 2004, p.24).

Despite this consensus, there is a need for systematic evidence on the poor's exposure to natural risks. UNDP (2007, p.26) suggests that disaster risks are higher for developing countries, but without a specific consideration of the incidence on the poor people. In the early 2000s, 85% of the people exposed to earthquakes, tropical cyclones, floods and droughts lived in countries having either medium or low human development (UNDP 2004, p.1). Efforts to measure the exposure to risks using disaggregated data have recently emerged, such as Dilley et al. (2005) and LIRI (2006).

The causal relationship between poverty and exposure to natural risks is complex. Further, there are not integrated hazard information and poverty indicators (Dercon and Shapiro 2007). As a result, an indicator for the poor's exposure to natural hazard that is consistent over time is hard to find. This paper proposes a simple indicator for exposure that directly connects poverty and risks of natural disasters. The next section reviews current literature. Section 3 describes the indicator and the data set. Section 4 presents empirical findings and Section 5 concludes.

2. Literature review

Much of the literature on the effect of weather-related hazards has focused on the impact analysis of disasters (Freeman et al. 2003; Hallstrom and Smith 2005; Sadowski and Sutter 2005). Others have focused on the response to disaster risks, such as insurance (Cummins et al. 2004). This paper attempts to look at how much people are exposed to disasters. To be specific, only natural disasters, such as droughts, earthquakes, extreme temperatures, floods, slides, volcano eruptions, waves, wild fires, and wind storms, are included in the analysis.

Some studies find that general economic development is negatively correlated to vulnerability to natural disasters. UNDP (2004) reports that GDP per capita and the Human Development Index are negatively correlated with deaths caused by natural disasters. The risk of being affected by a natural disaster is much higher for developing countries than for high-income OECD countries (UNDP 2007, p.76).

Poor countries are less equipped to deal with natural hazards. Kahn (2005) uses data on annual deaths from disasters in 73 nations from 1980 to 2002, and concludes that, though richer nations do not experience fewer natural disasters than poorer nations, richer nations do suffer less death from disaster. Economic development provides implicit insurance against nature's shocks. Strömberg (2007, p.221) argues that strong growth rates in China and India promise further reductions in the fatalities from natural disasters. Toyaa and Skidmoreb (2007) use disaster impact data over time to examine the degree to which the human and economic losses from natural disasters are reduced as economies develop. They find that countries with higher income, higher educational attainment, greater openness, more complete financial systems and smaller government experience fewer losses.

A few case studies show that poor people are much more vulnerable to natural disasters. Cartera et al. (2007) analyze the asset dynamics of Ethiopian and Honduran households in the wake of severe environmental shocks. While the patterns are different across countries, both reveal situations in which the poorest households struggle most with shocks, adopting coping strategies which are costly in terms of both short term and long-term wellbeing.

Since the resources that people possess and the vulnerability that they are facing are closely linked together, researchers and policy makers have considered strategies to deal with natural risks in the framework of poverty reduction (Wisner et al. 2003; Linnerooth-Bayer et al. 2007). De Haen and Hemrich (2007) argue that, in order to mitigate the impact of disasters on poor population groups, development policy and disaster management need to become mutually supportive. Focusing on challenges disasters pose to food security, it proposes that in disaster-prone locations measures to improve disaster resilience should be an integral part of food security policies and strategies.

The question of how to measure the vulnerability could play a critical role in assessing the situation for the poor. Adgera (2006) presents a nice summary of measuring vulnerability related to environmental changes. Research on mapping vulnerability increasingly attempts to validate and triangulate data to derive more robust measures for both policy analysis and intervention (Haddad 2005; Brooks et al. 2005). To capture the dynamics of vulnerability, efforts have been devoted to measure vulnerability both in chronic and spatial dimension (Burg 2008).

This paper lies in the line of research that seeks to measure the exposure of people to natural disasters. Unlike the studies measuring the exposure in relation to the average income level, such as GDP per capita per country used in Strömberg (2007), this paper specifically considers the geographical distribution of poor people, testing whether and how much the poor are exposed to natural disasters, relative to non-poor people. The measurement would shed light on how their exposure changes over time, and which factors might drive the change.

3. Measurement and Data

Exposure to natural disasters for the poor (γ^P) and non-poor (γ^{NP}) is defined as follows:

$$\gamma^P = \sum_i \gamma_i^P \frac{M_i^P}{M^P} \quad ,where\ M^P = \sum_i M_i^P , \quad i = area\ i \tag{1}$$

$$\gamma^{NP} = \sum_i \gamma_i^{NP} \frac{M_i^P}{M^{NP}} \quad ,where\ M^{NP} = \sum_i M_i^{NP} \tag{2}$$

M^P is the total population of the poor, and M_i^P is the number of poor people in area i. M^{NP} is the total population of the non-poor, and M_i^{NP} is the number of non-poor people in area i. Exposure measure in area i ($\gamma_i^P, \gamma_i^{NP}$) can be regarded as the probability of being hit by natural disasters. Since the ex-ante probability is hard to be measured, I use ex-post indicators using a certain time period. Simply put, the hazard is measured by realized occurrence or severity of events. Therefore, the exposure of each population group to natural disasters is defined as an average exposure measure across area, weighted by the poor (or non-poor) population share of each area.

