Evidence to the House of Lords Select Committee on Economic Affairs On Aspects of the Economics of Climate Change

by

Indur M. Goklany

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EVIDENCE TO THE HOUSE OF LORDS SELECT COMMITTEE ON ECONOMIC AFFAIRS ON ASPECTS OF THE ECONOMICS OF CLIMATE CHANGE

Indur M. Goklany
E-mail: igoklany@ios.doi.gov

SUMMARY

Dependence of damage estimates upon assumptions of economic growth and technological development

- Greater economic growth could, by increasing emissions, lead to greater damages from climate change. On the other hand, by increasing wealth and advancing technological development and human capital, economic growth would also increase a society's adaptive capacity and reduce those damages. Although analyses of the impacts (or damages) of climate change generally incorporate economic growth into the emissions and climate change scenarios that they use as inputs, these analyses do not adequately account for the increase in adaptive capacity resulting from that very growth. Because of this inconsistency, these analyses generally tend to overstate impacts.
- For instance, the average GDP per capita for developing countries in 2100 is projected to be $11,000 (in 1990 US$, at market exchange rates) under A2, the slowest economic growth scenario, and $66,500 under A1, the scenario with both the greatest economic growth and largest climate change. By comparison, in 1990 the GDP per capita for Greece, for example, was $8,300 while Switzerland, the country with the highest income level at that time, had a GDP per capita of $34,000. Based on historical experience, one should expect that at the high levels of GDP per capita projected by the IPCC scenarios in 2100, wealth-driven increases in adaptive capacity alone should virtually eliminate damages from many climate-sensitive hazards, e.g., malaria and hunger, whether or not these damages are caused by climate change.
- Current damage estimates are inflated further because they usually do not adequately account for secular (time-dependent) improvements in technology that, if history is any guide, ought to occur in the future unrelated to economic development.
- A compelling argument for reducing greenhouse gases is that it would help developing countries cope with climate change. It is asserted that they need this help because their adaptive capacity is weak. Although often true today, this assertion becomes increasingly invalid in the future if developing countries become wealthier and more technologically advanced, per the IPCC's scenarios. Damage assessments frequently overlook this.

Are scenario storylines internally consistent in light of historical experience?

- Regardless of whether the economic growth assumptions used in the IPCC scenarios are justified, their specifications regarding the relationship between wealth and technological ability are, in general, inconsistent with the lessons of economic history. They assume that the less wealthy societies depicted by the B1 and B2 scenarios would have greater environmental protection and employ cleaner and more efficient technologies than the wealthier society characterized by the A1F1 scenario. This contradicts general experience in the real world, where richer countries usually have cleaner technologies.
- Under the IPCC scenarios, the richer A1 world has the same population as the poorer B1 world, but in fact total fertility rates — a key determinant of population growth rates — are, by and large, lower for richer nations and, over time, have dropped for any given level of GDP per capita (Goklany 2001a).

Merits of reallocating expenditures from mitigation to international development

- Halting climate change at its 1990 level would annually cost substantially more than the $165 billion estimated for the minimally-effective Kyoto Protocol. According to DEFRA-sponsored studies, in 2085, which is at the limit of the foreseeable future, such a halt would reduce the total global population at risk (PAR) due to both climate change and non-climate-change-related causes by 3 percent for malaria, 21 percent for hunger, and 86 percent for coastal flooding, although the total PAR for water shortage might well increase.
- The benefits associated with halting climate change — and more — can be obtained more economically through “focused adaptation”, i.e., activities focused on reducing vulnerabilities to the above noted climate-sensitive hazards, or through broadly advancing sustainable development in developing countries by meeting the Millennium Development Goals (MDGs) by 2015. In fact, such efforts, which together could annually cost donor countries $150 billion according to UN Millennium Project and World Health Organization studies, should reduce global malaria, hunger, poverty, and lack of access to safe water and sanitation by 50 percent (each); reduce child and maternal mortality by at least 66 percent; provide universal primary education; and reverse growth in AIDS/HIV, and other major diseases.
- These numbers also indicate that no matter how important climate change might be in this century, for the next several decades it would be far more beneficial for human well-being, especially in developing countries, to deal with non-climate change related factors.
- Not only would either focused adaptation or adherence to the MDGs provide greater benefits at lesser costs through the foreseeable future than would any emission reduction scheme, they would help solve today’s urgent problems sooner and more certainly. Equally important, they would also increase the ability to deal with tomorrow’s problems, whether they are caused by climate change or other factors. None of these claims can be reasonably made on behalf of any mitigation scheme today.

