It's a Material World: Trends in Material Extraction in China, India, Indonesia, and Japan

Richard York, Christina Ergas, Eugene A. Rosa, and Thomas Dietz

ABSTRACT
We examine trends since 1980 in material extraction in China, India, Indonesia, and Japan—which together contain over 40% of the world's population—to assess the environmental consequences of modernization. Economic and population growth has driven rapid expansion of material extraction in China, India, and Indonesia since 1980. China and India exhibit patterns consistent with the Jevons paradox, where the economic intensity of extraction (extraction/GDP) has steadily declined while total extraction grew. In Indonesia, extraction intensity grew along with total extraction. In Japan, total extraction remained roughly constant, increasing somewhat in the 1980s and then slowly declining after 1990, while extraction intensity declined throughout the entire period. These different patterns can be understood to some degree by drawing on political-economic and world-systems perspectives. Japan is an affluent, core nation that can afford to import materials from other nations, thereby avoiding escalation of material extraction within its borders. China and India are rapidly industrializing nations that, although increasingly drawing on resources from beyond their borders, still rely on their own natural resources for growth. Indonesia, an extraction economy with less global power than the other nations examined here, exports its own natural resources, often unprocessed, to spur economic growth. The trends highlighted here suggest that in order to avert environmental crisis, alternative forms of development, which do not involve traditional economic growth, may need to be adopted by nations around the world.

KEYWORDS
material extraction, modernization, Jevons paradox, world-systems, Asian development

Introduction

The ecological fate of the world may be largely determined by what happens in Asia over the coming decades. In particular, China, India,

doi:10.3167/nc.2011.060201

Indonesia, and Japan—the first, second, fourth, and seventh most populous nations in the world respectively, together containing over 42% of the world's population—have an extraordinary influence on the global environment. In the case of the first three of these nations, this influence is growing rapidly. China has come to exceed even the United States in total annual carbon dioxide emissions, and its appetite for natural resources of all types has expanded at a startling pace (Cyranoski 2007; Liu and Diamond 2005, 2008). India, with a population of well over a billion people, and Indonesia, with a population over 230 million, seem poised to follow China and become major consumers of the world's resources. Although Japan recently has received less attention than the emerging economies of Asia, with the second largest economy in the world it continues to be a major resource consumer. Important lessons can be learned from an examination of recent trends in natural resource exploitation in all four of these nations, along with the economic and demographic changes associated with these trends.

Here, we focus on trends in material extraction in these nations in order to further our understanding of the environmental consequences of development. In particular, we aim to describe these trends and offer some explanation of them drawing on political-economic theory. To contextualize our assessment, we start with a discussion of theoretical issues relating to development, technology, and the structure of the modern world-system. We then present an empirical assessment of material extraction trends in China, India, Indonesia, and Japan, drawing on the theoretical concepts we introduce to interpret and explain these trends.

The Structure of the World-System and the Dark Side of Efficiency

World-system analysts understand the modern world-system in a variety of ways, recognizing the subtle and complex fashion in which a bloc of powerful nations controls economic, political, and social relations around the world to a large extent (Chase-Dunn and Babones 2006; Wallerstein 1997, 2004). One conceptualization postulates that all nations in the world are hierarchically organized in a single global economy that includes core, semi-peripheral, and peripheral nations. Wealthy nations, including the United States, Japan, and western European nations, make up the core and are the primary consumers of natural resources. Peripheral nations, such as Afghanistan and Bangladesh, are poor countries with little economic diversification, are often dependent on extracting and exporting raw materials, such as timber and minerals, to the core and semi-periphery, and have high levels of inequality. The upper-strata nations use the raw materials for the production of high value commodities consumed mostly in the core nations. Semi-peripheral nations, including China and India, are intermediary between core and periphery: they are countries in the process of rapid industrialization with pollution-intensive industries, diversifying their economies while reducing their dependency on the export of raw materials to the core. As a result they have some power relative to peripheral nations but are, nevertheless, still subject to the economic needs of the core (Chase-Dunn 2000; Frey 1998, 2003; Roberts et al. 2003; York, Rosa, and Dietz 2003; Roberts and Parks 2007).

