Could Biofuel Policies Increase Death and Disease in Developing Countries?

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ABSTRACT

Higher global demand for biofuels, driven mainly by policies in industrialized countries with the stated purpose of enhancing energy independence and retarding climate change, has contributed to rising global food prices. As a consequence, more people in developing countries suffer from both chronic hunger and absolute poverty. Hunger and poverty are major contributors to death and disease in poorer countries. Results derived from World Bank and World Health Organization (WHO) studies suggest that for every million people living in absolute poverty in developing countries, there are annually at least 5,270 deaths and 183,000 Disability-Adjusted Life Years (DALYs) lost to disease. Combining these estimates with estimates of the increase in poverty owing to growth in biofuels production over 2004 levels leads to the conclusion that additional biofuel production may have resulted in at least 192,000 excess deaths and 6.7 million additional lost DALYs in 2010. These exceed WHO's estimated annual toll of 141,000 deaths and 5.4 million lost DALYs attributable to global warming. Thus, policies intended to mitigate global warming may actually have increased death and disease in developing countries.

Biofuels: Rationale and Questions

In the past few years, in response to concerns about global warming and increased dependency on foreign sources of petroleum, several developed countries, most notably the United States and the European Union, have instituted subsidies and mandates to stimulate production and use of biofuels in order to help displace hydrocarbon fuel consumption.[1-4] This has engendered substantial debate about the merits of these policies, much of it focused on (a) whether production and consumption of biofuels (e.g., ethanol from corn or biodiesel from soybean oil) would indeed reduce net energy consumption from non-renewable sources[5-9] and net greenhouse gas emissions,[2,10-12] and (b) their environmental consequences for land, water, and wildlife resources.[3,10,13,14]

Questions have also been raised regarding the unintended consequence of biofuel production on human well-being. In particular, it has been argued, and several analyses confirm, that higher food prices, induced in part by greater demand for biofuels, could increase hunger and poverty in developing countries.[15-21] Since hunger and poverty are major contributors to death and disease around the world,[22,23] it is, therefore, conceivable that the higher demand for biofuels could add to the global burden of death and disease.

If that were the case, it would, ironically, militate against one of the reasons offered to encourage biofuel production, namely, to reduce the health effects of global warming, particularly in developing countries.[24] It would also reduce the perceived net benefits of policies designed to encourage biofuel production, whether they are instituted to reduce global warming or enhance energy security. To date, however, no estimates are available of the potential magnitude, if any, of the global health impacts of biofuel production, precluding a more comprehensive analysis of policies designed to stimulate biofuel production.

Methods

This exploratory analysis develops order-of-magnitude estimates of increases in death and disease in developing countries in 2010 due to greater global demand for biofuels and the resulting increase in poverty.

Absolute poverty is defined as living on less than $1.25 per day, in 2005 international dollars. Poverty-related global health risk factors are identified using information provided in the World Health Organization (WHO) 2009 report, *Global Health Risks*.[23] The cumulative burden of death and disease from these poverty-related health risk factors in the developing world is assumed to be proportional to the poverty headcount. This assumption is used to estimate the coefficients of proportionality between the poverty headcount in developing countries on the one hand, and their burdens of death and disease for poverty-related health conditions on the other hand. These coefficients are then used to estimate increases in the burdens of death and disease attributable to biofuel policy-induced increases in absolute poverty.

The measure of disease burden is "disability-adjusted life years" lost to disease (DALYs). This is the cumulative sum over the population of (a) the number of years lost due to premature death from disease, and (b) the number of years spent in a disabled condition due to disease, weighted by the severity of the disease (WHO 2009).[23]

Connecting Biofuel Production to Death and Disease in Developing Countries

Based on current technologies, higher biofuel production necessarily means greater diversion of crops and/or cropland to the production of fuel rather than food. The iron law of supply and demand dictates that this would almost unavoidably increase global food prices over what they would otherwise be. Indeed, this is confirmed by studies of the impact of biofuel production on global food prices, although the magnitude of the effect varies from study to study.[25-27]

To the extent that a household is a net food consumer and depending on how close it might be to the poverty line (however defined), higher food prices could deepen that household's poverty level or add to the poverty headcount. On the other hand, if the household is a net food producer, higher food prices could move it out of, or further away from, the poverty line.[20,21,28-31] However, several studies done in the wake of the run-up in global food prices from the early 2000s to 2008**,** which employed surveys of household incomes and economic activities, have found that higher food prices, regardless of cause, would, on net, increase absolute poverty levels in virtually all developing countries or groups of countries that they had analyzed.[20,21,29-32] Therefore, biofuel production, which would inevitably increase global food prices, should increase net poverty, although the magnitude of increase is uncertain.