- Accordingly, over the next few decades the focus of climate policy should be to: (a) broadly advance sustainable development, particularly in developing countries since that would generally enhance their adaptive capacity to cope with the many urgent problems they currently face, including many that are climate-sensitive, (b) specifically reduce vulnerabilities to climate-sensitive problems that are urgent today and might be exacerbated by future climate change, and (c) implement "no-regret" emission reduction measures, while (d) concurrently striving to expand the universe of no-regret options through research and development to increase the variety and cost-effectiveness of available mitigation options.

Ancillary benefits associated with greenhouse gas (GHG) reductions

- Some GHG emission control options might provide substantial co-benefits by concurrently reducing problems not directly caused by climate change (e.g., air pollution or lack of sustained economic growth, especially in developing countries). However, in both these instances, the same, or greater, level of co-benefits can be obtained more economically by directly attacking the specific (non-climate change related) problems rather than indirectly through greenhouse gas control. On the other hand, a direct assault on the numerous climate-sensitive hurdles to sustainable development (e.g., hunger, malaria, and many natural disasters) would, as indicated, provide greater benefits more cost-effectively than would efforts to mitigate climate change.

1. Introduction. I am an energy and environmental policy analyst with over 30 years experience in the United States working for state and federal governments, think tanks, consulting enterprises, and the private sector. I have participated in the IPCC's activities and deliberations off and on since its founding in 1988 to the present. I was the *rapporteur* for the Resource Use and Management Subgroup of IPCC's Work Group III for the First Assessment Report, and helped develop the program leading to the Second Assessment Report.

2. I have written extensively on climate change, adaptation, biodiversity, sustainable development, human well-being, technological change, bioengineered crops, and the precautionary principle. I also have a Ph.D. in Electrical Engineering from Michigan State University.

3. I am currently Assistant Director, Science and Technology Policy, Office of Policy Analysis, at the US Department of the Interior, which manages 20 percent of U.S. surface area, all its Outer Continental Shelf, and their biological, water and mineral resources. This evidence, however, is submitted in an individual capacity. I do not represent any agency, group or institution.

4. I am grateful for the opportunity to submit evidence to the Select Committee.

5. **Scope of Evidence.** My evidence is limited to the following issues: (a) Dependence of estimates of climate change damages on assumptions about future

economic growth and technology development. (b) Whether the basic specifications for the IPCC's scenarios, i.e., their "storylines", regarding economic growth and technological development are internally consistent in light of historical experience. (c) The relative costs and benefits of allocating resources to climate change control rather than to greater international development assistance. (d) What other associated benefits might there be from reducing greenhouse gas emissions?

6. My evidence draws upon a set of impacts analyses funded by DEFRA (and its predecessor, DETR). These studies (Parry and Livermore, 1999, Parry *et al.,* 2001, Arnell *et al.,* 2002) apparently form the basis of claims by several advocates of stronger greenhouse gas (GHG) controls, e.g., Sir David King (2004), that, unless curbed, climate change would place additional millions at risk of diseases such as malaria, hunger, water shortage and coastal flooding. I will also touch on recent updates to these studies (Parry 2004). Along with the authors of these studies, I will: (a) assume — optimistically, I believe — that socio-economic scenarios are not credible beyond 2085 and, therefore, 2085 is at the limit of the foreseeable future, and (b) restrict myself to the impacts of "gradual", as opposed to abrupt, climate change.

7. For brevity's sake, my evidence concentrates on damage estimates for the four above-mentioned climate-sensitive hazards to human health and safety, namely, malaria, hunger, water shortage and coastal flooding. However, analyses of the impacts of climate change on "natural" systems — to the extent that natural systems still exist anywhere — are provided in two papers that I am submitting to supplement my comments. The first, "Relative Contributions of Global Warming to Various Climate Sensitive Risks, and Their Implications for Adaptation and Mitigation", was published in *Energy & Environment* in 2003. The second, "Reducing Climate-Sensitive Risks in the Medium Term: Stabilisation or Adaptation?" is an extended abstract of a poster presented at the UK-government sponsored *Symposium on Avoiding Dangerous Climate Change*, in Exeter, February 1 to 3, 2005. These papers are identified in the following as Goklany (2003) and Goklany (2005a), respectively.

