Potential impacts of climate change on $2-a-day poverty and child mortality in Sub-Saharan Africa and South Asia

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1 Summary

This note presents estimates of the impacts of alternative climate change scenarios on poverty and child mortality in Sub-Saharan African and South Asia. As with any long-term projections, simplifying assumptions are used, and the outcome of the analysis should be seen as illustrative only. Two main scenarios are considered:

- A baseline-climate-change scenario, in which global mean temperature increases to 3.9°C above pre-industrial levels by 2100;
- A high-climate-change scenario, in which global mean temperature increases to 4.3°C above pre-industrial levels by 2100.

The first of these scenarios is based largely on scientific evidence in the Third Assessment Report of the International Panel on Climate Change (IPCC). The high-climate-scenario is designed to explore the impacts that may be seen if the level of temperature change is pushed to higher levels through positive feedbacks in the climate system, as suggested by recent studies

Under each of these scenarios, gross domestic product (GDP) is projected to be lower in future years than it would be in the absence of climate change. This in turn has implications for poverty and child mortality, by an amount depending on the elasticity of each variable with respect to GDP. This note presents estimates of the additional amounts of poverty and child mortality arising under the baseline and high climate change scenarios, over and above a scenario in the absence of climate change.

For each of the above scenarios, estimates are provided both of the mean expected impact of climate change and the possible range (or variance) of those impacts. The variance in the possible impacts is driven by random variation (within pre-determined probability distributions) of a large number of model parameters, ranging from the temperature response to CO_2 emissions to the economic impacts of those emissions. The variance in possible impacts is measured by the difference between the 5th and the 95th percentile of those impacts.

The main projections are shown in Tables 1-2 and Figures 1-4. According to Table 1 and Figures 1-2, climate change in Sub-Saharan Africa could by 2100 cause between 86 and 131 thousand additional child deaths per year, and between 46 and 70 million additional people to be living on less than $2-a-day per year. These are the higher (95th percentile) impacts, in which the region's GDP is lower in 2100 by between 7% and 10% as a result of climate change. The mean impacts are smaller, but still significant: between 22 and 32 thousand additional child deaths per year, and between 12 and 17 million additional people living on less than $2-a-day per year. The lower (5th percentile) impacts, however, are small.

Table 2 and Figures 3-4 show the projections for South Asia. Here, climate change could by 2100 cause between 81 and 120 thousand additional child deaths, and

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between 98 and 149 million additional people living on less than $2-a-day. These again are the higher (95th percentile) impacts, in this case in which GDP is lower in 2100 by between 9% and 13% as a result of climate change. The mean impacts are again smaller, but still significant: between 21 and 29 thousand additional child deaths per year, and between 24 and 34 million additional people living on less than $2-a-day per year. Again however, the lower (5th percentile) impacts are small.

Estimates of the impact of climate change on child mortality are also produced using alternative assumptions regarding the precise value of the elasticity of child mortality with respect to GDP.. Previous econometric work has suggested this parameter to lie somewhere between -0.3 and -0.7. (The results in Tables 1-2 assume an elasticity of -0.5.) These are shown in Tables 3-4. They show that, when assuming a higher value of the elasticity, the impacts of climate change on child mortality are higher, while when assuming a lower estimate the impacts are lower. Nevertheless, these differences are relatively small in size. The results in Tables 1-2 and Figures 1-4 are therefore robust to alternative assumptions about the precise value of the elasticity of child mortality with respect to GDP.

There are however two main caveats which should be noted. First, the method used assumes that reductions in poverty and child mortality between 2002 and 2100 are driven primarily by GDP growth. It assumes no further reductions in poverty or child mortality from net improvements in income distribution within countries, or from 'exogenous' sources of child mortality reductions such as global vaccination programmes. These may be significant in practice, but are difficult to project. Including them would tend to reduce the estimated impacts of climate change on poverty and child mortality in absolute terms.

Second, the method used assumes that climate change affects poverty and child mortality only through its effect on GDP. It does not allow for any effects that climate change may have on the distribution of income within countries, or on the extent to which a given level of GDP growth is translated into lower child mortality. Again, these effects may be significant in practice, but are difficult to project. Including them would, in all likelihood, increase the estimated impacts of climate change on poverty and child mortality.

The remainder of this note outlines the methods by which the estimates of climate change on poverty and child mortality were calculated, and the sources of data used.

