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Affluence, Technology, and Well-Being

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AFFLUENCE, TECHNOLOGY, AND WELL-BEING

Indur M. Goklany†

INTRODUCTION

In the Hans Christian Andersen fairy tale, the child, having examined the data and concluded that the Emperor's clothes lacked substance, recorded his verdict by blurting out, "The Emperor has no clothes!" Fortunately for him, the sovereign and his retinue ignored this injudicious finding, and continued with the procession. Had Bjørn Lomborg only been that lucky! Having examined the data and concluded that the "Litany" – his term for the collection of horrors environmentalists and Malthusian are convinced stalk humanity and the rest of nature because of population growth, economic development and new technologies[1] – lacked empirical substance, he recorded his verdict in the book, *The Skeptical Environmentalist.* But unlike the child, he was not ignored. True believers in the Litany, his fellow-environmentalists, unleashed a withering attack with the special vitriol reserved for apostates[2] giving new meaning to the whimsical observation attributed to Don Quixote that "Perhaps the greatest madness is not in failing to see things as they are, but in failing to see things as they should be."[3] Perhaps Lomborg's major failing was that he saw the evidence as it was, rather than as it should have been.

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1 BJØRN LOMBORG, THE SKEPTICAL ENVIRONMENTALIST: MEASURING THE REAL STATE OF THE WORLD (Cambridge University Press 2001) (1998).

2 Perhaps nothing better illustrates this better than the treatment Lomborg received from the editors of *Scientific American.* An account of the shabby – one might say un-American and unscientific – treatment meted out to Lomborg by that magazine's editors can be found at *Defending Science*, THE ECONOMIST, Feb. 2-8, 2002, at 15. Editorial and additional links available at http://www.economist.com/displayStory.cfm?Story_ID=965718.

3 Jeff House, *Jesters, Fools & Madmen: The World Turned Upside Down. Only Fools and Children Tell the Truth, at* http://www.jeffhouse.addr.com/mythology/fools.htm (last visited Aug. 21, 2002). This echoes a line from DALE WASSERMAN & JOE DARION, MAN OF LA MANCHA 61 (1966): "And maddest of all, to see life as it is and not as it should be." *See also A Tribute to Don Quixote De La Mancha, at* http://together.net/~donutrun/quix.htm (last visited Jan. 2, 2002).

Lomborg's examination shows that the empirical data are at odds with the Litany: that although the population continues to grow, albeit at a decelerating pace, the state of humanity has never been better and that the average person on the globe has never been less hungry, better educated, richer, healthier, and longer lived than today.[4] No less important, not only is human well-being advancing, in many cases so seems to be the state of the environment, especially in the rich countries of the world. While others had made similar observations[5] — Lomborg himself notes that his book originated in an effort to use data to disprove the economist Julian Simon's conclusions that the state of humanity and the environment had advanced in the long run[6] — they have gained fresh legitimacy because of Lomborg's credentials as an erstwhile sympathizer of Greenpeace and a teacher of statistics at the University of Aarhus.

I. WHY THE HOSTILITY TO LOMBORG'S SKEPTICISM?

There is a long tradition in environmental thought that predates the Club of Rome's 1972 book, *Limits to Growth*, which holds that the fundamental causes of environmental degradation lie in human population, economic growth and technology.[7] This Weltanschauung has been captured in a deceptively simple identity called the "IPAT identity,"[8] which serves as a cornerstone of environmental faith. This identity, which can often be found in one form or another in many an introductory biology and ecology textbook,[9] is expressed as:

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[4] LOMBORG, *supra* note 1, at 60-62 (hunger), 81-82 (education), 70-71 (wealth), 53-54 (health as measured by infant mortality), 50-53 (life expectancy).

[5] *See* JULIAN L. SIMON, THE STATE OF HUMANITY 26-27 (1995) (presenting data that standards of living have risen since the beginning of time, and that entrepreneurs have made life better by discovering ways to cure environmental shortages); *see also* GREGG EASTERBROOK, A MOMENT ON THE EARTH: THE COMING AGE OF ENVIRONMENTAL OPTIMISM xv-xvii (1995) (arguing that Western environments are becoming cleaner); THE TRUE STATE OF THE PLANET 1-6 (Ronald Bailey ed., 1995) (arguing that global health and productivity have greatly improved, and air and water in the West are much cleaner); INDUR M. GOKLANY, ECONOMIC GROWTH AND THE STATE OF HUMANITY (Political Economy Research Center, PERC Policy Series No. PS-21, 2001), *available at* http://www.perc.org/pdf/ps21.pdf [hereinafter EG&SH]; Indur M. Goklany, *The Future of Industrial Society*, Invited Paper, International Conference on Industrial Ecology and Sustainability, University of Technology of Troyes, Troyes, France, Sep. 22-25, 1999 (presenting data showing that human welfare has advanced remarkably since the start of industrialization).

[6] LOMBORG, *supra* note 1, at xix.

[7] *See* Paul R. Ehrlich & John P. Holdren, *Impact of Population Growth*, 171 SCIENCE 1212, 1212-1217 (1971). Notably, Holdren was one of Lomborg's *Scientific American* critics.

[8] Barry Commoner fully developed this identity but it was popularized in its present form by Ehrlich and his collaborators. *See* Barry Commoner, *The Environmental Cost of Economic Growth*, 8 CHEMISTRY IN BRITAIN 52, 55 (1972); *see also* ANNE H. EHRLICH & PAUL R. EHRLICH, EARTH 109, 109-12 (1987); PAUL R. EHRLICH & ANNE H. EHRLICH, THE POPULATION EXPLOSION 58, 273 (1990) [hereinafter POPULATION EXPLOSION].

[9] *See, e.g.*, PAUL R. EHRLICH, ANNE H. EHRLICH & JOHN P. HOLDREN, ECOSCIENCE: POPULATION, RESOURCES, ENVIRONMENT 720-25 (2d ed. 1977). The Club of Rome's model can also be stylistically collapsed to resemble the IPAT identity.

$$I = P \times A \times T,$$

where I is a measure of man's impact on the environment;[10] P is the population; A stands for affluence, a surrogate for production or consumption of materials and goods per capita and commonly approximated by the gross domestic product per capita or per capita income;[11] and T, denoting technology, serves as a measure of the impact per unit of production or consumption.[12]

The genius of this beguilingly simple identity is that it seems intuitively and obviously "right." According to the IPAT identity, if all else remains the same and population increases, so should production to satisfy not only the population's basic needs, but also its superfluous wants; hence, pollution must necessarily increase with population. Similarly, the more affluent the population, the greater its wants, and the higher the production and consumption levels have to be to meet those wants. That too leads to higher environmental impacts. Moreover, with the march of time, the growth in the population and level of affluence place ever-greater demands on the earth's natural resources. But in this world view, natural resources – being finite and, therefore, scarce – will necessarily be depleted, and the only way to produce as much, if not more, is to work harder and harder with more and more powerful technology. While recognizing that "benign" technologies could, in fact, reduce impacts,[13] believers in the IPAT identity argue that for most important activities, new technology would only bring diminishing returns because as the best resources (e.g. minerals, fossil fuels and farm land) are used up, society would increasingly have to turn to marginal or less desirable resources to satisfy demand, and that would lead to greater energy use and pollution.[14] Thus T, the technology term, in this worldview would, in due course of time, necessarily escalate.[15]

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[10] The scale – global, regional or local – at which impact is measured also determines the scale at which each of the three terms ought to be determined.

[11] EHRLICH, EHRLICH & HOLDREN, *supra* note 9, at 721-24.