8. **Dependence of damage estimates on future assumptions of economic growth and technological development.** Greater economic growth leads to greater emissions and, therefore, increased impacts from climate change. But it also leads to greater wealth, which allows societies to better afford the development and use of new and improved technologies to combat adversity in general, and climate change (and its impacts), in particular. Cross country studies also show that greater levels of economic development (measured as per capita income or GDP per capita) are associated with higher agricultural yields, lower hunger and malnutrition, better health, higher levels of education, and increased resources for research and development — all factors that directly or indirectly increase human capital and technological prowess (Goklany 2001a, 2002). Thus, economic development spurs technological change and human capital. In turn, technological change and human capital reinforce economic growth. Hence, wealthier societies have greater "adaptive capacity" and resilience.

9. Adaptive capacity is a key determinant of impacts, or damages, due to climate change. This is because the greater a society's adaptive capacity, the greater its ability to: (a) forestall or reduce some impacts through a combination of "spontaneous" (or "autonomous") adaptations and proactive adaptations, and (b) cope with any residual impacts through reactive adaptations.

10. Although the DEFRA-sponsored impacts analyses use climate (and emissions) scenarios that are driven in large part by assumptions regarding economic growth, they fail to adequately account for increases in adaptive capacity due to that very growth. Because of this inconsistency, these studies generally overstate impacts.

11. Cross country analyses also show that for any given level of economic development, various indicators of human development — agricultural yields, food supplies per capita, malnutrition, infant mortality, life expectancy, access to safe water and sanitation, educational levels — improve with time (Goklany, 2001a, 2002). That is, for each of these indicators there is a secular (time-dependant) rate of technological progress unrelated to economic development, which also increases a society's capacity to cope with adversity. But this increase in future adaptive capacity is either ignored or inadequately addressed in current impact estimates, further reinforcing the tendency to overestimate the future impacts of climate change.

12. Consider, for example, estimates of the impacts of climate change on *malaria* (Arnell *et al.,* 2002, van Lieshout *et al.,* 2004), which is both a problem in its own right and a good surrogate for other climate-sensitive diseases. These studies provide damage estimates in terms of the future global population at risk (PAR), implicitly assuming that incidences and deaths due to malaria would be proportional to PAR. But these studies estimate changes in PAR on the basis of changes in climatic factors and population. They assume no change in adaptive capacity of these populations in the future, i.e., they ignore the improvements in prevention and cure of malaria that should occur over the next several decades[1], and the fact that, with economic growth, societies should be better able to combat all climate-sensitive diseases, including malaria. But with current technology, malaria is functionally eliminated in societies with annual per capita income of $3,100 (Tol and Dowlatabadi, 2001) and, since incomes are expected to grow under every SRES scenario, few, if any, countries will be below this $3,100 threshold by the end of this century. In fact, according to the A2 scenario — the scenario with the lowest economic growth — the average income in developing

1 It is, however, possible that despite increased technological prowess and economic development, these diseases could extract a greater toll in the future because of maladaptation. Perhaps the best example of maladaptation is the suspension of indoor residual spraying with DDT to control malaria in many developing countries, which then contributed to the disease's resurgence. When such spraying was reinitiated, e.g., in South Africa, malaria once again declined (Goklany, 2001b, Tren and Bate, 2004). This maladaptation attests to the importance of being open to technology to help cope with adversity, the perils of over-precaution, and the need for risk-risk analysis to identify the lesser of two evils (Goklany, 2001b).

countries will be $11,000 in 2100 (in 1990 US$, at market exchange rates or MXR; Arnell *et al.*, 2004), while under the A1 scenario — the scenario with both the greatest economic growth and climate change — their average income would be $66,500, which is greater than any individual country's heretofore. Thus, even ignoring secular trends in technological ability, malaria should be restricted to a much smaller area, if not totally eliminated. Clearly, the DEFRA-funded studies overestimate the impacts of climate change on malaria in a richer and more technologically advanced world.