Poverty is itself a factor that could exacerbate risk factors for death and disease. Greater poverty is associated with greater hunger and malnutrition; lower access to safe water, adequate sanitation, vaccinations, antibiotics, and other public health interventions; greater reliance on wood, dung**,** and coal for heating and cooking, which exacerbates indoor air pollution; as well as other factors that affect health (e.g., health spending and educational levels).[33-40] It follows that increased demand for biofuels, whether generated by the free market or by subsidies and mandates, should increase poverty, which then should increase the risk of premature death and disease.

Estimate of the Increase in the Poverty Headcount Due to Biofuel Production

Many studies of the impacts of higher food prices on poverty have only analyzed the situation immediately following price increases, that is, they looked only at short term (or "first order") effects [29-31,41] but did not allow for longer term ("second order") effects that would allow adjustments on the part of consumers, producers, economies and governments in order to alleviate hunger and poverty. Consideration of second-order effects should, therefore, reduce the increase in the poverty headcount. Moreover, many studies looked at effects of food price increases in general, but not increases due to biofuels production in particular.[29-31,40] Also, some looked at effects on individual countries or a small set of countries,[29-31] or on urban populations.[41]

Only two studies—De Hoyos and Medvedev[20] and Cororaton et al.[32]—provide estimates of (a) potential increases in poverty induced by greater biofuel production in both rural and urban populations for a large segment of the developing world's population, and (b) also account for second-order effects. In addition, both analyses covered 90% of the developing world's population. Both indicate that higher biofuel production increases global poverty, even in the longer term. Although these increases may be small in relative terms, they can be large in absolute numbers.

Both studies used the same suite of World Bank models to estimate the effects of additional biofuel production on the poverty headcount. Both estimated the increases in poverty headcounts as the difference in poverty levels between pairs of scenarios, with one scenario assuming a higher level of biofuel production and the other being a baseline scenario with a lower biofuel production level.

The baseline scenario of Cororaton et al. assumed that there would be growth in global biofuel production from 2004 through 2020.[32, pp 16-17] Therefore their calculation underestimates the contribution of total biofuel production to the poverty headcount. On the other hand, De Hoyos and Medvedev's baseline scenario assumed that biofuel production would stay at the actual 2004 level. They calculated the increase in poverty over the baseline scenario for a scenario in which biofuel production increased after 2004 along its historical path through 2007, and then increased further through 2010 in response to current biofuel mandates and production trends.[20, p 15] Thus, this latter study should give a more accurate estimate of the increase in poverty due to biofuel subsidies and mandates, although it too would be an underestimate, since it assumes 2004 production levels as part of the baseline. That study estimates that in 2010, there would be 32 million additional people in absolute poverty in developing countries due to an increase in biofuel production over 2004 levels. Without the additional biofuel production, the poverty headcount would be 798 million.

It should also be noted that De Hoyos and Medvedev estimated that the poverty headcount in 2005 was 1,208 million. The dramatic drop in headcount from 2005 to 2010 is due to increasing economic development. Thus, biofuel production would retard the developing world's progress against poverty.

Poverty-Related Health Risk Factors

The World Health Organization's 2009 report, *Global Health Risks* (GHR), provides estimates of the global burdens of death and