[12] Technology, as used here, is construed broadly to include any thing that is devised by human beings. It includes both "hardware" (e.g., electric power plants, machines, scrubbers, catalytic converters and carbon adsorption systems) and "software" (e.g., institutions, policies, management techniques, social organizations, knowledge of accounting, hygiene, and so forth, and other elements of culture, as well as computer programs to track waste, model environmental quality, or emissions trading). *See generally* Jesse H. Ausubel, *Does Climate Still Matter?*, 350 NATURE 649 (1991); Indur M. Goklany, *Strategies to Enhance Adaptability: Technological Change, Economic Growth and Free Trade*, 30 CLIMATIC CHANGE 427 (1995) [hereinafter Goklany, *Strategies*].

[13] Ehrlich & Holdren, *supra* note 7, at 1214.

[14] *Id.* at 1213-14.

[15] Commoner, *supra* note 8, at 65; Ehrlich & Holdren, *supra* note 7, at 1216.

Based on this identity, Commoner indicted technology, specifically those adopted widely since World War II, as the source of environmental degradation. On the other hand, Ehrlich and co-workers concluded that population and affluence, particularly in "overdeveloped" countries such as the United States, are its primary causes and have to be curbed.[16]

As one measure of the IPAT identity's influence, consider that Garrett Hardin, the well-known ecologist, has called it "the third law of ecology."[17] Following the lead of its originators, many have concluded that population, affluence, and technology are the root causes of pollution and environmental degradation, that doomsday is inevitable, and that the human enterprise, as currently constituted, is unsustainable in the long run, unless all three factors – population growth, economic development, and technological change – are slowed down dramatically, if not halted and reversed.[18] Thus if one holds the world view embodied in the IPAT identity, it is inconceivable that the well-being of the world could be improving since clearly the earth is getting more populated, richer, and more addicted to consumption of energy, timber, and other natural resources. It is this chain of premises and logic that undergirds faith in the Litany. And when Lomborg shows that, contrary to the Litany, air and water quality has improved in the developed countries, that an increasing share of the population now has access to safe water and sanitation, or that despite the population explosion people are better fed, he is not so much as correcting factual misconceptions as he is undermining a system of beliefs.

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[16] Ehrlich & Holdren, *supra* note 7, at 1214; Paul Ehrlich, *Too Many Rich People: Weighing Relative Burdens on the Planet*, International Conference on Population and Development, Cairo, Sep. 5-13, 1994, *available at* http://dieoff.org/page43.htm.

[17] GARRETT HARDIN, LIVING WITHIN LIMITS: ECOLOGY, ECONOMICS, AND POPULATION TABOOS 202 (1993).

[18] *See* Norman Myers, *Consumption: Challenge to Sustainable Development . . .* , 276 SCIENCE 53, 54-55 (1997); *see also* ROBERT ENGELMAN, STABILIZING THE ATMOSPHERE: POPULATION, CONSUMPTION AND GREENHOUSE GASES 35-39 (1994); EXPLODING THE POPULATION MYTH: CONSUMPTION VERSUS POPULATION: WHICH IS THE CLIMATE BOMB? (A. Rahman et al. eds., 1993); PAUL HARRISON, THE THIRD REVOLUTION 293-305 (1992); POPULATION EXPLOSION, *supra* note 8, at 190, 215; Stephen Boyden & Stephen Dover, *Natural-resource Consumption and Its Environmental Impacts in the Western World: Impacts of Increasing Per Capita Consumption*, 21 AMBIO 63, 68-69 (1992); Norman Myers, *Population/Environment Linkages: Discontinuities Ahead*, 21 AMBIO 116, 118 (1992); J. Cairns, *Eco-Societal Restoration: Re-Examining Human Society's Relationship With Natural Systems*, The Abel Wolman Distinguished Lecture, National Research Council, Washington, DC, Dec. 5, 1994. Another option would be to use a "strict" version of the precautionary principle to ensure that there are no untoward impacts from new technologies. *See, e.g.*, PROTECTING PUBLIC HEALTH & THE ENVIRONMENT: IMPLEMENTING THE PRECAUTIONARY PRINCIPLE (Carolyn Raffensperger and Joel A. Tickner eds., 1999). Under this view, the precautionary principle essentially embodies a presumption against further technological change unless proven absolutely safe and clean. *See* INDUR M. GOKLANY, THE PRECAUTIONARY PRINCIPLE: A CRITICAL APPRAISAL OF ENVIRONMENTAL RISK ASSESSMENT 2 (2001) [hereinafter GOKLANY, PRECAUTIONARY PRINCIPLE].

This paper examines whether increases in affluence and advances in technology are, consistent with the environmentalist credo, inimical to human and environmental well-being. In order to do that, Part II examines how various indicators of human well-being vary with the level of economic development for a cross section of countries, and with technological change, while Part III addresses trends in indicators of environmental quality. The Conclusion is a synthesis of the forgoing. The approach used in this paper complements Lomborg's analysis, which was largely confined to temporal trends.[19] And like Lomborg's, it relies heavily on empirical data.

II. AFFLUENCE, TECHNOLOGICAL CHANGE, AND HUMAN WELL-BEING

A. *Empirical Trends*

Figure 1, based on cross country data from the World Bank,[20] is a graph of what arguably are among the most critical – or first order – indicators of human well-being[21] plotted against the level of economic development (or wealth, as measured by per capita income or GDP per capita, henceforth, "income"). It shows that each of these indicators improves with advances in income. Although Figure 1 limits itself to availability of food (a surrogate for hunger and malnutrition), infant mortality (a surrogate for public health), schooling, children in the labor force, access to safe water, and life expectancy, several other indicators of well-being or factors related to well-being, e.g., crop yield, prevalence of malnutrition, and access to sanitation,

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[19] Although Lomborg's focus was on temporal trends, some of his data does look at temporal trends in infant mortality and life expectancy for various income groups. These data suggest that richer groups are better off. *See* LOMBORG, *supra* note 1, at 52, 55. He also discusses the variation of air pollution (particulate matter and sulfur dioxide) with income. As can be seen from his Figures 96 and 97, this variation can be represented by an inverted-U shaped curve commonly called the "environmental Kuznets curve" or, less commonly, "the environmental transition curve." *Id.* at 175-77. For a more detailed discussion of such curves and the factors underlying them see generally INDUR M. GOKLANY, CLEARING THE AIR: THE REAL STORY OF THE WAR ON AIR POLLUTION (1999) (discussing the environmental transition); BRUCE YANDLE ET AL., THE ENVIRONMENTAL KUZNETS CURVE: A PRIMER (Political Economy Research Center, PERC Research Studies No. 02-1, 2002), *available at* http://www.perc.org/pdf/rs02_1.pdf (providing an introduction to the Environmental Kuznet Curve theory and the research that has been conducted in this area); Indur M. Goklany, *Richer is Cleaner: Long Term Trends in Global Air Quality*, *in* THE TRUE STATE OF THE PLANET, at 339-45 (discussing the relationship between technology, affluence and the environment).

[20] *See* World Bank, *World Development Indicators* (World Bank CD-ROM (2001)). Earlier versions of Figures 1 and 2 (below) were presented in: Indur M. Goklany, *The Globalization of Human Well-Being*, POLICY ANALYSIS, Aug. 22, 2002, at 2. Those figures were based on older data and a slightly different methodology outlined in EG&SH, *supra* note 5, at 29-31.

[21] *See* Goklany, *Globalization of Human Well-Being*, *supra* note 20, at 3-4 (discussing the five indicators of human well-being including available food supplies per capita, infant mortality, prevalence of child labor, life expectancy at birth, and United Nations human development index).

also show similar improvements with income.[22] Remarkably, total fertility rate – a critical measure of the population growth rate and directly related to P in the IPAT identity – also declines as income goes up.[23]

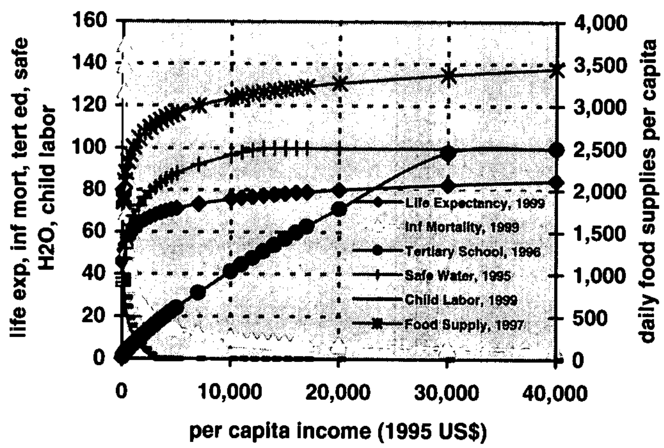

Figure 1: Human well-being vs. economic development, 1990s. Source: Goklany, *Globalization of Human Well-Being*, updated using data from *World Development Indicators* (2001).