13. By contrast, the recent analysis of *hunger* (Parry *et al.*, 2004) does a better job of including changes in adaptive capacity. It allows for some increases in agricultural productivity over time, fertilizer-driven increases in crop yield with economic growth (but not necessarily yield increases due to other underused technologies that might become more affordable at higher incomes), decreases in hunger due to economic growth, and for some adaptive responses at the farm level to boost agricultural productivity. However, as this study itself acknowledges, these adaptive responses are based on currently available technologies, not on technologies that would be available in the future or any technologies developed to specifically cope with the negative impacts of climate change (Parry *et al.*, 2004, p. 57). The potential for future technologies to cope with climate change is large, especially if one considers bioengineered crops (Goklany, 2001b, 2003).

14. With respect to *water shortage*, the DEFRA-sponsored studies indicate that climate change might, in fact, *reduce* the overall population under water stress (defined as people living in areas where available water is less than 1,000 m^3 per capita per year) (Arnell, 1999, 2004). However, summaries of these studies which have advanced the notion that additional millions are at risk of climate change (Parry *et al.*, 2001, Arnell *et al.*, 2002) report the increase in PAR without subtracting out the population for whom the risk would be reduced (Goklany, 2003).

15. Recent analysis of the impacts of climate change on *coastal flooding* (Nicholls, 2004) has, so far, done the best job in incorporating improvements in adaptive capacity due to increasing wealth. In particular, it assumes that the level of protection against coastal flooding would rise step-wise as a function of a country's GDP per capita. But, arguably, the relationship should be more linear (or there should be more and shorter steps from the lowest protection level to the highest). More important, this study makes no adjustments for a country's expenditures on coastal protection as the size of its coastal population increases relative to its total population. It would be more reasonable to assume that would lead to greater expenditures for coastal protection on a per-GDP basis (through a push-and-pull effect).

16. Nicholls (2004) coastal flooding study inadvertently points to **the possibility that specifications for various IPCC (SRES) scenarios are internally inconsistent in light of historical experience** regarding the relationship between wealth, technological capabilities, and environmental protection. Consider that the "storyline" for the A1 scenario is that it reflects a world with increased globalization, materialism,

less regard for the environment, and rapid technological change (but, apparently, not with regard to environmental technologies), while the B2 storyline reflects a more heterogeneous world, greater priority for the environment, and clean and efficient technologies. Economic growth is assumed to be faster, and substantially greater, under A1 than B2. Consequently, in 2100, absolute GDP is projected to be 2.2 times larger under A1 than under B2, while GDP per capita is projected to be twice as large for industrialized countries and 3.7 times as large for developing countries. Nevertheless, Nicholls (2004) assumes that adaptive responses would be quicker, and subsidence protection greater, under B2 than A1. Although this assumption conforms with the SRES's manufactured storylines, it is contrary to real world experience which indicates that richer countries generally respond quicker to environmental problems, spend more, and have greater environmental protection, than poorer ones, especially at the high levels of development that are projected to exist virtually everywhere later this century under the IPCC's scenarios (Goklany, 2002). Hence, one should expect that the richer (A1) world would spend more on subsidence protection, and be better protected, than would the B2 world. Moreover, if greater concern for the environment is expressed as a larger fraction of GDP spent on the environment then, despite spending a smaller fraction under A1, that could still provide greater protection than what might be obtained under B2, given the wide gaps in GDPs (and GDPs per capita) between A1 and B2.

17. Under the IPCC scenarios, the richer A1 world has the same population as the poorer B1 world, but empricial evidence shows that total fertility — a key determinant of population growth rates — are, by and large, lower for richer nations and, over time, have dropped for any given level of GDP per capita (Goklany, 2001a).

18. Nicholls' (2004) damage estimates from coastal flooding show lower damages in the B1 world than the A1F1 world. But for the reasons outlined in paragraphs 16 and 17, this could be an artifact of the assumptions rather than a general rule that the former is necessarily a more superior world to A1F1.

