The Economics of Adaptation to Extreme Weather Events in Developing Countries

Brian Blankespoor, Susmita Dasgupta, Benoit Laplante, and David Wheeler

Abstract

Without international assistance, developing countries will adapt to climate change as best they can. Part of the cost will be absorbed by households and part by the public sector. Adaptation costs will themselves be affected by socioeconomic development, which will also be affected by climate change. Without a better understanding of these interactions, it will be difficult for climate negotiators and donor institutions to determine the appropriate levels and modes of adaptation assistance. This paper contributes by assessing the economics of adaptation to extreme weather events. We address several questions that are relevant for the international discussion: How will climate change alter the incidence of these events, and how will their impact be distributed geographically? How will future socioeconomic development, notably an increased focus on education and empowerment for women and girls, affect the vulnerability of affected communities? And, of primary interest to negotiators and donors, how much would it cost to neutralize the threat of additional losses in this context?

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1. Introduction

Without international assistance, developing countries will adapt to climate change as best they can. Part of the cost will be absorbed by households and part by the public sector. Adaptation costs will themselves be affected by socioeconomic development, which will also be affected by climate change. Without a better understanding of these interactions, it will be difficult for climate negotiators and donor institutions to determine the appropriate levels and modes of adaptation assistance. This paper attempts to contribute by assessing the economics of adaptation to extreme weather events. We address several questions that are relevant for the international discussion: How will climate change alter the incidence of these events, and how will their impact be distributed geographically? How will future socioeconomic development affect the vulnerability of affected communities? And, of primary interest to negotiators and donors, how much would it cost to neutralize the threat of additional losses in this context?

From a narrow technical perspective, it might be desirable to address the latter question with a detailed engineering cost analysis of specific disaster prevention measures. However, as we show in the paper, existing cross-country information about relevant emergency preparedness programs is far too sparse to support systematic analysis and projection. And in any case, we believe that the effectiveness of such measures is contingent on the characteristics of the communities that employ them. We therefore adopt an alternative approach in this paper, focusing on the role of socioeconomic development in increasing climate resilience.

Our analysis builds on empirical work and case studies that have documented the role of socioeconomic development in reducing vulnerability to climate shocks. Horwich (2000), Tol and Leek (1993), Burton, et al. (1993) and Kahn (2005) have focused on the effect of rising income per capita: As communities get richer, they have greater willingness and ability to pay for preventive measures. Kahn (2005) finds that the institutional improvement that accompanies economic development also plays a significant role, through enhanced public-sector capability to organize disaster prevention and relief.

Other work focuses on the role of political and human development. Albala-Bertrand (1993) identifies political marginalization as a source of vulnerability to natural disasters Toya and Skidmore (2005) find a significant role for education in reducing vulnerability, through better choices in areas ranging from safe construction practices to assessment of potential risks. Recently, Oxfam International (2008) has drawn on extensive evidence from South Asia to highlight the particular vulnerability of women, who often suffer far greater losses than men in natural disasters:

> *Nature does not dictate that poor people, or women, should be the first to die. Cyclones do not hand-pick their victims. Yet, history consistently shows that vulnerable groups end up suffering from such events disproportionately … In the 1991 Bangladesh cyclone, for example, four times more women*

> *died than men … Disasters are therefore an issue of unsustainable and unequal development at all levels …(Oxfam (2008), p. 1)*

A logical inference from Oxfam (2008), Albala-Bertrand (1993) and Toya and Skidmore (2005) is that empowering women through improved education may be a critical factor in reducing families' vulnerability to weather-related disasters. This would also be consistent with the extensive literature that documents the powerful effect of female education on community-level social capital and general welfare measures such as life expectancy (King and Mason, 2001).

To the best of our knowledge, no empirical research has focused on female education as a potentially-critical determinant of vulnerability to extreme weather events. Assessing its importance and implications is a core feature of this paper. Drawing on an econometric analysis of panel data, we address two key questions: As climate change increases potential vulnerability to extreme weather events, can expanding female education neutralize this increased vulnerability? If so, how much would it cost?

The remainder of the paper is organized as follows. Section 2 provides a summary of losses from extreme weather events in developing countries during the period 1960-2006. In Section 3, we review recent projections of climate impacts, economic growth and demographic change. We focus particularly on projections by integrated assessment models that incorporate links between climate change and economic activity. Section 4 specifies a set of risk equations for weather-related disasters and estimates them by fixed-effects. In Section 5, we develop country-specific projections for female education. Section 6 uses our econometric results and education projections to forecast future risks under alternative assumptions about climate change. In Section 7, we use these projections to estimate the cost of reducing future weather-related risks through more intensive investment in female education. Section 8 summarizes and concludes the paper.

2. Losses from Extreme Weather Since 1960

The most comprehensive data on weather-related losses are maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université Catholique de Louvain, Brussels.[1] For developing countries[2], the CRED data provide a sobering view of weather-related losses since 1960. Table 1 presents the numbers of people killed and affected by floods and droughts by decade. Flood-related deaths rose steadily from 17,000 in the 1960's to over 58,000 in the 1990's. Droughts killed far more people, although their impact was heaviest in the 1960's (1.5 million

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[1] To be entered in CRED's EM-DAT database, a natural disaster must involve at least 10 people reported killed; 100 people reported affected; the declaration of a state of emergency; or a call for international assistance. Recorded deaths include persons confirmed as dead and persons missing and presumed dead. Total affected persons include people suffering from disaster-related physical injuries, trauma or illness requiring medical treatment; people needing immediate assistance for shelter; or people requiring other forms of immediate assistance, including displaced or evacuated people.

[2] We define these as countries identified by the World Bank as Low Income or Lower Middle Income.

deaths) and basically absent in the 1990's (800 deaths). Aside from those killed, floods and droughts affected huge numbers of people who were injured, made homeless, or forced to seek emergency assistance. Trends for persons affected parallel the trends for deaths: rising for floods, but not for droughts.

To understand this phenomenon better, it is useful to separate losses into their two components: risk of loss (total losses/population) and population. The latter component increased rapidly in developing countries, from 2.2 billion in 1961 to 4.7 billion in 2000. Figures 1a-d provide graphical evidence on the risk component. For floods, the trends in risk of being killed or affected are clearly positive, while no trend is apparent for droughts. Figures 1a-d show that the risk series for floods and droughts are very different. Floods exhibit roughly continuous behavior through time, while droughts have exhibited huge, rare pulses that have not recurred since the early 1980's. The sources of these pulses are provided by Table 2, which presents the worst nine cases of drought-related death since 1960. Truly catastrophic losses of life in droughts in previous decades have been limited to four countries: India (1.5 million total), Ethiopia (600,000), Sudan (150,000) and Mozambique (100,000).

To summarize, losses from flooding have increased markedly since 1960 for two reasons: The risk of loss has increased significantly, and the population subject to risk has more than doubled. Droughts present a very different case, with risks dominated by catastrophic events in a few countries decades ago, and no clear overall trend. Even with rapidly-increasing population, there is no clear upward trend in persons affected by drought (Figure 2). Nevertheless, as Table 1 and Figure 2 show, the number of people affected by droughts continues to be huge.

3. What Lies Ahead

Our approach to impact forecasting incorporates projected socioeconomic and demographic trends as well as climate change. This requires us to adopt internally-consistent assumptions about future changes in emissions, economies, human development levels and populations. The emissions scenario leads to a forecast of greenhouse gas concentration in the atmosphere, which is related to changes in global and local climate through one of a large number of global circulation models (GCMs). For the economic forecast, we draw on a recent summary of integrated assessment models by Hughes (2009), who draws on a critical assessment of the IPCC's SRES scenarios by Tol, et al. (2005). Hughes develops a consensus economic projection by taking an average growth rate from five integrated assessment models. We use Hughes' constant-dollar GDP series, because our econometric risk estimation requires the use of data extending back to 1960. For the population forecast (which includes projections of life expectancies and total fertility rates), we use the UN's Medium Variant Projection (2006 Revision). Because our economic projections incorporate interactions with projected climate change, they are moderate in their view of future prospects. Overall, the economic and demographic projections we employ are relatively close to those in the SRES A2 Scenario.[3]

We attempt to bound the set of reasonable expectations about future climate using GCMs with strongly-contrasting predictions. Within the SRES A2 scenario, the GCMs provide a relatively uniform view of future increases in temperature. However, this is not the case for precipitation which, as we will show in the following section, is closely related to losses from floods and droughts. To provide a sense of what is possible from the current scientific perspective, our projections use two GCMs that are the wettest and driest of approximately 20 available GCMs at the global level. The driest overall is CSIRO's Mk 3.0 model, which was transmitted to the IPCC's data collection center in 2005.[4] The driest is NCAR's Community Climate System Model (CCSM), version 3.0, which was released to the public in 2004[5]

To illustrate the implications of the forecasts, Figure 3 provides historical and projected data for India for income per capita, population, life expectancy, fertility, mean annual rainfall, and maximum (monthly) annual temperature. We include both the CSIRO and NCAR weather projections. It is immediately clear that the India of 2050 bears little resemblance to present-day India, even in our relatively moderate scenario. GDP grows at an annual rate of 4.4%, increasing GDP per capita (constant $US 2000) from $450 in 2000 to $4,300 in 2050. Life expectancy increases from 63 to 76 years and the total fertility rate declines from 3.25 to 1.85 (below replacement). In 2050, India is an upper middle income country by current World Bank standards, closely resembling the Chile of 2000 in income per capita, life expectancy and fertility. But not, of course, in population: By 2050, India has 1.66 billion people in this scenario.

