Human Health

Health Impacts of Climate Change

The health impacts of climate change are diverse and wide-ranging. Weather and climate are among the factors that determine the geographic range and incidence of several major causes of ill health, including undernutrition, which affects 17% of the world's population in developing countries [FAO 2005]; diarrheal diseases and other conditions due to unsafe water and lack of basic sanitation, which cause 2 million deaths annually, mostly in young children [Kosek et al. 2003]; and malaria, which causes more than a million childhood deaths annually [WHO 2004]. The Human Health chapter in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change concluded that climate change has begun to negatively affect human health, and that projected climate change will increase the risks of climate-sensitive health outcomes [IPCC WGII SPM 2007]. Those at greatest risk include the urban poor, older adults, children, traditional societies, subsistence farmers, and coastal populations, particularly in low income countries.

Weather, climate variability, and climate change can affect health directly and indirectly. Directly, heatwaves, floods, droughts, windstorms, and fires annually affect millions of people and cause billions of dollars of damage. In 2003 in Europe, Canada, and the United States, floods and storms resulted in 101 people dead or missing and caused $9.73 billion in insured damages [Swiss Re 2004]. More than 35,000 excess deaths were attributed to the extended heatwave in Europe the same year [Kostasky 2005]. The health impacts of extreme events in developing countries are substantially larger. There is a growing body of scientific research projecting that the frequency and intensity of extreme weather events will likely increase over the coming decades as a consequence of climate change [Easterling et al. 2000; Meehl and Trebaldi 2004], suggesting that the associated health impacts also could increase.

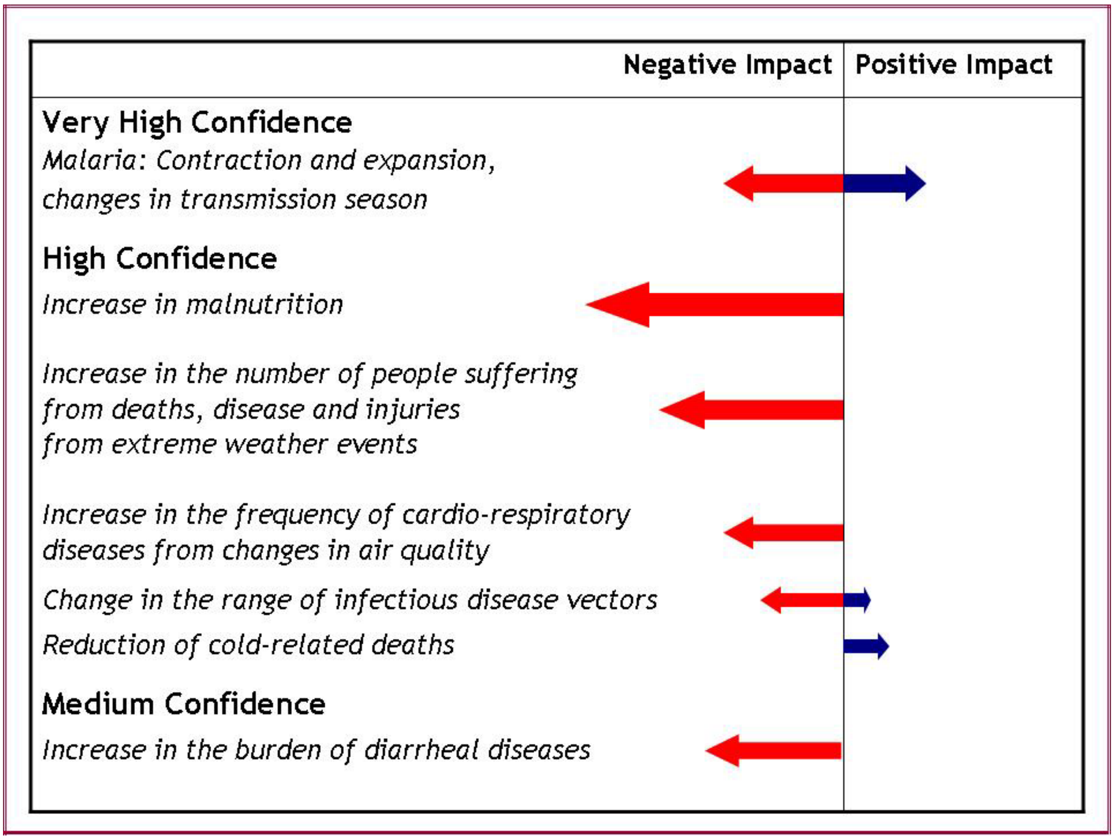
Indirectly, climate can affect health through alterations in the geographic range and intensity of transmission of vector-, tick-, and rodent-borne diseases and food- and waterborne diseases, as well as through changes in the prevalence of diseases associated with air pollutants and aeroallergens. Climate change could alter or disrupt natural systems, making it possible for diseases to spread or emerge in areas where they had been limited or had not existed, or for diseases to disappear by making areas less hospitable to the vector or the pathogen [NRC 2001]. Climate-induced economic dislocation and environmental decline also can affect population health.

The cause-and-effect chain from climate change to changing patterns of health determinants and outcomes is often complex and includes factors such as wealth, distribution of income, status of the public health infrastructure, provision of medical care, and access to adequate nutrition, safe water, and sanitation [Woodward et al. 1998]. Therefore, the severity of future impacts will be determined by changes in climate as well as by concurrent changes in nonclimatic factors and by the adaptation measures implemented to reduce negative impacts. In the next few decades, implementation of effective and timely adaptation measures will be critically important to reduce impacts. Mitigation of greenhouse gas emissions is needed to reduce the severity of impacts projected for the longer term.

Figure 1 summarizes the relative direction, magnitude, and certainty of climate change-related health impacts as concluded by the Human Health chapter of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Projected trends in climate change-related exposures will:

- Increase undernutrition and consequent disorders, including child growth and development;
- Increase injuries, illnesses, and deaths due to heatwaves, floods, droughts, storms, and fires;
- Increase cases of diarrheal diseases;
- Increase cardio-respiratory diseases where ozone exposure concentrations increase;
- Increase the number of people at risk of dengue fever;
- Increase the geographic range and length of the transmission season of malaria in some regions, and decrease the range in others;
- Bring some benefits to health, including fewer deaths due to exposure to the cold.

Summary of the Relative Direction, Magnitude, and Certainty of Climate Change-Related Health Impacts



Source: Confalonieri, Menne, et al. 2007

Methods

This paper provides initial estimates of the costs of interventions to cope with the health impacts of climate change in 2030. There have not been previous efforts, and only a small subset of the required data is available. The estimates are for the costs of climate change only and do not take into consideration population growth; there is limited consideration of socioeconomic development.