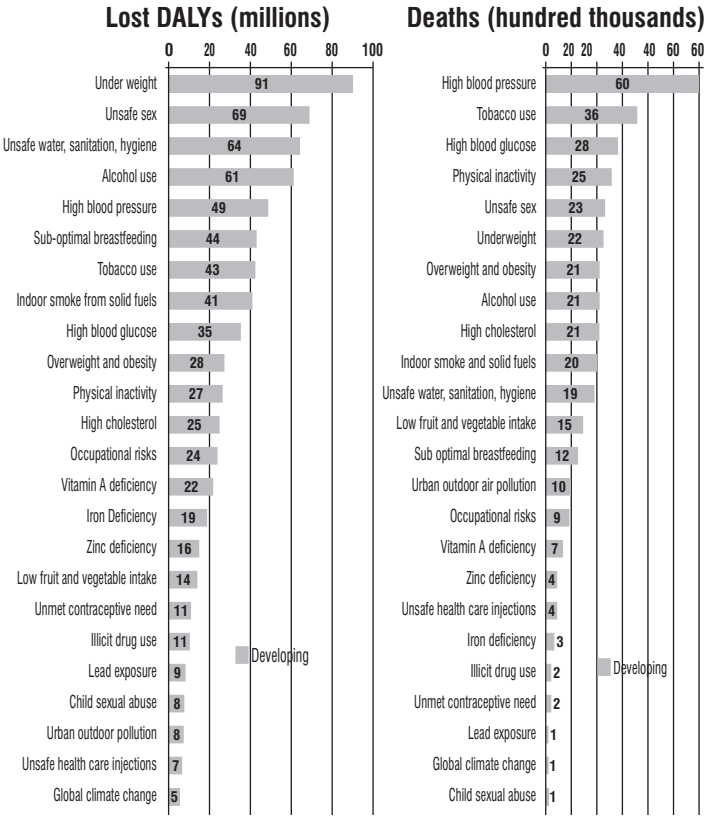

Figure 1. Ranking of 24 Health Risk Factors Based on the Burden of Death (right-hand panel) and Disease (left-hand panel) in Developing Countries for 2004 (WHO[23])

		Ratio of Low Income to Lower Middle Income	
		Ratio for Deaths per capita	Ratio for Disease Burden per capita
1	Global warming	13.2	11.9
2	Underweight	13.1	10.7
3	Zinc deficiency	9.3	9.0
4	Vitamin A deficiency	8.9	9.0
5	Unsafe sex	8.1	7.9
6	Unsafe water, sanitation, hygiene	6.1	5.2
7	Unmet contraceptive need	8.7	4.7
8	Indoor smoke from solid fuels	1.9	4.7
9	Sub-optimal breastfeeding	4.1	4.0
10	Iron deficiency	5.1	2.6
11	Child sexual abuse	1.8	1.8
12	Lead exposure	1.7	1.6
13	High cholesterol	1.1	1.3
14	High blood glucose	1.2	1.1
15	Unsafe health care injections	0.7	1.1
16	Physical inactivity	0.9	1.1
17	Illicit drug use	1.3	1.0
18	Low fruit and vegetable intake	0.8	0.9
19	Occupational risks	0.7	0.9
20	High blood pressure	0.7	0.9
21	Urban outdoor air pollution	0.5	0.8
22	Alcohol use	0.6	0.6
23	Tobacco use	0.6	0.6
24	Overweight and obesity	0.5	0.6

Table 1: Poverty-related Health Risks. These are identified based on the ratio of disease burden rates for lower income and lower middle income groups. The grey shaded rows indicate risk factors for which the ratio for disease burden rates is at least 5.[23]

disease for 24 major health risk factors (WHO 2009).[23] Cumulatively, this report attributes 73% and 52% of global mortality and lost DALYs in 2004, respectively, to these risk factors. According to these estimates, 92% of the burden of disease (as measured by lost Disability Adjusted Life Years, DALYs) due to these risk factors, and 85% of the mortality, occurs in developing countries. However, considering that developing countries also accounted for 85% of the world's population in 2004 but have a much younger population profile, they should therefore be less prone to death and disease. Thus, developing countries are afflicted by a disproportionately large share of global disease, if not of death.

Notably, GHR estimates indicate that of the 24 health risk factors, global warming would rank below the top 20 in terms of the burdens of death and disease in 2004. This is true both globally as well as for developing countries. This reaffirms Goklany's earlier finding, based on WHO's analysis for 2000, that global warming currently presents a relatively trivial risk compared to the other risk factors for public health.[42]

Figure 1 provides the GHR's estimates for developing countries of mortality (right-hand panel) and burden of disease (left-hand panel, as measured by lost DALYs) in 2004 for 24 global health risk factors. The risk factors are arranged in descending order of their contribution to mortality or lost DALYs for developing countries.

For each of these 24 risk factors, Table 1 shows the ratio of deaths per capita for low-income countries compared to that of lower-middle-income countries, as well as the corresponding ratio for the disease burden per capita. The risk factors are arranged in descending order of these ratios for the disease burden per capita (last column). These ratios range from 0.6 to 11.9, with global warming having the highest ratio.