The climate projections provide a sense of the disparities in GCM predictions associated with the IPCC A2 scenario. From a monthly average of 88 mm in 2000, precipitation increases 8% by 2050 to 95 mm in the NCAR scenario, and decreases by 8% to 81 mm in the CSIRO scenario. Thus, the total difference attributable to GCM variation within the same IPCC scenario is 16% -- a very large number in this context. The two scenarios are much closer on mean monthly temperature. After an increase of 1° C. since 1970, both predict another increase of 1° C. by 2050.

This illustration serves to make one point very clearly: In scenario A2, the GCMs concur that India's temperature will rise steadily as greenhouse gases accumulate in the atmosphere. They also predict significant impacts on precipitation, but not consistently, and with different implications for extreme events. A wetter India will experience more floods, while a drier India will have more droughts. But in either case, it is critical to

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[3] IPCC (2000) characterizes A2 as follows: "A very heterogeneous world, characterized by self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in high population growth. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other scenarios."

[4] CSIRO is Australia's Commonwealth Scientific and Industrial Research Organization (www.csiro.au/)

[5] NCAR is the US National Center for Atmospheric Research. For a detailed description of the CCSM program, see http://www.ccsm.ucar.edu/about/.

note that a changed climate in the full scenario is associated with a changed country. By 2050, India has become a middle income country, whose per capita income, human resources and institutional capabilities give it much greater resilience in the face of weather changes.

The Indian case reflects a more general and under-appreciated feature of scenario A2, as well as the other SRES scenarios: Anticipated future emissions increases reflect the expectation that development will also continue. By implication, many of the countries currently termed Low Income or Lower Middle Income by the World Bank will have departed that status by 2050.

Tables 3a and 3b, calculated from the Hughes' (2009) projections, provide striking evidence of this shift for 94 countries identified as Low Income and Lower Middle Income by the World Bank in 2000. Table 3a tracks the status of 56 Low Income Countries through the succeeding decades. By 2050, 27 have moved to Lower Middle Income Status or higher. Table 3b provides the same information for 38 countries identified as Lower Middle Income in 2000. By 2050, only one has not advanced beyond that group.

Table 4 provides related information on changes in life expectancy, which are linked to the population projections. Life expectancy information is not available for two of the countries tabulated in Tables 3a and 3b. During the present decade, 14 countries still have life expectancies between 41 and 50 years and 18 have life expectancies between 51 and 60 years, while 29 have life expectancies above 70 years. By 2050, the tabulation has reversed. From 32 countries with life expectancies between 41 and 60 years in 2000-2010, the number has dropped to 7. And the number of countries with life expectancies greater than 70 has increased from 29 to 64.

In summary, even our moderately optimistic projections entail very large changes for developing countries during the next four decades. And, more importantly for this analysis, these changes are directly tied to the emissions scenario that generates the climate change problem. Countries with much higher incomes and life expectancies will also have much greater willingness and ability to pay for protection from extreme weather events. They will also have more highly-educated populations with much greater ability to avoid losses from adverse weather. This turns out to have major consequences for our assessment of future risk, as we will see in the next section.

4. Development and Vulnerability to Extreme Weather Events

As we noted in Section 2, extreme weather events have killed over 170,000 people and seriously affected billions since 1960. A changing climate may carry even greater risks in the future. But, as we noted above, changing development levels will also affect resilience in the face of weather shocks. To determine the balance between worsening weather and growing resilience over time, we specify a model of weather-related impact risk and estimate it using panel data for the period 1960-2002. Panel estimation allows for relatively clear interpretation of results, because it absorbs many sources of potentially-misleading cross-sectional correlation into estimated country effects. At the same time, however, the need for lengthy time series limits the estimation variables to a sparse set.

Our specification of the risk model incorporates three effects: economic development, weather, and education. We focus on female education, for reasons that we explained in the introduction. The formal specification is as follows for country i in period t:

$$(1)\ \ln(R_{it}) = \ln\left[\frac{L_{it}}{P_{it}}\right] = \beta_0 + \beta_1 G_{it} + \beta_2 E_{it} + \beta_3 R_{it} + \beta_4 T_{it} + \varepsilon_{it}$$

where R = Impact risk (death from floods; affected by floods and droughts)
L = Total loss (persons killed or affected)
P = Population
G = GDP per capita
E = Female educational enrollment rate
R = Precipitation
T = Temperature
ε = A random error term

Event-related losses are drawn from the CRED database; data on population, GDP per capita (in constant $US 2000) and education are drawn from the World Bank's World Development Indicators. We use constant-dollar GDP data to maximize the sample size for years prior to 1980. Data on net female primary and secondary enrollment rates are limited to the period since 1990. To extend the series for panel estimation, we "backcast" them using panel regressions that relate enrollment ratios to income per capita, life expectancy and the total fertility rate (see Section 5). These associational regressions are a transformation of the conventional fertility equation, in which the total fertility rate is a function of income per capita, life expectancy and female schooling.

We specify the education rates as flogs, to ensure that predictions are restricted to the interval 0-100%. For a probability p between 0 and 1, the flog is defined as log [p/(1-p)]. This is an appropriate specification for the regressions in any case, since it is consistent with natural lower and upper bounds for net enrollment rates. These are, in effect, first-stage regressions, with the total fertility rate, life expectancy and per capita income playing the role of instruments for second-stage estimation of the climate impact regressions. Life expectancy is not significantly affected by deaths from floods, which are minuscule by comparison with deaths from other causes. Therefore, use of this variable as a first-stage instrument should not lead to biased estimates for schooling in the regression for death from floods.

Table 5 presents the fixed-effects estimation results, which are extremely robust in both regressions for the total fertility rate and life expectancy. Per capita income is not a significant determinant of net female primary enrollment, but it has great explanatory power in the secondary enrollment regression.

Prior experimentation has indicated that the appropriate functional form for equation (1) is log-linear, and that some climate indicators are much more robust than others. In every case, mean rainfall is far more robust than either maximum or minimum rainfall, as well as other possible transformations (max/min ratio, etc.). No measure of temperature (mean, maximum, minimum, max/min ratio, etc.) is significant in any of the three risk equations.

Table 6 presents results for the risk of being killed or affected by floods, and affected by droughts. Footnote 1 provides a detailed explanation of the criteria for determining persons affected. Our instrumental variables approach creates high collinearity for primary and secondary enrollment ratios, so we estimate separate equations for primary and secondary schooling. This serves our primary objective – inferring the schooling needed to neutralize future climate impacts – but raises the risk of upward bias in the separately-estimated impact of each schooling variable. Such bias would lead to an ultimate under-estimate of schooling required to neutralize climate change (the higher the estimated effect of schooling on risk, the lower the schooling needed to neutralize additional risk from worsening weather). However, we compensate for this by using the two sets of econometric results to calculate demands for primary and secondary education separately. This introduces something akin to double-counting, thereby reducing or eliminating the effect of upward bias in the regressions themselves.

The panel estimation results in Table 6 are quite robust for flooding risk, with all variables highly significant and all parameter signs consistent with prior expectations. Flood risk rises significantly as mean precipitation rises and falls significantly as per capita income rises. The two schooling variables have highly-significant impacts of approximately equal magnitude: Flood risk falls as female enrollment increases. The results are much weaker for drought risk, partly because the smaller sample size reduces degrees of freedom for estimation. GDP per capita is insignificant and has a perverse sign when it is included in these regressions, so we have excluded it from the estimates. Education and rainfall retain the correct signs, although only female primary enrollment is significant at 5%. These are the maximum likelihood estimates in any case, and we need to project drought effects, so we retain the two drought equations in Table 6.

To explore the implications of our results, we compare actual historical losses with a counterfactual case in which countries at each World Bank development level are assigned the same female primary enrollment ratio as the "best practice" country in the same World Bank class in the same year (e.g., all Low Income countries in 1985 are assigned the highest female primary enrollment ratio among Low Income countries in 1985). We perform this experiment to see how much difference feasible policy changes could have made for extreme weather risk. As Table 7 and Figure 4 show, our results strongly indicate that more progressive policies would have made an enormous difference. From 1970 to 1999, the CRED database records 153,079 deaths from floods in low income and lower middle income countries. In our "best practice" counterfactual, by contrast, flood deaths number 91,541: 61,538 fewer people lose their lives. For numbers affected, the estimated differences are very large. From 1960 to 1999, the CRED database indicates that 2.12 billion people in developing countries were affected by floods. In the counterfactual best practice case, this falls by 465 million to 1.65 billion. For droughts, the number affected falls by about 667 million – from 1.34 billion to 676 million.

We conclude that a huge number of weather-related tragedies could have been averted if more developing countries had focused on progressive but feasible female education policies. Countries that focused on female education suffered far fewer losses from extreme weather events than less-progressive countries with equivalent income and weather conditions. It seems reasonable to assert that what has been true in the past will also be true in the future. Given the significance of income and female education in determining vulnerability to extreme weather events, we would expect countries' future resilience to increase with economic growth and improvements in education.

5. Projecting Baseline Changes in Female Education

The panel estimation results in Table 5 provide a reasonable basis for projecting the future paths of female primary and secondary education in each country, given our exogenous projections of income and population. Our projections for life expectancy and the total fertility rate are taken directly from the UN's Medium Variant population forecast. Given the paths of the three variables (life expectancy, total fertility rate, income per capita), we use the fixed-effects results reported in Table 5 to plot the paths of future net female primary and secondary enrollment rates. Here it is worth repeating that we estimate both equations in Table 5 using flog transformations on net enrollment rates, which insure that projections are bounded in the range 0-100.