19. One of the most compelling arguments advanced for reducing greenhouse gas emissions is that mitigation would help developing countries because, it is asserted, they lack the requisite economic resources and human capital to cope with the impacts of climate change. Although many developing countries indeed lack adequate adaptive capacity today, this assertion becomes increasingly suspect if they become wealthier and technologically more developed, per the IPCC's scenarios, especially if there is no undue aversion to new or improved technologies (see footnote 1). [As noted in paragraph 12, the average GDP per capita for developing countries is projected to be between $11,000 (under A2) and $66,500 (under A1) in 2100.]

20. **Costs and benefits of using resources for international development rather than emission control.** The studies cited by King (2004) to bolster the claim that climate change could indeed place additional millions at risk also show that, for the most part, *many more millions would be at risk in the absence of climate change* (Goklany 2003, 2005a; Goklany and King 2004).

Table 1. Percent reduction in the total global population at risk (PAR) in 2085 under various mitigation scenarios

Climate-sensitive hazard	% Reduction in total PAR* in 2085			
	Due to the Kyoto Protocol (KP)	Assuming stabilization at 750 ppmv	Assuming stabilization at 550 ppmv	If there is no climate change
Malaria	0.2%	1.3%	0.4%	3.2%
Hunger	1.5%	16.6%	9.7%	21.1%
Water shortage §				
Method A	–4.1% to 0.8%			–58.6% to 11.8%
Method B	2.4%	4.0%	26.3%	34.1%
Coastal flooding	18.1%	62.8%	80.1%	86.2%

*Total PAR = (PAR without climate change) + (PAR due to climate change).

§A negative sign indicates that emission reductions will increase PAR. Method A calculates the net change in the global population under greater water stress using Arnell (1999); Method B provides an estimate of only the population experiencing greater stress (Arnell *et al.*, 2002).

Source: Goklany (2005a), based on Arnell (1999) and Arnell *et al.* (2002), with revisions

21. For instance, Arnell *et al.*, (2002) estimate that, without any additional climate change, the global population at risk of *malaria* (PAR-M) would be 8,820 million in 2085. By contrast, unmitigated climate change would increase PAR-M by another 300 million in 2085.

22. Hence, halting climate change at its 1990 levels would reduce total PAR-M in 2085 by 3% [= (100 × 300)/(300 + 8,820)], at a cost of trillions of dollars (IPCC 2001).

23. Table 1, which despite the many reservations noted above, is based on the results of DEFRA-sponsored studies. It provides estimates of the percent reduction in total global populations at risk (PAR) in the year 2085 for malaria, hunger, water shortage and coastal flooding under four mitigation scenarios, namely, the Kyoto Protocol (KP), stabilization of greenhouse gas concentrations at 750 ppm in 2250, stabilization at 550 ppm in 2150, and “no climate change”.

24. This table assumes, charitably, that in 2085 the Kyoto Protocol would reduce climate change by 7 percent, which would reduce the impacts of climate change on malaria, hunger and water shortage by a like amount, and the impacts of coastal flooding by thrice that (Goklany 2003).

25. The Protocol, whose annual cost is estimated at about 0.5 percent of the GDP of Annex I nations in 2010 (equivalent to about $165 billion in 2003 US$, MXR; Goklany 2005b), would by 2085 reduce total PAR by 0.2 percent for malaria, 1.5 percent for hunger, and 18.1 percent for coastal flooding (see Table 1). On the other hand, there is no certainty that the Protocol would not increase total PAR for water shortage.

26. But these benefits — and much more — could be obtained by focusing on reducing vulnerabilities to these climate-sensitive hazards today, and at substantially lesser cost:

- Malaria's current global death toll of 1 million/yr can be halved for less than $1.5 billion/yr by improving treatment and prevention of the disease (WHO, 1999).
- A $5 billion annual increase in agricultural R&D should sufficiently raise productivity of agricultural land and water to more than erase any climate-change-caused deficit in agricultural production in 2085, especially if these additional R&D resources are focused on solving developing countries' agricultural problems that might be further exacerbated by warming (Goklany, 2005a, 2003).
- Coastal protection against a sea level rise of 0.5 meters by 2100 can be effected at an annual cost of $1 billion (IPCC 1996). Notably, the DEFRA-sponsored studies on which Table 1 is based project that global sea level will rise by 0.41 meters by 2085.