I will deem arbitrarily that those risk factors that have disease burden ratios that exceed 5 are poverty-related. Six risk factors meet this criterion. They are global warming; underweight (largely synonymous with chronic hunger); zinc deficiency; Vitamin A deficiency; unsafe sex; and unsafe water, sanitation and hygiene. As Figure 1 indicates, three of these listed—underweight; unsafe sex; and unsafe water, sanitation and hygiene—are also the top three health risk factors for developing countries based on their contribution to the burden of disease.

Cumulatively, GHR attributed 7.7 million deaths and 268 million lost DALYs worldwide to these six poverty-related risk factors for 2004. Of these, more than 99.3% of the deaths and lost DALYs were in developing countries. These six risk factors account for 37% of lost DALYs and 21% of deaths in developing countries from the 24 risk factors.

Arguably, the next four risk factors listed in Table 1—unmet contraceptive needs, indoor smoke from solid fuels, sub-optimal

breast feeding and iron deficiency—should also be considered to be poverty-related.[43] Including these in the list of poverty-related risks would increase their cumulative toll to 11.3 million deaths and 384 million lost DALYs. For the purpose of this analysis, in order to develop a conservative (lower bound) estimate for the effect of biofuel production on death and disease, I will, however, stay with the more restrictive definition of "poverty related."

Coefficients of Proportionality between Poverty, and Death and Disease from Poverty-Related Health Risks

For 2004, the population in absolute poverty in developing countries (the "headcount") is estimated at 969 million people.[44] However, that estimate is based on old data on prices paid by households, and a different threshold for absolute poverty than currently used by the World Bank and the De Hoyos and Medvedev study.[20,21,45] The new poverty estimates using the new data and poverty threshold give headcounts that are 1.48–1.50 times higher than those using the older data and methods (for 2002 and 2005).[44] Thus, the adjusted 2004 headcount for developing countries (using a factor of 1.5) should be 1,454 million. The assumption that mortality and lost DALYs from poverty are proportional to the headcount implies that there are 5,270 deaths and 183,000 lost DALYs per million people living in absolute poverty in developing countries.

Increase in Death and Disease in 2010 for Developing Countries due to Biofuels

Recall that De Hoyos and Medvedev estimated an increase in the poverty headcount of 32 million in 2010 due to the increase in biofuel production over the 2004 level. They also estimated that the poverty headcount in developing countries for 2005 was 1,208 million. By contrast, the World Bank estimated that the 2005 poverty headcount was 14% higher, that is, 1,374 million.[21]

The difference between the two estimates is mainly that the World Bank's analysis covered more countries. To reconcile these two estimates, De Hoyos and Medvedev's estimate for increase in headcount due to higher biofuel production should be adjusted upward by 14% to 36.4 million. Thus, assuming proportionality in developing countries between the headcount for absolute poverty on one hand and poverty-related death and disease on the other, and keeping all else the same, the increase in the poverty headcount in 2010 due to biofuel demand translates into 192,000 additional deaths and 6.7 million additional lost DALYs.

It may be argued that these are overestimates since biofuel use should reduce greenhouse gas emissions, thereby, hypothetically, reducing the contribution of man-made global warming to death and disease. However, the above estimates exceed the WHO's estimate of the contributions of global warming to death and disease in 2004—141, 000 deaths and 5.4 million lost DALYs (see Figure 1). Although there are reasons to be skeptical of these global warming estimates,[42] even if one were to assume that they are valid, it is unlikely that global warming policies that encourage biofuel consumption and production would save more than a small fraction of this toll, primarily because of the inertia of the climate system.[46] Because of this climatic inertia, decades would have to elapse before emission reductions are manifested as any temperature reductions. Moreover, greenhouse gas reductions effected by biofuels seem marginal at best.[8,10-12] Nevertheless, if one assumes, unrealistically, that biofuel policies eliminate *all* man-made greenhouse gas emissions *and* would roll back global warming to 1990 levels, biofuel policies would still result in a net increase of 51,000 deaths and 1.3 million lost DALYs in 2010.

Conclusions

Policies to increase production and use of biofuels retard the developing world's progress against reducing poverty levels and would exacerbate their burden of death and disease from the various diseases of poverty.