In estimating the adaptation needs for the health sector, the primary data sources used are:

- Data from WHO on the current number of cases of diarrheal diseases, malnutrition, and malaria;
- The World Health Organization (WHO) Global Burden of Disease (GBD) study that projected the relative risks associated with climate change in 2030 for a range of climate-sensitive health determinants and outcomes [McMichael et al. 2004]; and
- Published data on the costs of interventions for diarrheal diseases, malnutrition, and malaria. Most of the data were generated as part of the Disease Control Priorities in Developing Countries project (http://www.dcp2.org). The Disease Control Priorities project, among other activities, estimated the costs of interventions for selected diseases, including diarrheal diseases, malnutrition, and malaria.

The approach used was to (1) assume that the current annual number of cases of diarrheal diseases, malnutrition, and malaria would remain constant to 2030; (2) multiply the number of current cases by the relative risks for climate change estimated by the Global Burden of Disease Study (under three different emission scenarios, described below) to estimate the number of additional cases of these diseases that could be attributed to climate change in 2030; and (3) multiply the number of additional cases by the current costs of treatment per case to estimate the additional costs of treating climate change-related cases of diarrheal diseases, malnutrition, and malaria. The costs estimated are only the costs of adaptation and make a number of necessary, but questionable assumptions, including that the number of annual cases will remain constant; countervailing forces include population growth and improvements in health care delivery and technology. The cost of treatment also is assumed to remain constant, which is improbable. Historically, costs of current treatments tend to decrease over time. However, development of new, more effective treatments, tend to replace current treatments and to cost more. Assumptions related to the exposure-response relationships are noted below. Because of the large uncertainties, the costs estimated should be viewed as indicators of the relative magnitude of health adaptation costs.

Current Annual Number of Cases of Diarrheal Diseases, Malnutrition, and Malaria

Table 1 gives the current annual incidence of, and Table 2 gives annual mortality from, diarrheal disease, malnutrition, and malaria. Note that the numbers for malnutrition only include stunting and wasting, not all the health impacts, and don’t include micronutrient deficiencies such as deficiencies of zinc and vitamin A that also have serious health consequences.

Table 1: Annual incidence of diarrheal diseases, malnutrition (stunting and wasting) and malaria by WHO sub-region, 2002

Sub-region	Population (000s)	Diarrheal diseases (000s)	Malnutrition (000s)	Malaria (000s)	Total (000s)
Afr-D	301 878	389 842	5 033	180 368	575 243
Afr-E	353 598	449 192	5 912	176 651	631 755
Amr-A	328 176	77 578	137	0	77 715
Amr-B	437 142	390 590	1 124	2 866	394 580
Amr-D	72 649	73 271	603	718	74 592
Emr-B	141 835	96 324	585	363	97 272
Emr-D	351 256	345 605	4 523	16 898	367 026
Eur-A	412 512	79 219	134	0	79 353
Eur-B	219 983	78 509	649	0	79 158
Eur-C	241 683	47 886	262	0	47 912
Sear-B	297 525	179 213	2 251	6 951	188 415
Sear-D	1 262 285	1 051 538	18 040	21 568	1 091 146
Wpr-A	154 919	30 026	64	6	30 096
Wpr-B	1 546 770	1 225 188	7 035	1 838	1 234 061
World	6 122 211	4 513 981	46 352	408 227	4 968 560

Source: http://www.who.int/healthinfo/bodestimates/en/index.html; accessed 20 May 2007

Table 2: Annual mortality from diarrheal diseases, malnutrition (stunting and wasting) and malaria by WHO sub-region, 2002

Sub-region	Population (000s)	Diarrheal diseases	Malnutrition	Malaria	Total
Afr-D	301 878	351 322	50 224	556 577	958 123
Afr-E	353 598	356 335	54 458	579 284	990 077
Amr-A	328 176	1 975	4 545	4	6 524
Amr-B	437 142	33 529	28 827	1 050	63 406
Amr-D	72 649	20 890	8 568	441	29 899
Emr-B	141 835	14 574	2 416	1 620	18 610
Emr-D	351 256	244 144	23 888	56 712	324 744
Eur-A	412 512	2 294	2 826	78	5 198
Eur-B	219 983	12 697	1 075	51	13 823
Eur-C	241 683	1 466	596	10	2 072
Sear-B	297 525	40 823	10 477	11 905	63 205
Sear-D	1 262 285	562 519	57 608	53 047	673 174
Wpr-A	154 919	1 368	1 408	5	2 781
Wpr-B	1 546 770	152 900	12 779	10 743	176 422
Total	6 122 211	1 797 972	260 152	1 272 393	3 330 517

Source: http://www.who.int/healthinfo/bodestimates/en/index.html; accessed 20 May 2007

Global Burden of Disease Study

The World Health Organization (WHO) Global Burden of Disease study began in 1992 with the objective of quantifying the burden of disease and injury in human populations [Murray and Lopez 1996]. The burden of disease refers to the total amount of premature death and morbidity within a population. The goals of the study were to produce the best possible evidence-based description of population health, the causes of lost health, and likely future trends in health in order to inform policy-making. The WHO Global Burden of Disease 2000 project (GBD) updated the 1990 study [Murray et al. 2003]. It drew on a wide variety of data sources to develop internally consistent estimates of incidence, health state prevalence, severity and duration, and mortality for over 130 major health outcomes, for the year 2000 and beyond. To the extent possible, the GBD synthesized all relevant epidemiologic evidence on population health within a consistent and comprehensive framework, the comparative risk assessment. Twenty-six risk factors were assessed, including major environmental, occupational, behavioral, and lifestyle risk factors. Climate change was one of the environmental risk factors assessed [McMichael et al. 2004].

The GBD used two summary measures of population health, mortality and the Disability Adjusted Life Years lost (DALYs). DALYs provide a better measure than mortality of the population health impacts of diarrheal diseases, malnutrition, and malaria. The attributable burden of DALYs for a specific risk factor was determined by estimation of the burden of specific diseases related to the risk factor; estimation of the increase in risk for each disease per unit increase in exposure to the risk factor; and estimation of the current population distribution of exposure, or future distribution as estimated by modeling exposure scenarios. Counterfactual or alternative exposure scenarios to the current distribution of risk factors were created to explore distributional transitions towards a theoretical minimum level of exposure (e.g. for exposure to carcinogens, the theoretical minimum level of exposure would be no exposure).