To illustrate the implications of our approach, Table 8 presents projected future schooling rates by region. We compute these rates in several steps. First, we estimate the panel regressions, incorporating subregional dummies as well as country effects.[6] Then we combine the results with country projections of GDP per capita, life expectancy and the total fertility rate to predict future net female primary and secondary enrollment rates. We combine these rates with appropriate UN Medium Variant female population cohort data to calculate the actual number of females enrolled in primary and secondary school. Finally, we total enrolled females and relevant cohort females by region for primary and secondary schooling, and form the ratios to project regional primary and secondary enrollment ratios.

Although our economic and demographic projections are "moderate" by current standards, they nevertheless entail continued rapid progress in female education. By 2050, Sub-Saharan Africa increases its net female primary enrollment rate from 54.9 to 93.5, and its net female secondary enrollment rate from 19.7 to 78.0. South Asia also makes rapid progress, moving its female primary and secondary enrollment rates from 69.5 to 92.4 and 42.0 to 90.8, respectively. East Asia/Pacific, Latin American/Caribbean and Middle East/North Africa also move upward, but proportionately less because they start from higher bases. While educational progress is quite noteworthy in this scenario,

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[6] We include fixed effects for 25 subregions.

it still falls well short of the Millennium Development Goals. For example, Sub-Saharan Africa only approaches the MDG for female primary education by 2050.

6. Climate Change, Development and Future Vulnerability

Now we turn our attention to simulating the future. Our approach is identical to the counterfactual approach in Section 4, except that all of the righthand variables are projected for this exercise. To get a clear sense of the stakes, we introduce several variants: We estimate impacts with and without climate change, for both GCM climate projections, and with and without improvements in income and female education. We introduce the latter variant to highlight the stark difference in results when only future emissions are counted, not the economic and human development that accompany those emissions. As we have noted in Section 3, forty years hence many of today's low and lower middle income countries will have experienced major growth in income and female education. Our panel results in Table 6 suggest that the latter changes will have a significant impact on climate vulnerability. To assess the relevant magnitudes, we develop a detailed illustration for India that incorporates variations in the GCMs and development conditions.

We focus on computed risks, or incidence probabilities, because they provide clear insight into the impact of model variables on projected future losses. In each case, the relevant probability is multiplied by population to provide an overall loss estimate. India's population is projected to continue growing to about 1.66 billion people by 2050. Since the population is growing, even constant risk (measured as a loss probability) will translate to more losses when it is multiplied by the growing population.

In Figure 5, our historical baseline for India is set at income per capita and life expectancy in 2000, and mean precipitation during the period 1995-2000. The associated annual loss probabilities are .62 per million for being killed by a flood; 0.0039 for being affected by a flood; and .0509 for being affected by a drought. From this baseline, we forecast the impact of GCM-projected changes in mean precipitation while holding income and life expectancy at their 2000 levels. The results, labeled "Static" in Figure 5, show the magnitudes of the projected impacts, as well as their directions. NCAR is the wettest global scenario, and this is reflected in the Indian projections. In the static NCAR case, the risk of death from flooding rises from 0.62 in 2000 to 0.66 in 2050. Conversely, CSIRO, which produces the driest scenario, projects a drop in mean precipitation and an associated fall in flood-related death risk: from 0.62 in 2000 to 0.57 in 2050.

Thus, holding economic and social development constant at 2000 levels, precipitation variations across GCMs include a range of about .09 per million in flood death risk. In all cases, the deviation from current death risk is sufficiently small to be dominated by population growth in the assessment of losses. Table 9 presents the relevant projections. In the Historical case, projected annual deaths increase from 626 to 1,023 (the risk of death remains constant, while population continues growing). Projected annual deaths from flooding rise to 1,092 for NCAR, the wettest scenario, and fall to 950 for CSIRO, the driest. Clearly, the differences are quite small in absolute terms: By 2050, climate is responsible for 69 additional flood-related deaths per year in the NCAR scenario, and 73 fewer deaths in CSIRO. For the entire fifty-year period, continuation of the historical climate pattern in a static India (at 2000 income per capita and educational enrollment rates) would yield 44,038 expected deaths from flooding. In the static case, this rises to 45,458 for the NCAR climate change scenario and falls to 41,325 for CSIRO.

In comparison to these relatively small mortality effects, the number of people affected by floods is larger by one order of magnitude and people affected by droughts by two orders of magnitude. For floods, the baseline probability of being affected (in the static-India case with no climate change) is .0039. This rises to .0043 for NCAR climate change and falls to .0035 for CSIRO. These are much larger fractions than the death risks, and they translate to large absolute numbers. Projected people affected annually rises from 4.0 million to 6.5 million in the baseline case (constant risk, population growth), rises to 7.2 million for NCAR (in a static India) and falls to 5.7 million for CSIRO. Thus, the range of impacts is between 700,000 more people and 800,000 fewer people affected by floods. The associated totals and differences in Table 9 are quite large: A fifty-year increase from the baseline of 15 million for NCAR (293.6 vs. 278.6 million), and a decrease of 27.7 million for NCAR. The numbers are larger by another order of magnitude for drought, but in the opposite direction. For annual numbers affected by drought, the baseline case rises from 51.6 million in 2000 to 84.4 million in 2050. The numbers rise less rapidly in the NCAR (wet) case for a static India, to 77.1 million and more rapidly for CSIRO (dry), to 93.4 million. Translated to fifty-year totals, the differences are huge: 337 million more people affected for CSIRO, and 153 million fewer for NCAR.

All of the cases discussed above have elements in common: In an India that experiences no change in income and life expectancy, population growth alone (with constant loss risk) ensures that losses from extreme weather events increase substantially, even if there is no climate change. The projected range of climate changes will alter the forecast, making it lower in some cases and higher in others. But in the static-India case, all the scenarios project greater future losses, and climate effects that are smaller proportionally than anticipated effects from population change.

Of course, all of the projections above are unrealistic, because they assume a static India that bears no resemblance to the India in the climate change forecasts. As we have seen in a previous section, that India is quite close to present-day Chile in income and education levels by 2050. Despite their unreality, we have included the static-India forecasts because we believe that they reflect the implicit assumptions in many current climate-impact analyses.

For an instructive contrast, we now turn to projections that also utilize the fixed-effects estimates for equation (1), but incorporate our income and education projections for India. Although we will review the numbers in some detail, the basic results are made graphically clear by the Development scenarios in Figure 5. For flooding, in both NCAR and CSIRO scenarios, the probabilities of being killed or affected plunge so sharply that they dominate rising population in the calculation of total losses. The result is many fewer deaths and people affected by floods in 2050, although there is still a climate affect at a much lower level. A rapid fall is also evident for risk in the NCAR scenario for drought, although much less so for CSIRO.

When we translate these risks into total losses, the results are quite striking. The India of 2050 has annual flooding deaths of about 461 for NCAR and CSIRO, vs. 1,023 in the baseline. It has 3.6 million people affected by floods in NCAR and 2.8 million in CSIRO, vs. 6.5 million in the baseline. In the case of droughts, 62.5 million are affected in NCAR and 75.7 million in CSIRO, vs. 84.4 million in the baseline.

We draw two conclusions from these results. First, it still makes sense to discuss financial support for adaptation to climate change in this context, because risks and losses can still be greater with climate change than without it. But second, and perhaps more important, our results strongly indicate that the India of 2050 will suffer fewer losses from extreme weather after four more decades of climate change than present-day India suffers.

For global perspective, we have included the same projection comparisons for all developing countries in Table 10. Although the magnitudes are larger, they replicate the patterns that we have just discussed. The developing world of 2050 may well suffer more losses with climate change than without it (the impact depends on whether the wet or dry scenario dominates), but the available evidence makes it very likely that it will suffer far fewer losses than presently in either case. And our results for female education in equation (1) reinforce a fundamental point: If we are really interested in reducing losses from climate events, assistance for greater resiliency now can make a huge difference.

7. Estimating The Cost of Adapting to Extreme Weather Events

7.1 Data on Weather Emergency Preparedness Costs.

Systematic work on the cost of adaptation to extreme weather events has been hindered by scanty data on the cost of measures for emergency preparedness. A study of this type would be aided considerably by country-specific cost information for measures targeted on floods or droughts. However, the representative information in Table 11 illustrates why we have not been able to employ such information. Its entries have been extracted from country reports by the Asian Disaster Reduction Center. The reports generally focus on summary information rather than specific information for emergency preparedness by type of disaster (e.g., floods, droughts). In the case of Japan, for example, much of the $34 billion expenditure is clearly for earthquake-related measures. The listed funds for Bangladesh are more than twice China's and four times Indonesia's, and they include both emergency food assistance and disaster management. Much of the Indonesian fund undoubtedly relates to geologic disasters (earthquakes, volcanic eruptions, tsunamis) as well as weather-related disasters.

Most reports do not provide time series information, nor do they go beyond reporting for single funds or national-level agencies.[7] Local expenditures are not included.

In summary, the available data are far too spotty, non-specific, non-standardized, and temporally limited to permit estimation of cost functions that could be used for projection. In addition, they cover relatively few countries. There is simply no way to construct a reasonable cost analysis from such information.

7.2 The Education Alternative

Since direct cost measures cannot be derived from the available data, we turn to an indirect approach. As the panel results in Table 6 show, improvements in female education are powerfully associated with reductions in disaster risks once changes in weather and income are accounted for. In this section, we exploit this relationship to address the adaptation cost question indirectly.