This analysis concludes that the production of biofuels may have led to at least 192,000 additional deaths and 6.7 million additional lost DALYs in 2010. These estimates are conservative. First, they exclude consideration of a number of health risks that are, in fact, directly related to poverty (e.g., indoor smoke from burning coal, wood, and dung indoors; and iron deficiency).[43] Second, the analysis only considered the poverty effects of biofuel production over and above the 2004 level; therefore, it does not provide a full estimate of the effect of all biofuel production. Despite the underestimations, these estimates exceed the WHO's estimates of the toll of death and disease for global warming. Thus, policies to stimulate biofuel production, in part to reduce the alleged impacts of global warming on public health, particularly in developing countries, may actually have increased death and disease globally.

There can be no honest analysis of the costs and benefits of biofuel policies if they do not consider their effects on death and disease in developing countries.

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Acknowledgment: The author is grateful to a number of anonymous reviewers whose comments have substantially improved this manuscript. All errors and other flaws, however, must be credited to the author.

REFERENCES

1 Jordan N, Boody G, Broussard W, et al. Environment: sustainable development of the agricultural bio-economy. *Science* 2007;316:1570-1571.

2 Searchinger T, Heimlich R, Houghton RA, et al. Use of US croplands for biofuels increases greenhouse gases through emissions from land use change. *Science* 2008;319:1238 -1240.

3 Robertson GP, Dale VH, Doering OC, et al. Agriculture: sustainable biofuels redux. *Science* 2008;322:49-50.

4 Tyner WE. The US ethanol and biofuels boom: its origins, current status, and future prospects. *BioScience* 2008;58: 646-653.

5 Patzek TW. Thermodynamics of the corn-ethanol biofuel cycle. *Crit Rev Plant Sciences* 2004;23:519-567.

6 Patzek TW, Pimentel D. Thermodynamics of energy production from biomass. *Crit Rev Plant Sciences* 2005;24:329-364.

7 Pimentel D, Patzek TW. Ethanol production using corn, switchgrass, and wood; biodiesel production using soybean and sunflower. *Natural Resources Res* 2005;14:65-76.

8 Wang M. A comparison between the new Pimentel/Patzek study and other studies. Center for Transportation Research, Argonne National Laboratory; 2005: Available at: www1.eere.energy.gov/biomass/pdfs/brief_comparison_pimentel_patzek.pdf. Accessed Dec 11, 2010.

9 Wesseler J. Opportunities (costs) matter: a comment on Pimentel and Patzek ethanol production using corn, switchgrass, and wood; biodiesel production using soybean and sunflower. *Energy Policy* 2007;35:1414 -1416.

10 Scharlemann JPW, Laurance WF. How green are biofuels? *Science* 2008;319:43-44.

11 Fargione J, Hill J, Tilman D, Polasky S, Hawthorne P. Land clearing and the biofuel carbon debt. *Science* 2008;319:1235-1238.

12 Hertel TW, Golub AA, Jones AD, et al. Effects of US maize ethanol on global land use and greenhouse gas emissions: estimating market-mediated responses. *BioScience* 2010;60:223-231.

13 Service RF. Another biofuels drawback: the demand for irrigation. *Science* 2009;326:516 -517.

14 Fargione JE, Cooper TR, Flaspohler DJ, et al. Bioenergy and wildlife: threats and opportunities for grassland conservation. *BioScience* 2009;59:767-777.

15 Goklany IM. Meeting global food needs: environmental trade-offs between increasing land conversion and land productivity. *Technology* 1999;6:107-130.

16 Pimentel D, Patzek T. Green plants, fossil fuels, and now biofuels. *BioScience* 2006;56: 875.

17 Food and Agricultural Organization (FAO). State of Food Insecurity 2008. Rome: FAO; 2008.

18 Food and Agricultural Organization. *State of Food Insecurity* 2009. Rome: FAO; 2009.

19 Godfray HCJ, Beddington JR, Crute IR, et al. Food Security: The challenge of feeding 9 billion people. *Science* 2010;327:812-818.

20 De Hoyos RE, Medvedev D. Poverty effects of higher food prices: a global perspective. World Bank Policy Research Working Paper No. 4887. Washington, D.C.: World Bank; 2009.