The plot for each indicator in Figure 1 is based on regression analyses, which established the equation that best fit the data for that indicator as a function of income.[24] The results of these analyses

[22] *See* EG&SH, *supra* note 5, at 29, 38; for access to sanitation, see NEMAT SHAFIK AND S. BANDOPADHYAY, WORLD BANK, ECONOMIC GROWTH AND ENVIRONMENTAL QUALITY: TIME SERIES AND CROSS-COUNTRY EVIDENCE (World Bank, Policy Research Working Papers, 1992); for malnutrition, this is based on unpublished analysis (on file) by the author.

[23] GOKLANY, PRECAUTIONARY PRINCIPLE, *supra* note 18, at 76-77.

[24] The following methodology was used to generate the plots in Figures 1 and 2. First, data for the indicator and for income were obtained for the various countries for two separate years, e.g., for life expectancy, I used the years 1960 and 1999. The reason for using two years worth of data was to see whether there was any change in the apparent relationship between the indicator and income with the passage of time (that is, as one went from one year to the next; *see* Figure 2 and *infra* note 25). Second, these data were analyzed to determine the relationship that best fit these data using linear, log-linear, and log-log regression analyses. In these analyses, a "dummy variable": was assigned to distinguish between data for the first year and the second year. The dummy variable for life expectancy, for example, was assigned a value of zero for 1960 and one for 1999. This allows data – and results – for the indicator to be distinguished by year. Third, the regression analysis that explained more of the variation in the indi-

showed that each indicator improved as income advanced, and that this upward trend was statistically significant at the 99 percent level.

Figure 2, also based on World Bank data, shows that as we advance from 1960 to 1999, the life expectancy curve shifts upward and the infant mortality curve moves downwards. That is, both indicators improve with the passage of time.[25] Equally important, the shifts in time are statistically significant at the 99 percent level, and these improvements are independent of improvements in economic growth.

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cator of well-being than any other, was selected as the basis for the best fit equation, i.e., in the parlance of statistics, the regression that had the highest (adjusted) R^2 was used to generate the so-called best fit equation. The results of this regression analysis were also checked to verify whether any trend in the indicator with respect to income was statistically significant at least at the 95 percent level. Indeed, for each indicator shown in Figure 1, increases in income also improved human well being, and these improvements were statistically significant at the 99 percent level. Finally, the regression line that best fit the indicator's data from the most recent year was plotted in Figure 1 (e.g., 1999 for life expectancy). For indicators that have theoretical maxima or minima, e.g., 0 percent for child labor and 100 percent for the proportion of population with access to safe water, the best fit lines were truncated at these extremes. In these cases, the best fit lines were generated using a Tobit regression model which allows for truncation. Pertinent details of the regression analyses are shown in the following Table. Note that the R^2 shown for these indicators in the Table are for the normal (non-Tobit) model.

Indicator	Initial Year	Final Year	Number of Data Points	Type of Regression	R^2
Infant Mortality	1960	1999	264	log-log	0.83
Life Expectancy	1960	1999	264	log-linear	0.69
Child Labor	1960	1999	244	log-linear	0.56
Average Daily Food Supplies	1961	1997	258	log-linear	0.65
Access to Safe Water	1970	1995	121	log-linear	0.63
Enrollment in Tertiary Schools	1965	1996	219	log-log	0.68

Notably the R^2 for each of the indicators were quite respectable, ranging from 0.56 for child labor to 0.83 for infant mortality, i.e., the variation in income explained between 56 and 83 percent of the variation in child labor and infant mortality respectively.

[25] Figure 2 was generated from the same set of analyses discussed in *supra* note 24, above, by substituting, in the "best fit" equation for each indicator, zero for the "dummy variable" to generate the curve for the first year, and one for the second. Thus, we end up with two plots for the same indicator, one for the first year and the other for the second year. Figure 2 illustrates the results of this exercise for life expectancy and infant mortality.

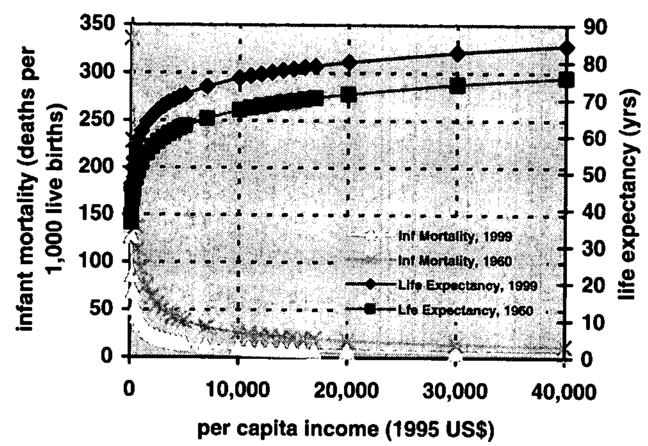

Figure 2:Infant mortality and life expectancy vs. economic development, 1960-1999. Source: Goklany, *Globalization of Human Well-Being*, updated using data from *World Development Indicators* (2001).

So what is independent of economic growth, changes with time, and can improve life expectancy and infant mortality? That would be technology, broadly defined.[26] The passage of time, in fact, is a surrogate for technological change, i.e., for the accretion of technology and its diffusion through learning, and trade and commerce in ideas, goods and services.

Although not illustrated in Figure 2, these conclusions, namely, that the indicators improve with time and these improvements are statistically significant (also at the 99 percent level), also hold for all the other indicators plotted in Figure 1. The effects of technological change on each of those critical indicators of human well-being are summarized in Table 1. Specifically, it shows the improvements in the indicators if wealth had been frozen at $100, $1000 and $10,000 per capita (in 1995 US dollars using market exchange rates). Thus, if a country's income had stayed constant at $100, then because of technological change alone, average daily food supplies would have gone up by 241 kilocalories per day between 1961 and 1997, while between 1960 and 1999 infant mortality would have declined by 208

[26] *See supra* note 12 and accompanying text.

points (from 335 to 127 deaths per 1000 live births), and life expectancy would have increased 8.4 years, and so forth.

Income (1995 US$)	**Daily Food Supplies per Capita[a] (kcal)**		**Infant Mortality (per 1000 live births)**		**Life Expectancy (years)**		**Tertiary Student Enrollment (percent)**		**Access to Safe Water[b] (percent)**		**Child Labor (percent)**	
Year	*1961*	*1997*	*1960*	*1999*	*1960*	*1999*	*1965*	*1996*	*1970*	*1995*	*1960*	*1999*
$100	1,688	1,929	335	127	38.2	46.8	0.3	1.1	12.8	37.9	47.3	36.0
$1,000	2,269	2,510	93	35	52.7	61.3	1.6	6.7	42.2	67.3	22.9	11.7
$10,000	2,851	3,092	26	10	67.2	75.6	10.0	41.3	71.6	96.8	0.0	0.0
Low Income Countries	2,006[c]	2,412[c]	159	77	43.9	59.1	2.9	NA	19.6	69.3	31.7	18.6
World	2,256[c]	2,794[c]	127	54	50.3	66.5	6.8	13.7	NA	75.3	24.8	11.8

[a] Based on data from World Resources Institute (2000), except as noted.
[b] Based on data from World Bank (1999).
[c] Based on data from FAOSTAT (2002).