Of course, world-system analysts recognize that this conceptualization of a tripartite structure of the world systems is a rough categorization imposed on a more complex world, and that there are not necessarily clear cut boundaries among nations. For example, there is some disagreement among world-system analysts over which nations to include in the semi-peripheral category. Wallerstein (1997) lists 35, while Chase-Dunn, Kawano, and Brewer (2000) list 13. Counter to many others, Arrighi (2009) considers China a core, rather than a semi-peripheral, nation. Obviously, the division of nations among these three tiers depends on the particular criteria of interest to various analysts, and does not reflect a simple one-dimensional objective reality. Thus, thinking in terms of core, semi-periphery, and periphery can be a useful analytic approach, but should not be seen as an effort to definitively classify the complexity of the world.

Additionally, world-system processes are not necessarily strictly captured by cross-national differences, but include intra-national and supra-national phenomena. In particular, it is generally recognized that it is not simply the case that a few powerful nations dominate the globe, but that also large multinational corporations and a capitalist elite, generally, but not necessarily, centered in core nations, exert considerable influence over the global economy, including what goods are manufactured where. Thus, from this conceptual perspective, the "core" is not comprised of nations per se, but rather a handful of powerful, elite actors spread around the world. Nonetheless, thinking in terms of nations divided among the core, periphery, and semi-periphery is useful for helping us to understand global processes now unfolding.

Hence, we follow this conceptualization here, while recognizing that it only roughly captures the nature of some world-system processes and misses others.

World-system analysts have advanced the argument that economic production is the predominant driver of environmental degradation (Bunker 1984; Jorgenson and Clark 2009). Whereas modernization theorists (e.g., Grossman and Krueger 1995; Mol 2001) argue that as nations "develop" and technologically "advance," they reduce environmental impacts due to increases in the efficiency of resource use, world-system researchers contend that most environmental improvements that occur within a nation as it modernizes are typically due to shifting environmental impacts beyond its borders. Rather than engaging in genuine environmental reforms, nations that modernize often do so by importing natural resources and exporting pollution. A nation's historical integration into and position in the world-system affect the types of goods it produces and the stages of economic throughput in which it engages with respect to the material flow from raw resources to manufacturing of commodities to waste (Frey 2003). A global economy comprises a kind of division of labor among nations. Core nations have disproportionate access to natural resources due to relationships of unequal exchange, a legacy of colonialism and neo-colonialism (Jorgenson and Clark 2009). In addition, core nations increasingly export hazardous waste to nations in the lower strata (the periphery and semi-periphery), moving environmental problems away from the affluent societies that are most responsible for generating them (Frey 2003). Due to their minimal power in the world-system, peripheral nations tend to extract raw materials and export these resources to semi-peripheral and core nations that, in turn, create and consume higher valued commodities. Consequently, peripheral nations send resources abroad, rather than using them internally to further develop their own societies (Bunker 1984).

Modernization theorists tend to analyze the environmental degradation that occurs *within* a nation as it develops economically. This analytic practice leads researchers to focus on impacts only within a nation's borders, rather than looking at impacts that occur elsewhere due to that nation's consumption. The assumption that environmental degradation is geographically confined within the boundaries of the nation responsible for production and/or consumption is known as the "Netherlands fallacy" (Ehrlich and Holdren 1971). This is in reference to the observation that while the Netherlands is known for its internal decline in overall environmental impacts, it imports most of its natural resources, so the environmental impacts it causes occur in other (typically peripheral and semi-peripheral) nations. The Netherlands fallacy of consumption with remote impacts exemplifies a practice among affluent nations in general. Thus, developed, core nations may see a decline in local environmental impacts, but do so because of an increase in impacts in the lower strata of the world-system.

Counter to world-system researchers, a variety of scholars argue that the modernization project, particularly the advance of technological development and reform of social institutions, can, will, and, indeed, are leading to ecological improvements and the dematerialization of economies around the world (Grossman and Krueger 1995; Mol 2001; Mol and Sonnenfeld 2000). It has become common to point to the improving resource efficiency of economies—i.e., the amount of materials or energy consumed per unit of GDP—as a sign of ecological reform in modern societies (Andersen 2002; Ausubel 1996; Hawken, Lovins, and Lovins 1999). Fan et al. (2007), for example, suggest that the decline in the carbon intensity (i.e., increase in carbon efficiency) of China's economy in recent decades is a sign of progress on environmental reform. However, as York, Rosa, and Dietz (2009) point out, this focus on improving efficiency is misplaced, since it is the *absolute* quantity of natural resources extracted from the environment and pollution emitted into the environment that matter from an ecological perspective, not how much money is generated per unit of extraction or pollution. An important question, then, with regards to the environment, is not simply whether economies are dematerializing relative to GDP, but whether they are dematerializing in an absolute sense.