Our approach applies straightforward algebra to equation (1). Given an anticipated change in precipitation, we calculate the increase in education that will be just sufficient to restore the risk level prior to the precipitation change. With subscripts B for the baseline case and N for the risk-neutralizing case, we impose the following constraint on the relevant elements of equation (1) (the others cancel because they remain unchanged):

$$(2)\quad \beta_2 E_{iN} + \beta_3 R_{iN} = \beta_2 E_{iB} + \beta_3 R_{iB}$$

This yields the change in the educational enrollment rate that will neutralize the change in risk introduced by deviation of rainfall from the baseline case:

$$(3)\quad \Delta E_i = E_{iN} - E_{iB} = -\frac{\beta_3}{\beta_2}[R_{iN} - R_{iB}] \quad (\beta_2<0,\ \beta_3>0)$$

For each education level, we calculate ΔE_i for persons killed by floods, persons affected by floods, and persons affected by droughts. Adopting a conservative approach, we only consider positive ΔE_i.[8] We compute the 50-year sum of positive ΔE_i for each of the three risks and, in keeping with our conservative approach, we choose the risk for which the sum is largest.

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[7] Our thanks to Tim Essam for his help with gathering this information.

[8] In a wetter climate regime the number of people killed and affected by floods will rise, but the number affected by droughts will fall. The converse is true for a dryer regime. A complete accounting would therefore involve calculation of net impacts (losses from flooding vs. losses from droughts) But in the case of floods, such an exercise would require assigning relative weights to being killed and being affected (injured, rendered homeless, or requiring temporary assistance). It would also require the assignment of relative weights to the affects of floods and droughts. Rather than adopt arbitrary weights, we take the conservative approach and use the greatest change in enrollment ratio across the three risk categories.

7.3 The Cost of Climate Change Neutralization

Now we are ready to compute the cost of neutralizing the risk impact of more extreme weather events via increased schooling for young women. Once we have chosen the appropriate ΔE_i for each schooling level in each country, computing the associated incremental cost involves two steps. First, we obtain the number of new students by multiplying ΔE_i (as a percent) by the number of females in the appropriate age cohort.[9] Then we multiply by projected expenditure per pupil. To compute projected unit expenditures, we have drawn on the World Bank's World Development Indicators to estimate panel regressions for primary and secondary expenditures per student as a proportion of gdp per capita. After extensive experimentation with available and plausible righthand variables (e.g., per capita income, size of student population, time trend), we find significance only for country, subregional and regional fixed effects. We use all three sets of fixed effects to get the most accurate estimates for countries that have no unit expenditure data in the WDI. Then we apply the country estimates to projected per capita income to obtain predicted expenditures per primary and secondary student by year. We combine these with the calculated numbers of primary and secondary students required for "climate change neutralization" to obtain our estimate of the public cost.

Table 12 provides a set of illustrative results for three countries in different regions that have comparatively low baseline female enrollment rates: Republic of Congo, Nepal and Nicaragua. For ease of interpretation, we present results at ten-year intervals, beginning in 2010. The results highlight the global diversity that interacts with the GCM projections. Overall costs are higher for CSIRO in Congo and Nepal, and for NCAR in Nicaragua; we focus on the higher-cost scenario for each country. Here it is useful to recall that these are adjustments from a baseline in which the countries continue their socioeconomic development. Weather impact risks decline as income and life expectancy increase. The numbers in Table 12 reflect the deviations from this baseline, which assumes no climate change.

In Congo, neutralizing the effect of climate change in the CSIRO scenario requires 4.700 additional females in primary school in 2010, along with 4,100 additional female students in secondary school. The associated annual schooling costs for primary and secondary students are $97 and $233, respectively. When these are applied to the schooling increments, the result is an additional expenditure of $1.4 million in 2010. The numbers increase steadily through 2040. In that year, the addition to schooling is 32,900 primary students and 32,400 secondary students which, at projected unit costs of $218 and $524, yields a total expenditure of $24.2 million. Projected short-term moderation of climate impact after 2040 reduces the numbers in 2050.

In Nepal, the number of needed additional students in the CSIRO (higher-cost) scenario is far greater than for the Congo and the unit costs substantially lower. When combined, the two factors yield climate-neutralizing costs that increase from $5.9 million in 2010 to $27.2 million in 2040, then fall to $26.5 million in 2050. The NCAR scenario is more

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[9] Our primary-school cohort is young women in age group 5-9, plus half of young women 10-14. Our secondary cohort is half the age group 10-14, plus the age group 15-19.

potentially-damaging for Nicaragua than CSIRO. Neutralizing the impact of NCAR-projected change requires the addition of 35,900 young women to primary schooling and 69,400 to secondary schooling in 2010. The total cost is $5.9 million in 2010, increasing to $13.5 million in 2050.[10]

Table 13 summarizes our results at the regional level. Here the scale of effort needed for climate neutralization becomes apparent. In Sub-Saharan Africa, the overall impacts of CSIRO and NCAR are roughly similar. For both GCM scenarios, the requisite annual expenditure rises from about $200 million in 2010 to over $2 billion in 2050. By the latter date, climate neutralization in CSIRO requires 1.7 million additional primary school students and 3.5 million additional secondary students. In the NCAR case, these numbers rise to 3.0 million primary students and 7.1 million secondary students. The Sub-Saharan case points to another feature of geographic diversity that has implications for the cost of climate neutralization. Climate changes in the two scenarios have different geographic distributions. In the African case, by happenstance, the countries most adversely affected in NCAR have significantly lower unit schooling costs than the countries with the greatest effects in CSIRO. As a result, climate-neutralizing expenditure is slightly lower in NCAR, even though the number of additional students is substantially higher.

South Asia is also not far from cost parity in the two climate scenarios. Although the expenditure difference is large in 2010 -- $529 million in CSIRO vs. $266 million in NCAR – by 2050 the numbers are proportionally much closer ($5.4 billion and $4.9 billion, respectively). Other regions exhibit disparities, but with different patterns. East Asia and the Pacific Islands are dominated by China, whose rising prosperity generates steadily-increasing schooling costs. Costs in the CSIRO scenario dominate until 2040, when a projected climate shift significantly moderates climate stress during the same period that it increases in NCAR. The result is a reversal for CSIRO, as regional expenditures fall from $2.1 billion in 2040 to $796 million in 2050, while NCAR expenditures continue expanding, from $1.7 billion to $2.6 billion. In the remaining three regions, NCAR dominates expenditures in varying degrees.

Table 14 summarizes the annual results, which tell a story of impressive magnitudes. Overall, annual expenditures are remarkably close for CSIRO and NCAR until 2040. Climate-neutralizing educational expenditure is about $1.6 billion for both in 2010. By 2040, NCAR is slightly ahead ($9.5 billion vs. $9.2 billion). Projected short-run climate shifts and a host of other factors shift the balance by 2050, and NCAR finishes well ahead of CSIRO ($13.6 billion annually, vs. $10.9 billion). In both scenarios, the implications for climate-neutralizing female education are massive. By 2050, neutralizing CSIRO requires 7 million additional young women in primary school and 11.3 million in secondary school. The corresponding numbers for NCAR are 8.3 million and 14.9 million.

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[10] Like many countries in Latin America, Nicaragua is reported by the World Development Indicators as spending more per capita on primary students than on secondary students. The results for Nicaragua in Table 12 reflect this disparity.

Table 16 provides a final summary by totaling annual expenditures for the period 2002-2050[11] at varying discount rates. Overall, at a 0 discount rate, impact-neutralizing expenditures for additional female education are \$279.4 billion for CSIRO and \$288.1 billion for NCAR. The totals fall sharply as the discount rate increases. At 7%, present values in 2002 are \$40.2 billion for CSIRO and \$39.5 billion for NCAR. Among the world's regions, it is both clear and unsurprising that the largest climate-neutralizing expenditures are in the areas whose low incomes and schooling rates are associated with higher climate impact risks. South Asia has the greatest expenditure in both climate scenarios, with CSIRO much more costly than NCAR (\$121.2 billion vs. \$89.7 billion for a zero discount rate). Sub-Saharan Africa and East Asia/Pacific Islands are in the next rank, with rough balance across the two scenarios: Around \$46 billion for Sub-Saharan Africa and \$55 billion for East Asia/Pacific. In the next rank, both Eastern Europe/Central Asia and Latin America/Caribbean have NCAR expenditures about twice as high as CSIRO expenditures. The pattern reverses for Middle East/North Africa, where expenditures are \$15.7 billion for CSIRO and \$12.9 billion for NCAR.

8. Summary and Conclusions

In this paper, we have addressed several questions that are relevant for the international discussion of adaptation to climate change: How will climate change alter the incidence of these events, and how will their impact be distributed geographically? How will future socioeconomic development affect the vulnerability of affected communities? And, of primary interest to negotiators and donors, how much would it cost to neutralize the threat of additional losses in this context?

From a narrow technical perspective, it might be desirable to address the latter question with a detailed engineering cost analysis of specific disaster prevention measures. However, as we show in the paper, existing cross-country information about relevant emergency preparedness programs is far too sparse to support systematic analysis and projection. And in any case, we believe that the effectiveness of such measures is contingent on the characteristics of the communities that employ them. We therefore adopt an alternative approach in this paper, focusing on the role of socioeconomic development in increasing climate resilience. Drawing on extensive research, our approach highlights the importance of female education and empowerment in reducing weather-related loss risks. Our cost analysis asks two key questions: As climate change increases potential vulnerability to extreme weather events, how many additional young women would have to be educated to neutralize this increased vulnerability? And how much would it cost?