Table 1: Improvement in human well-being with time (or technological change) and economic growth. (Based on calculations using data from World Bank (2001), except where noted.)

Notably, for each of the six indicators shown in Figure 1 and Table 1, the improvements, whether due to economic development or technological change, are most rapid at the lowest levels of wealth. Thus in 1999, going from a income of $100 to $1000 would have improved the infant mortality rate by 92 points (from 127 to 35 deaths per 1000 live births) but going further to $10,000 would have resulted in a smaller additional improvement (of 25 points). Table 1 also confirms what should be obvious from the previous figures, that increases in wealth are much more critical for poorer countries than equivalent increases for richer ones because the former live closer to the margin. In other words, the poorer the country, the more crucial are wealth and the ability to obtain (and use) technology for the well-being of its population.[27]

And, in fact, because of the combination of technological change and general increases in income, the progress in these indicators over the last several decades has been pretty remarkable, as shown in Ta-

[27] This is one of the major reasons why, whether income inequalities between nations are widening or not, by and large the gaps in human well-being are diminishing. *See* Goklany, *Globalization of Human Well-Being*, *supra* note 20, at 6, 14.

ble 1. For the low income countries, for example, between 1960 and 1999 life expectancy increased 15.2 years while infant mortality dropped by 82 points, and between 1970 and 1995 access to safe water increased from 19.6 percent of population to 69.3 percent.

B. *The Cycle of Progress*

In the foregoing, economic development and technological change were treated as if they are independent of one another. But, in reality, they are mutually reinforcing coevolving forces.[28] Greater wealth translates into greater resources for researching and developing new technologies, which directly or indirectly advance human well-being.[29] It also means increased resources for advancing literacy and education (see Figure 1) which is also generally conducive to greater technological innovation and diffusion.[30] Equally importantly, wealthier societies are better able to afford new and existing-but-underused technologies,[31] which, as I argue below, is a crucial mechanism whereby economic development improves well-being. In turn, technological change increases productivity and, thereby, economic growth.

So what accounts for the association between the various indicators of human well-being, and the level of economic development?

One explanation is that economic development indeed improves these indicators. The wealthier the society, the more it can afford technologies targeted to the improvement of specific facets of well-being. Thus, with respect to health – captured in Figure 1 by both infant mortality and life expectancy – wealthier societies have, for instance, greater access to safe water (see Figure 1), sanitation, vaccinations, antibiotics and pasteurization,[32] AIDS and oral rehydration therapies, organ transplants, and mammograms and other diagnostic tests.[33] They can also better afford yield-enhancing agricultural tech-

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[28] Goklany, *Strategies*, *supra* note 12, at 427.

[29] Not surprisingly, expenditures on research and development increase with per capita GDP. Using data for 1994, linear regression analysis of cross-country data for 1994 from World Bank, *World Development Indicators* CD-ROM (1999) shows that the slope is significant at the 95 percent level (N = 53, $R^2 = 0.506$). This analysis used GDP per capita for 1994 adjusted for purchasing power parity. *See also* Goklany, *Strategies*, *supra* note 12, at 444-45.

[30] RICHARD A. EASTERLIN, GROWTH TRIUMPHANT 46 (1996). *See also* WILLIAM EASTERLY, THE ELUSIVE QUEST FOR GROWTH 71-84 (2001) (discussing several theories regarding whether an increase in education makes a difference in poor countries). *But see* JOEL MOKYR, THE LEVER OF RICHES 174-75 (1990) (arguing that if educated people are not engaged in economically productive activities then there may be no link between technology and education).

[31] *See* Indur M. Goklany, *Saving Habitat and Conserving Biodiversity on a Crowded Planet* 48 BIOSCIENCE 941-45 (1998) [hereinafter Goklany, *Saving Habitat and Conserving Biodiversity*]; Goklany, *Strategies*, *supra* note 12, at 435-37.

[32] *See* EASTERLIN, *supra* note 30, at 161.

[33] Perhaps nothing better illustrates the importance of wealth in addressing health problems than the vastly different AIDS experiences of the United States and Sub-Saharan Africa countries. Being wealthy and possessing the requisite human capital, the U.S. launched a mas-

nologies,[34] which increases their food supply and, thereby, reduces hunger and malnourishment[35] and, with it, the toll of infectious and parasitic diseases.[36] That, too, reduces mortality and increases life expectancy.[37] And if despite increased food production a country is still short of food, greater wealth makes it possible, through trade, to purchase food security.[38] Greater wealth also makes it more likely that a society will establish and sustain food programs for those on the lower rungs of the economic ladder.[39] Therefore, while "you can't eat GDP,"[40] if GDP is larger, you are less likely to go hungry or be undernourished (except by choice). Thus, as Figure 1 illustrates, greater wealth, through a multiplicity of mechanisms, e.g., higher literacy, higher food supplies and greater access to safe water, leads to better health.[41]

Second, the causation might be in the reverse direction. Perhaps it is advances in human well-being that stimulate economic development, rather than vice versa. Healthier people are more energetic, less prone to absenteeism and, therefore, more productive in whatever

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sive assault on the disease that led to the development of several technologies reducing its toll. As a consequence, between 1995 and 1999 U.S. deaths due to AIDS dropped by over two-thirds, despite a 50 percent increase in the numbers infected. On the other hand, although various therapies now exist, Sub-Saharan countries can barely afford them, and similar improvements have not been registered yet. Goklany, *Globalization of Human Well-Being*, *supra* note 20, at 10-11.

[34] Cereal yields across countries increase with the log of income, similar, for instance, to life expectancy. *See* GOKLANY, PRECAUTIONARY PRINCIPLE, *supra* note 18, at 77-78.

[35] *See* Goklany, *Strategies*, *supra* note 12, at 435-36; *see also* Goklany, *Saving Habitat and Conserving Biodiversity*, *supra* note 31, at 945.

[36] *See* ROBERT WILLIAM FOGEL, THE FOURTH GREAT AWAKENING 79 (2000); Robert William Fogel, *The Contribution of Improved Nutrition*, *in* THE STATE OF HUMANITY, at 61-71. *See generally* EASTERLIN, *supra* note 30, at 69-82; Goklany, *Saving Habitat and Conserving Biodiversity*, *supra* note 31, at 945.

[37] Historically, reductions in hunger and undernourishment have been among the first practical steps nations have taken to improve public health, reducing infant mortality, and increasing life expectancy. *See* EASTERLIN, *supra* note 30, at 69; FOGEL, *supra* note 36, at 145-51.

[38] *See* Goklany, *Saving Habitat and Conserving Biodiversity*, *supra* note 31, at 946-47; Goklany, *Strategies*, *supra* note 12, at 135; *see also* Indur M. Goklany, *Potential Consequences of Increasing Atmospheric CO_2 Concentration Compared to Other Environmental Problems*, 7S TECHNOLOGY 189-213 (2000) [hereinafter Goklany, *Potential Consequences*].

[39] *See* Goklany, *Meeting Global Food Needs: The Environmental Trade-offs Between Increasing Land Conversion and Land Productivity*, 6 TECHNOLOGY 107-30 (1999); Goklany, *Strategies*, *supra* note 12, at 435.

[40] This was one of the slogans anti-globalization demonstrators rallied around during the period of the Free Trade Area of the Americas' negotiations in Quebec City in April, 2001. *See* Zach Dubinsky, *Amid the Tears: Protesters, Police, Politics and the People of Quebec*, CLEVELAND TIMES, April 25 - May 1, 2001, on file with author. This slogan is reminiscent of the title of a book by ERIC A. DAVIDSON, YOU CAN'T EAT GNP: ECONOMICS AS IF ECOLOGY MATTERED (2000).

