A Climate Policy for the Short and Medium Term: Stabilization or Adaptation?

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Reprinted from

ENERGY &
ENVIRONMENT

VOLUME 16 No. 3&4 2005

MULTI-SCIENCE PUBLISHING CO. LTD.
5 Wates Way, Brentwood, Essex CM15 9TB, United Kingdom

A CLIMATE POLICY FOR THE SHORT AND MEDIUM TERM: STABILIZATION OR ADAPTATION?

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ABSTRACT
An evaluation of analyses sponsored by the predecessor to the U.K. Department for Environment, Food and Rural Affairs (DEFRA) of the global impacts of climate change under various mitigation scenarios (including CO_2 stabilization at 550 and 750 ppm) coupled with an examination of the relative costs associated with different schemes to either mitigate climate change or reduce vulnerability to various climate-sensitive hazards (namely, malaria, hunger, water shortage, coastal flooding, and losses of global forests and coastal wetlands) indicates that, at least for the next few decades, risks and/or threats associated with these hazards would be lowered much more effectively and economically by reducing current and future vulnerability to those hazards rather than through stabilization. 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 numerous problems that currently beset them, including climate-sensitive problems), (b) 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 at the same time striving to expand the universe of such measures through research and development of cleaner and more affordable technologies. Such a policy would help solve current urgent problems facing humanity while preparing it to face future problems that might be caused by climate change.

1. INTRODUCTION

Climate change is, for the most part, projected to add to existing, rather than create new problems. Of particular concern are the problems of malaria, hunger, water shortage, coastal flooding, and threats to biodiversity (Parry and Livermore, 1999; Parry *et al.,* 2001; Arnell *et al.,* 2002; King, 2004). This paper examines whether the

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1 Views expressed here are the author's, and not necessarily those of the U.S. government or any of its units. This paper is based on a poster presentation at the Symposium sponsored by the UK Department for Environment, Food and Rural Affairs on Avoiding Dangerous Climate Change, Exeter, February 1 to 3, 2005.

total magnitude of these problems at the global level from both climate change (assuming unmitigated emissions) and non-climate change related factors would, in the foreseeable future, be reduced more effectively through stabilization of atmospheric CO_2 concentrations, or through efforts to reduce the vulnerability of societies to these problems. The "foreseeable future" is limited to 2085 because socioeconomic scenarios are not credible beyond that (Arnell *et al.,* 2002). Given this time horizon, this paper will not consider potentially high-impact-low-probability events such as the shutdown of the thermohaline circulation or complete melting of the Greenland or West Antarctic Ice Sheets that are unlikely to occur during this century (DEFRA, 2004).

In addressing the above issue, this paper will also shed light on: (a) whether, in the short to medium term, stabilization would be the best approach to satisfying the twin goals of reducing climate-sensitive problems and advancing sustainable development, and (b) the efficacy of fully implementing the Kyoto Protocol (KP).

To the extent possible, this paper adopts the results of recent studies (Parry and Livermore, 1999; Arnell *et al.,* 2002) sponsored by DEFRA's predecessor that compared the global consequences of unmitigated emissions (UE) against those of two stabilization scenarios, namely, stabilization at 750 ppm in 2250 and 550 ppm in 2150, notwithstanding the fact that these studies suffer from significant shortcomings (Parry and Livermore, 1999; Arnell *et al.,* 2002; Goklany, 2003). Most notably, they do not adequately account for either the future level of economic development or technological change which were assumed in the scenarios used to generate the emissions (and the amount of climate change) underlying their impact assessments, i.e., the impacts analyses are internally inconsistent with the scenarios on which they are based. In general, increases in economic resources and technological options ought to make societies less vulnerable and reduce the adverse impacts of climate change (Goklany, 2000, 2001). As a result, impact estimates in these studies are probably biased upwards (Goklany, 2003; Goklany, Evidence submitted to House of Lords, this volume).