Our study relies heavily on fixed-effects estimation of risk equations that link losses from floods and droughts during the period 1960-2003 to three basic determinants: weather events that increase potential losses, income per capita, and female education. We estimate separate equations for the risk of death from a flood, the risk of being affected

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[11] A few missing value problems prevent generation of fully-comparable numbers for 2000 and 2001.

by a flood, and the risk of being affected by a drought (the data are too sparse to support estimation for death from droughts).

Our analysis combines the estimated risk equations with projections of economic growth and population change, along with accompanying changes in primary and secondary schooling. We develop three scenarios: A baseline in which socioeconomic development continues but the climate does not change, and two scenarios with the same baseline development path but alternative weather paths driven by particularly "wet" and "dry" GCMs. For each GCM scenario, we calculate the associated changes in the risks of death from floods and being affected by floods or droughts. Then, choosing the worst-case risk, we calculate the increase in female schooling that would neutralize this additional risk. We multiply the results by expenditures per student to estimate the total educational investment required to neutralize the additional weather risk posed by climate change.

Our approach is conservative, in the sense that it is very unlikely to underestimate the required investment. First, we base our cost assessment on general preparedness via increased education, rather than more narrowly-targeted investment in emergency preparedness. Second, we base our cost calculation on worst-case risk scenarios, which require the greatest increase in schooling to neutralize. Third, we incorporate only projected increases in vulnerability, not decreases. As an alternative, for example, we could perform a net impact analysis for a wet climate scenario that would subtract expected decreased losses from drought from expected increased losses from flooding. Fourth, our analysis employs the two GCMs (among approximately twenty) that generate the wettest and driest scenarios at the global scale. Other GCMs would generate more moderate intermediate results. Finally, we do not average across the two GCMs, which would have the effect of neutralizing their extreme signals.

In summary, we believe that our approach is sufficiently conservative to create a strong upward bias in our cost estimation.[12] It is certainly possible that the "true" cost of adaptation to extreme weather events is lower than our estimates, but we very much doubt that it is higher.

At the same time, our approach offers significant co-benefits because female education has a much broader sphere of potential influence than direct investment in emergency

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[12] One potential caveat relates to disparities between male and female enrollment rates. Where female rates are significantly lower than male rates, climate-neutralizing increases in female education are not likely to produce female enrollment rates higher than their male counterparts before the latter reach 100%. In this case, increases in female education would also be defensible on equal-opportunity grounds. In the converse case – in which climate-neutralizing increases would actually raise female enrollment rates above their male counterparts at some future point – there might well be pressure for subsequent matching increases in male enrollment. In this case, our approach would underestimate full educational costs for the countries in question (although it would remain conservative in all other dimensions). However, it is important to note that our benchmark forecasts already incorporate rapid expansion of educational enrollments in all poor countries. And in many of these countries, large enrollment rate disparities imply that male-parity claims would not be a problem because male enrollment would reach 100% long before female enrollment. Nevertheless, we acknowledge that our approach could underestimate full educational costs for some countries. Our thanks to Nancy Birdsall for raising this issue.

preparedness. As the development literature has noted for many years, educating young women is one of the major determinants (indeed, some would argue, *the* major determinant) of sustainable development. A disaster-prevention approach that focuses on investment in female education therefore has an expected social rate of return on other margins that probably warrants the exercise, even if the expected benefits in reduced disaster vulnerability are overstated (and in fact, we believe the opposite to be true).

Our analysis has generated a set of estimates for required female schooling and associated costs by GCM scenario, country and year. Variations in projected climatic, socioeconomic and demographic variables are more than sufficient to produce wide disparities in outcomes by 2050, even among countries within the same region. At the country and regional levels, neither climate scenario dominates in all cases. The "wet" scenario generates higher risk-neutralizing expenditure on female schooling in come countries and regions; the "dry" scenario is more costly in others. Among regions, South Asia requires the most expenditure in both climate scenarios, followed by Sub-Saharan Africa and East Asia, and then more distantly by the other regions.

At both regional and global levels, we find an impressive scale for the requisite increases in female education expenditure. By mid-century, neutralizing the impact of extreme weather events requires educating an additional 18 to 23 million young women at a cost of $11 to $14 billion annually. For the period 2000-2050 as a whole, both GCM scenarios entail about $280 billion in additional expenditure. The present value of these expenditures is substantially reduced by time-discounting, even at modest rates, but the basic result stands: In the developing world, neutralizing the impact of worsening weather over the coming decades will require educating a large new cohort of young women at a cost that will steadily escalate to several billions of dollars annually. However, it will be enormously worthwhile on other margins to invest in education for millions of young women who might otherwise be denied its many benefits.

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Table 1: Losses From Extreme Weather Events:
Developing Countries, 1960-1999

	Deaths („000)		Number Affected („000)	
Period	Floods	Droughts	Floods	Droughts
1960-69	17.0	1,510.1	34,256	110,000
1970-79	46.4	319.1	200,000	460,000
1980-89	50.3	556.9	480,000	700,000
1990-99	58.5	0.8	1,400,000	190,000
Total	172.2	2,386.9	2,114,256	1,460,000

Source: CRED (EM-DAT)

Table 2: Catastrophic Death Tolls From Droughts, 1960-2002

Country	Year	Deaths
India	1965	500,000
India	1966	500,000
India	1967	500,000
Ethiopia	1984	300,000
Ethiopia	1974	200,000
Sudan	1984	150,000
Mozambique	1984	100,000
Ethiopia	1973	100,000
Somalia	1974	19,000

Source: CRED (EM-DAT)

Table 3a: Year 2000 Low Income Countries Through 2050

Decade	Low Income	Lower Middle Income	Higher	Total
2001-2010	56	0	0	56
2011-2020	49	7	0	56
2021-2030	42	14	0	56
2031-2040	34	22	0	56
2041-2050	29	24	3	56

Table 3b: Year 2000 Lower Middle Income Countries Through 2050

Decade	Lower Middle Income	Higher	Total
2001-2010	38	0	38
2011-2020	26	12	38
2021-2030	11	27	38
2031-2040	7	31	38
2041-2050	1	37	38

Table 4: Year 2000 Low Income and Lower Middle Income Countries:
Changes in Life Expectancy Through 2050

	Life Expectancy at Birth					
Decade	41-50	51-60	61-70	71-80	81-90	Total
2001-2010	14	18	31	29	0	92
2011-2020	8	18	31	35	0	92
2021-2030	4	18	20	50	0	92
2031-2040	0	14	22	55	1	92
2041-2050	0	7	21	60	4	92

Table 5: Determinants of Net Female Enrollment Ratios

Dependent Variable: Flog Net Enrollment Rate

	(1) Primary	(2) Secondary
Total Fertility Rate	-0.349	-0.555
	(7.35)**	(14.87)**
Life Expectancy	0.068	0.043
	(6.04)**	(6.51)**
Log GDP Per Capita	0.139	0.893
	(1.34)	(10.67)**
Constant	-1.774	-5.213
	(1.39)	(8.14)**
Observations	1849	1025
R-squared	0.89	0.98

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

Table 6: Weather Risk Model: Fixed-Effects Estimates

Dependent Variables [Log(Variable/Population)]

	(1) Floods Killed	(2) Floods Killed	(3) Floods Affected	(4) Floods Affected	(5) Droughts Affected	(6) Droughts Affected
Female Primary Enrollment Rate	-0.018 (4.67)**		-0.017 (2.70)**		-0.020 (2.05)*	
Female Secondary Enrollment Rate		-0.017 (5.36)**		-0.015 (2.87)**		-0.011 (1.16)
GDP Per Capita ($'000)	-0.137 (6.22)**	-0.122 (5.46)**	-0.120 (2.91)**	-0.107 (2.53)*		
Precipitation (mm.)	0.010 (3.28)**	0.010 (3.23)**	0.016 (3.61)**	0.016 (3.60)**	-0.013 (1.75)	-0.014 (1.79)
Constant	-12.833 (28.38)**	-13.438 (36.28)**	-6.630 (9.29)**	-7.297 (12.92)**	-0.883 (1.08)	-1.752 (2.67)**
Observations	933	929	1051	1047	323	322
Countries	120	120	134	134	83	82
R-squared	0.46	0.46	0.41	0.42	0.54	0.53

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

Table 7: Historical and Simulated “Best Practice” Weather-Related Losses 1970-2000

Risk Category	Historical	Best Practice	Difference	% Difference
Flood Deaths	153,079	91,541	61,538	40.2%
Floods Affected ('000)	2,116,243	1,651,065	465,178	22.0%
Droughts Affected ('000)	1,342,337	675,797	666,540	49.7%

Table 8: Projected Net Female Primary and Secondary Enrollment Ratios by Region

Region	Sub-Saharan Africa		East Asia and Pacific Islands		Latin America and Caribbean		Middle East and North Africa		South Asia	
Year	P	S	P	S	P	S	P	S	P	S
2000	54.9	19.7	95.0	80.5	90.8	61.3	80.5	56.0	69.5	42.0
2010	68.7	28.5	96.9	86.5	93.3	73.1	89.1	67.4	81.3	60.5
2020	78.0	43.8	97.8	89.9	94.9	81.1	92.9	77.6	85.8	73.5
2030	86.0	59.4	98.2	93.0	96.0	85.8	94.9	84.7	88.8	81.9
2040	90.8	70.9	98.6	94.8	96.9	89.6	96.1	89.3	90.7	87.2
2050	93.5	78.0	98.8	96.2	97.4	92.1	96.9	92.1	92.4	90.8