27. Such measures, referred to as "focused adaptation" because they focus on reducing damages from specific climate-sensitive hazards, will not only help reduce present-day climate-sensitive problems, they will also help reduce these problems in the future, whether they are caused by climate change or another factor. On the other hand, mitigation would mainly reduce damages only caused by climate change (although they may be accompanied by some "co-benefits", see below).

28. More important, reducing present-day vulnerabilities will start to provide a steady stream of benefits in the very near term, while the benefits of mitigation will not be significant until decades have elapsed (because of the inertia of the climate system).

29. Moreover, as the case of water shortage illustrates (see Table 1), mitigation would indiscriminately reduce all impacts of climate change, whether they are positive or negative. But adaptation can capture the positive aspects of climate change, while reducing its negatives.

30. Curiously, Table 1 indicates that in 2085 the PAR for malaria and hunger would be greater under the 550 ppm stabilization pathway than the 750 ppm pathway.

31. Table 1 also indicates that no matter how important climate change might be in this century, through the foreseeable future other non-climate change related factors ought to be even more critical for human well-being, particularly for developing countries.

32. Focused adaptation is far more likely to deliver benefits than is mitigation because of the greater uncertainties related to warming and its impacts.

33. Not least, co-benefits (or ancillary benefits) of focused adaptation, most of which would flow directly or indirectly from reduced malaria and increased agricultural productivity, include lower hunger, better health, increased economic growth, and greater human capital (Goklany, 2001a, 2002). In addition, increased agricultural productivity per unit of land and water would reduce the diversion of land and water to agricultural purposes, thereby, helping address the greatest threats to terrestrial and

freshwater biodiversity. In other words, focused adaptation should enhance sustainable development (Goklany, 2005a).

34. Moreover, increased economic development and human capital should further increase the capacity to adapt to or mitigate climate change (Goklany, 1995, 2005a).

35. Thus, even if the cost estimates (in paragraph 26) for reducing present day vulnerabilities are overoptimistic by an order of magnitude, the set of focused adaptations listed in that paragraph will, through the foreseeable future, cost less than the Kyoto Protocol while providing greater benefits than would a complete halt in further climate change — even ignoring discounting.

36. Yet another option for using resources that might otherwise be expended on mitigation would be to advance sustainable development more broadly. In fact, the Millennium Development Goals (MDGs) were formulated to achieve just such an end.

37. Such an approach would subsume focused adaptation, and provide the same qualitative advantages.

38. The additional annual cost to the richest countries of attaining the Millennium Development Goals (MDGs) by 2015 is pegged at about $143 billion (in 2003 US$) in 2010, according to the UN Millennium Project (2005). That is somewhat below the cost of the barely-effective Kyoto Protocol, and less than the cost of stabilization at either 750 or 550 ppm.

39. However, through the foreseeable future, the benefits of meeting the MDGs far outweigh the benefits of either the deepest mitigation or focused adaptation (see Table 2). They include halving global poverty, hunger, lack of access to safe water and sanitation, reducing child and maternal mortality by 66% or more; universal primary education, and reversing growth in malaria, AIDS/HIV, and other major diseases.

40. Adhering to the MDGs would directly or indirectly advance human well-being in many more aspects than would focused adaptation, because the former is much wider in scope (Goklany, 2005a). It would also more broadly increase: (a) adaptive capacity to cope with adversity in general, and warming in particular, and (b) the capacity to mitigate greenhouse gas concentrations in the atmosphere.

41. Assuming it takes 50 years to replace the energy infrastructure, Tables 1 and 2 suggest that we have at least 30 years (=2085-50-2005) before deciding on targets and timetables for emission cuts.

42. In the meantime, we should focus on increasing adaptive capacity, whether through pursuit of MDGs or through adaptation focused on climate-sensitive hazards that might be exacerbated by climate change. This could raise the level at which GHG concentrations might become “dangerous” and/or allow mitigation to be postponed.