[41] *See* Goklany, *Saving Habitat and Conserving Biodiversity*, *supra* note 31, at 946; *see also* Lant Pritchett and Lawrence H. Summers, *Wealthier is Healthier*, 31 JOURNAL OF HUMAN RESOURCES 841, 841-43 (1996).

activity – economic or otherwise – they might undertake.[42] When malaria was eradicated in Mymensingh (Bangladesh), crop yields increased 15 percent because farmers had more time and energy for cultivation.[43] In other areas, elimination of seasonal malaria enabled farmers to plant a second crop. A joint study by the Harvard University Center for International Development and the London School of Hygiene and Tropical Medicine estimates that had malaria been eradicated in 1965, Africa's GDP would have been 32 percent higher in 2000.[44]

Moreover, healthier people can also devote more time and energy to education and their intellectual development.[45] Good health is particularly important during a child's formative years. Also, the incentives for investing in the development of human capital increase if individual beneficiaries expect to live to sixty rather than, say, a mere forty. Not surprisingly, educational levels increase with life expectancy.[46] Today it is not unusual to encounter aspiring doctors and researchers in their mid-thirties, in effect, spending what once was literally a lifetime learning their trade. And having acquired this expertise, these doctors and researchers are poised to contribute to technological innovation and diffusion in their chosen fields and to guide others along the same path. Thus, better health helps raise human capital, which aids the creation and diffusion of technology, further advancing health and accelerating economic growth.

But probably both explanations are valid, with causes and effects reinforcing each other in a set of interlinked cycles. One such cycle is the health-wealth cycle in which wealth begets health and health, wealth. Another cycle consists of food production, food access, education, and human capital, and which also helps turn the health-wealth cycle. These cycles are embedded in a larger Cycle of Pro-

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[42] WORLD BANK, WORLD DEVELOPMENT REPORT: INVESTING IN HEALTH 17-21 (1993); *see also* EASTERLIN *supra* note 30, at 89-91; WORLD HEALTH ORGANIZATION, WORLD HEALTH REPORT 1999 (1999) (arguing that there is a link between health and per capita income, since health among other things leads to better education outcomes and higher productivity); Barry Bloom, *The Future of Public Health*, 402 NATURE C63-64 (Supplement 1999) (arguing that increased health leads to a greater per capita income); Fogel, *The Contribution of Increased Nutrition*, *supra* note 36, at 63-65.

[43] EASTERLIN, *supra* note 30, at 90.

[44] HARVARD UNIV. CTR. FOR INT'L DEV. & THE LONDON SCH. OF HYGIENE AND TROPICAL MED., ECONOMICS OF MALARIA, EXECUTIVE SUMMARY (2000), *available at* http://www.malaria.org/jdsachseconomic.html.

[45] *See* WORLD HEALTH REPORT 1999, *supra* note 42, at 11 (stating that better adult health increases work output and decreases absenteeism); Fogel, *supra* note 36, at 64-65 (finding that improved nutrition resulted in increased productivity in France and England during the Industrial Revolution).

[46] *See* EG&SH, *supra* note 5, at 11 fig.3, 18 fig.7 (showing that both life expectancy and post-secondary school enrollment increase as GDP per capita increases).

gress in which economic growth and technological change reinforce each other.[47]

Yet another explanation for the association between human well-being and wealth is that what improves one also improves the other. These would be the institutions and processes that fuel the Cycle of Progress by stimulating both economic growth and technological change. They include legal and economic systems that – through free markets, secure property rights, honest, predictable and fiscally responsible governments and bureaucracies, and adherence to the rule of law – encourage competition not only in the commercial sphere, but also in the scientific and intellectual spheres, and allow those who venture their labor, intellectual capital and financial resources to profit from the risks they incur.[48] These institutions are also the foundations of civil societies and democratic systems.

Trade is an integral part of the Cycle of Progress. Freer trade directly stimulates economic growth,[49] helps disseminate new technologies, and creates pressures to invent and innovate.[50] For instance, competition from foreign car makers accelerated the introduction of several automobile safety and emission control systems to the United States, improving both environmental and human well-being.[51] Competitive trade also helps contain the costs of basic infrastructure, including water supply, sanitation, and power generation (although the full benefits are often squandered because of corrupt, inefficient, and opaque bureaucracies and governments).[52] And trade, of course, has

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[47] The Cycle of Progress is briefly described in EG&SH, *supra* note 5, at 26-31. *See also* Goklany, *The Future of Industrial Society*, *supra* note 5.

[48] *See* ROBERT J. BARRO, DETERMINANTS OF ECONOMIC GROWTH (2d paperback ed., 1999) (using econometrics to conclude that higher, non-productive government spending results in slower economic growth, while increased maintenance of the rule of law encourages economic growth); JAMES GWARTNEY, ROBERT LAWSON, WALTER PARK & CHARLES SKIPTON, ECONOMIC FREEDOM OF THE WORLD: ANNUAL REPORT 2001 (2001); James Gwartney, Randall Holcombe & Robert Lawson, *The Scope of Government and the Wealth of Nations*, 18 CATO J. 163, 186-190 (1998) (finding that once government expenditures exceed 15 to 20 percent of GDP, the economic growth rate declines). *See generally* DAVID DOLLAR & AART KRAAY, WORLD BANK, GROWTH IS GOOD FOR THE POOR (2001), *available at* http://www.worldbank.org/research/growth/pdfiles/GIGFTP3.pdf (examining the relationship between the average incomes of the poorest 20 percent of the population in various countries with average incomes overall in those countries and concluding that increased growth due to legal and economic systems benefits the poor as much as the average citizen).

[49] *See* BARRO, *supra* note 48, at 28-31 (finding that improvement in trade terms stimulates economic growth); DOLLAR & KRAAY, *supra* note 48; Jeffrey A. Frankel & David Romer, *Does Trade Cause Growth?*, 89 AM. ECON. REV. 379, 394 (1999) (using regression analysis to conclude that trade increases income).

[50] *See* Goklany, *Strategies*, *supra* note 12, at 442 (stating that trade has, throughout history, helped spread ideas, knowledge, and different modes of thought).

[51] *Id.*

[52] A vivid example of the importance of trade in improving human well-being comes from Iraq whose inability, because of trade sanctions, to fully operate and maintain its water, sanitation and electrical systems or to obtain sufficient food for its population contributed to a deterioration of public health and lowered life expectancies since the Gulf War. The need to alleviate

globalized food security.[53] Currently, grain imports amount to 10 percent of the production in developing countries and 20 percent in Sub-Saharan Africa.[54] Without such imports, food prices in those countries would no doubt be higher, and more of their people would be priced out of the market, which would swell the ranks of the hungry and undernourished.

III. TRENDS IN ENVIRONMENTAL INDICATORS

A. *The Environmental Transition*

The foregoing showed that trends in first order indicators of human well-being improve with wealth and time. What about environmental indicators, some of which, while important, are not necessarily first order concerns?[55] Examination of temporal trends in many environmental indicators for specific societies shows that they first deteriorate, then they go through a transitional period during which the rate of deterioration slows down, and finally they start to improve. This is the case, for instance, for indoor and outdoor air pollution from traditional pollutants (e.g., sulfur dioxide, carbon monoxide and particulate matter); cropland and agricultural water use (measures for the amount of land and water diverted to human use); and levels of DDT and PCBs in human and wildlife tissue.[56] Such behavior is stylistically depicted in Figure 3.

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these problems was the basis for various Security Council resolutions to extend its "Oil-for Food" program. Press Release SC/6872, United Nations, Security Council Extends Iraq 'Oil-for-Food' Programme for Further 180 Days, (June 8, 2000), *available at* http://www.un.org/News/Press/docs/2000/20000608.sc6872.doc.html.

[53] *See* Goklany, *Saving Habitat and Conserving Biodiversity*, *supra* note 31, at 942-43, 946 (discussing the globalizing effect of trade on the sustainability of both rich and poor nations); Goklany, *Strategies*, *supra* note 12, at 440-41(discussing today's global market and countries' mutual sustainability).

[54] FOOD AND AGRICULTURAL ORGANIZATION, UNITED NATIONS, FAOSTAT DATABASE 2001, *available at* http://apps.fao.org.