2 Methods and data

This section describes the methods and sources of data used to generate the poverty and child mortality forecasts under the baseline- and high-climate-change scenarios.

1 Climate change scenarios

Table 5 shows the amount (in percentage terms) by which GDP is assumed to be lower under the alternative climate change scenarios at three points in time between 2002 and 2100.

The GDP of each country within each region is assumed to be affected by the amounts shown in the table. This assumption is an approximation, and is based on the regional projections used within PAGE. It should be noted that the projections of the PAGE (Policy Analysis of the Greenhouse Effect) 2002 model group all of Africa and the Middle East into one regional group, and all of South East Asia (including India and South Asia) into another. The impacts in Table 5 also apply to these larger regions.

2 Growth projections

The baseline projections of growth in GDP, GDP per capita and population between 2002 and 2100 used for the calculations are shown in Table 6. The A2 SRES scenario is an illustrative 'business as usual' projection developed by the IPCC. This scenario is built around the assumption of relatively rapid convergence between developing and developed countries in levels of GDP per capita (in the absence of climate change).

Each country within each region is assumed to grow at the rates shown in the table. This is again an approximation. Furthermore, as in Table 5 the figures shown in Table 6 apply to the larger regions: Africa and Middle East, and India and South East Asia.

3 Other data

The source of the poverty estimates for 1990 and 2002 is the World Bank's PovcalNet website (http://iresearch.worldbank.org/PovcalNet/jsp/index.jsp). These are in turn based on nationally-representative household surveys. Estimates for these years are shown in Table 7.

The source of the child mortality estimates for 1990 and 2002 is the World Bank World Development Indicators CD-ROM (2004 edition). These refer to the number of children who do not survive to the age of 5, per thousand live births. (This is generally referred to more precisely as the under-5 mortality rate. This note therefore uses the term child mortality to refer to under-5 mortality). Estimates for these years are also shown in Table 7.

All other data (e.g. population, birth rates) are also taken from the World Bank World Development Indicators CD-ROM (2004 edition). Birth rates between 2002 and 2100 are forecast by assuming a steady process of convergence in each country to a rate of 12 births per 1,000 people.

4 Poverty forecasts

The poverty forecasts are based on two assumptions. The first is that average household income grows at 0.8 times the rate of GDP per capita: e.g. if GDP per capita grows at 3% per year, it is assumed that average household income grows at 2.4% per year. The 0.8 figure is obtained from a cross-country regression of rates of growth in mean household expenditure per capita on rates of growth in GDP per capita (e.g. Ravallion 2003). The second is that the distribution of income remains constant within each country. This is made mainly because there is no simple way to forecast distributional changes.

Given these assumptions, poverty estimates for each country and in each year between 2002 and 2100 can be calculated using the formulae for the poverty headcount used in World Bank calculations and outlined in Datt (1998). These formulae express the level of poverty as a function of: a) the poverty line, b) average household income and c) the distribution of income. The $2-a-day poverty line is used throughout. Given estimates of the poverty headcount (expressed as a proportion of total population), the total number of people living below the $2-a-day poverty line in any one year can be calculated given forecasts of total population in each year.

The so-called ‘poverty elasticity of growth’ – the rate at which poverty declines for each 1% increase in GDP per capita – is also determined by the formulae in Datt (1998). It varies across countries, with countries in which income distribution is more unequal having a lower elasticity. It also varies over time within each country, tending to increase in size as GDP per capita rises. However, the elasticity of poverty with respect to GDP growth does tend to be higher in South Asia than in Sub-Saharan Africa, mainly because of its more equal distribution of income. This helps explain the larger impact of climate change on $2-a-day poverty in South Asia (another reason being the larger predicted reductions in GDP arising from climate change in South Asia than in Sub-Saharan Africa).

The method could be extended to incorporate specific changes in income distribution in one or more countries, and the poverty forecasts recalculated. These changes could be caused by some factor exogenous to climate change (e.g. expansion of school enrolment). If there are such factors tending to shift income distributions in ways which reduce poverty, the estimated impacts of climate change on poverty would be lower. The reason is that, the lower is estimated poverty in 2100, the smaller would be the increase in the absolute number of people living on less than $2-a-day stemming from a given proportional increase in the poverty rate caused by climate change.