This paper will examine climate change impacts under five emission reduction scenarios denoted, in order of increasing stringency, by UE ("Unmitigated Emissions"), KP (Kyoto Protocol), 750 (stabilization at 750 ppm in 2250), 550 (stabilization at 550 ppm in 2150), and NCC ("No Climate Change" or "baseline").

The following nomenclature will be used in this paper:

- The magnitude of the problem (P) with respect to any climate-sensitive hazard under the "No Climate Change" scenario at any time (t) is denoted by P(NCC,t).
-)P(UE,t) is the increase in the problem over P(NCC,t) due to climate change, assuming unmitigated emissions (UE).
- P(T,t) denotes the *total* magnitude of the problem in year t, assuming unmitigated emissions (UE), i.e., P(T,t) = P(NCC,t) + ΔP(UE,t).
- For the other four scenarios, −ΔP(SCENARIO,t) is the *reduction* in P(T,t) under the specified scenario.

For malaria, hunger, water shortage and coastal flooding, P is measured by the global population at risk (PAR) or suffering from the specific risk factor. Thus, for these four hazards, P and PAR will be used interchangeably. With respect to biodiversity, the magnitude of the problem (P) is measured by global losses in the extent of forests and coastal wetlands. According to Parry *et al.*, (2001), which is based on the same set of DEFRA-sponsored studies that this paper uses for projections of future climate change impacts, the global mean temperature increases relative to the 1990 level are estimated to be about 3.2°C for the UE scenario, and 1.8°C and 1.4°C for the 750 and 550 ppm stabilization scenarios, respectively.

2. CONTRIBUTION OF CLIMATE CHANGE TO TOTAL PAR FROM VARIOUS HAZARDS IN 2085

Table 1, based on the results of the DEFRA-sponsored studies, indicates the contribution in 2085 of unmitigated climate change and non-climate change-related factors to the magnitude of the total problem for each of the four previously listed hazards to human health and safety, namely, malaria, hunger water shortage and coastal flooding. To provide context for the changes in PAR for hunger, this — and subsequent — tables also indicate corresponding changes in global cereal production, a surrogate for global food production.

Table 2 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 due to each of the four mitigation scenarios. The columns in this table are arranged in order from the least stringent mitigation scenario (KP) on the left to the most stringent (NCC, i.e., "No Climate Change") on the right.

Table 1. Magnitude of problem (P) without additional climate change and due to unmitigated emissions, 1990 and 2085

Climate-sensitive risk factor	Population at risk if no climate change after 1990 = P(NCC,t)		Additional population at risk in 2085, assuming "unmitigated emissions" = ΔP(UE,2085)	
	In 1990 (in millions)	In 2085 (in millions)	In 2085 (in millions)	As % of P(T,2085)§
Malaria	4,413	8,820	256 to 323	2.8 to 3.5%
Hunger	521	300	69 to 91	18.7 to 23.3%
*Cereal production**	1,800	4,000	–73	–1.9%
Water shortage†				
Method A	1,750	6,464	–2,387 to 862	–58.5 to 11.8%
Method B	1,710	6,405	3,316	34.1%
Coastal flooding	10	13	81	86.2%

*Units for cereal production are in millions of metric tons. †For water shortage, Method A calculates the net change in the population under greater water stress using Arnell (1999); Method B provides an estimate of only the population experiencing greater stress (Arnell *et al.*, 2002). §P(T,t) = total P in year t = P(NCC, t) + ΔP(UE, t).

Sources: Unless otherwise mentioned, the data for this table are from Arnell *et al.*, (2002).

Table 2. Percent reduction in total population at risk (P) in 2085 under various mitigation scenarios

Climate-sensitive risk factor	% Reduction in P(T,2085) in 2085			
	Due to the Kyoto Protocol (KP) **= −ΔP(KP,2085)**	Assuming a stabilization path toward 750 ppmv **= −ΔP(750,2085)**	Assuming a stabilization path toward 550 ppmv **= −ΔP(550,2085)**	If there is no climate change **= −ΔP(NCC,2085)**
Malaria	0.2%	1.3%	0.4%	3.2%
Hunger	1.5%	16.6%	9.7%	21.1%
Cereal production	−0.1%	−1.5%	−0.6%	−1.9%
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%

Note: P(T,2085) = P(NCC,2085) + ΔP(UE,2085). Negative sign for cereal production indicates that yields would increase over levels under unmitigated climate change, while for water shortage it indicates a worsening situation. Reductions due to KP are per Goklany (2003).