Proponents of technological development have long assumed, as they do now, that improving the resource efficiency of production naturally leads to resource conservation. This assumption is amnesic to history. William Stanley Jevons, a pioneer ecological economist, made a significant observation that proponents of technological development virtually ignore. England's industrial revolution in the nineteenth century was fueled by coal—in large quantities. Jevons noted that while technological advancement increased coal use efficiency (i.e., less coal was used per unit of goods produced), this increase in efficiency paradoxically correlated with an increase in overall coal consumption rather than a decrease.

Jevons observed a string of events that occurred when production became more efficient. Increases in efficiency made coal dependent technologies more attractive to producers, since the higher the efficiency, the lower the cost per unit of production. In addition, the profits gained by lowering the costs of production were often reinvested, further increasing the scale of production. The lower costs that came with increasing efficiency also made goods affordable to more people, and latent demand increased commodity consumption. Thus, improvements in efficiency often led to an overall increase of resource consumption because the scale of production increased more rapidly than efficiency improved. This phenomenon is known as the Jevons paradox, or the paradox of dematerialization (Alcott 2005; Clark and Foster 2001, Jevons 2001, Polimeni et al. 2008). A body of empirical research has shown that the Jevons paradox is a common phenomenon at the national level, where declining ecological intensity (i.e., rising efficiency) of the economy (resources or energy consumed per unit of economic output) is associated with rising total resource or energy consumption (York 2006, 2010a, 2010b; York et al. 2003, 2004, 2009). Therefore, one important focus in our assessment of material extraction trends is the change in the resource intensity/efficiency of economies relative to total resource extraction.

The Global Shift in Material Extraction

For our analysis, we examine the material and energy throughputs of the economic system. We measure material flows by using data on total material extraction measured by mass, which includes biomass, minerals (metals and industrial and construction minerals), and fossil fuels, for 1980-2006. The mass of total material extraction is a good indicator of anthropogenic environmental impact, since it provides a straightforward indicator of the extent to which humans alter the physical environment. Note that this is a measure of activity *within* the country and thus does not take account of environmental disruption driven by a country that takes place outside its borders. It also, of course, does not take into account the qualitative differences across different types of materials with respect to their impacts on the environment. However, by measuring the mass of materials extracted, it allows for a combination of many different types of impacts on the environment into a single measure with a minimum of assumptions regarding how these should be combined.

The data we use were downloaded from www.materialflows.net, which is maintained by the Sustainable Europe Research Institute (SERI). SERI compiles data on material extraction drawing on multiple sources, and the method of calculation is explained in SERI (2008). We focus on the total material extraction measure, which includes both used and unused (e.g., overburden from mining activities or residuals of biomass extraction) materials, since it includes the broadest measure of human influence on the environment.[1]

A comparison of major regions of the world shows that it is among semi-peripheral nations where rates of growth in material extraction are highest (SERI 2008). These trends in material extraction illustrate major global shifts currently in motion, where the large industrializing nations of Asia have an increasingly dominant effect on the global environment. As shown in Table 1, while material extraction in the world as a whole increased 65% between 1980 and 2006, material extraction in China, India, and Indonesia increased at the astounding rates of 252%, 217%, and 353% respectively. Due to these rapid rates of growth relative to the worldwide average, India nearly doubled and China and Indonesia more than doubled their shares of the world's total material extraction between 1980 and 2006 (see Table 2). In contrast, the two largest economies in the world, the United States and Japan, increased their material extraction only 35% and 5% respectively, both below the worldwide rate of 65%. Therefore, the United States' and Japan's shares of the world's total material extraction declined between 1980 and 2006. Clearly, the literal weight of the global system of extraction has shifted.