This indicator is simpler than many composite indexes, such as UNDP's Disaster Risk Index (UNDP 2004). The Disaster Risk Index combines information including type of disaster, occurrence and severity, as well as other social and mitigation factors. Although composite indexes include rich information, it is not always easy to interpret differences or changes in the level of this type of indicators. The exposure measure in this paper does not account for as many factors. However, it explicitly considers the poor people in regards to the exposure to disasters, and it is much easier to interpret.

The exposure measure within an area for poor and non-poor ($\gamma_i^P, \gamma_i^{NP}$) would likely be different. Non-poor people tend to have larger resources to cope with natural risks, and thus, the exposure should be lower for non-poor people than poor people in the same area (World Bank 2000). There are at least three possible reasons. First, settling in risky places can aggravate the exposure to natural hazards within an area. Second, poor people's behavior during normal times can increase the probability to be affected by disasters, for instance, by exploitation of forest woods to cause land slide in flash flood. Third, market factors and regulations can make the poor unable to mobilize their resources (Fuentes et al. 2008, p.8.)

Unfortunately, the difference in exposure to natural disasters between the poor and non-poor within the same area is hardly observable unless the household level survey data with living condition and natural hazard information is available. This type of detailed data sets is rare, especially for developing countries. For this practical reason, the exposure to poor and non-poor people is assumed to be identical within an area ($\gamma_i^P = \gamma_i^{NP} = \gamma_i$). Based on this assumption, the measure is simplified as follows:

$$\gamma^P = \sum_i \gamma_i \frac{M_i^P}{M^P} \quad , where\ M^P = \sum_i M_i^P \tag{3}$$

$$\gamma^{NP} = \sum_i \gamma_i \frac{M_i^{NP}}{M^{NP}} \quad , where\ M^{NP} = \sum_i M_i^{NP} \tag{4}$$

$$\gamma^P - \gamma^{NP} = \sum_i \gamma_i \frac{M_i^P}{M^P} - \sum_i \gamma_i \frac{M_i^{NP}}{M^{NP}} = \sum_i \gamma_i \left(\frac{M_i^P}{M^P} - \frac{M_i^{NP}}{M^{NP}}\right) \tag{5}$$

The exposure is likely to be higher for the poor if poor people are concentrated in an area with higher risk. Should it be true that the exposure of the non-poor is always lower than the poor

($\gamma_i^P > \gamma_i^{NP} = \gamma_i \quad, \forall i$), the gap between the poor and non-poor shown in this paper might have underestimated the difference between the poor and non-poor.

Any method of identifying poverty is applicable for this measure. Poverty estimation usually depends on many practical and theoretical issues, such as poverty lines, use of income or expenditure aggregates, and the purchasing power factor (Chen and Ravallion 2007). The only requirement for the analysis in this paper is that the poverty indicator should be compatible for the sub-group. As we use this measure for global or regional assessment, the international poverty measure is plausible because the poverty indicator must be consistent across countries. Should we assess the exposure at the country level, the national poverty line can be used because the poverty indicator should only be consistent across sub-national level.

Figure 1 illustrates the exposure and poverty distribution in a simple hypothetical case. The number in a cell represents the cell percentage to the total population, and Area S (or Area R) represents a safe (or risky) area in regards to natural disasters. In Region A, 64% of the entire population are non-poor people living in Area S, and 16% are non-poor people living in Area R. Another 16% are poor people living in Area S, while the rest 4% are poor people living in Area R. Region B has four different population groups, similarly.

The exposure measures for Region A and B are different, although descriptive statistics look very much alike. Region A and Region B have the same poverty headcount rate (20%). The concentration of the population in the risky area (Area R) does not seem to be much different (20% and 28%, respectively). However, the geographical distribution of poor people is widely different. In Region A, only 20% of poor people live in the risky area (4 out of 20), while 60% of them are living in the risky area in Region B (12 out of 20). In other words, people in Region B are heavily penalized for being poor in terms of the exposure to natural disasters. If we assign zero for the area exposure indicator in Area S ($\gamma_S = 0$), and one for Area R ($\gamma_R = 1$), the exposure measure would be .2 both for the poor and non-poor in Region A, while it would be .6 for the poor and .2 for the non-poor in Region B. We can argue that poor people are three times more exposed to disasters than non-poor people in Region B.

I use three different indicators for the exposure within an area: (a) Total cumulative number of disasters reported in every decade; (b) Total cumulative number of deaths in every decade; (c)

Total cumulative number of affected people in every decade. The measures (b) and (c) are normalized by a million people. Another candidate would be the estimated total damage caused by disasters reported in the EM-DAT data. However, there is no standard procedure for the estimation for the value of damage, resulting in an inconsistent measure across country and across time for global aggregation. The exposure measure using total value of damage is, therefore, excluded in this paper.