Sources: Except as otherwise noted, all the numbers are based on Table 1 and Arnell *et al.*, (2002).

2.1 Malaria

Table 2 shows that halting further climate change as of 1990 would at best reduce the total P for malaria in 2085 by 3.2%. Reductions from either stabilization scenario would be even smaller, despite potentially costing trillions of dollars (IPCC, 2001). Reductions under KP would, at 0.2%, verge on the relatively trivial despite costing anywhere between 0.1 and 2.0 percent of the GDP of Annex I countries in 2010 (IPCC, 2001). Assuming that the cost of KP is at the lower end of this range, say 0.5 percent, in 2010 it would nevertheless cost about $165 billion (in 2003 dollars).[2] But, according to the World Health Organization (1999) malaria's current annual death toll of a million could be *halved* with annual expenditures of $1.5 billion or less (in 2003 dollars)[3] through measures designed to reduce present-day vulnerabilities to malaria. For example, this includes further development and better delivery of public health services for, and research targeted at, treatment and prevention of malaria. Therefore, with respect to malaria, even if the WHO's cost estimate is overoptimistic by an order

2 The cumulative GDP of Annex I countries in 2003 was $29 trillion (in 2003 dollars; World Bank, 2005). By 2010 their GDP should be $33 trillion (also in 2003 dollars), assuming that it continues to grow at the same rate as it did between 1996 and 2003.

3 WHO (1999) specifies that malaria deaths could be halved at a cost of less than $1.25 billion. The $1.5 billion is calculated assuming that WHO's estimates are in terms of 1995 dollars and that average inflation rate between 1995 and 2003 is 2 percent per annum, which is relatively close to the GDP deflator for the U.S. per World Bank (2005).

of magnitude, the benefit-cost ratio for the latter set of vulnerability-reducing (or adaptation) approaches would still be much greater than that of the Kyoto Protocol.

Curiously enough, Table 2 indicates that stabilization at 750 ppm reduces the total PAR for malaria in 2085 by a greater amount than stabilization at 550 ppm — a reduction of 1.3 percent versus a reduction of 0.4 percent.

Notably, measures (i.e., technologies, practices and institutions) developed to reduce vulnerability to malaria today will also help reduce malaria tomorrow, whether the disease is due to warming or non-climate change related factors. Thus, they would reduce risks to 100% of the PAR today and in 2085 (estimated at four and nine billion per year, respectively — see Table 1). While, as noted, mitigation would at most address only 3.2% of the problem in 2085, and even less than that for the billions at risk annually between now and then.

Perhaps even more importantly, reducing malaria in developing countries today would enhance their adaptive capacity. It would improve public health and assure fuller development of their human capital and potential for economic development which then would enhance their resiliency and reduce their vulnerability to any adversity, whether it is caused by warming or another agent (Goklany, 2000, 2001).

2.2 Hunger and food production

Just as for malaria, stabilization at 750 ppm reduces the total PAR for hunger in 2085 by a greater amount than stabilization at 550 ppm (see Table 2). Table 2 also indicates that post-1990 warming would be responsible for 21% of the total PAR for hunger by 2085. This amount, seemingly large, is in fact the result of a small (1.9%) warming-related drop in future global food production between 1990 and 2085. In effect, unmitigated warming would reduce the annual growth in food productivity from 0.84% per year to 0.82% per year.[4] But in the 1990s the world spent about $33 billion annually on agricultural R&D, including $12 billion in developing countries. Therefore an increase in R&D investments, say $5 billion per year, which is relatively modest compared to the costs associated with the Kyoto Protocol, should help more than compensate for the 0.02% annual shortfall caused by unmitigated warming, particularly if the additional investment is targeted toward solving developing countries' current agricultural problems that might be further exacerbated by warming (Goklany, 2003).