[55] Exceptions to this are access to safe water and sanitation, which clearly are among the most critical indicators of human well-being, and were discussed in conjunction with Figures 1 and 2 *supra* Part II.A.

[56] *See* GOKLANY, CLEARING THE AIR, *supra* note 19, at 49-86 (discussing the trends in indoor and outdoor air quality and emissions); INDUR M. GOKLANY, DEPARTMENT OF THE INTERIOR, AIR AND INLAND SURFACE WATER QUALITY 34-35 (1994) [hereinafter GOKLANY, WATER QUALITY] (discussing DDT and PCBs); LOMBORG *supra* note 1, at 164-77 discussing outdoor air pollution trends and dangers in London, the United Kingdom, and the United States); Indur M. Goklany, *Comparing Twentieth Century Trends in U.S. and Global Agricultural Water and Land Use*, *in* 2001 AM. WATER RESOURCES ASS'N CONF (discussing cropland and agricultural water use); Indur M. Goklany, *Factors Affecting Environmental Impacts: The Effects of Technology on Long- term Trends in Cropland, Air Pollution and Water-related Diseases*, 25 AMBIO 497, 497-99 (1996) [hereinafter Goklany, *Factors*] (discussing trends in cropland use); Goklany, *Saving Habitat and Conserving Biodiversity*, *supra* note 31, at 943 (discussing the impact of investment and clean technologies on DDT and PCB levels in the Great Lakes and elsewhere).

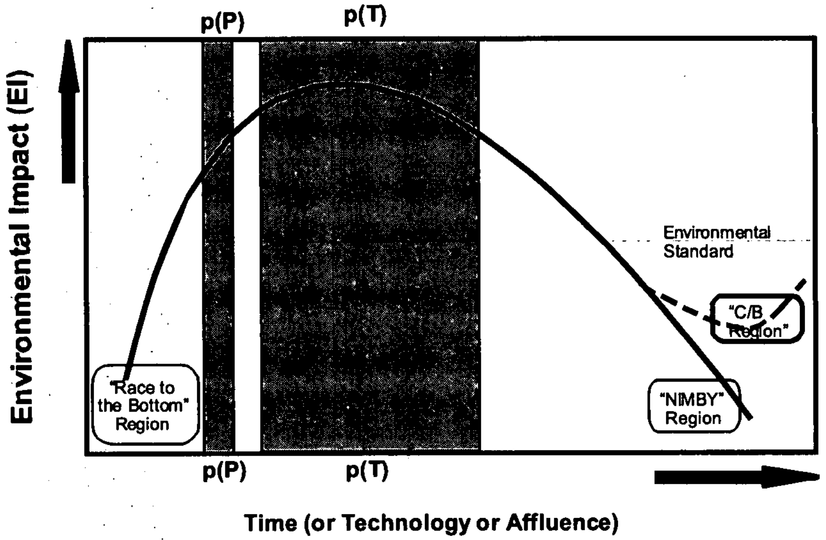

Figure 3: The Environmental Transition. Source: GOKLANY, CLEARING THE AIR (1999), p. 96. NOTE: p(P) = period of perception; p(T) = period of transition; NIMBY Region = "not in my backyard region" (EI enters this region if benefits far exceed costs to beneficiaries); C/B Region = cost/benefit region (in this region benefits and costs have to be more carefully balanced).

In this Figure, the y-axis indicates the environmental impact (EI) on a *country or society* as measured by a particular indicator (e.g., the level of air quality, cropland use or DDT level in human tissue) while the x-axis represents time which – as discussed previously – is a surrogate for technological change. In most countries of the world, time has also brought with it, affluence or economic development.[57] For the United States, for example, the correlation between affluence and time between 1900 and 1994 is 0.96.[58] Therefore, for most countries the x-axis could just as well be affluence.

Figure 3 shows that the trajectory of EI is shaped like a camel's back or an inverted-U (IU); it first goes up, then it goes through an "environmental transition" (ET) after which it declines. For some indicators (e.g., access to sanitation or safe water), the transitions have historically occurred earlier in a country's developmental history.[59] For others, because the problem, real or perceived, has, for

[57] ANGUS MADDISSON, THE WORLD ECONOMY: A MILLENNIAL PERSPECTIVE 264-65 (2001) (depicting World GDP per Capita and Rates of Growth of World GDP per Capita from year 0 to year 1998 A.D.).

[58] GOKLANY, CLEARING THE AIR, *supra* note 19, at 88. The remainder of the discussion in this part relies heavily on Goklany, *The Future of Industrial Society*, *supra* note 5, and references therein.

[59] Therefore, long term plots of trends in access to safe water and sanitation for individual societies (e.g., going back to the mid-1800s for the rich countries) would indeed show environmental transitions (because until societies became aware of their importance to their well-being,

whatever reason, yet to be addressed successfully, e.g., carbon dioxide (CO_2) emissions, an ET may not be evident in trend data, i.e., the country may still be on the upward slope of the ET.[60]

Notably, *cross-country* data for some pollutants also result in hump-backed curves (called Environmental Kuznets Curves, EKCs) when EI is plotted against affluence.[61] Despite the superficial resemblance between the curves representing the ET and EKC hypotheses, the two are not identical. The x-axis represents time (a proxy for both affluence and technological development) in the former, and affluence in the latter. Also, a set of single-country humpback ETs does not necessarily result in a similarly shaped IU-shaped cross-country EI vs. affluence curve; instead it could be N- or even U-shaped.[62]

An explanation offered for an environmental transition is that society is on a continual quest to improve its quality of life (QoL) which is determined by numerous social, economic, and environmental factors. The weight given to each determinant is constantly changing with society's precise circumstances and perceptions. In the early stages of economic and technological development which, as we have seen, co-evolve, society places a higher priority upon increasing affluence than on other determinants, even if that means tolerating some environmental deterioration, because that provides the means for obtaining basic needs and amenities (e.g., food, shelter, water, education and electricity) and, as indicated by Figure 1, reducing more significant risks to public health and safety (e.g., malnutrition, infectious and parasitic diseases, mortality and other risks whose mitigation increases life expectancy). Also, in these early stages, society may be unaware of the risk posed by EI. However, as society becomes wealthier, tackles these more significant problems, and possibly, gains more knowledge, reducing EI automatically rises higher on its priority list (even if EI itself does not worsen). But since economic activity further increases EI, lowering EI becomes even more urgent. Thus, environmental quality becomes a more important determinant of the overall quality of life. This stage is represented in Figure 3 as the period of perception or p(P).

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there would have been little or no improvement). However, because current data has been collected after the end of p(P) for these indicators, and from the downhill (post-ET) segment of Figure 3, their plots against affluence for various countries would not necessarily show any ETs. *See generally* SHAFIK AND BANDOPADHYAY, *supra* note 22 (analyzing environmental quality indicators, through regression analysis, for up to 149 countries from 1960 to 1990). *See also* Goklany, *Richer is Cleaner*, *supra* note 19, at 343.

[60] *See* Goklany, *Richer is Cleaner*, *supra* note 19, at 342-43; Goklany, *Strategies*, *supa* note 12, at 436.

[61] *See* LOMBORG, *supra* note 1, at 177 (showing the connection between GDP per Capita and particle pollution); Goklany, *Richer is Cleaner*, *supra* note 19, at 341-44. *See generally* BRUCE YANDLE ET AL., *supra* note 19.

[62] *See* GOKLANY, CLEARING THE AIR, *supra* note 19, at 98-102.

Prior to p(P) one should not expect society to require, or private parties to volunteer, to reduce EI, although reductions may occur due to secular improvements in technology or other reasons.[63] For example, for SO_2 in the U.S., p(P) dates to the 1950s, but indoor SO_2 levels had begun to improve before the 1940s. From p(P) onward, a democratic society will often translate its desire for a cleaner environment into laws, either because clean up is not voluntary or rapid enough, or because of sheer symbolism. The wealthier such a society, the more affordable – and more demanding – its laws.