Assuming that the exposure measure and poverty indicator be consistent over time, we can derive time series decomposition from the exposure indicator as follows:

$$\gamma_{t+1}^{P} - \gamma_{t}^{P} = \sum_i \gamma_{i,t+1} \frac{M_{i,t+1}^{P}}{M_{t+1}^{P}} - \sum_i \gamma_{i,t} \frac{M_{i,t}^{P}}{M_{t}^{P}} = \underbrace{\sum_i (\gamma_{i,t+1} - \gamma_{i,t}) \frac{M_{i,t+1}^{P}}{M_{t+1}^{P}}}_{Component\ A} + \underbrace{\sum_i \gamma_{i,t} \left(\frac{M_{i,t+1}^{P}}{M_{t+1}^{P}} - \frac{M_{i,t}^{P}}{M_{t}^{P}} \right)}_{Component\ B} \quad (6)$$

In the case of the poor, the pure exposure change component (Component A) represents the changes in areal exposure, holding the geographic distribution of the poor constant. There could be a large number of reasons why the area exposure could change over time. Number of disasters could increase or decrease due to many natural or other variations in weather patterns. The severity or intensity of disasters could change over time as climate changes. Should the climate change be able to cause changes in the frequency or the intensity of natural disasters, this component will capture some of the effect.

The concentration component (Component B) represents all other changes in the concentration of poor people in risky areas, given the exposure fixed. A number of factors can cause changes in this distributional component. To name a few, migration, demography or growth can change the geographic concentration of poor people. Migration will change the distribution of the existing poor people. It is true that international migration would decrease poverty in developing countries, but because of considerable travel costs associated with international migration, international migrants come from those income groups which are just above the poverty line in middle-income developing countries (Page and Adams 2003, p.1). As a result, poor people could be more concentrated in poor areas with higher probability to be affected by disasters, unable to migrate to higher income countries.

There will also be a demographic factor, as poor people have different population growth and fertility rates. Developing countries have much higher population growth rates than high-income countries. The annual population growth rate in 2007 is 2.14% for low income countries, while it is .65% in high income countries (calculated from World Bank 2008). The fertility rate is 4.2 per woman in low-income countries, while it is 1.7 in high-income countries in 2006 (Ibid). The number of poor people is growing faster in developing countries than in developed countries, resulting in the concentration of poor people in developing countries.

In addition, when the economy grows, a number of people move out of poverty. It will result in a change in geographical distribution of the poor unless the rate of growth is identical everywhere, for everyone. If the growth is less pro-poor in developing countries with worse initial income condition, poor people would be more concentrated in developing countries over time. The poverty's responsiveness to income growth and changes in inequality significantly decreases with initial inequality and density of people near the poverty line (Kalwij and Verschoor 2004, p.23).

This paper studies the exposure at the global and regional level. Data required for this analysis is country level data, one level below the level of analysis. But the exposure indicator proposed here does not limit the analysis at the aggregate level. It can be used for disaggregated levels, as long as the data is available at the appropriate level. If we are to do a country (or local) level analysis, one must have disaster and poverty indicators at sub-national (or sub-local) level. In this paper, I use World Bank estimates for poverty indicators, and the EM-DAT, a disaster dataset maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the University of Louvain, Belgium.

For the purpose of measuring poverty consistently across countries, the World Bank's "$2 a day" poverty measures are appropriate for the analysis in this paper. They apply an internationally common standard for all countries (Chen and Ravallion 2008, p.2). A recent revision of the estimation of Purchasing Power Parity (PPP) exchange rate in the 2005 International Comparison Program (ICP) improved the compatibility of poverty identification across countries.[1]

[1] For a more detailed explanation of the revision, please refer to the ICP website (www.worldbank.org/data/icp).

The EM-DAT dataset covers the occurrence and effects of over 16,000 mass disasters in the world from 1900 to present.[2] The disasters listed in the EM-DAT dataset fulfill at least one of the four criteria: Ten or more people reported killed; 100 or more people reported affected; Declaration of a state of emergency; Call for international assistance. The database covers various events, including natural and non-natural disasters. In this paper, only natural disasters are accounted for the analysis. The types of natural disasters considered are drought, earthquake, extreme temperature, flood, slide, volcano, wave, wild fire, and wind storm.

4. Empirical Findings

Table 1 describes the exposure measure for the poor and non-poor at the global level. Each row represents the corresponding decade, and each column represents indicators for the poor or non-poor. The disaster and poverty datasets cover data up to 2006. The statistics for 2000-2009 are for the current decade, which are proportionately expanded from the figures for 2000-2006, by the factor of 1.43. This is to illustrate the trend of exposure, assuming that the occurrence and severity of disasters in 2000-2006 will be constant until the end of the current decade.[3]

The first panel of Table 1 shows a steady increase in the exposure, measured by the total cumulative number of disasters by decade. The upward trend of reported disasters is common to the poor and non-poor. It is also clear that poor people are experiencing more disasters than non-poor people. On average, the global population living on $2 or less per day has been experiencing 121 disasters in the early 2000s on average, while the non-poor population has experienced 101 disasters for the same decade. When we measure the exposure by the number of disasters, poor people have been 20% more exposed to disasters relative to non-poor people worldwide.