These problems include growing crops in poor climatic or soil conditions (e.g., low soil moisture in some areas, too much water in others, or soils with high salinity, alkalinity or acidity). Because of warming, such conditions could become more prevalent, agriculture might have to expand into areas with poorer soils, or both. Thus actions to improve current production under marginal conditions would alleviate hunger in the future whether or not climate changes. Similarly, since both CO_2 and temperatures will increase regardless, cultivars should be developed to take advantage of such conditions as, and when, they come to pass. Notwithstanding current lack of confidence in location-specific details of climate change impacts analyses, substantial

4 This calculation assumes that changes in food production would be achieved through changes in productivity, i.e., "effective" yields, rather than in the area under cultivation.

progress can be made on these approaches in the short-to-medium term (Goklany, 2003). Such focused measures should be complemented by measures that would broadly increase the productivity of the food and agricultural sector so that more food becomes available to consumers per unit of agricultural land or water (Goklany, 1998, 2002).

By 2085, the above set of measures would help reduce not only the 80 million increase in PAR for hunger due to unmitigated warming but also the 300 million at risk because of non-warming related factors (Arnell *et al.*, 2002). Equally important, they would do more than any mitigation efforts to reduce PAR for hunger in the interim, whether it is 521 million in 1990 or 300 million in 2085 (Table 1).

The approach outlined above would also boost adaptive capacity by improving public health, enhancing human capital and economic growth which then would reduce developing countries' vulnerability to any adversity, whether caused by warming or another agent (Goklany, 2001).

Other "co-benefits" associated with this approach include:

- Reduced demand for additional agricultural land (because of increased availability of usable food per unit of land under cultivation), which would limit habitat conversion. Such conversion is the biggest threat to global terrestrial biodiversity today and, as will become clearer in Section 3 (below), probably in the foreseeable future. It would help reduce habitat fragmentation and loss of migratory corridors which, in turn, would help species adapt more "naturally" via migration and dispersion, and also conserve carbon stores and sinks and, thereby, aid mitigation (Goklany, 2003).
- Reduced demand for water, which would generally reduce pressure on water resources (see below). This will help overcome what some have argued could be the major future constraint to meeting global food needs, i.e, insufficient water (Goklany, 2002, 2003) and reduce pressure on global freshwater biodiversity (see below).

2.3 Water shortage

Results for water shortage are similar to that for malaria and hunger: through 2085 the net effect of warming on PAR is relatively small, the effects of mitigation will be smaller, and measures that would reduce water shortages now will also help reduce shortages in the future.

Table 2 also indicates that warming might, in fact, reduce water shortages for some populations. Thus mitigation would make matters worse for these people, which would lower, if not eliminate, net water-related benefits from mitigation. This unfortunate outcome also holds for other hazards for which warming results in a mix of positive and negative outcomes, e.g., hunger and malaria. By contrast, adaptation allows communities to capture the benefits while reducing, if not avoiding the downsides.

Measures that would help societies cope with present and future water shortages regardless of cause include institutional reforms to ensure that water is treated as an economic commodity, allowing water pricing and transferable property rights to water. Such institutional reforms should stimulate greater adoption of existing-but-underused conservation technologies, and lead to more resources from the private sector for innovation and R&D that would reduce the demand for water by all sectors (e.g., by developing new or improved crops and techniques to increase agricultural water use efficiency). These resources should be supplemented by additional public sector resources.

Improvements in water conservation following such reforms are likely to be most pronounced for the agricultural sector since that sector is responsible for 85 percent of global water consumption (Goklany, 2002). Accordingly, an 18 percent reduction in agricultural water consumption would, on average, double the amount of water available for all other water uses which would free up substantial water for household, industry, and in-stream uses, e.g., conservation of aquatic species and recreation.

Notably, just as land conversion is the greatest threat to terrestrial biodiversity, so is water diversion the greatest threat to freshwater biodiversity. Thus, in addition to helping reduce hunger, another co-benefit of these approaches would be to reduce pressures on freshwater biodiversity now and in the future.