Table 9: Alternative Scenarios for India, 2000-2050

	Year	Flood Deaths			Affected by Floods (Million)			Affected by Droughts (Million)		
		CSIRO	NCAR	Historical	CSIRO	NCAR	Historical	CSIRO	NCAR	Historical
2000		626.1	626.1	626.1	4.0	4.0	4.0	51.6	51.6	51.6
2050	Static	950.4	1,092.3	1,023.4	5.7	7.2	6.5	93.4	77.1	84.4
2050	Devel	461.0	461.0	1,023.4	2.8	3.6	6.5	75.7	62.5	84.4
Totals										
2000-50	Static	41,325.2	45,457.6	44,038.4	250.9	293.6	278.6	3,967.4	3,477.1	3,630.2
2000-50	Devel	27,768.1	30,269.3	44,038.4	176.7	204.1	278.6	3,362.6	2,956.4	3,630.2

Table 10: Alternative Scenarios for Developing Countries, 2000-2050

	Year	Flood Deaths			Affected by Floods (Million)			Affected by Droughts (Million)		
		CSIRO	NCAR	Historical	CSIRO	NCAR	Historical	CSIRO	NCAR	Historical
2000		5,520	5,520	5,520	16.4	16.4	16.4	142.7	142.7	142.7
2050	Static	10,861	11,018	10,871	24.6	27.1	25.5	262.2	241.6	250.5
2050	Devel	3,425	3,464	10,871	8.3	9.3	25.5	184.8	169.2	250.5
Totals										
2000-50	Static	419,849	427,755	423,185	1,054	1,140	1,102	10,690	10,116	10,304
2000-50	Devel	231,330	234,889	423,185	645	693	1,102	8,516	8,055	10,304

Table 11: Disaster Preparedness and Management Data

Country	Agency	Year	Annual Equivalent (Million $US)
Armenia	Emergency Management Administration	2006	7.0
Bangladesh	Food and Disaster Management Budget	Annual	500.0
China	Various agencies	2005	217.7
Indonesia	Contingency budget for disaster response	Annual	125.8
India	Calamity Relief Fund	2000-2005	5.1
Japan	Budget for disaster risk reduction	Annual	34,000.0
Kazakhstan	For debris flows	1999	200.0
Republic of Korea	National Emergency Management Agency	Annual	300.0
Thailand	Department of Disaster Prevention and Mitigation	2003	25.6
Thailand	Department of Disaster Prevention and Mitigation	2006	63.9
Thailand	Department of Disaster Prevention and Mitigation	2005	46.0
Thailand	Department of Disaster Prevention and Mitigation	2004	32.4
Mongolia	Total Buget	2006	12.5
Malaysia	Disaster Relief Fund	Annual	15.5
Nepal	Emergency Fund	2006	0.015
Pakistan	Ten Year Perspective Development Plan	2001-2011	18.8
Philippines	National Calamity Fund	2005	12.8
Russian Federation	Fund for prevention and elimination of emergency situations	2003	687.4
Tajikistan	activities for disaster management	Annual	5.5

Source: Asian Disaster Reduction Center, Country Reports
http://www.adrc.asia/

Table 12: Climate-Neutralizing Female Education - Students and Costs
Republic of Congo, Nepal and Nicaragua

Year	CSIRO Total Cost ($'000)	NCAR Total Cost ($'000)	CSIRO New Primary Students („000)	CSIRO New Secondary Students („000)	NCAR New Primary Students („000)	NCAR New Secondary Students („000)	Cost Per Primary Student ($US)	Cost Per Secondary Student ($US)
	Republic of Congo							
2010	1,399	0	4.7	4.1	0.0	0.0	97	233
2020	4,341	0	10.5	9.8	0.0	0.0	128	307
2030	11,868	4,729	21.9	20.9	8.7	8.3	164	395
2040	24,179	16,055	32.9	32.4	21.8	21.5	218	524
2050	23,501	23,501	24.8	24.7	24.8	24.7	280	672
	Nepal							
2010	5,935	0	93.6	88.4	0.0	0.0	32	33
2020	15,059	0	182.5	183.7	0.0	0.0	40	42
2030	27,796	500	274.9	262.4	4.9	4.7	51	53
2040	27,237	9,382	198.8	204.6	68.5	70.5	66	69
2050	26,494	14,319	151.4	154.8	81.8	83.7	85	88
	Nicaragua							
2010	0	5,889	0.0	0.0	35.9	69.4	89	39
2020	0	12,343	0.0	0.0	37.0	155.3	118	51
2030	1,788	12,488	6.1	11.8	27.7	116.9	159	69
2040	9,425	12,911	21.6	46.0	21.6	81.4	226	99
2050	3,695	13,549	6.4	12.4	17.8	58.3	313	137

Table 13: Climate-Neutralizing Female Education - Students and Costs
Developing Regions

	CSIRO Total Cost ($'000)	NCAR Total Cost ($'000)	CSIRO New Primary Students („000)	CSIRO New Secondary Students („000)	NCAR New Primary Students („000)	NCAR New Secondary Students („000)
Year	Sub-Saharan Africa					
2010	179,036	211,757	800	880	981	974
2020	562,746	672,806	1,847	2,258	2,422	2,508
2030	1,001,736	1,044,923	2,117	2,843	3,038	4,262
2040	1,680,756	1,623,282	2,038	3,311	3,383	6,481
2050	2,294,642	2,203,969	1,708	3,488	2,967	7,053
	South Asia					
2010	528,691	266,339	2,264	2,603	990	1,020
2020	1,567,993	784,403	4,354	5,277	1,961	2,024
2030	2,983,226	1,771,123	5,129	7,143	2,960	3,139
2040	4,101,156	3,502,443	4,470	6,040	3,752	4,056
2050	5,446,895	4,853,930	4,277	5,357	3,539	3,681
	East Asia and Pacific Islands					
2010	339,783	397,749	1,100	1,237	872	1,276
2020	883,470	1,019,321	1,423	2,580	1,561	1,984
2030	1,352,575	1,312,094	990	2,681	1,130	1,635
2040	2,104,735	1,723,739	768	3,367	820	1,554
2050	795,767	2,636,736	241	1,315	780	2,307
	Eastern Europe and Central Asia					
2010	112,192	150,593	200	246	214	313
2020	339,834	479,968	419	436	459	561
2030	417,795	727,301	301	359	375	561
2040	476,751	868,335	216	265	311	429
2050	524,959	1,554,609	148	156	345	447
	Middle East and North Africa					
2010	60,080	32,367	114	147	46	93
2020	171,062	95,127	269	318	101	205
2030	327,340	226,553	255	339	135	259
2040	573,419	443,764	232	322	181	312
2050	891,987	958,291	219	323	244	372
	Latin America and the Caribbean					
2010	396,497	513,496	465	597	619	959
2020	1,016,825	1,266,047	555	1,486	929	1,928
2030	617,302	1,187,125	412	833	700	1,687
2040	218,728	1,370,353	200	644	526	1,445
2050	962,013	1,396,755	365	703	407	1,032

Table 14: Climate-Neutralizing Female Education
Global Totals, 2010-2050

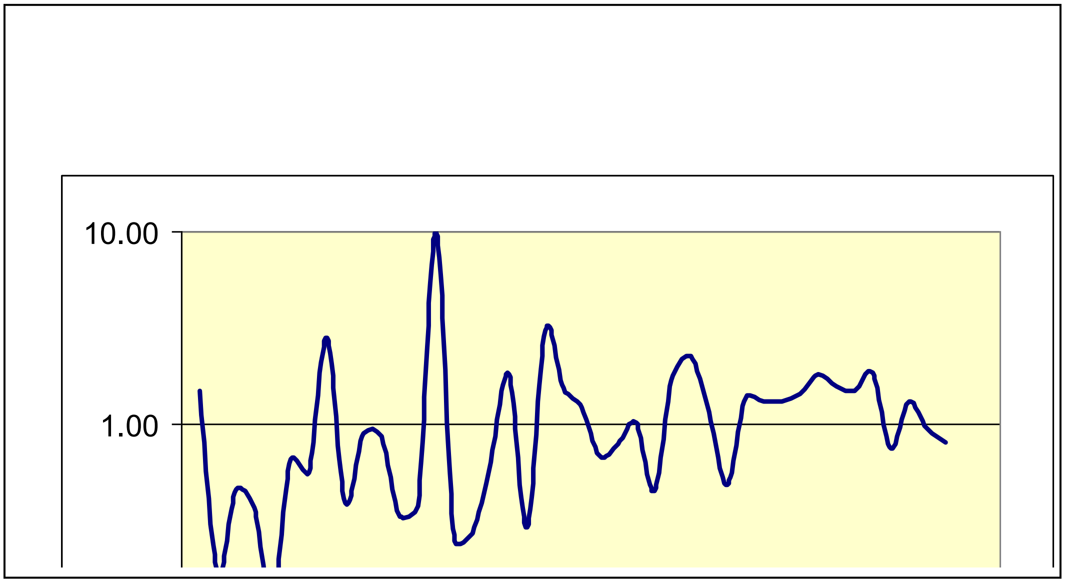
Year	CSIRO Total Cost ($Million)	NCAR Total Cost ($Million)	CSIRO New Primary Students („000)	CSIRO New Secondary Students („000)	NCAR New Primary Students („000)	NCAR New Secondary Students („000)
2010	1,616,279	1,572,299	4,943	5,710	3,721	4,634
2020	4,541,929	4,317,672	8,867	12,355	7,433	9,209
2030	6,699,975	6,269,119	9,203	14,199	8,339	11,542
2040	9,155,545	9,531,917	7,923	13,948	8,973	14,278
2050	10,900,000	13,600,000	6,959	11,341	8,282	14,892