The second panel of Table 1 suggests that the exposure, measured by total number of deaths per million, has been decreasing over time. In the 1970s, about 230 for every million poor people

[2] For descriptive statistics of the dataset, see the EM-DAT website (www.emdat.be/).

[3] The actual statistics for 2000-2006 are presented in Table 2.

used to die in natural disasters. The number of fatalities for the poor is only 23 persons per million people in the early 2000s, a 90% decrease. The fatalities are always substantially lower for the non-poor than the poor until the 1990s. In the early 2000s, the number of deaths is almost the same for the non-poor (33 deaths per million people) and the poor (23 deaths per million people). The time trend of fatalities is consistent with the global trend of decreasing total fatalities in the dataset using a longer time period of the 20th century.[4] Overall, people are not much penalized for being poor in terms of fatalities caused by natural disasters.

However, the extensiveness of disasters has grown disproportionately for the poor. More and more poor people are affected by natural disasters, and they are much more affected than the non-poor. The last panel of Table 1 describes the upward trend of the poor's exposure and the increasing gap of exposure between the poor and non-poor, measured by the total number of people affected per one million people. In the early 2000s, about 50% of poor people (507,916 people per one million for $2 poor) have been affected by natural disasters. The number is only 27% for the non-poor (268,497 people per one million), suggesting that the poor are almost two times more exposed to natural disasters than the non-poor.

There is a regional disparity in the exposure measured by the number of affected people. Figure 2 shows the exposure measured by the number of affected people by region, for the people living on $2 or less per day. While the global exposure rises over time, not many regions show such monotonic increases. Comparing the 1970s and the early 2000s, the East Asia and Pacific region shows the largest increase in exposure, from 24% of a million poor people affected by disasters in the 1970s, to 68% of a million poor people in the early 2000s. When we focus on recent years since the 1990s, the exposure increased for the poor people living in South Asia (from 34% of a million poor people affected by disasters in the 1990s to 63% in the early 2000s) and Sub-Saharan Africa (from 13% of a million poor people affected by disasters in the 1990s to 18% in the early 2000s).

Figure 3 shows the trend for the poor and the non-poor in East Asia and Pacific, measured by the number of people affected by disasters in the decade. The upward trend of exposure is clear for

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[4] See EM-DAT website for the trend since 1900, Global Disaster Trend, Fatalities in Disasters. (www.emdat.be/Database/Trends/trends.html)

the poor and non-poor until the 1990s, and the exposure decreased in the early 2000s. The relative magnitude of the exposure of the poor to the non-poor changes over time. The exposure for the poor was much higher than the non-poor in the 1990s (81% of a million for the poor and 66% for the non-poor), but the gap decreased in the early 2000s (68% and 64%, respectively). Figure 3 suggests that the East Asia and Pacific region has improved in regards to the exposure to natural hazards.

Figure 4 displays a recent increase of exposure for the poor in the Sub-Saharan Africa region, measured by the number of people affected by disasters in the decade. In the early 2000s, 19% of a million poor people have been affected by natural disasters, while 14% were affected in the 1990s. Non-poor people are less affected by disasters in the early 2000s (14% per million people) than in the 1990s (17%). The overall exposure is relatively low compared to the East Asia and Pacific region, but the recent increase in the gap between the poor and non-poor is noticeable.

Figure 5 also presents a non-monotonic trend in the exposure in South Asia, measured by the number of people affected by disasters in the decade. The exposure has been increasing since the 1990s, from 34% to 63% for every million poor people, and from 29% to 58% for every million non-poor people. The non-poor people have always been less exposed to natural disasters than the poor in South Asia since the 1970s. It suggests that the poverty penalty for natural hazards has been persistent in this region.

The Latin America and the Caribbean region has improved in terms of exposure to natural disasters. Figure 6 describes that the exposure measured by the number of people affected by disasters decreased between the 1980s and the early 2000s, from 13% to 5% for every million poor people, and from 14% to 7% for every million non-poor people. The absolute figures are very small relative to other regions. Other two regions, Europe and Central Asia and Middle East and North Africa, do not show much of a trend or fluctuation because the exposure measure for those regions is relatively low.

The time series decomposition in Equation 6 provides evidence that poor people are left behind in disaster-prone areas. Table 2 shows the exposure change from the 1970s to the early 2000s. It is decomposed to two factors, (A) the pure exposure and (B) the migration/demography/growth components. The first column shows the estimated figure for the decade of the 1970s, and the second column the figure for the years of 2000-2006. The third column presents the total net change, that is, the difference between columns (1) and (2). The last two columns represent the total change decomposed into two components.