2.4 Coastal flooding

If there is any hazard for which emission reductions ought to be more cost-effective than adaptation, it is coastal flooding. Table 2 indicates that by 2085, unmitigated warming, estimated by the studies underlying this table to raise global sea level by 0.41 m (Hulme *et al.*, 1999), would contribute 86 percent of the total PAR. By 2085, stabilization at 550 ppm would reduce total PAR by as much as 80 percent at a cost of trillions of dollars (IPCC, 2001). But, the global cost for protecting against a 0.5 m rise in 2100 has been estimated at about $1 billion annually (IPCC, 1996a). Thus significant emission reductions would not only cost more but could also provide less protection in 2085 than an adaptive approach that would protect against flooding.

3. PRESSURES ON NATURAL SYSTEMS: GLOBAL FORESTS AND COASTAL WETLANDS

Table 3 compares projected changes in the global area of forests and coastal wetlands with and without unmitigated climate change. It shows that the effect of unmitigated climate change is projected to be small and/or positive compared to the effect of baseline (or non-climate change related) factors, at least through 2085. Whether increases in global forest area can be sustained beyond that (under the UE scenario) is another matter.

Table 3 also indicates that unless baseline problems are addressed relatively quickly, a substantial portion of currently existing global forests and wetlands might be converted to other uses, and the benefits of mitigation may arrive too late to stem the loss of habitat (and biodiversity).

As noted, many adaptation approaches outlined previously for reducing vulnerability to hunger and water shortage — enhancing food productivity per unit of land and water — would in fact decelerate, if not forestall, further diversion of land and water to human uses and reduce habitat fragmentation.

This is illustrated for land conversion by Figure 1, which indicates the inverse relationship between cropland demand and increases in the average annual agricultural

Table 3. Projected changes in extent of various ecosystems, with and without climate change

Ecosystem	Change in baseline relative to 1990 (assumes no climate change)	Impact of unmitigated climate change, relative to 1990 (excludes land use changes)
Potential forests (global area)	Decrease 25–30% in the 2050s (IPCC, 1996b)	Increase by 5% in 2085 (Arnell *et al.*, 2002)
Coastal wetlands (global area)	Decrease by 40% in 2085 (Arnell *et al.*, 2002)	Decrease by 13% in 2080s (Arnell *et al.*, 2002)

productivity (AAAP). It shows that if AAAP increases by 1.0 percent per year between 1990 and 2085 instead of 0.84 percent as is estimated under the UE scenario (see Section 2.2), then cropland could be reduced by 13.7 percent without making global hunger worse, all else being equal.

Enhancing agricultural productivity, whether for land or water, would therefore reduce the socioeconomic cost of setting aside any land or water for *in situ* conservation (Goklany, 1998, 2002, 2003), which is one of the goals of the Convention on Biological Diversity. It would also reduce the costs associated with carbon sequestration. Moreover, by reducing habitat loss and fragmentation it would advance one of the principal objectives of the UN Framework Convention on Climate Change enshrined in its Article 2, namely, to allow ecosystems to adapt naturally to climate change.

It is often argued that adaptation is inferior to mitigation since, it is claimed, the former is unsuitable for dealing with the impacts of climate change on natural systems

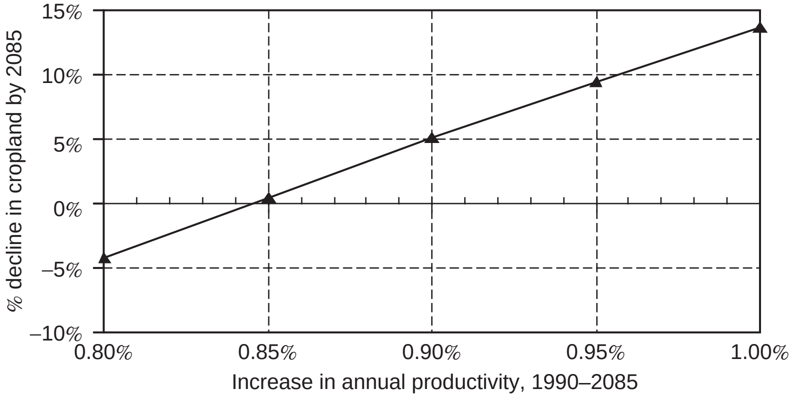

Figure 1. Dependence of the potential decline in cropland by 2085 on the average annual agricultural productivity increase between 1990 and 2085. The figure assumes that food production will be maintained at the same level as projected under the "unmitigated emissions" case.