Table 15: Climate-Neutralizing Female Education, 2002-2050
Global and Regional Costs: Selected Discount Rates
($US Billion)

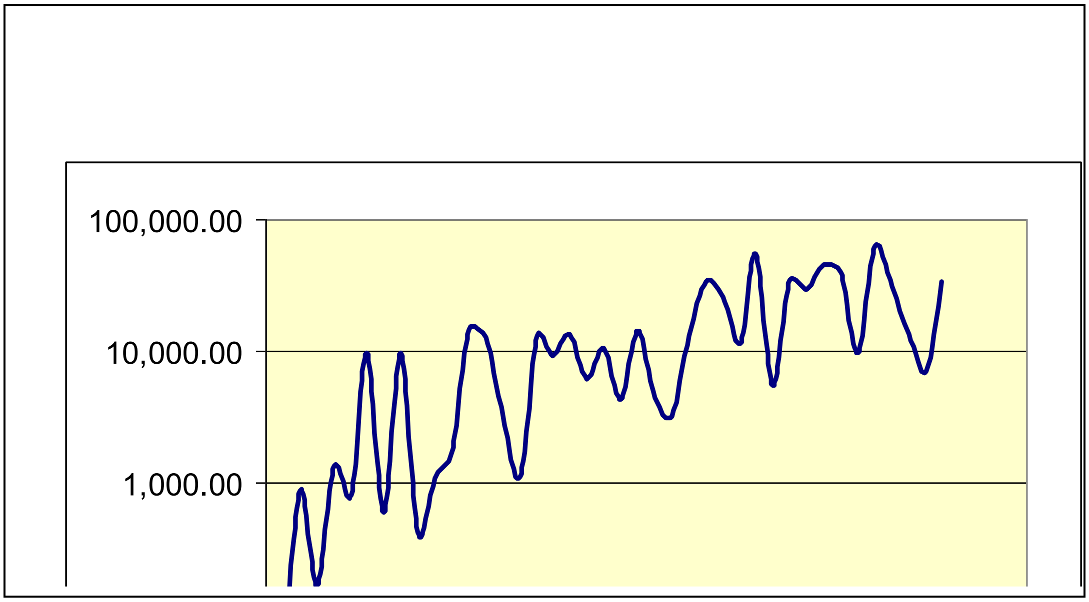
Discount Rate (%)	**Global Total**	**Global Total**	**Sub-Saharan Africa**		**East Asia and Pacific Islands**		**Eastern Europe and Central Asia**		**Latin America and Caribbean**		**Middle East and North Africa**		**South Asia**	
	CSIRO	**NCAR**	**CSIRO**	**NCAR**	**CSIRO**	**NCAR**	**CSIRO**	**NCAR**	**CSIRO**	**NCAR**	**CSIRO**	**NCAR**	**CSIRO**	**NCAR**
0	279.4	288.1	46.4	47.0	53.8	57.7	15.8	30.2	26.5	50.6	15.7	12.9	121.2	89.7
3	110.3	111.1	17.1	17.8	21.7	23.2	6.6	11.7	13.0	22.3	5.7	4.4	46.1	31.7
5	64.5	64.1	9.5	10.1	12.8	13.8	4.0	6.8	8.8	14.0	3.2	2.3	26.2	17.1
7	40.2	39.5	5.7	6.1	8.0	8.8	2.6	4.2	6.2	9.3	1.9	1.3	15.8	9.8

Figure 1: Trends in Risks From Extreme Events, 1960-2000
(Source: CRED: EM-DAT)

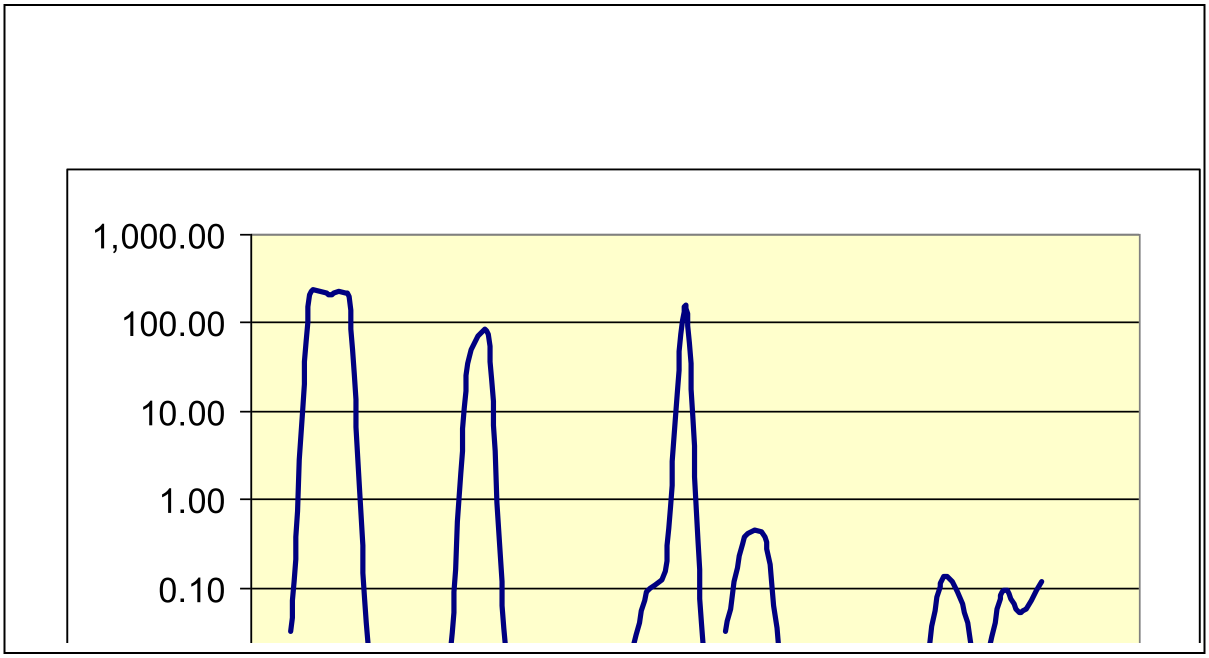
1a: Risk of Death From Flooding (per Million – Log Scale)



1b: Risk of Being Affected by Flooding (Per Million – Log Scale)



1c: Risk of Death From Drought (Per Million – Log Scale)



1d: Risk of Being Affected by Drought (Per Million – Log Scale)

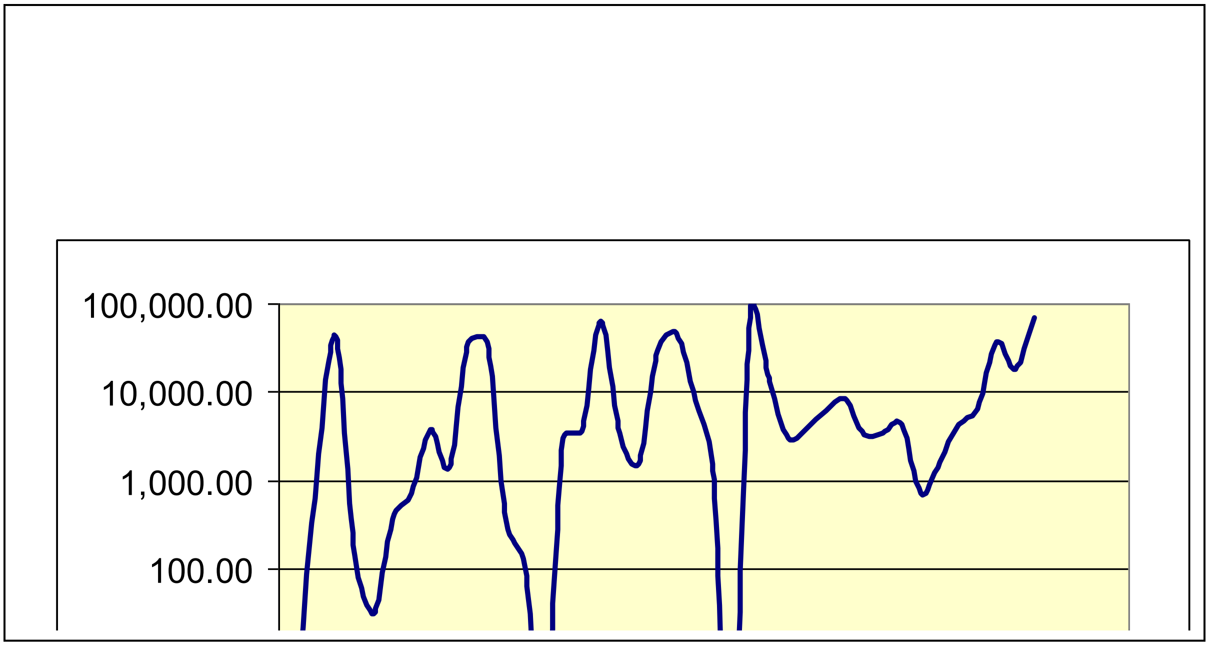
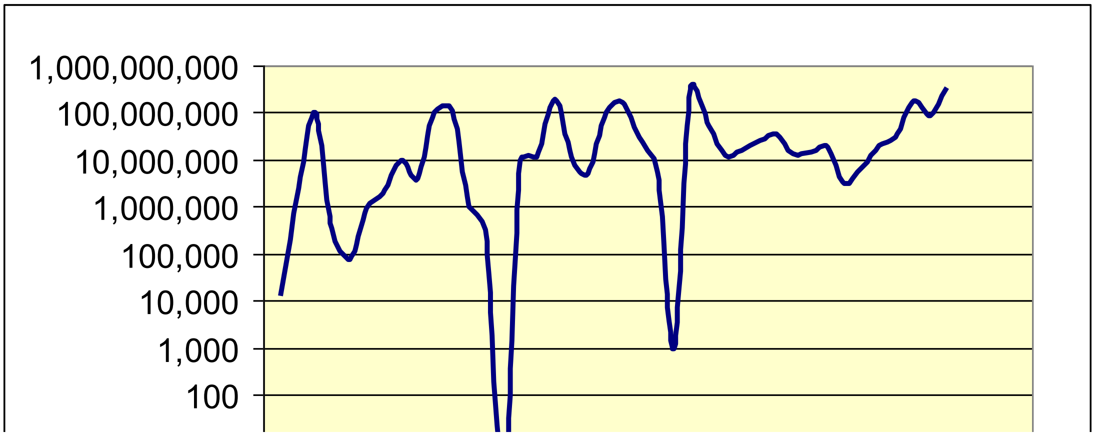