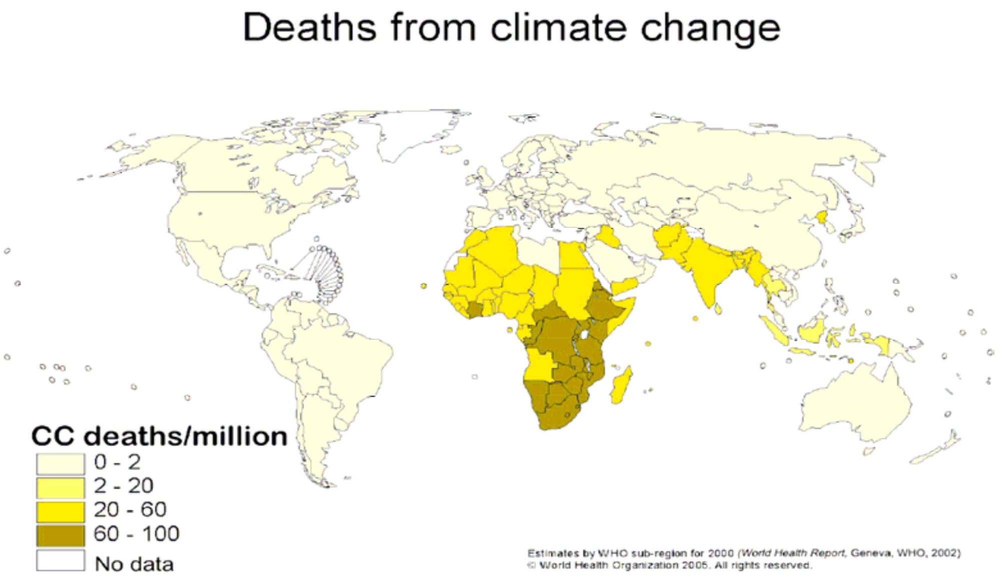
For climate change, the questions addressed were what will be the total health impact caused by climate change between 2000 and 2030 and how much of this burden could be avoided by stabilizing greenhouse gas emissions [McMichael et al. 2004]. The alternative exposure scenarios defined were:

- Unmitigated emission trends (i.e., approximately following the IPCC IS92a scenario);
- Emissions reductions resulting in stabilization at 750 ppm CO_2 equivalent by 2210 (s750); and
- Emissions reductions resulting in stabilization at 550 ppm CO_2 equivalent by 2170 (s550).

Climate change projections were generated by the HadCM2 global climate model [Johns et al. 2001]. The health outcomes included in the analysis were chosen based on sensitivity to climate variation, predicted future importance, and availability of quantitative global models (or feasibility of constructing them). The health outcomes selected were the direct impacts of heat and cold, episodes of diarrheal disease, cases of *Plasmodium falciparum* malaria, fatal unintentional injuries in coastal floods and inland floods/landslides, and non-availability of recommended daily calorie intake (as an indicator for the prevalence of malnutrition). Global and WHO specific region estimates were generated (see Annex 1 for definitions of WHO regions).

In the year 2000, the mortality attributable to climate change was estimated to be 154,000 (0.3%) deaths, and the attributable burden was 5.5 million (0.4%) DALYs, with approximately 50% of the burden due to malnutrition, based on models of the relationship between climate and health outcomes [McMichael et al. 2004]. These estimates are for a year when the amount of climate change since baseline (1990) was near zero; therefore, future disease burdens would be expected to increase with increasing climate change, unless effective adaptation measures were implemented. About 46% of the DALYs attributable to climate change were estimated to have occurred in the WHO South-East Asia Region, 23% in countries in the Africa region with high child mortality and very high adult male mortality, and 14% in countries in the Eastern Mediterranean region with high child and adult male mortality. Figure 2 shows the current mortality burden due to climate change.

Figure 2: Current Health Burden due to Climate Change



For each health outcome, ranges of estimates were projected for relative risks attributable to climate change in 2030 under the alternative exposure scenarios [McMichael et al. 2004].

Assumptions about socioeconomic development were that there would be no increased risk of diarrheal diseases when GDP per capita (as estimated by EMF 14 [Energy Modeling Forum 1995]) rose above US$6,000/year. For malnutrition, the food- trade model assumed future increases in crop yields from technological advances, increased liberalization of trade, and increased GDP (as estimated by EMF14). Socioeconomic development was assumed to not affect the incidence of malaria.

The projected relative risks attributable to climate change in 2030 vary by health outcome and region, and are largely negative, with the majority of the projected disease burden due to increases in diarrheal disease and malnutrition, primarily in low-income populations already experiencing a large burden of disease [McMichael et al. 2004]. Absolute disease burdens depend on assumptions of population growth, future baseline disease incidence, and the extent of adaptation.

Estimates of Climate Change-Related Cases of Diarrheal Diseases, Malnutrition, and Malaria in 2030

Tables 3 - 5 show the relative risk estimates for malnutrition, diarrheal diseases, and malaria projected for 2030. Lower range estimates are not shown as they assumed complete adaptation (that is, the relative risks were 1.00 or close to 1.00).

Diarrheal Diseases

For diarrheal diseases, developing countries were defined as those with per capita incomes less than US$6,000/year in 1990 US dollars. For such countries, the exposure-response relationship used was a 5% increase in diarrheal incidence per ºC increase in temperature.

The study assumed that the climate sensitivity of diarrhea would decrease with increasing GDP; once a country was projected to reach per capita incomes of UD$6,000/year, then overall diarrhea incidence was assumed to not respond to changes in temperature. The study assumed that diarrheal incidence in richer countries is insensitive to climate change. The relative risks for each region are a population-weighted average of the countries within the region.