5 Child mortality forecasts

The child mortality forecasts are obtained by assuming a specific value for the elasticity of the child mortality rate (deaths per 1,000 births) with respect to per capita income. Previous econometric studies (e.g. Pritchett and Summers 1996, Filmer and Pritchett 1999) have reported a range of values for this elasticity, the vast majority of which are between -0.3 and -0.7. The -0.5 figure used in Tables 1-2 and Figures 1-4 is the mid-point of this range, while Tables 3-4 test the robustness of results to the range of values reported in recent econometric work. Given estimates of the child mortality rate, the number of child deaths in any one year can be calculated given forecasts of a) the number of births per 1,000 people per year and b) the total population in each year.

Whichever precise value of the elasticity is used, it is assumed to be a constant across countries and over time. This is also consistent with the econometric evidence (e.g. Kakwani 1993). Note however, that the average elasticity of child mortality with respect to GDP over a period of time will typically not be the same as the actual elasticity which applies on a year-to-year basis, even if the latter is assumed constant. Thus in Table 1 under the high climate change scenario (95th percentile, A2 SRES baseline), a reduction of 10% in GDP by 2100 in Sub-Saharan Africa increases the child mortality rate in 2100 by 4.4 deaths per 1,000 births, which amounts to a proportional increase in child mortality of 6%.[2] This implies an average elasticity of -0.6, compared to the value of -0.5 used on a year-to-year basis. The reason for differences such as these is compounding. The projections in this note are based on calculations made on a year-to-year basis, which is the more accurate method.

Finally, as noted in Section 1 Tables 3-4 show that the impacts of climate change on child mortality are actually quite similar when using alternative estimates of the elasticity of child mortality with respect to GDP. This is because there are two off-setting effects. On the one hand, a higher elasticity causes a reduction in GDP caused by climate change to have a larger proportional impact on the child mortality rate (and vice versa for a lower elasticity). On the other hand, a higher elasticity causes the estimated level of the child mortality rate to be lower in future years, so that a given proportional reduction in the child mortality rate caused by climate change implies a smaller reduction in the absolute number of child deaths per year (and vice versa for a lower elasticity).

References

Filmer, D. and Pritchett, L. (1999). The impact of public spending on health: does money matter? *Social Science and Medicine* 49(10): 1309-1323.

Kakwani, N. (1993). Performance in living standards: an international comparison. *Journal of Development Economics* 41(2): 307-336.

Pritchett, L. and Summers, L. (1996). Wealthier is healthier. *Journal of Human Resources* 31 (4): 841-868.

Ravallion, M. (2003). Measuring aggregate welfare in developing countries: how well do national accounts and surveys agree? *Review of Economics and Statistics* 85 (3): 645-652.

[2] The proportional increase can be calculated using the projected level of the child mortality rate in 2100 (details available on request).

Table 1 Potential impacts of climate change on poverty and child mortality in Sub-Saharan Africa (A2 SRES baseline)

	2080	2100	2080	2100
$2-a-day poverty	*Additional no. of people (million)*		*Additional % points*	
95th percentile, low impact	21	46	0.9	2.0
95th percentile, high impact	33	70	1.5	3.0
Mean, low impact	7	12	0.3	0.5
Mean, high impact	9	17	0.4	0.7
5th percentile, low impact	1	1	<0.1	<0.1
5th percentile, high impact	1	1	<0.1	0.1
Child mortality (elasticity=0.5)	*Additional no. of deaths (thousands)*		*Additional deaths per 1,000 births*	
95th percentile, low impact	39	86	1.4	2.9
95th percentile, high impact	61	131	2.1	4.4
Mean, low impact	13	22	0.4	0.8
Mean, high impact	17	32	0.6	1.1
5th percentile, low impact	2	2	0.1	0.1
5th percentile, high impact	2	2	0.1	0.1

Table 2 Potential impacts of climate change on poverty and child mortality in South Asia (A2 SRES baseline)

	2080	2100	2080	2100
$2-a-day poverty	*Additional no. of people (millions)*		*Additional % points*	
95th percentile, low impact	49	98	1.7	3.3
95th percentile, high impact	76	149	2.6	5.1
Mean, low impact	15	24	0.5	0.8
Mean, high impact	21	34	0.7	1.1
5th percentile, low impact	2	2	0.1	0.1
5th percentile, high impact	2	2	0.1	0.1
Child mortality (elasticity=0.5)	*Additional no. of deaths (thousands)*		*Additional deaths per 1,000 births*	
95th percentile, low impact	34	81	1.0	2.3
95th percentile, high impact	53	120	1.5	3.5
Mean, low impact	11	21	0.3	0.6
Mean, high impact	14	29	0.4	0.8
5th percentile, low impact	1	2	<0.1	<0.1
5th percentile, high impact	1	2	<0.1	<0.1