When measured by the total number of disasters (the first panel of Table 2), the total change in exposure for the poor is 61, suggesting that poor people experienced 61 more natural disasters in the early 2000s than in the 1970s. Of this 61 total changes, 57 are due to the change in pure exposure change, and the remaining 4 are due to the migration/demography/growth. Therefore, the increase in total number of disasters is, in some part, caused by the fact that poor people are more concentrated in risky areas in the early 2000s than in the 1970s. For the non-poor, the pure exposure change Component is 54.2, and the Component B is -.2, the net change being 54. The negative value of the Component B for the non-poor people suggests that the non-poor people have been moving out of those risky areas, reducing the net exposure measure.

The second panel of Table 2 uses the total number of deaths per million people per decade to measure the exposure change, and it illustrates a much larger impact of Component B, the migration/demography/growth factor. The total net change in exposure for the poor is -214 from the 1970s to the early 2000s, suggesting 214 less poor people per million die in natural disasters. The decomposition shows that the pure exposure component is actually -326 and Component B is +112. It implies that 326 less people would have died in natural disasters if the geographical distribution of the poor had been hold constant. But because poor people are more concentrated in risky areas than before, the downward change is, in part, offset by having 112 more people that died. For the non-poor, the total change in exposure is almost completely driven by the pure exposure change.

The last panel of Table 2 also shows the role of Component B. The total net change in exposure for the poor measured by the number of affected is 196,281 people between the 1970s and the early 2000s (a 19.6 percentage point change for a million people). When decomposed, 144,820 are coming from Component A, while 51,461 are from Component B. Component A contributes 74% and Component B contributes the remaining 26% to the total exposure change, suggesting that about a quarter of the total increase in exposure comes from the increase in concentration of the poor people in risky areas. For the non-poor, the share of Component B is only 6% of the total net exposure change, suggesting that the population share of the non-poor in the risky area is not increasing as fast as the poor people are concerned.

In summary, the decomposition analysis suggests that poor people are more exposed to disasters, because they are more concentrated in risky areas. When we look at the pure exposure change only, there is no reason why the poor should be more exposed to disasters. The absolute value of the pure exposure change is almost the same for the poor and non-poor when measured by the number of disasters or the number of affected people. When measured by number of deaths, the decrease in exposure is even more pro-poor, the decrease of fatalities being much bigger for the poor than for non-poor. However, the total net changes in exposure measures are disproportionately bad for the poor, because of Component B, the migration/demography/growth factor. The findings show that poor people live more in disaster-prone areas than before, causing the exposure gap between the poor and non-poor to become larger.

5. Conclusion

This paper proposes a simple indicator to measure the exposure to natural disasters for the poor and non-poor population. The indicator proposed in this paper allows for the assessment of the global and regional trends in exposure to natural hazards and poverty. It quantifies the gap of the exposure between the poor and non-poor, how much it changes over time, and which factor drive the change.

The main findings of this paper can be summarized as follows. Worldwide, poor people are almost two times more exposed to natural disasters than the non-poor, when measured by total number of affected people per decade. When measured by the number of disasters, the poor are 20% more exposed to disasters than the non-poor. The time trend varies across regions: poor people in East Asia and the Pacific being most exposed the natural disasters, followed by those in South Asia and Sub-Saharan Africa. However, the exposure of the poor in the East Asian and Pacific region started to decrease in recent years, while it is rising in South Asia and Sub-Saharan Africa.

The decomposition of the change in exposure indicators suggests that the geographical distribution plays a bigger role for the poor. The pure exposure change component is almost identical for the poor and non-poor, or favorable for the poor. However, the concentration component is bigger for the poor, suggesting that poor people are more concentrated in disaster-prone areas, compared to the non-poor. Poor people are exposed to natural disasters not only due to the simple increase of the probability to be hit by disasters, but also by the increased concentration in risky areas due to migration, higher population growth, or less pro-poor growth.

The analysis in this paper has been done using country level poverty and disaster data, illustrating the aggregate trend and factor decomposition at the global and regional level. However, the exposure of the poor would become most meaningful when it could be measured at the individual or household level. More disaggregated data on poverty or disaster at the sub-national or local community level would definitely improve the general measurement proposed in this paper.

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Table 1. Exposure to Natural Disaster of the Poor ($2 per day) and Non-poor, Global

	Poor	Non-poor
Total number of disasters, cumulative for decade		
1970-1979	24	17
1980-1989	67	36
1990-1999	78	60
2000-2009*	121	101
Total death per million, cumulative for decade		
1970-1979	230.1	63.0
1980-1989	143.7	101.4
1990-1999	86.3	36.9
2000-2009*	23.3	33.2
Total affected per million, cumulative for decade		
1970-1979	159,260.8	45,451.9
1980-1989	388,518.4	109,249.5
1990-1999	460,544.6	229,699.0
2000-2009*	507,916.4	268,497.7

Note: The figure for 2000-2009 is proportionately expanded from the figure for 2000-2006, by the factor of 1.43.
Source: Author’s calculation from World Bank (2008) and CRED (2008).