Table 3: Central and high projections of the relative risk of diarrhea for alternative climate scenarios relative to baseline climate

Sub-region	Climate	2000		2010		2020		2030	
		Mid	High	Mid	High	Mid	High	Mid	High
Afr-D	S550	1.01	1.03	1.03	1.06	1.04	1.08	1.05	1.10
	S750	1.02	1.04	1.04	1.07	1.05	1.11	1.06	1.13
	UE	1.02	1.05	1.05	1.09	1.07	1.14	1.08	1.16
Afr-E	S550	1.01	1.03	1.03	1.06	1.04	1.08	1.05	1.11
	S750	1.02	1.04	1.03	1.07	1.05	1.10	1.06	1.13
	UE	1.02	1.05	1.03	1.09	1.06	1.13	1.08	1.16
Amr-A	S550	1.00	1.02	1.00	1.03	1.00	1.05	1.00	1.06
	S750	1.00	1.02	1.00	1.03	1.00	1.05	1.00	1.06
	UE	1.00	1.02	1.00	1.04	1.00	1.06	1.00	1.08
Amr-B	S550	1.00	1.02	1.00	1.03	1.00	1.04	1.00	1.05
	S750	1.00	1.02	1.00	1.03	1.00	1.05	1.00	1.06
	UE	1.00	1.02	1.00	1.04	1.00	1.06	1.00	1.08
Amr-D	S550	1.01	1.03	1.03	1.05	1.02	1.06	1.02	1.07
	S750	1.02	1.03	1.03	1.06	1.02	1.07	1.02	1.08
	UE	1.02	1.04	1.04	1.08	1.03	1.09	1.02	1.10
Emr-B	S550	1.01	1.03	1.02	1.06	1.00	1.05	1.06	1.06
	S750	1.02	1.03	1.02	1.05	1.00	1.05	1.06	1.06
	UE	1.02	1.04	1.04	1.08	1.00	1.08	1.09	1.09
Emr-D	S550	1.02	1.03	1.03	1.06	1.05	1.10	1.00	1.12
	S750	1.02	1.03	1.03	1.07	1.05	1.10	1.00	1.13
	UE	1.03	1.05	1.05	1.10	1.08	1.15	1.00	1.19
Eur-A	S550	1.00	1.02	1.00	1.03	1.00	1.05	1.00	1.06
	S750	1.00	1.02	1.00	1.03	1.00	1.05	1.00	1.06
	UE	1.00	1.02	1.00	1.04	1.00	1.06	1.00	1.08
Eur-B	S550	1.01	1.03	1.02	1.05	1.02	1.07	1.01	1.07
	S750	1.01	1.03	1.02	1.05	1.02	1.07	1.01	1.08
	UE	1.01	1.03	1.02	1.06	1.02	1.09	1.01	1.09
Eur-C	S550	1.02	1.03	1.01	1.04	1.01	1.06	1.00	1.07
	S750	1.02	1.03	1.01	1.04	1.01	1.06	1.00	1.07
	UE	1.02	1.04	1.01	1.06	1.01	1.08	1.00	1.08
Sear-B	S550	1.01	1.02	1.00	1.03	1.00	1.04	1.00	1.05
	S750	1.01	1.03	1.00	1.04	1.00	1.05	1.00	1.06
	UE	1.02	1.04	1.00	1.04	1.00	1.07	1.00	1.08
Sear-D	S550	1.02	1.03	1.03	1.07	1.05	1.10	1.06	1.13
	S750	1.02	1.04	1.04	1.08	1.06	1.12	1.07	1.15
	UE	1.03	1.05	1.05	1.10	1.07	1.15	1.09	1.19
Wpr-A	S550	1.00	1.01	1.00	1.03	1.00	1.04	1.00	1.05
	S750	1.00	1.01	1.00	1.02	1.00	1.04	1.00	1.05
	UE	1.00	1.02	1.00	1.04	1.00	1.06	1.00	1.07
Wpr-B	S550	1.01	1.03	1.03	1.06	1.00	1.05	1.00	1.06
	S750	1.01	1.03	1.03	1.06	1.00	1.05	1.00	1.06
	UE	1.02	1.05	1.05	1.09	1.00	1.08	1.01	1.09

Malnutrition

Estimates of national food availability were based on the effects of temperature and precipitation, and the beneficial effects of higher CO_2 levels, projected using the IBSNAT-ICASA dynamic crop growth models [IBSNAT 1989]. Principal characteristics of this model include:

- No major changes in the political or economic context of world food trade or in food production technology;
- Population growth follows the World Bank mid-range estimate (i.e. 10.7 billion by the 2080s);
- GDP to accumulate as projected by EMF14 [Energy Modeling Forum 1995]; and
- A 50% trade liberalization in agriculture is introduced gradually by 2020.

Analyses suggested that the model output was positively related to more direct measures of malnutrition, including incidence of underweight, and stunting and wasting in children <5 years of age. The relative risks of malnutrition in Table 4 were interpreted as being directly proportional to underweight; this applies to all diseases affected by underweight (including diarrhea and malaria). The model output was used to generate mid-range estimates; the high relative risks were calculated as a doubling of the mid-range estimate.

Table 4: Central and high projections of the relative risk of malnutrition for alternative climate scenarios relative to baseline climate

Sub-region	Climate	2000		2010		2020		2030	
		Mid	High	Mid	High	Mid	High	Mid	High
Afr-D	S550	1.01	1.02	1.02	1.04	1.03	1.06	1.03	1.06
	S750	1.01	1.03	1.03	1.05	1.04	1.08	1.04	1.09
	UE	1.01	1.01	1.01	1.03	1.02	1.04	1.02	1.04
Afr-E	S550	1.01	1.02	1.02	1.04	1.03	1.06	1.03	1.06
	S750	1.01	1.02	1.02	1.05	1.04	1.07	1.04	1.08
	UE	1.01	1.01	1.01	1.03	1.02	1.04	1.02	1.05
Amr-A	S550	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	S750	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	UE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Amr-B	S550	1.02	1.03	1.03	1.06	1.05	1.09	1.05	1.10
	S750	1.03	1.07	1.07	1.13	1.10	1.20	1.11	1.22
	UE	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00
Amr-D	S550	1.02	1.03	1.03	1.06	1.05	1.09	1.05	1.10
	S750	1.03	1.07	1.07	1.13	1.10	1.20	1.11	1.22
	UE	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00
Emr-B	S550	1.01	1.02	1.02	1.04	1.03	1.06	1.03	1.06
	S750	1.02	1.04	1.04	1.08	1.06	1.12	1.06	1.13
	UE	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00
Emr-D	S550	1.02	1.04	1.04	1.09	1.07	1.13	1.07	1.15
	S750	1.03	1.07	1.07	1.13	1.10	1.20	1.11	1.22
	UE	1.02	1.05	1.05	1.10	1.07	1.15	1.08	1.16
Eur-A	S550	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	S750	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	UE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Eur-B	S550	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	S750	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	UE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Eur-C	S550	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	S750	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	UE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sear-B	S550	1.02	1.03	1.03	1.06	1.05	1.09	1.05	1.10
	S750	1.03	1.06	1.06	1.12	1.09	1.18	1.10	1.19
	UE	1.00	1.00	1.00	1.01	1.00	1.01	1.00	1.01
Sear-D	S550	1.04	1.07	1.07	1.15	1.11	1.22	1.12	1.25
	S750	1.04	1.10	1.10	1.21	1.16	1.31	1.17	1.35
	UE	1.05	1.10	1.10	1.20	1.15	1.31	1.17	1.33
Wpr-A	S550	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	S750	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	UE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wpr-B	S550	1.00	1.01	1.01	1.01	1.01	1.02	1.01	1.02
	S750	1.01	1.02	1.02	1.03	1.03	1.05	1.03	1.05
	UE	1.00	1.00	1.00	1.00	0.99	1.00	0.99	1.00

Malaria

Estimates for the projected populations at risk of *Plasmodium falciparum* malaria were based on the MARA/ARMA model. The model output was used to generate mid-range estimates; the high relative risks were calculated as a doubling of the mid-range estimate (Table 5).