Table 3 Potential impacts of climate change on child mortality in Sub-Saharan Africa (A2 SRES baseline, alternative elasticity assumptions)

	2080	2100	2080	2100
Child mortality (elasticity = 0.7)	*Additional no. of deaths (thousands)*		*Additional deaths per 1,000 births*	
95th percentile, low impact	41	90	1.5	3.0
95th percentile, high impact	69	136	2.4	4.6
Mean, low impact	14	23	0.5	0.8
Mean, high impact	19	33	0.7	1.1
5th percentile, low impact	2	2	0.1	0.1
5th percentile, high impact	2	2	0.1	0.1
Child mortality (elasticity=0.3)				
95th percentile, low impact	29	70	1.0	2.4
95th percentile, high impact	46	105	1.6	3.6
Mean, low impact	9	18	0.3	0.6
Mean, high impact	13	26	0.4	0.9
5th percentile, low impact	1	2	<0.1	0.1
5th percentile, high impact	1	2	<0.1	0.1

Table 4 Potential impacts of climate change on child mortality in South Asia (A2 SRES baseline, alternative elasticity assumptions)

	2080	2100	2080	2100
Child mortality (elasticity=0.7)	*Additional no. of deaths (thousands)*		*Additional deaths per 1,000 births*	
95th percentile, low impact	38	87	1.1	2.5
95th percentile, high impact	60	129	1.7	3.7
Mean, low impact	12	22	0.3	0.6
Mean, high impact	16	31	0.5	0.9
5th percentile, low impact	1	2	<0.1	0.1
5th percentile, high impact	1	2	<0.1	0.1
Child mortality (elasticity=0.3)				
95th percentile, low impact	25	64	0.7	1.8
95th percentile, high impact	39	94	1.1	2.7
Mean, low impact	8	16	0.2	0.5
Mean, high impact	11	23	0.3	0.7
5th percentile, low impact	1	1	<0.1	<0.1
5th percentile, high impact	1	1	<0.1	<0.1

Table 5 Reductions in GDP arising under alternative climate change scenarios

	2010				2080	2100
Baseline climate change, 95th percentile						
A2 SRES, Sub-Saharan Africa	*0.14%*				*2.73%*	*6.92%*
A2 SRES, South Asia	*0.14%*				*3.42%*	*9.31%*
Baseline climate change, mean						
A2 SRES, Sub-Saharan Africa	*0.05%*				*0.89%*	*1.85%*
A2 SRES, South Asia	*0.05%*				*1.09%*	*2.49%*
Baseline climate change, 5th percentile						
A2 SRES, Sub-Saharan Africa	*0.01%*				*0.11%*	*0.17%*
A2 SRES, South Asia	*0.00%*				*0.12%*	*0.21%*
High climate change, 95th percentile						
A2 SRES, Sub-Saharan Africa	*0.15%*				*4.24%*	*10.21%*
A2 SRES, South Asia	*0.15%*				*5.22%*	*13.31%*
High climate change, Mean						
A2 SRES, Sub-Saharan Africa	*0.05%*				*1.19%*	*2.65%*
A2 SRES, South Asia	*0.05%*				*1.48%*	*3.48%*
High climate change, 5th Percentile						
A2 SRES, Sub-Saharan Africa	*0.01%*				*0.12%*	*0.19%*
A2 SRES, South Asia	*0.00%*				*0.12%*	*0.20%*

Table 6 Baseline projections of growth in GDP, GDP per capita and population, 2002-2100

	2002-2010	2010-2020	2020-2040	2040-2060	2060-2080	2080-2100
GDP (% per year)						
India and South Asia, *A2SRES baseline*	2.9	2.9	2.9	1.8	1.8	1.8
Sub-Saharan Africa, *A2SRES baseline*	3.8	3.8	3.8	2.3	2.3	2.3
GDP per capita (% per year)						
India and South Asia, *A2SRES baseline*	1.2	1.5	1.8	1.1	1.4	1.7
Sub-Saharan Africa, *A2SRES baseline*	1.0	1.4	1.9	1.0	1.6	2.0
Population (% per year)						
India and South Asia, *A2SRES baseline*	1.7	1.4	1.1	0.7	0.4	0.1
Sub-Saharan Africa, *A2SRES baseline*	2.8	2.4	1.9	1.3	0.7	0.3