Table 2. Exposure Change Decomposition, from 1970s to 2000s

	(1) 1970-1979	(2) 2000-2006	(3) Total Change (2)-(1)	(4) Comp A (Pure exposure)	(5) Comp B (Migration/Demography /Growth)
Total number of disasters					
Poor	24	85	61.0	57.6	3.8
Non-poor	17	71	54.0	54.3	-0.2
Total number of death (per million)					
Poor	230.1	16.3	-213.8	-325.8	111.9
Non-poor	62.9	23.2	-39.7	-46.4	6.7
Total number of affect (per million)					
Poor	159,260.8	355,541.5	196,280.7	144,819.7 (74%)	51,461.1 (26%)
Non-poor	454,51.89	187,948.4	142,496.5	133,222.1 (94%)	9,274.5 (6%)

Note: Figures in parentheses are row percentages of the Column (3).
Source: Author’s calculation from World Bank (2008) and CRED (2008).

Figure 1. Illustration of the Exposure Measure and Poverty

Region A

	Area S	Area R	Total
Nonpoor	64	16	80
Poor	16	4	20
Total	80	20	100

Region B

	Area S	Area R	Total
Nonpoor	64	16	80
Poor	8	12	20
Total	72	28	100

$\gamma_S = 0, \quad \gamma_R = 1$

For Region A:

$$\gamma^P = \gamma_S \frac{M_S^P}{M^P} + \gamma_R \frac{M_R^P}{M^P} = 0 \times \frac{16}{20} + 1 \times \frac{4}{20} = .2$$

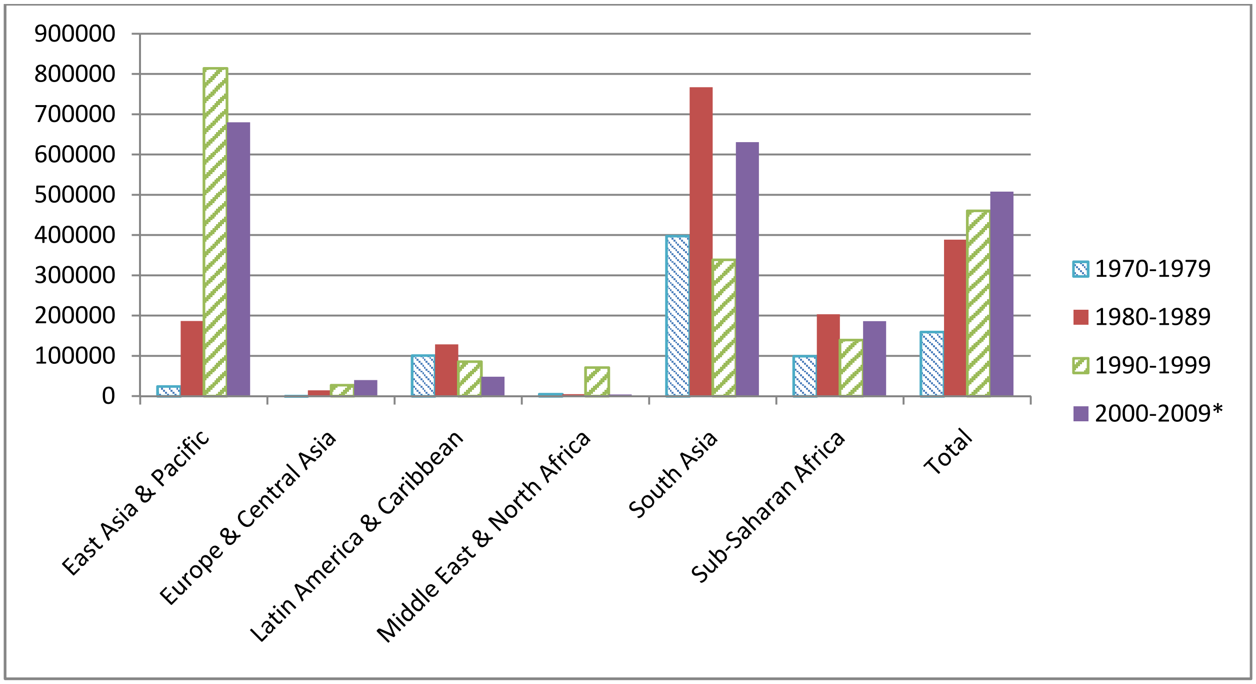
$$\gamma^{NP} = \gamma_S \frac{M_S^{NP}}{M^P} + \gamma_R \frac{M_R^{NP}}{M^P} = 0 \times \frac{64}{80} + 1 \times \frac{16}{80} = .2$$

For Region B:

$$\gamma^P = \gamma_S \frac{M_S^P}{M^P} + \gamma_R \frac{M_R^P}{M^P} = 0 \times \frac{8}{20} + 1 \times \frac{12}{20} = .6$$