At the same time, increasing affluence and the secular march of technology enables society to better and more cheaply improve its environmental quality. Affluence also makes R&D targeted on cleaner technologies more affordable, as it does the purchase and use of such technologies, especially if their up-front costs are higher. Thus, EI undergoes a period of transition. Ultimately, greater affluence and technological change should result in a decline in EI.[64]

Other factors have reinforced ETs in the richer countries for traditional (industry-related) pollutants. Historically, economic development involved technology-mediated transformations from, first, an agrarian to an industrial society and, then, an industrial to a post-industrial knowledge- and information-based society. Emissions of industrial pollutants per capita or per GNP (both leading, rather than true, indicators of environmental impacts)[65] increased with the first transformation but declined with the second, and temporal trends for these leading indicators also look like stylized IUs. Second, as the industrial sector waxed and waned so did its political and demographic power. In 1900 the U.S. mining and manufacturing sectors, traditionally associated with pollution, employed 40.2 percent of non-farm labor. This had dropped to 28.2 percent in 1970 and 17 percent in 1997. A decline in a sector's economic and demographic power only makes stiffer environmental laws more likely for that sector, particularly in a democracy. Currently we see this principle in operation for the U.S. ranching, mining, forestry and agricultural sectors.

Once past the ET and EI drops below the environmental standard, it could then move in one of several different directions. If the (perceived) benefits of control substantially exceed (perceived) social and economic costs, or if the costs are shifted to others while benefits

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[63] *See* Goklany, *Factors*, *supra* note 56, at 499; Goklany, *Richer is Cleaner*, *supra* note 19, at 345-58 (discussing, among other things, how the use of cleaner energy sources, more efficient power plants, and various government regulations has contributed to reductions in both indoor and outdoor air pollution).

[64] This point is evident from Figures 96 and 97 in LOMBORG, *supra* note 1, at 177, which are similar to Figure 2, *supra* Part II.A. The difference being that the former represent second order indicators of well-being, while the latter represents first order problems. *See also* Goklany, *Richer is Cleaner*, *supra* note 19, at 341-45.

[65] *See* GOKLANY, CLEARING THE AIR, *supra* note 19, at 2, 72-74.

are retained, EI will be driven down farther (as indicated by the solid post-transition curve in Figure 3). In effect, the EI trajectory enters a "not-in-my-backyard" (NIMBY) phase. However, if EI enters a region where costs approximate benefits, which may occur if technological progress has been unable to substantially reduce costs or costs cannot be shifted to someone else, then the precise trajectory will depend upon a more careful balancing of the perceived costs and benefits.[66] Such a region is denoted in Figure 3 as the "cost-benefit" or CB region. In a democracy, such balancing is often done by legislators or agencies authorized by them. Almost inevitably, such balancing is qualitative and imprecise.[67]

The dashed line in Figure 3 depicts a case where further control is no longer perceived to enhance QoL, i.e., the additional costs of further control once again exceed additional benefits, and EI swings upward. That may occur, for example, if the costs of additional cleanup increase exponentially while benefits diminish, as is not unusual; society decides that for the particular EI, the environment is clean enough, and scarce resources should now be spent on other unmet needs; and limits of clean technologies have been reached, and no cleaner substitutes are available.[68]

B. *Does Greater Wealth Lead to Cleaner Environments?*

Based upon cross-country EKCs and single-country ETs for various environmental indicators, it has been suggested that as a country gets richer, it will ultimately get cleaner, at least to a point (see Figure 3).[69] One of the arguments against this proposition is that some cross-country data indicate that at high levels of affluence, a cross-country plot of ambient sulfur dioxide (SO_2) concentrations vs. affluence may swing up, i.e., the curve may be N-shaped.[70] But as noted previously, a N-shaped cross-country curve can be constructed from a hypothetical set of IU-shaped single-country ET curves.[71] Thus, an N-shaped cross-country EKC is not by itself a persuasive argument against the notion that as a country becomes richer it will

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[66] *Id.* at 95-98.

[67] *Id.* at 97.

[68] *See id.* at 106-07; GOKLANY, WATER QUALITY, *supra* note 56; Goklany, *Richer is Cleaner*, *supra* note 19, at 371 n.4.

[69] Goklany, *Richer is Cleaner*, *supra* note 19, at 371, n.4.

[70] Mariano Torras & James K. Boyce, *Income, Inequality, and Pollution: A Reassessment of the Environmental Kuznets Curve*, 25 ECOLOGICAL ECON. 147, 157-58 (1998); *see also* Dale S. Rothman & Sander M. de Bruyn, *Probing Into the Environmental Kuznets Curve Hypothesis*, 25 ECOLOGICAL ECON. 143, 144 (1998) ("The presumption of income determinism hampers a fuller understanding of the factors underlying the changes in environment-income relationships and can result in naïve conclusions about the role of economic growth in reducing environmental pressure.").

[71] GOKLANY, CLEARING THE AIR, *supra* note 19, at 99-102.

eventually become cleaner. In fact, an analysis of trends in "national" composite ambient SO_2 concentrations for the 13 of the richest countries showed that although for this subset of countries there was no correlation between SO_2 levels and income, each of these countries is currently on the downhill side of the SO_2 ET and none, so far, shows a sustained upswing.[72] This example suggests that although a richer country is not necessarily cleaner than a poorer one, the richer a country, the more likely that it will ultimately be cleaner, at least until it is "clean enough."

Greater wealth and improved technology create conditions that are conducive to a cleaner environment, but they do not guarantee that. For an ET to occur there needs to be a mechanism that reliably converts society's desire for improving its quality of life by cleaning up the environment into voluntary or, failing that, involuntary action. This is more likely to occur in democratic societies, and if people are rich enough and have the technology to effect that.[73]

It has also been argued that EKCs (and ETs) might be consistent with local pollution problems, but they have not been shown to be valid for "pollutants involving long-term and more dispersed costs (such as CO_2),"[74] because the benefits and costs of control would accrue disproportionately to different populations. Indeed this is a reasonable argument, although the problem with CO_2 is not just that it is a disperse pollutant per se, rather that the global costs of controlling it, even minimally (per the Kyoto protocol, for instance), seem to outweigh its global benefits.[75] However, the ozone depletion problem offers a good example where, despite the fact that it is due to long term and disperse pollutants, there is an apparently successful global effort underway to address that problem.

Another argument that has been made is that cross-country plots of several CO_2 related emission indicators vs. affluence are not humpbacked in shape or, if they are, the transitions occur at such high levels of affluence that many developing countries will, they claim,

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[72] *Id.* at 103-04; Goklany, *The Future of Industrial Society*, *supra* note 5.

[73] *See* INDUR M. GOKLANY, CTR. FOR THE STUDY OF AM. BUS., WASHINGTON UNIV., DO WE NEED THE FEDERAL GOVERNMENT TO PROTECT AIR QUALITY? 30-31 (1998) ("Wealthier and more technologically-advanced societies (or individuals) are more likely to tip the balance toward environmental quality. And if individuals' actions cannot affect their environment sufficiently, they will attempt, in a democratic society, to persuade their political jurisdictions to take action in consonance with their perceived collective interests."); Torras & Boyce, *supra* note 70, at 149-51, 158 ("[E]fforts to achieve a more equal distribution of power, for example, via more equitable income distribution, wider literacy, and greater political liberties and civil rights, can positively affect environmental quality. The effects of these variables appear to be particularly strong in low-income countries.").

[74] Kenneth Arrow et al., *Economic Growth, Carrying Capacity, and the Environment*, 268 SCIENCE 520, 520 (1995).