Table 7 Estimated levels of poverty and child mortality in 1990 and 2002

	1990	2002	1990	2002
$2-a-day poverty	*No. of people (millions)*		*Percentage of population*	
Sub-Saharan Africa	430	488	73.2	74.7
South Asia	965	1,075	85.7	76.7
Child mortality	*No. of deaths (thousands)*		*Deaths per 1,000 live births*	
Sub-Saharan Africa	4,087	4,480	186	173
South Asia	4,402	3,267	127	94

Figure 1

Potential impact of climate change on $2-a-day poverty in Sub-Saharan Africa, 2002-2100 (A2 SRES baseline)

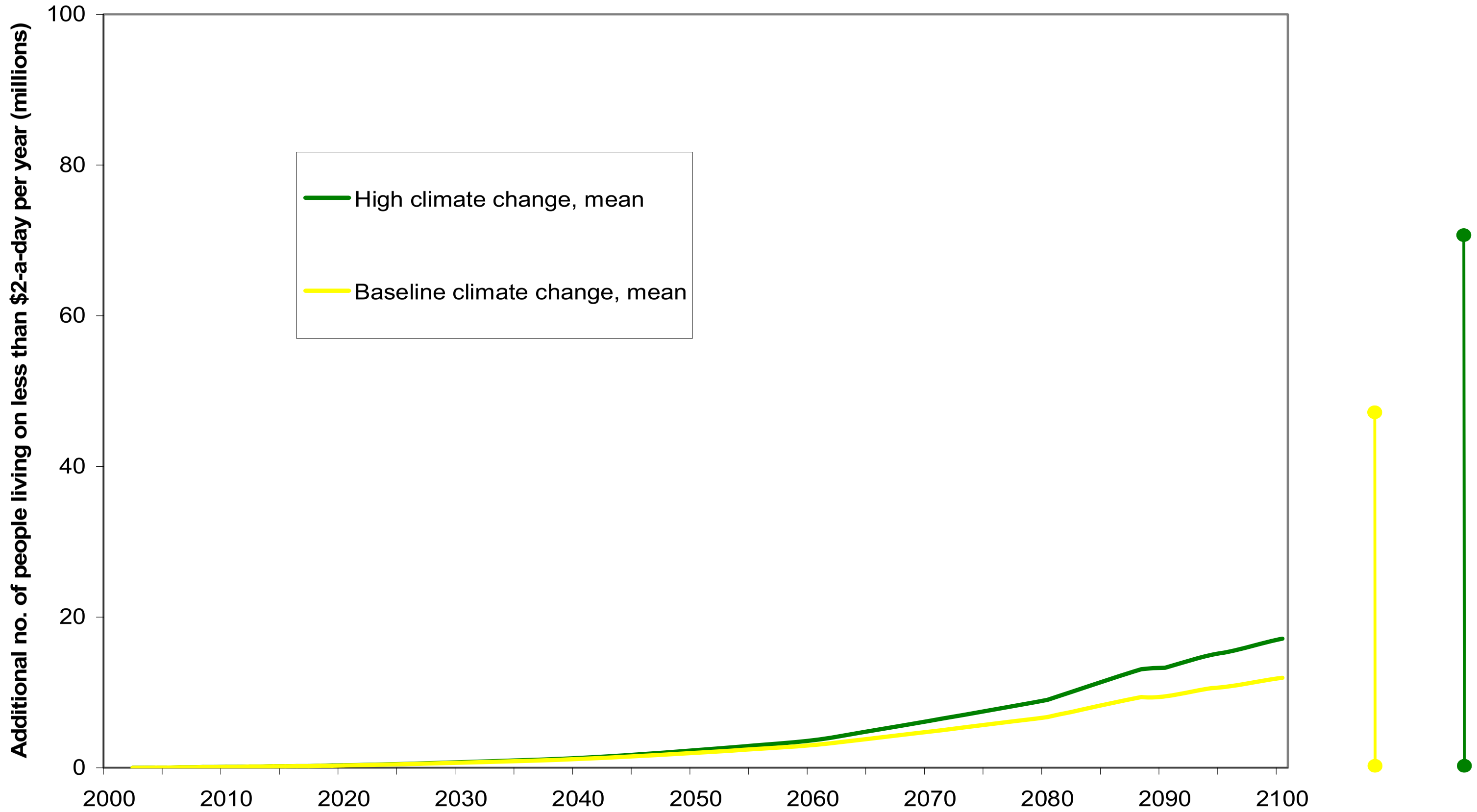


Figure 2

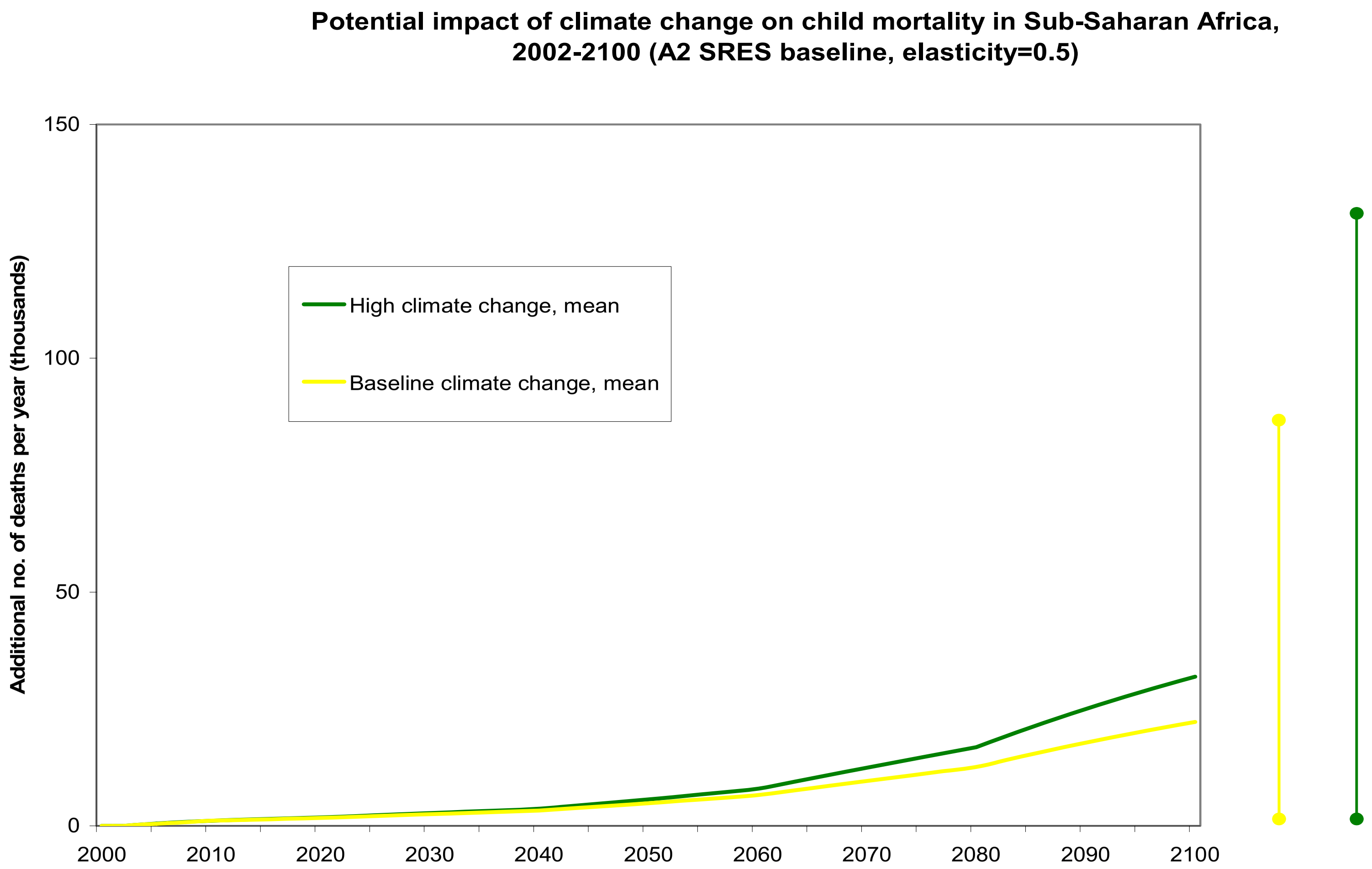

Potential impact of climate change on child mortality in Sub-Saharan Africa,
2002-2100 (A2 SRES baseline, elasticity=0.5)
Additional no. of deaths per year (thousands)
150
100
50
0
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
High climate change, mean
Baseline climate change, mean