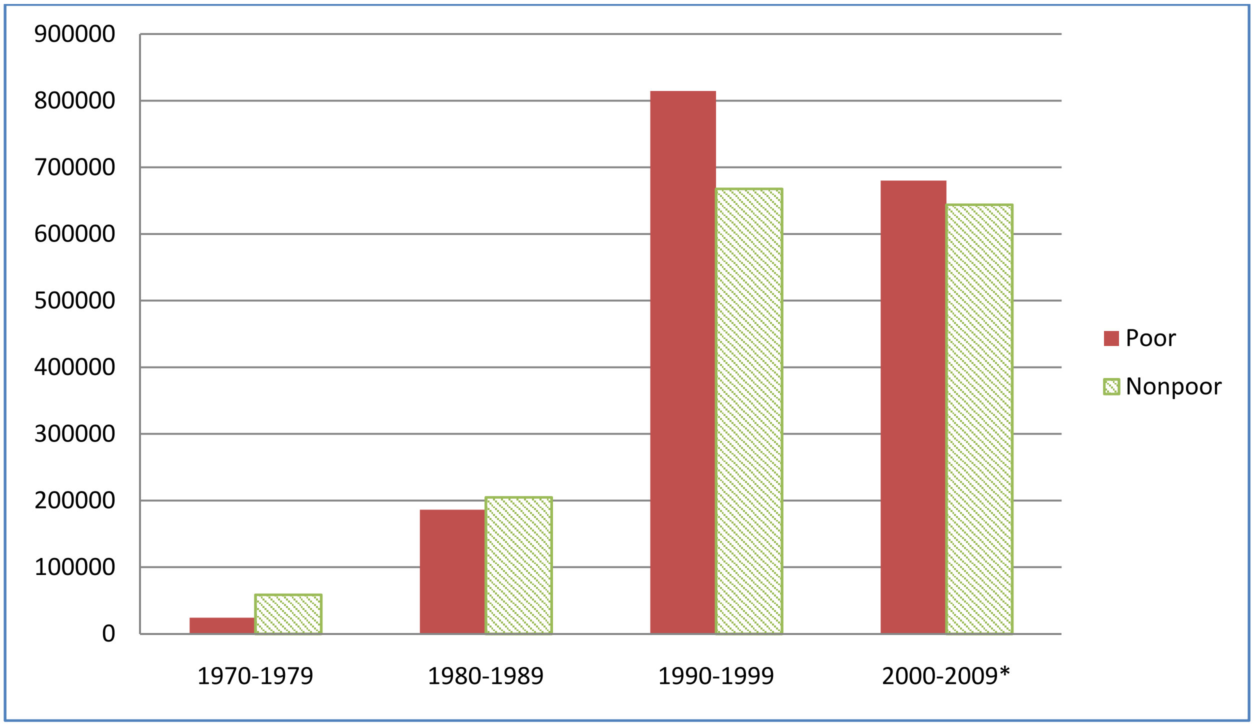
$$\gamma^{NP} = \gamma_S \frac{M_S^{NP}}{M^P} + \gamma_R \frac{M_R^{NP}}{M^P} = 0 \times \frac{64}{80} + 1 \times \frac{16}{80} = .2$$

Figure 2. Exposure Measured by Number of Affected per Million, for the poor ($2 per day) by Region



Note: The figure for 2000-2009 is proportionately expanded from the figure for 2000-2006, by the factor of 1.43.
Source: Author's calculation from World Bank (2008) and CRED (2008).

Figure 3. Exposure Measured by Number of Affected per Million, East Asia and Pacific