[75] *See* GOKLANY, PRECAUTIONARY PRINCIPLE, *supra* note 18, at 67, 72-73; LOMBORG, *supra* note 1, at 302-05.

never reach that point.[76] There are a number of problems with this analysis. First, the perception that CO_2 is a problem that needs to be addressed did not really take hold with the general public until at least 1990, when the first report of the Intergovernmental Panel on Climate Change (IPCC) was published.[77] It is, therefore, unreasonable to expect to see transitions for CO_2 so soon after that, especially given the cost and time it takes to replace the existing energy infrastructure. Moreover, there has never been any credible showing that global warming is as important as the numerous other social, economic, and environmental problems facing humanity and the globe, including, for instance, indoor air pollution due to burning of solid fuels inside the home or sulfates outdoors, loss of habitat for agricultural needs, and water-related deaths and diseases.[78] In the few studies this question has been explicitly examined, the answer to this question seems to be in the negative, at least for the foreseeable future (50 to 100 years from now).[79] Thus, lacking a compelling rationale for placing a higher priority on global warming than on these other more urgent environmental problems, the absence of an ET for CO_2 emissions is unsurprising. Third, turnover of energy systems, although inherently slow, has been further retarded by the lack of enthusiasm for a number of non-combustion alternatives to fossil fuels (such as nuclear or hydro) even among the most vociferous institutional supporters of greenhouse gas controls. This suggests that despite their rhetoric, other environmental problems take precedence. In fact, it can be argued that unless one is willing to consider second-best solutions, the problem is probably not critical to begin with. Fourth, the above CO_2

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[76] S.M. de Bruyn et al., *Economic Growth and Emissions: Reconsidering the Empirical Basis of Environmental Kuznets Curve*, 25 ECOLOGICAL ECON. 161, 164 (1998). However, although CO_2 emissions do not indicate an ET has been reached, a number of the richer countries – the U.S., for example – show long term declines in CO_2 emissions *per GDP* since 1850. INT'L INST. FOR APPLIED SYS. ANALYSIS & WORLD ENERGY COUNCIL, GLOBAL ENERGY PERSPECTIVES 57-61 (Nebojsa Nakicenovic et al eds., 1998). CO_2 emissions per GDP, however, is a "leading," rather than a true, environmental indicator, and serves as a surrogate for technological change. GOKLANY, CLEARING THE AIR, *supra* note 19, at 2, 69-74.

[77] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC), CLIMATE CHANGE: THE IPCC SCIENTIFIC ASSESSMENT (J.T. Houghton et al. eds., 1990) (reviewing data on global warming, green house gases, the greenhouse effect, sea level changes, forcing of climate, and the Earth's climate history).

[78] Indur M. Goklany, *The Importance of Climate Change Compared to Other Global Changes*, *in* GLOBAL CLIMATE CHANGE - SCIENCE, POLICY, AND MITIGATION/ADAPTATION STRATEGIES, PROCEEDINGS OF THE SECOND INTERNATIONAL SPECIALTY CONFERENCE: WASHINGTON, D.C., OCTOBER 13-16, 1998 (Air & Waste Mgmt. Ass'n, Pittsburgh, 1999); Indur M. Goklany, *Richer is More Resilient: Dealing With Climate Change and More Urgent Environmental Problems*, *in* EARTH REPORT 2000: REVISITING THE TRUE STATE OF THE PLANET 155 (Ronald Bailey ed., 2000); Goklany, *Strategies*, *supra* note 12, at 430-31; Indur M. Goklany, *Adaptation and Climate Change*, Annual Meeting of the Am. Ass'n for the Advancement of Science, Chicago, Ill. (Feb. 6-11, 1992).

[79] GOKLANY, PRECAUTIONARY PRINCIPLE, *supra* note 18, at ch.4; LOMBORG, *supra* note 1, at 333-43; Goklany, *Strategies*, *supra* note 12, at 430-31.

analysis assumes no technological change or technology transfer which would, in time, cause environmental transitions to occur at lower levels of affluence, but the 150-year history of declining CO_2 emissions per GDP in the rich countries indicates that technological change is alive and well, even for CO_2 emissions.[80] And, as the fate of numerous Malthusian projections, e.g., the *Limits to Growth* and *The Population Bomb*, shows, ignoring technological change can make a mockery of those projections.[81]

CONCLUSION: UNDERDEVELOPMENT IS UNSUSTAINABLE

Historical evidence shows that as a society becomes wealthier and technology advances with the passage of time, it first addresses the problems it perceives to be the most critical – hunger, malnutrition, safe water, sanitation, education, and health care – before turning to those perceived to be less critical, such as air pollution, non-public health related water pollution, and solid waste. This makes sense in a world where the resources, both human and fiscal, needed to address all these myriad problems are scarce. Accordingly, we see that the critical indicators of well-being improve more or less steadily with wealth and technology,[82] and while second order problems initially become worse, then they go through a period of transition before finally improving. For these second order problems, wealth and technology make matters worse before the transition, but after the transition, wealth and technology help solve the very problems they may have helped aggravate, if not create.

Thus, the evidence neither supports the Litany of environmental horrors, nor does it support at least two of the three basic tenets on which the Litany rests, namely, that advances in economic development and technology diminish human and environmental well-being. Wealth and technology are, in fact, integral parts of the Cycle of Progress, which provides the means for improving well-being in all its dimensions, both for humanity and the rest of nature.

But advances in wealth and technology are not inevitable. To help ensure that the Cycle of Progress keeps moving forward, it is important to bolster the institutions and processes that fuel the Cycle. These include: free markets; secure property rights; honest, predictable, transparent, and fiscally responsible governments and bureaucracies; adherence to the rule of law; competition in the commercial, scientific, intellectual, and political spheres; trade in ideas, goods, and

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80 *See* Goklany, *Factors Affecting Environmental Impacts*, *supra* note 56, at 498, tbl.1, 500; sources cited *supra* note 75.

81 *See* LOMBORG, *supra* note 1, at 29-30, 60-64; Goklany, *Factors Affecting Environmental Impacts*, *supra* note 56, at 501.

82 *But see supra* note 59 and accompanying text.

services; and rules and laws to encourage entities that risk their intellectual capital, manual labor, and fiscal resources to profit from the risks they incur.

Nor are advances in technology and wealth panaceas. Nevertheless, global experience from the past several decades shows that human and environmental well-being are more likely to be advanced by wealth and technology than without them. This is amply illustrated by the present situation in Sub-Saharan Africa. Because of the lack of the one (wealth), it is unable to afford the other (technology) – AIDS therapies being cases in point.[83] Hence, despite the progress in much of the rest of the world, Sub-Saharan Africa has fallen back in the past decade. Exacerbating this deteriorating situation is the well-intentioned, environmentally-inspired technophobia that, by limiting the use of DDT, has allowed malaria to rebound.[84] Similarly, the world is now confronted with the bizarre situation where on grounds of precaution (no less!), Zambia seems recklessly bent on rejecting genetically modified (GM) crops even as it stands on the threshold of famine.[85] The problem isn't – as *The New York Times* declared in an editorial, "Sustaining the Planet," published on the eve of the 2002 Johannesburg World Summit on Sustainable Development – "that current patterns of *development* are unsustainable," rather it is that underdevelopment is even more unsustainable.

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[83] *See supra* note 33 and accompanying text.

[84] GOKLANY, PRECAUTIONARY PRINCIPLE, *supra* note 18, at 15-18, 22; Goklany, *Globalization of Human Well-Being*, *supra* note 20, at 11-12.

[85] Zambian President Levy Mwanawasa is quoted as having said, "There is a worldwide uncertainty on the use of GMOs in food, we are merely taking precautionary measures and remain open to conclusive scientific evidence that GMOs are indeed safe." Johannesburg World Summit Co., News, *Zambia Will Not Expose People to 'Poisonous' GM Foods* (Mar. 9, 2002) *at* http://www.josummit.com/news/fullstory.sps?iNewsid=21067. For a different take on how a precautionary approach might be applied to GM crops, see GOKLANY, PRECAUTIONARY PRINCIPLE, *supra* note 18, at 8-11, ch.3.