21 World Bank. *Global Economic Prospects* 2009. Washington, D.C.: World Bank; 2009.

22 World Health Organization. *The World Health Report 2002— Reducing Risks, Promoting Healthy Life*. Geneva: WHO; 2002.

23 World Health Organization. *Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks*. Geneva: WHO; 2009.

24 Goklany IM. Is climate change the "defining challenge of our age"? *Energy & Environment* 2009;20:279-302.

25 Msangi S, Sulser T, Rosegrant M, Valmonte-Santos R, Ringler C. Global scenarios for biofuels: impacts and implications. *Farm Policy J* 2007;4(2):1-9.

26 Rajagopal D, Hochman G, Timilsina G., Zilberman D. *Quantifying the Role of Biofuels in the Global Food Crisis.* Energy Biosciences Institute, University of California, Berkeley; 2009.

27 Baffes J, Haniotis T. Placing the 2006/08 commodity price boom into perspective. World Bank Policy Research Working Paper No. 5371. Washington, D.C.: World Bank; 2010.

28 Ravallion M, van de Walle D. The impact on poverty of food pricing reforms: a welfare analysis for Indonesia. *J Policy Modeling* 1991;13(2):281-299.

29 Ivanic M, Martin W. 2008. Implications of higher global food prices for poverty in low-income countries. *Agric Econ* 2008;39(Suppl):405-416.

30 Wodon QC, Tsimpo P, Backiny-Yetna G, et al. Potential impact of higher food prices on poverty: summary estimates for a dozen west and central African countries. Policy Research Working Paper No. 4745. Washington D.C.: World Bank; 2008.

31 Zezza A, Davis B, Azzarri C, et al. The Impact of Rising Food Prices on the Poor. International Association of Agricultural Economists Conference, Beijing, China, Aug 16-22, 2009.

32 Cororaton CB, Timilsina G, Mevel S. 2010. Impacts of large scale expansion of biofuels on global poverty and income distribution. IATRC Public Trade Policy Research and Analysis Symposium, Global Warming in World Agriculture: Mitigation, Adaptation, Trade and Food Security, Universität Hohenheim, Stuttgart, Germany, June 27 -29, 2010.

33 Preston SH. The changing relation between mortality and level of economic development. *Population Studies* 1975;29(2):231-248.

34 World Bank. *World Development Report: Investing in Health*. New York, N.Y.: Oxford University Press; 1993.

35 Pritchett L, Summers LH. Wealthier is healthier. *J Human Resources* 1996;31:841-868.

36 Murray CJL, Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S. Comparative quantification of health risks: conceptual framework and methodological issues. *Population Health Metrics* 2003;1:1-20.

37 Goklany IM. *Economic Growth and the State of Humanity*. Policy Study 21. Bozeman: Political Economy Research Center; 2001.

38 Goklany IM. *The Improving State of the World: Why We're Living Longer, Healthier, More Comfortable Lives on a Cleaner Planet*. Washington, D.C.: Cato Institute; 2007.

39 Blakely T, Hales S, Kieft C, Wilson N, Woodward A. Distribution of risk factors by poverty. In: *Comparative Quantification of Health Risks: Global and Regional Burden of Disease due to Selected Major Risk Factors.* Geneva: World Health Organization; 2004:1941-2127.

40 Bates I, Fenton C, Gruber J, et al. Vulnerability to malaria, tuberculosis, and HIV/AIDS infection and disease. Part 1: determinants operating at individual and household level. *Lancet Infectious Diseases* 2004;4:267-277.

41 Dessus S., Herrera S, De Hoyos R. Impact of food inflation on urban poverty and its monetary cost: Some back-of-the-envelope calculations. *Agricultural Economics* 2008;39(supplement):417-429.

42 Goklany IM. Global public health: global warming in perspective. *J Am Phys Surg* 2009;14: 69-75.

43 Brundtland GH. Statement by the Director-General, 111th session of the Executive Board. Geneva: WHO, 2003. Available at: www.who.int/dg/brundtland/speeches/2003/eb111_jan2003/en/index.html. Accessed Dec 11, 2010.

44 Chen S, Ravallion M. Poverty and hunger special feature: absolute poverty measures for the developing world, 1981-2004. *Proc Nat Acad Sci* 2007;104:16757-16762.

45 Chen S, Ravallion M. China is poorer than we thought, but no less successful in the fight against poverty. Policy Research Working Paper No. 4621. Washington, D.C.: World Bank; 2008.

46 Intergovernmental Panel on Climate Change. *Climate Change 2007: The Physical Science Basis.* Cambridge: Cambridge University Press; 2007.