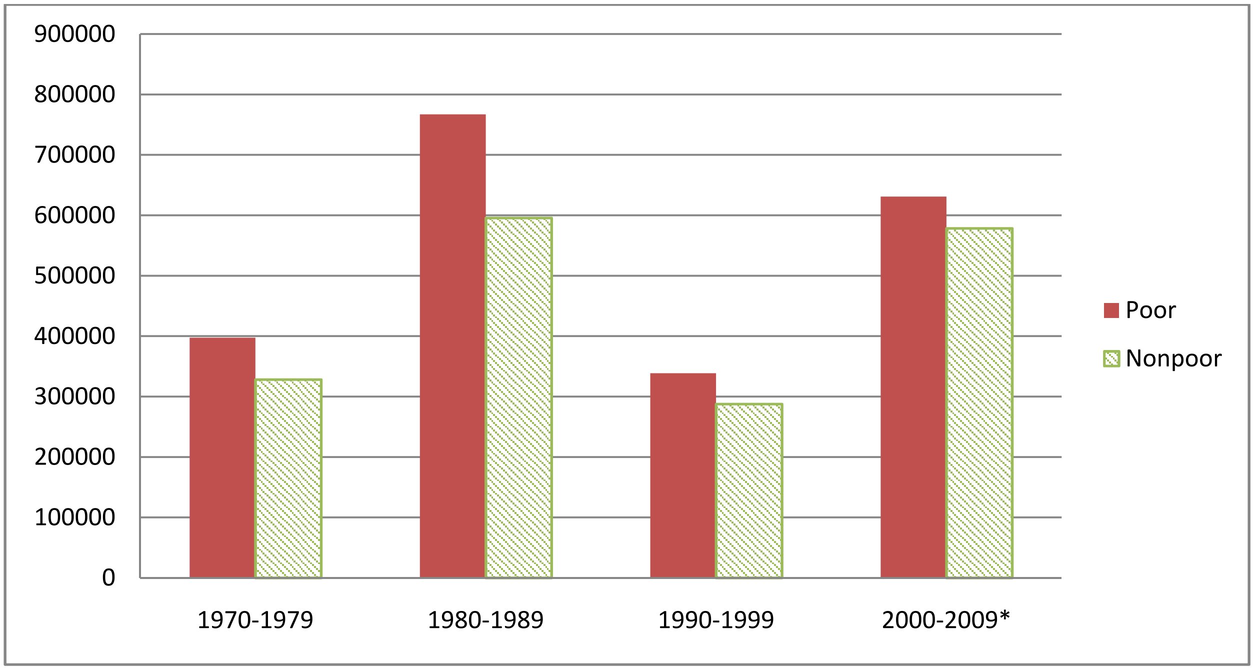


Note: The figure for 2000-2009 is proportionately expanded from the figure for 2000-2006, by the factor of 1.43.
Source: Author's calculation from World Bank (2008) and CRED (2008).

Figure 4. Exposure Measured by Number of Affected per Million, Sub-Saharan Africa

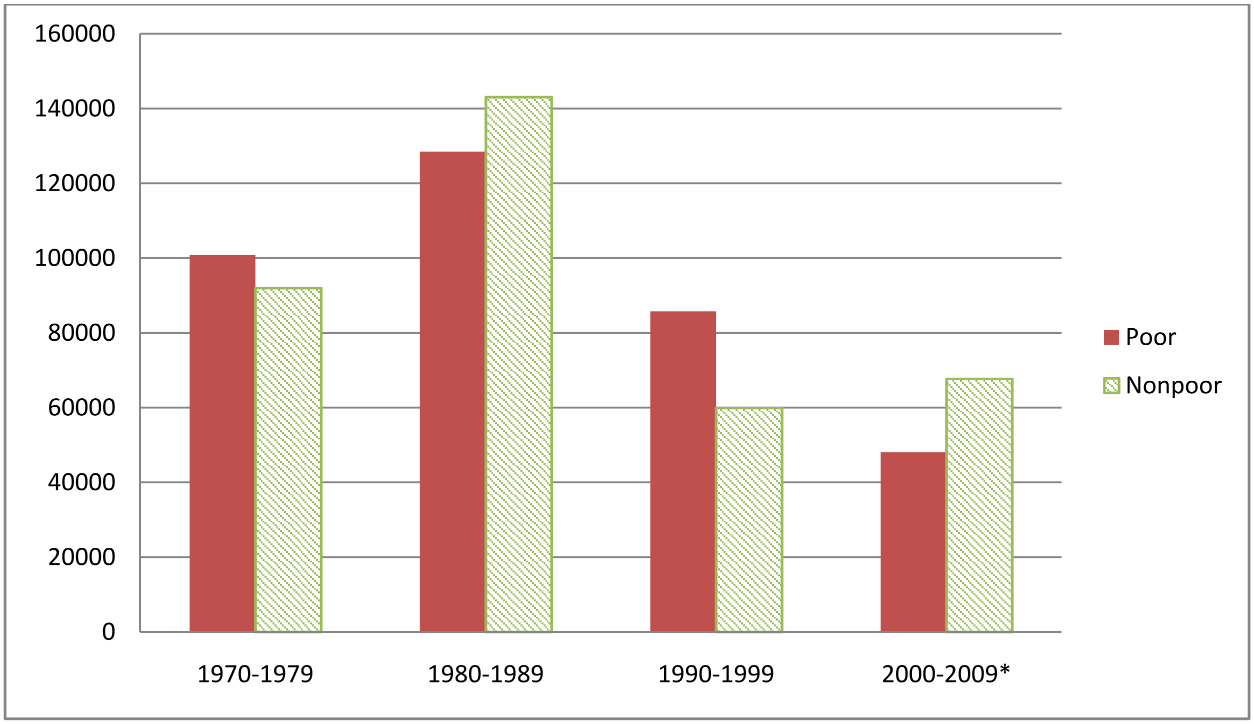
Note: The figure for 2000-2009 is proportionately expanded from the figure for 2000-2006, by the factor of 1.43.
Source: Author's calculation from World Bank (2008) and CRED (2008).

Figure 5. Exposure Measured by Number of Affected per Million, South Asia



Note: The figure for 2000-2009 is proportionately expanded from the figure for 2000-2006, by the factor of 1.43.
Source: Author’s calculation from World Bank (2008) and CRED (2008).

Figure 6. Exposure Measured by Number of Affected per Million, Latin America and the Caribbean



Note: The figure for 2000-2009 is proportionately expanded from the figure for 2000-2006, by the factor of 1.43.
Source: Author's calculation from World Bank (2008) and CRED (2008).