Table 2. Comparing benefits and costs associated with Millennium Development Goals (MDGs), mitigation and focused adaptation

Risk factor	Dependence of risk factor on climate change (CC)	Reduction in total PAR[a]			
		Due to Kyoto Protocol (in 2085)	Due to a halt in CC (in 2085)	Focused adaptation (in 2015)	Due to MDGs (in 2015)
Malaria[b,c]	Yes	0.2%	3%	50%[f]	+
Hunger[b,c]	Yes	2%	21%	50%[d]	50%
Water shortage	Yes	–4 to +1%	–59 to +12%	+	Not addressed explicitly
Coastal flooding[c]	Yes	18%	86%	++[g]	+
Poverty[b,c]	Indirect	Unknown sign, but small	Unknown sign	++[b,e]	50%
Child mortality rate[b,c]	Indirect	Small +	+[e]	++[b,e]	67%
Maternal mortality rate[b,c]	Indirect	Small +	+[e]	++[b,e]	75%
Lack of access to safe water[c]	No	No effect	No effect	No effect	50%
Lack of access to sanitation[c]	No	No effect	No effect	No effect	50%
Lack of primary education[b,c]	No	Minor +[e]	Small +[e]	+[b,e]	100%
AIDS, TB[b,c]	No	No effect	Zero to small +[e]	+[b,e]	++
Annual costs		**~ $165 billion in 2010**	**> cost of Kyoto Protocol**	**< cost of MDGs**	**~$143 billion in 2010**

Notes: (a) + denotes a positive reduction in P, while ++ denotes a larger positive reduction. (b) Reductions in malaria and/or hunger should directly or indirectly reduce risks associated with each other, poverty, child and maternal mortality rates, educability, AIDS and TB. (c) Risks associated with these categories should decline with economic development. (d) Assumes same measures to reduce hunger as used to meet MDGs. (e) Indirect improvements because hunger/malaria would be reduced under focused adaptation. (f) Assumes $1.5 billion per year spent to halve malaria mortality. (g) Assumes $1 billion per year spent on protection (IPCC, 1996a).

Sources: For costs, IPCC (2001), WHO (1999), World Bank (2005) and UN Millennium Project (2005); for reduction in risks, Table 1 and World Bank (2002).

Simultaneously, we should strive to improve the cost-effectiveness of mitigation so that, if or when mitigation becomes necessary, net costs would be lower even if emission reductions have to be more drastic.

43. Pursuing either the MDGs or focused adaptation would be entirely consistent with the UN Framework Convention on Climate Change's objectives outlined in Article 2, namely, "to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner" (Goklany 2003).

44. Co-benefits or ancillary benefits of reducing greenhouse gas emissions. Some options for GHG emissions control might provide substantial co-benefits by reducing problems not directly caused by climate change. For example, a reduction in fossil fuel usage could, by lowering traditional air pollutants (e.g., sulfur dioxide, nitrogen oxides and particulate matter), provide significant public health and environmental co-benefits. Similarly, a reduction in global warming could, arguably, contribute to sustainable development — "arguably", because one cannot be confident that such reductions might not result in costs in excess of benefits (Tol 2005; Goklany 2001b).

45. One procedure to evaluate control (or response) options is to compare marginal costs versus marginal benefits (both appropriately discounted). If the latter exceed the former, the option being evaluated is frequently deemed to have passed the test of economic reasonableness.

46. This procedure, however, can lead to less-than-optimal solutions for society if it reduces resources available for implementing other actions with higher benefit-to-cost ratios, or if there are other, more economic options for obtaining the same level of total benefits.

47. For example, it is, under current conditions in the US, cheaper to reduce traditional air pollutants through a direct assault on these pollutants (via add-on controls) than indirectly through measures designed to reduce GHG emissions. Thus, even if the sum of climate change-related and air pollution-related benefits of GHG reductions were to exceed the total cost of GHG controls, that could still lead to a squandering of scarce resources. Similarly, as shown in Table 2 (above), it is much more economic, for the foreseeable future, to advance sustainable development directly through adherence to the MDGs or focused adaptation than through mitigation measures.

48. Where benefits and co-benefits relate only to climate change and air pollution, for instance, the optimal set of response options is that which entails the least total cost to society. The optimal set can be identified by minimizing the sum of: (a) the cumulative cost of the response actions taken to reduce damages from climate change and/or air pollution, and (b) the cumulative cost of residual damages following the imposition of the response actions (which, in general, would include both mitigation and adaptation actions to reduce damages from climate change and/or air pollution).

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