(IPCC 2001; Wilbanks *et al.*, 2003). But, as discussed in the foregoing, adaptation can indeed relieve pressures on natural systems and over the next few decades that could more effectively conserve biodiversity than any mitigation efforts (Goklany, in preparation).

4. INTEGRATING MITIGATION, ADAPTATION AND SUSTAINABLE DEVELOPMENT

The foregoing examined two approaches to address warming through the foreseeable future. The first, mitigation, would reduce impacts — positive and negative — across the board. This entails significant near term costs, and the pay-off will be delayed. The second approach, which I will call “focused adaptation”, would reduce vulnerability to climate-sensitive effects now and through 2085 by focusing on one hazard at a time.

But developing countries are most vulnerable to warming because they lack adaptive capacity to cope with its impacts. Hence, a third approach to addressing climate change would be to enhance their adaptive capacity. This can be achieved by advancing economic development and human capital, which, of course, is the point of sustainable development (Goklany, 1995, 2000, 2001). Moreover, since the determinants of adaptive and mitigative capacity (IPCC, 2001; Yohe, 2001) are largely the same, enhancing the former should also boost the latter (Goklany, 1995; see also Goklany, in preparation).

Such an integrated strategy — simultaneously pursuing sustainable development while advancing the capacity to adapt to or mitigate climate change — can be accomplished by meeting the Millennium Development Goals (MDGs), which were devised to explicitly advance sustainable development in developing countries. The MDGs’ benefits — 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 — would generally exceed the benefits flowing from focused adaptation or even the deepest mitigation (see Table 4). Yet, according to the UN Millennium Project (2005), the additional annual cost to the richest countries of attaining the MDGs by 2015 is pegged at about 0.5 percent of their GDP.[5] That is approximately the same cost as that of the barely-effective Kyoto Protocol, and less than the cost of stabilization at either 750 or 550 ppm.

Moreover, while the benefits of stabilization would exceed those due to the Kyoto Protocol, they would still be substantially less than the benefits of the MDGs, despite costing more (see Tables 2 and 4).

Meeting the MDGs would directly or indirectly advance human well-being in its many facets (Goklany, 2001), while broadly increasing adaptive capacity to cope with adversity in general, and warming in particular. These benefits would be obtained sooner, at lesser cost, and because of the uncertainties related to warming and its impacts, far more certainly than through mitigation alone. In addition, increased adaptive capacity would either raise the level at which GHGs need to be stabilized to

5 A second estimate places the *additional* cost of attaining the MDGs by 2015 at $40–60 billion annually (World Bank, 2002).

Table 4. 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 problem[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 explicitly	Yes	–4 to +1%	–59 to +12%	+	Not addressed
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 (see footnote 3). (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 2 and World Bank (2002).

forestall warming from becoming "dangerous", allow mitigation to be postponed, or both. In any case, costs associated with any eventual stabilization could be reduced, particularly if, in the interim, resources are expended to improve the cost-effectiveness of mitigation options. And, as noted, adherence to the MDGs would advance mitigative capacity. In fact, such an approach would be entirely consistent with the UN Framework Convention on Climate Change's objectives outlined in Article 2, that is, "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."

Finally, an argument advanced for mitigation is that otherwise climate change would hinder sustainable development and lock developing nations into poverty (Watson and Johnson, 2001; Working Group on Climate Change and Development, 2004). However, through 2085 the impacts of unmitigated warming are, as shown, either smaller than the baseline problems that would exist in the absence of warming or it is more cost-effective to reduce the magnitude of the total problem via adaptation than through mitigation. Thus, even if in the longer term (i.e., beyond 2085) mitigation is inevitable, the problem *through the foreseeable future* is not that climate change will perpetuate poverty and hinder sustainable development, but that the lack of sustainable economic development will impede developing countries' ability to cope with all manners of adversity, including climate change (Morris, 2002; Goklany, 2001).