Figure 2: Number Affected by Droughts in Developing Countries, 1960-2002 (Log Scale)



Source: CRED: EM-DAT

Fig 3: India – Historical and Projected Data

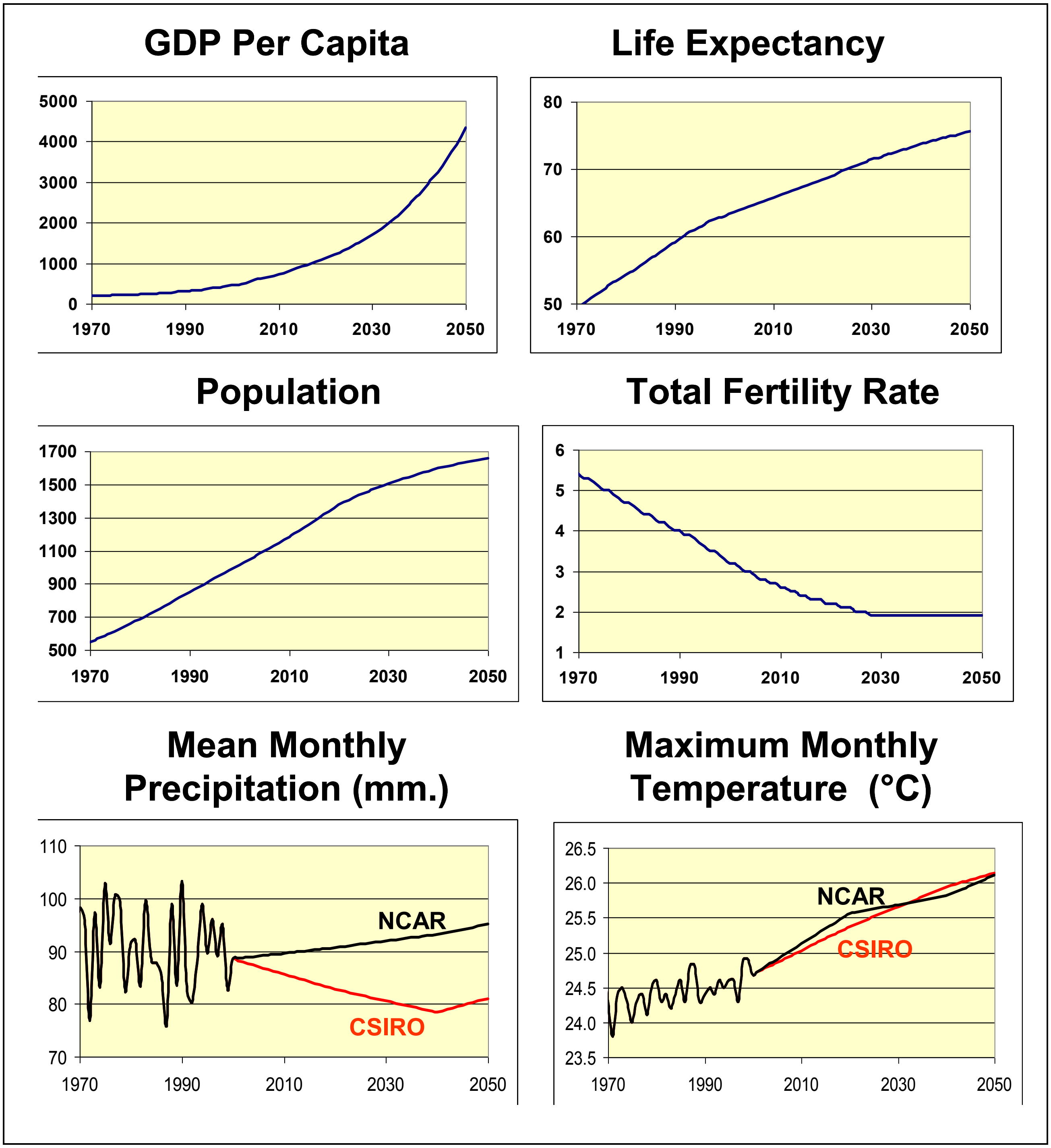
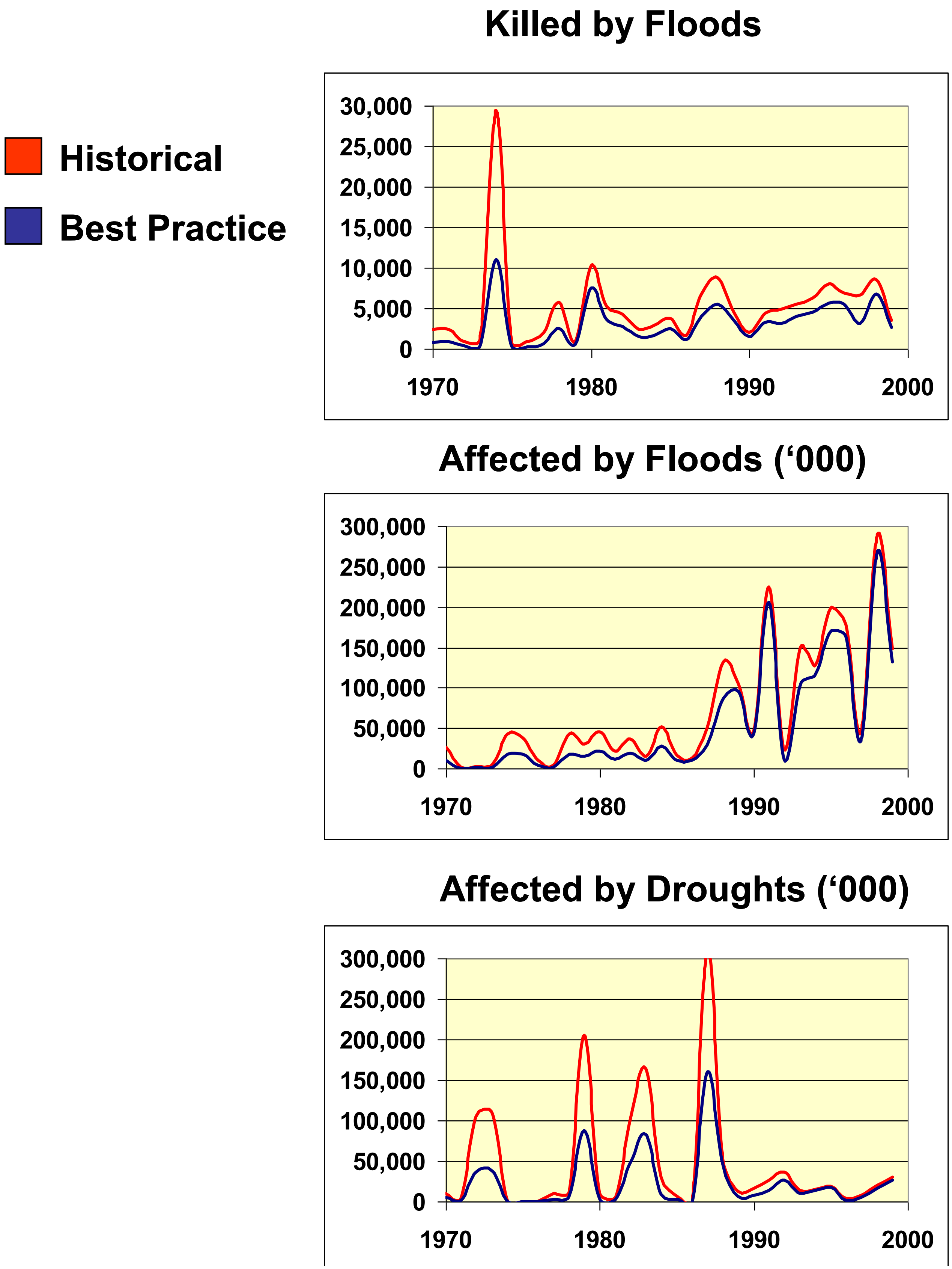


Figure 4: Extreme Weather Losses, 1970-1999
Historical and Best Practice


Killed by Floods

Affected by Floods ('000)

Affected by Droughts ('000)

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Figure 5: Loss Risks in India, 2000-2050