Table 5: Central and high projections of the relative risk of *Plasmodium falciparum* malaria for alternative climate scenarios relative to baseline climate

Sub-region	Climate	2000		2010		2020		2030	
		Mid	High	Mid	High	Mid	High	Mid	High
Afr-D	S550	1.00	1.01	1.01	1.01	1.01	1.02	1.01	1.02
	S750	1.00	1.01	1.01	1.02	1.01	1.02	1.01	1.03
	UE	1.01	1.01	1.01	1.03	1.02	1.04	1.02	1.05
Afr-E	S550	1.02	1.04	1.04	1.08	1.06	1.12	1.07	1.15
	S750	1.02	1.05	1.05	1.10	1.07	1.15	1.09	1.18
	UE	1.04	1.08	1.08	1.16	1.12	1.23	1.14	1.28
Amr-A	S550	1.08	1.15	1.15	1.30	1.23	1.46	1.27	1.53
	S750	1.09	1.19	1.19	1.37	1.28	1.56	1.33	1.65
	UE	1.15	1.26	1.29	1.59	1.44	1.88	1.51	2.03
Amr-B	S550	1.02	1.04	1.04	1.09	1.07	1.13	1.08	1.16
	S750	1.03	1.05	1.05	1.11	1.08	1.16	1.10	1.19
	UE	1.04	1.09	1.09	1.17	1.13	1.26	1.15	1.30
Amr-D	S550	1.01	1.02	1.02	1.05	1.03	1.07	1.04	1.09
	S750	1.01	1.03	1.03	1.06	1.04	1.08	1.05	1.10
	UE	1.02	1.04	1.04	1.09	1.07	1.13	1.08	1.17
Emr-B	S550	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	S750	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	UE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Emr-D	S550	1.03	1.07	1.07	1.13	1.10	1.20	1.15	1.30
	S750	1.04	1.08	1.08	1.16	1.12	1.24	1.19	1.37
	UE	1.06	1.13	1.13	1.26	1.19	1.38	1.29	1.59
Eur-A	S550	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	S750	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	UE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Eur-B	S550	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	S750	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	UE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Eur-C	S550	1.07	1.13	1.13	1.27	1.00	1.20	1.25	1.50
	S750	1.08	1.16	1.16	1.33	1.00	1.25	1.31	1.61
	UE	1.13	1.26	1.26	1.52	1.00	1.39	1.48	1.97
Sear-B	S550	1.00	1.00	1.00	1.00	1.05	1.00	1.00	1.00
	S750	1.00	1.00	1.00	1.00	1.09	1.00	1.00	1.00
	UE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sear-D	S550	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
	S750	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01
	UE	1.00	1.00	1.00	1.01	1.01	1.01	1.01	1.02
Wpr-A	S550	1.07	1.14	1.14	1.28	1.21	1.42	1.25	1.49
	S750	1.09	1.17	1.17	1.34	1.26	1.52	1.30	1.60
	UE	1.14	1.27	1.27	1.54	1.41	1.81	1.48	1.95
Wpr-B	S550	1.06	1.12	1.12	1.25	1.18	1.37	1.22	1.43
	S750	1.08	1.15	1.15	1.30	1.23	1.45	1.26	1.53
	UE	1.12	1.24	1.24	1.48	1.36	1.71	1.42	1.83

Estimated Climate Change-Related Excess Incident Cases of Diarrheal Diseases, Malnutrition, and Malaria in 2030

The data in the previous tables were used to estimate the excess incident cases of diarrheal diseases, malnutrition, and malaria in 2030 for the three scenarios (unmitigated emissions and stabilization at 550 and 750 ppm CO_2 equivalent).

The total estimated excess numbers of cases are shown in Tables 6 - 8.

Diarrheal Diseases

Table 6: Projected excess incident cases of diarrheal diseases (000s) for alternative climate scenarios relative to baseline climate (mid and high estimates)

Sub-region	Climate	2000		2030	
		Mid	High	Mid	High
Afr-D	S550	3,898	11,695	19,492	38,984
	S750	7,797	15,594	23,391	50,679
	UE	7,797	19,492	27,289	62,375
Afr-E	S550	4,492	13,476	22,460	49,411
	S750	8,984	17,968	26,952	58,395
	UE	8,984	22,460	35,935	71,871
Amr-A	S550	0	1,552	0	4,655
	S750	0	1,552	0	4,655
	UE	0	1,552	0	6,206
Amr-B	S550	0	7,812	0	19,530
	S750	0	7,812	0	23,435
	UE	0	7,812	0	31,247
Amr-D	S550	733	2,198	1,465	5,129
	S750	1,465	2,198	1,465	5,862
	UE	1,465	2,931	1,465	7,327
Emr-B	S550	963	2,890	5,779	5,779
	S750	1,926	2,890	5,779	5,779
	UE	1,926	3,853	8,669	8,669
Emr-D	S550	6,912	10,368	0	41,472
	S750	6,912	10,368	0	44,929
	UE	10,368	17,280	0	65,665
Eur-A	S550	0	1,584	0	4,753
	S750	0	1,584	0	4,753
	UE	0	1,584	0	6,338
Eur-B	S550	785	2,355	785	5,496
	S750	785	2,355	785	6,281
	UE	785	2,355	785	7,066
Eur-C	S550	958	1,437	0	3,352
	S750	958	1,437	0	3,352
	UE	958	1,915	0	3,831
Sear-B	S550	1,792	3,584	0	8,960
	S750	1,792	5,375	0	10,753
	UE	3,584	7,169	0	14,337
Sear-D	S550	21,031	1.03	63,092	136,700
	S750	21,031	42,062	73,608	157,731
	UE	31,546	52,577	94,638	199,792
Wpr-A	S550	0	300	0	1,501
	S750	0	300	0	1,501
	UE	0	601	0	2,102
Wpr-B	S550	12,252	36,756	0	73,511
	S750	12,252	36,756	0	73,511
	UE	24,504	61,259	12,252	110,267