Figure 3

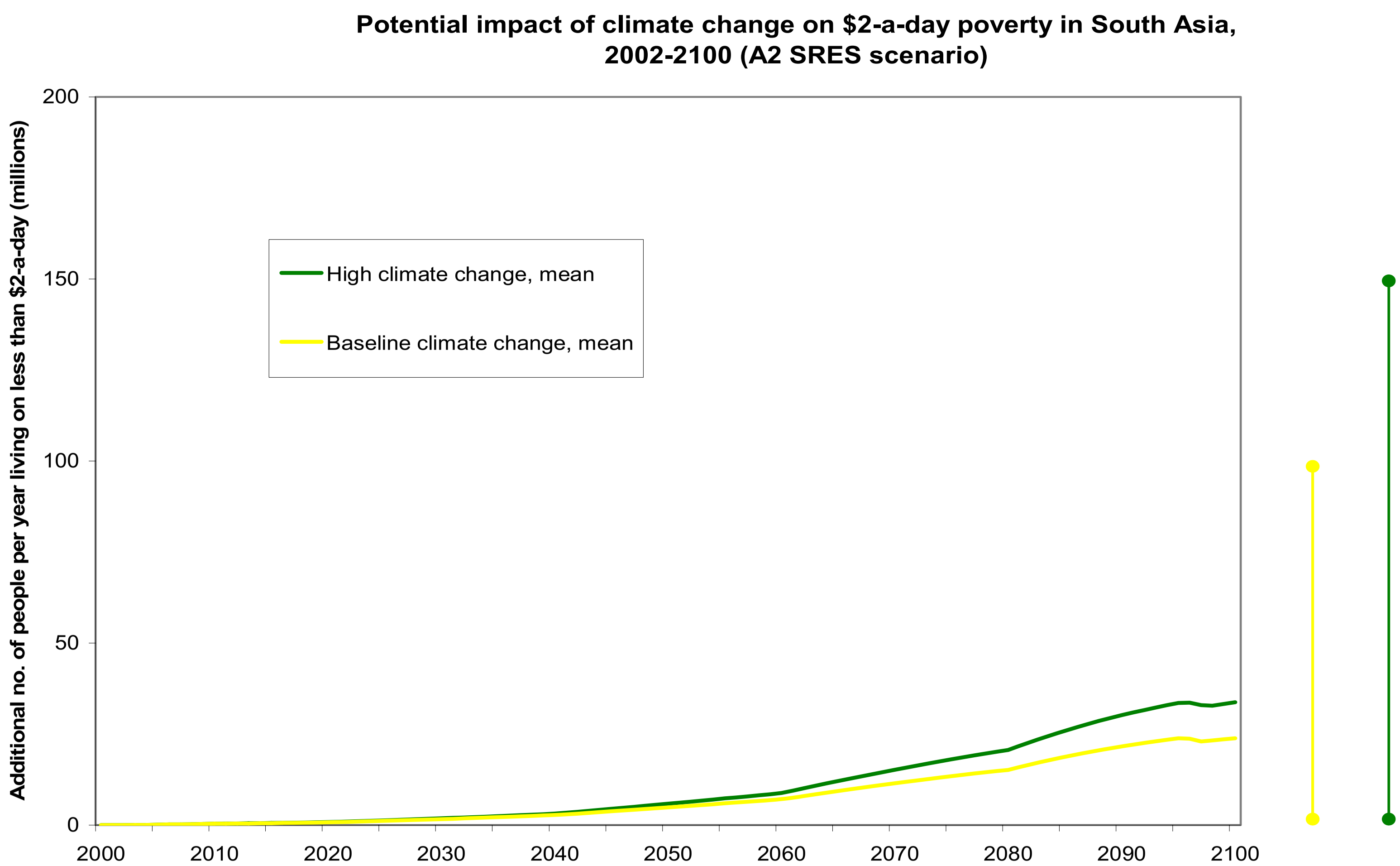
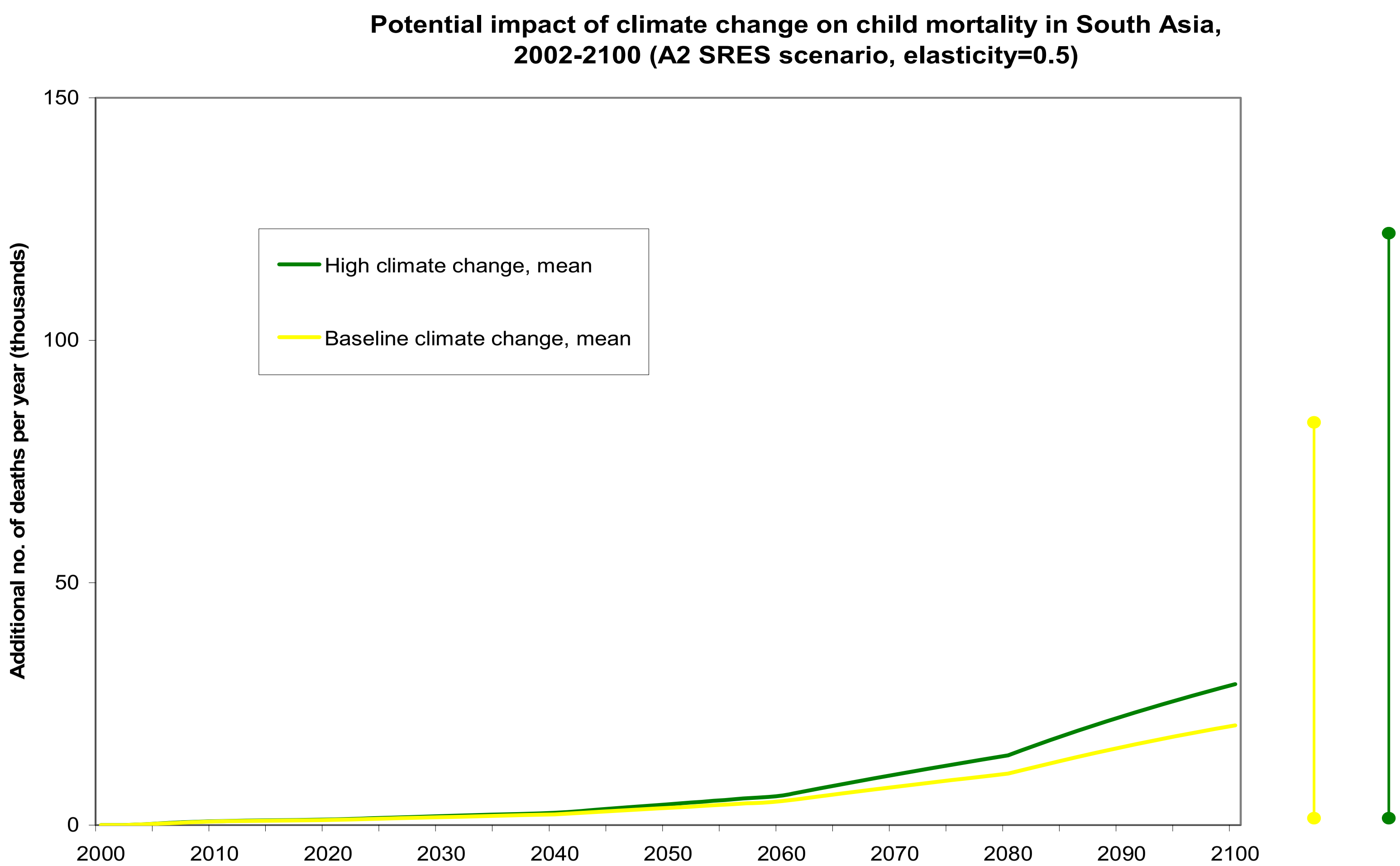

Potential impact of climate change on $2-a-day poverty in South Asia, 2002-2100 (A2 SRES scenario)
Additional no. of people per year living on less than $2-a-day (millions)
200
150
100
50
0
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
High climate change, mean
Baseline climate change, mean

Figure 4


Potential impact of climate change on child mortality in South Asia, 2002-2100 (A2 SRES scenario, elasticity=0.5)
Additional no. of deaths per year (thousands)
150
100
50
0
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
High climate change, mean
Baseline climate change, mean