5. CONCLUSION: SOLVING TODAY'S PROBLEMS WITHOUT IGNORING TOMORROW'S

Many — scientists and politicians alike — have declared that global warming is the most important environmental challenge facing the globe (Cordis News, 2004; King, 2004). Prime Minister Blair and President Chirac in a joint declaration proclaimed that "Climate change is the world's greatest environmental challenge" (Cordis News, 2004). Notwithstanding these claims, Tables 1 through 4 indicate that over the foreseeable future, the magnitude of the problem due to unmitigated climate change is generally smaller than that due to non-climate change related factors, and, where it is not, as in the case of coastal flooding, it is more economical to remedy it via adaptation. Therefore, global warming is unlikely to be the most important environmental problem facing the world, at least for most of the remainder of this century.

For the next several decades, any mitigation scheme, whether it is as modest in its effect as the Kyoto Protocol or as ambitious as stabilizing CO_2 concentrations, would expend scarce resources without commensurate improvements in global well-being (Table 4). Despite the claim that mitigation would help developing nations in particular, it would not cost-effectively reduce the enormous present-day risks to their populations from various climate-sensitive hazards that might be exacerbated by climate change. On the other hand, increasing adaptive capacity, through focused adaptation or, preferably, the pursuit of MDGs, is likely to reduce these risks faster, more cost-effectively and by a greater amount. Equally important, as Table 4 indicates, various non-climate-sensitive indicators of human well-being, while being barely improved by mitigation, would also be advanced much further, faster and more economically by advancing sustainable development and/or reducing current vulnerabilities to urgent climate-sensitive problems. They would, incidentally, also contribute to mitigation and to an increase in mitigative capacity.

Some have argued for some mitigation as an insurance policy. But enhancing adaptive capacity is better than an insurance policy. Unlike a climate insurance policy, by addressing urgent and larger baseline problems it will pay handsome dividends whether or not climate changes. And if climate changes, it will help reduce attendant risks much more contemporaneously with incurred costs than is possible through mitigation.

Assuming it takes 50 years to replace the energy infrastructure, that means we have at least 30 years (2085 − 50 = 2035) before deciding on targets and timetables for emission cuts. In the meantime, we should focus on increasing adaptive capacity at all scales. This could raise the level at which GHG concentrations might become "dangerous" and/or allow mitigation to be postponed. Simultaneously, we should strive to make mitigation more cost-effective so that, if or when mitigation becomes necessary, net costs would be lower even if emission reductions have to be more drastic.

Specifically, we should first and foremost pursue a broad adaptive strategy based on advancing sustainable development. Second, we should take measures to reduce vulnerability to today's urgent climate-sensitive risks — hunger, malaria, water shortages, coastal flooding, extreme events, and pressures on biodiversity — that could be exacerbated by warming. Together, these efforts would improve human and environmental well-being and enhance adaptive capacity of developing countries, which, it ought to be remembered, are most vulnerable to climate change. This can be accomplished while incidentally advancing sequestration and enhancing mitigative capacity more broadly by augmenting economic resources and human capital.

Third, we should ensure that "no-regret" mitigation measures (e.g., elimination of energy, land conversion and other agricultural subsidies) are implemented while constantly expanding the universe of such measures through R&D designed to improve their cost-effectiveness. Finally, we should continue to advance knowledge of climate change science, economics and responses to better evaluate and determine trade-offs and synergies between adaptation and mitigation, and continue to monitor trends to provide advance warning should the adverse impacts of warming occur faster, or threaten to be more severe or more likely than is currently projected (Goklany, 2003).

Such a climate policy would solve some of most critical problems facing the world today and tomorrow while preparing it to address the uncertain problems of the day after tomorrow, of which climate change is but one among many.

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