Malnutrition

Table 7: Projected excess incident cases of malnutrition (000s) for alternative climate scenarios relative to baseline climate (mid and high estimates)

Sub-region	Climate	2000		2030	
		Mid	High	Mid	High
Afr-D	S550	50	101	151	302
	S750	50	151	201	453
	UE	50	50	101	201
Afr-E	S550	59	118	177	355
	S750	59	118	236	473
	UE	59	59	118	296
Amr-A	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Amr-B	S550	22	34	56	112
	S750	34	79	134	247
	UE	0	0	0	0
Amr-D	S550	12	18	30	133
	S750	18	42	66	0
	UE	0	0	0	0
Emr-B	S550	6	12	18	35
	S750	12	23	35	76
	UE	0	0	0	0
Emr-D	S550	90	181	317	678
	S750	136	317	498	995
	UE	90	226	362	724
Eur-A	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Eur-B	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Eur-C	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Sear-B	S550	45	68	113	225
	S750	68	135	225	428
	UE	0	0	0	23
Sear-D	S550	722	1263	2165	4510
	S750	722	1804	3067	6314
	UE	902	1804	3067	5953
Wpr-A	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Wpr-B	S550	0	70	70	141
	S750	70	141	211	352
	UE	0	0	-70	0

Malaria

Table 8: Projected excess incident cases of malaria (000s) for alternative climate scenarios relative to baseline climate (mid and high estimates)

Sub-region	**Climate**	**2000**		**2030**	
		Mid	High	Mid	High
Afr-D	S550	0	1804	1804	3607
	S750	0	1804	1804	5411
	UE	1804	1804	3607	9018
Afr-E	S550	3533	7066	12366	26498
	S750	3533	8833	15899	31797
	UE	7066	14132	24731	49462
Amr-A	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Amr-B	S550	57	115	229	459
	S750	86	143	287	545
	UE	115	258	430	860
Amr-D	S550	7	14	29	65
	S750	7	22	36	72
	UE	14	29	57	122
Emr-B	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Emr-D	S550	607	1183	2535	5069
	S750	676	1352	3211	6252
	UE	1014	2197	4900	9970
Eur-A	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Eur-B	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Eur-C	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Sear-B	S550	0	0	0	0
	S750	0	0	0	0
	UE	0	0	0	0
Sear-D	S550	0	0	0	70
	S750	0	0	70	70
	UE	0	0	70	139
Wpr-A	S550	0.4	0.8	1.5	3
	S750	0.5	1.0	2	4
	UE	0.8	1.6	3	6
Wpr-B	S550	110	221	404	790
	S750	147	276	478	974
	UE	221	441	772	1526

Annual Costs of Interventions for Diarrheal Diseases, Malnutrition, and Malaria

Annual costs of intervention for diarrheal diseases, malnutrition, and malaria were based on the Disease Control Priorities project (http://www.dcp2.org). The costs are for interventions alone and do not include costs of implementing programs (including infrastructure and health care personnel costs) in new areas if these diseases increase their geographic range, as is projected with climate change. The costs of implementing programs in new areas can be significant, and include costs of infrastructure (i.e. building clinics, costs for equipment and drugs), training new personnel, maintenance costs, etc.

There are three major diarrhea syndromes requiring treatment: acute watery diarrhea that results in varying degrees of dehydration; persistent diarrhea that last 14 days or longer, manifested by malabsorption, nutrient losses, and wasting; and bloody diarrhea caused by inflammation of the intestinal tract. Viruses, bacteria, protozoa, and helminthes can cause diarrhea. Diarrheal diseases affect all populations, with the largest health burdens among the poor. The costs of two sets of intervention for treating diarrheal diseases in children under five were estimated: (1) breastfeeding promotion, rotavirus immunization, cholera immunization, and measles immunization; and (2) improvement of water supply and sanitation [Keusch et al. 2003]. The average cost per child in 2001 US$ for (1) was $15.09 (the costs range from $0.71 per child for oral rehydration therapy in Indonesia to $104.30 per child for rotavirus immunization in South Africa) and for (2) was $53.00 ($25.00 for rural areas and $81.00 for urban areas). These are long-term marginal costs and do not include the fixed costs of initiating a program where none currently exists.

The average costs of nutritional interventions per child for addressing underweight include breastfeeding promotion, child survival programs (with a nutritional component), nutritional programs, and growth monitoring and counseling range from $17.40 to $23.09 [Caulfied et al. 2003]. These costs are very conservative; Edejer et al. [2005] estimate the annual per capita cost of providing food to improve child health in Africa D and SEAR-D is $int (international dollar)[1] 116.23, and the cost per recipient is $int 310.91 to 317.30. Using these estimates would increase the estimated costs by more than 10-fold.

The costs of two sets of interventions for malaria were estimated: (1) insecticide-treated bednets plus case management with artemisinin-based combination therapy plus intermittent presumptive treatment in pregnancy; and (2) indoor residual spraying plus (1) [Morel et al. 2005]. The average cost for (1) for Africa D and E is $int 88.50 and the average cost for (2) is $int 123.5; these are incremental costs per disability adjusted life year lost and do not include the costs of implementing new malaria control programs.

Table 9 summarizes the projected excess costs in millions of US$ in 2030 to manage the excess cases of diarrheal diseases, malnutrition, and malaria due to climate change under the three scenarios.

[1] An international dollar is a hypothetical unit of currency that has the same purchasing power that the US$ has in the US at a given point in time, thus showing the average value of local currency units within each region's borders.

Table 9: Projected excess costs (million US$) in 2030 to manage climate change-related cases of diarrheal diseases, malnutrition, and malaria for three alternative climate scenarios relative to baseline climate (mid and high estimates)

Scenario	Diarrheal Diseases		Malnutrition		Malaria	
	Mid	High	Mid	High	Mid	High
S550	1,706	6,024	53.9 – 71.5	112.9 – 149.9	1,573 – 2,145	3,236 – 4,515
S750	1,983	6,814	81.3 – 107.9	162.5 – 215.6	1,928 – 2,691	3,994 – 5,573
UE	2,731	9,010	62.2 – 82.6	125.2 – 166.2	3,059 – 4,269	6,293 – 8,781

The total costs for these three diseases in 2030 under S550 are estimated to be $3,333 to $10,689 million; the total costs under S750 are $3,992 to $12,603 million; and the total costs under UE are $5,852 to $17,957 million.

Investment Flows in Health

Previous sections estimated the financial needs for adaptation in 2030. This section discusses current investment flows in health, and what will be needed to fill adaptation needs in the health sector.

Hecht and Shah [2003] estimated development assistance for health for the Disease Control Priorities in Developing Countries project (Table 10).

Table 10: Development assistance for health, selected years (millions US$)

Source	Annual Average, 1997-1999	2002
Bilateral agencies	2 560	2 875
Multilateral agencies	3 402	4649
European Commission	304	244
Global Fund to Fight AIDS, Tuberculosis, and Malaria	0	962
Bill & Melinda Gates Foundation	458	600
Total	6 724	9 330

Bilateral assistance for health rose from an annual average of US$ 2.2 billion during 1997-99 to US$ 2.9 billion in 2002. The US accounted for about 40% of the total, even though as a percentage of GDP its allocation was among the lowest of all high-income countries. Within the UN system, development assistance arose from an annual average of US$ 1.6 billion during 1997-99 to US$ 2 billion in 2002. Commitments from the development banks remained stationary at about US$ 1.4 billion. However, changes in accounting at the World Bank to include financing for health-related activities in other sectors (i.e. water and sanitation, transportation, and social development), suggest that new commitments rose from about US$ 1 billion in 2001 to US$ 1.7 billion in 2003.

Table 11 gives ODA by region for the health sector in 2000 and 2005 (millions 2000 US$). Total real ODA rose by two-thirds from 2000 to 2005, reaching almost $5 billion (in 2000 US$). Bilateral aid doubled. Africa received the largest share of aid in both years, with South Asia second.

Table 11. ODA assistance in the health sector (millions 2000 US$)

Region	Total bilateral (2000)	Total multilateral (2000)	Total bilateral (2005)	Total multilateral (2005)	Total ODA (2000)	Total ODA (2005)
South Asia	$256.3	$510.9	$592.1	$500.5	$767.2	$1,092.6
Southwest Asia	$63.4	$3.6	$280.4	$15.8	$66.3	$296.2
South East Asia	$121.9	$145.8	$234.3	$185.7	$267.7	$419.9
Central Asia	$7.0	$6.8	$44.8	$58.6	$13.8	$103.3
East Asia	$45.4	$6.0	$39.9	$31.1	$51.4	$71.0
LAC	$240.9	$400.3	$304.4	$267.8	$641.3	$572.2
North America	$ —	$ —	$ —	$ —	$ —	$ —
Pacific	$13.9	$10.3	$51.8	$4.5	$24.1	$56.3
Europe	$55.7	$20.3	$52.5	$35.8	$76.0	$88.4
Africa	$541.7	$488.8	$1,157.4	$1,024.2	$1,020.0	$2,181.7
Others	$3.6	$ —	$ —	$ —	$3.6	$ —
Total	$1,349.9	$1,592.8	$2,757.6	$2,124.0	$2,931.6	$4,881.6

Table 12 provides total health expenditures from the World Health Report 2006, at the country level for 1999 through 2003. WHO defines total health expenditure as the sum of general government expenditure on health and private expenditure on health. General government health expenditure is estimated as the sum of outlays by government entities to purchase health care services and goods, including by ministries of health and social security agencies. Private health expenditure includes total outlays on health by private entities, including commercial insurance, non-profit institutions, households acting as complementary funders to the previously cited institutions or disbursing unilaterally on health commodities. The revenue base of these entities may comprise multiple sources, including external funds. Numbers are estimated in million national currency units (million NCU) and in current prices. In many instances, the data were limited to those supplied by ministries of health. An effort was made to obtain data on health expenditure by other ministries, the armed forces, prisons, schools, universities and others, to ensure that all resources accounting for health expenditures were included.

What these tables make clear is that poor countries tend to have low health expenditures and to rely significantly on external donors. Currently, there are a number of donors quite interested in investing in health, which is increasing ODA. History suggests that this won't be maintained. As countries develop, they will improve their public health and health care systems, which should decrease the burden of many climate-sensitive diseases. However, the underlying assumption is that the currently developing countries will develop along similar pathways to those followed by the developed countries. There is ample evidence to suggest that this assumption is unlikely to hold. A key issue is water; most developing countries don't have as much available water as developed countries did when they were developing. Therefore, it will be more difficult to resolve issues like access to safe water and sanitation. Also, malaria is a different disease in Africa than it was in Europe or the US and continues to be much more difficult to control.

Overall, progress is being made in controlling climate-sensitive health outcomes. However, much of the progress has been in areas where the issues are easier to resolve. There are parts of Africa where people receive more than 1000 malaria-infective mosquito bites annually. Obviously, controlling malaria in these regions is more difficult. The world is not on track to meet the health-related MDGs by 2015, with climate change working against disease control efforts.

Future investment flows needed to fill in the gaps between the Reference and Mitigation scenarios

The Mitigation scenario results in fewer cases and lower investment needs than the BAU scenario. For the middle scenario, the annual needs are about $1 billion a year lower, from $4-5 billion down to $3-4 billion. Should the high scenario occur, the annual investment needs are about $2 billion lower from the BAU to the Mitigation scenario.

The mid-range costs of just climate change impacts on the three health outcomes examined here would be almost as much as current total annual ODA for health. The estimate of investment needs does not account for socioeconomic changes, in particular increased population and income.

Although an estimate of the increased investment need resulting from the socioeconomic changes in the BAU and Mitigation scenarios is not being developed for this study, an estimate of current financial needs can be derived by comparing the increase in health cases from climate change with the current number of cases. This can give an indication of the magnitude of investment that may be needed. Table 13 presents the current number of cases of the three health outcomes, the projected number of cases under the BAU climate change scenario, and the percentage increase.

Table 13. Comparison of current diarrheal disease, malnutrition, and malaria cases with estimated climate change impacts in 2030 assuming the 750 ppm of CO_2 scenario (thousands of cases)

	Diarrheal diseases	Malnutrition	Malaria
Total	4,513,981	46,352	408,227
Climate change impacts	131,980	4,673	21,787
% increase	3%	10%	5%

Assuming the cost per case remains unchanged, the total investment needs for combating diarrheal disease would be $67 billion, malnutrition $2 billion, and malaria $36 to $50 billion in 2030.

Assessment of needed changes in financial and policy arrangements to fill the gap between the BAU and Mitigation scenarios

Financial and policy arrangements will need to be altered to address the projected additional cases of diarrheal diseases, malnutrition, and malaria. Although current governmental health expenditures can be anticipated to increase with development, there are health problems other than those associated with climate change that need to be addressed, such as HIV/AIDS, tuberculosis, diabetes, and other diseases. Assuming that Ministries of Health, NGOs, and other actors will completely cover the additional costs is not realistic for many low-income countries; they have many urgent health issues, without sufficient funds to address all of them. Addressing climate-sensitive health outcomes completely would mean that other health issues of importance are not addressed.

Discussion

Estimating the adaptation needs in the health sector is challenging. Most of the health outcomes that are projected to be affected by climate change are current problems; there will not be death certificates, hospital admissions, or records of visits to health care providers indicating that a particular event was due to climate change. Instead, as with some other environmental exposures (particularly indoor and outdoor air quality), models are used to estimate the proportion of a disease burden that can be attributed to climate change based on exposure-response relationships and projected changes in weather patterns. Uncertainties in models, from limited data through to inadequate specification of all factors that influence the exposure-response relationship, will therefore lead to uncertainty as to the precise magnitude of the climate change impact.

Another complexity is estimating the economic cost of injuries, illnesses, and deaths across multiple countries and regions. Issues include not just how to value a human life, but how to measure economically the life-course consequences of malnutrition, for example. Mortality is a commonly used metric, but is an inadequate measure of the affect of a health outcome on the family and on society; a death at age 80 and a death at age 2 would be counted equally while having different impacts. Similarly, malnutrition decreases learning ability, affecting lifelong earning potential, among a myriad of other impacts. Therefore, counting cases of disease also is insufficient for estimating total impacts.

Because of the uncertainties in the estimated costs, they should be taken as indicators of the size of the financial needs and not as accurate predictions. The estimates are likely to include both under- and over-estimates of the actual costs. Emerging technologies, along with significant investments in research and development, are likely to reduce current health burdens over the next 30 years. On the other hand, the estimated costs were for only three of the health outcomes of concern with climate change; and then only a fraction of the burden of malnutrition was included.[2] In addition, the model used to estimate malnutrition does not take into account new projections that a few degree increase in global mean temperature may render some areas unsuitable for rainfed agriculture [IPCC SPM WGII 2007]; if this occurs, the short-term health consequences would likely be severe.

The costs estimated for adaptation are consistent with other estimates of financial needs for health care investment. Stenberg et al. [2007] estimated the costs to scale-up essential child health interventions to reduce by two-thirds child mortality under the four MDGs aimed at children’s health by 2015 in 75 countries; the countries chosen accounted for 94% of death among children less than fie years of age (Table 14). The interventions focused on malnutrition, pneumonia, diarrhea, malaria, and key newborn causes of death. Calculations were bottom-up, based on intervention, country, and year. Costs included program-specific investments needed at national and district levels. The authors estimated that an additional US$ 52.4 billion would be required for the period 2006-2015. Projected costs in 2015 were equivalent to increasing the average total health expenditures from all financial resources in the 75 countries by 8% and raising general government health expenditure by 26% over 2002

[2] According to Caulfied et al. 2003, the estimated prevalence of weight-for-age less than -2 SD (a measure of malnutrition) are 18% for Asia and the Pacific; 6% for Eastern Europe and Central Asia, and for Latin America and the Caribbean; 21% for the Middle East and North Africa; 46% in South Asia; 32% in Sub-Saharan Africa; and 2% in high-income countries.

levels. The authors noted that countries with weak health care systems may experience difficulties mobilizing enough domestic public funds.

Table 14: Estimated costs of scaling-up child-health interventions, 2006-2015 (US$)

Index Category*	No. Countries	Estimated Additional Cost (Millions US$)	Average Total Health Expenditure Per Capita	Average General Government Health Expenditure Per Capita	Average Incremental Cost Per Child <5 in 2015
1	22	11 667	14.62	4.60	17.78
2	19	8 994	41.09	9.51	12.77
3	20	5 537	35.49	15.54	11.83
4	14	26 241	73.01	27.82	10.35
All 75	75	52 440	59.93	22.17	12.31

*The Commission on Macroeconomics and Health's index classifies countries' health systems into four levels of strength, with lower numbers indicating greater need for incremental investments.

Source: Stenberg et al. 2007

Because of the large needs for investment in the health sector, capacity needs to be built to address climate-sensitive health outcomes. There needs to be greater awareness amongst Ministries of Health and ODA donors of how climate change could alter the burden of a range of health outcomes, so that appropriate modifications are made in current programs to better address these health outcomes to increase future adaptive capacity. As noted above, it is unlikely that will be sufficient, particularly in low income countries. Additional human and financial resources will be needed; these can be provided from donors, the Global Environment Facility, and other sources.

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Annex 1: WHO Regions

Region and Mortality Stratum	Description	Broad Grouping	Member States
Africa			
Afr-D	Africa with high child and high adult mortality	High-mortality developing	Algeria, Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Comoros, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Mauritania, Mauritius, Niger, Nigeria, San Tome and Principe, Senegal, Seychelles, Sierra Leone, Togo
Afr-E	Africa with high child and very high adult mortality	High-mortality developing	Botswana, Burundi, Central African Republic, Congo, Cote d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, Zimbabwe
Americas			
Amr-A	Americas with very low child and very low adult mortality	Developed	Canada, Cuba, United States of America
Amr-B	Americas with low child and low adult mortality	Low-mortality developing	Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, El Salvador, Grenada, Guyana, Honduras, Jamaica, Mexico, Panama, Paraguay, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela (Bolivarian Republic of)
Amr-D	Americans with high child and high adult mortality	High-mortality developing	Bolivia, Ecuador, Guatemala, Haiti, Nicaragua, Peru
South-East Asia			

Sear-B	South-east Asia with low child and low adult mortality	Low-mortality developing	Indonesia, Sri Lanka, Thailand
Sear-D	South-east Asia with high child and high adult mortality	High-mortality developing	Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal, Timor-Leste
Europe			
Eur-A	Europe with very low child and very low adult mortality	Developed	Andorra, Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland, United Kingdom
Eur-B	Europe with low child and low adult mortality	Developed	Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Georgia, Kyrgyzstan, Poland, Romania, Serbia and Montenegro, Slovakia, Tajikistan, The former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Uzbekistan
Eur-C	Europe with low child and high adult mortality	Developed	Belarus, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Ukraine
Eastern Mediterranean			
Emr-B	Eastern Mediterranean with low child and low adult mortality	Low-mortality developing	Bahrain, Iran (Islamic Republic of), Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates
Emr-D	Eastern Mediterranean with high child and high adult mortality	High-mortality developing	Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen
Western Pacific			
Wpr-A	Western Pacific with very	Developed	Australia, Brunei Darussalam, Japan, New Zealand, Singapore

	low child and very low adult mortality		
Wpr-B	Western Pacific with low child and low adult mortality	Low-mortality developing	Cambodia, China, Cook Islands, Fiji, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, Niue, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, Viet Nam