The reasons behind the rise in material extraction in China, India, and Indonesia are predominantly economic and demographic. As a substantial body of empirical research has shown, population and affluence are the key driving forces behind a considerable variety of environ-

Table 1 ■ Change in population, GDP per capita, and material extraction in China, India, Indonesia, Japan, the United States, and the world, 1980–2006.

	Population	*GDP per capita*	*Material extraction*
China	+32.39%	+624.74%	+252.15%
India	+67.25%	+174.08%	+217.12%
Indonesia	+51.46%	+146.12%	+352.76%
Japan	+9.54%	+66.76%	+5.42%
United States	+31.15%	+69.67%	+35.15%
World	+48.86%	+41.21%	+65.38%

Table 2 ■ Population, GDP (in constant US$), and material extraction in China, India, Indonesia, Japan, and the United States presented as percentage of world total, 1980 and 2006.

	Population (% of world total)		*GDP (% of world total)*		*Material extraction (% of world total)*	
	1980	*2006*	*1980*	*2006*	*1980*	*2006*
China	22.24	19.81	1.34	6.11	5.89	12.53
India	15.53	17.47	0.85	1.86	2.75	5.27
Indonesia	3.41	3.47	0.33	0.58	1.13	3.10
Japan	2.63	1.94	15.51	13.47	2.33	1.48
United States	5.21	4.59	28.48	30.12	22.21	18.15

mental problems (Rosa, York, and Dietz 2004; York 2007, 2010a, 2010b; York, Rosa, and Dietz 2003, 2009). The population growth that occurred in the nations we examine here (see Table 1) clearly played an important role in escalating material extraction. However, China, India, and Indonesia collectively had approximately the same share of the global population in 2006 as they had in 1980 (see Table 2), so, while population growth helps explain the *absolute* rise in material extraction in these nations, it does not explain the dramatic shift in the *share* of global material extraction occurring in these nations. This shift is explained to a large extent by their very rapid economic growth—the affluence factor. While the GDP per capita in the world as a whole grew 41% from 1980 to 2006, in Indonesia and India it grew 146% and 174% respectively. In China it grew a whopping 625% (see Table 1). This growth led China to more than quadruple its share of world GDP and India and Indonesia to each approximately double their shares, while Japan's share declined modestly and the United States' increased modestly (see Table 2).

Material Flows and Efficiency in the World-System

As for material extraction, China and India both exhibit clear examples of the Jevons paradox. The economies of both nations from 1980 to 2006 dematerialized to a substantial degree in the sense that the material intensity of both economies (materials per unit of GDP) declined sharply (see Figures 1 and 2). However, the total materials

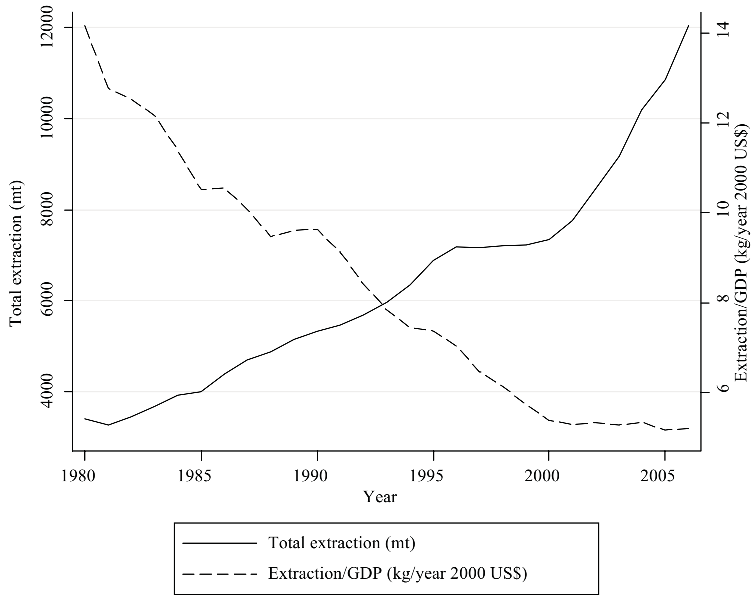

Figure 1 ■ China's total material extraction and extraction intensity (extraction/GDP), 1980–2006.

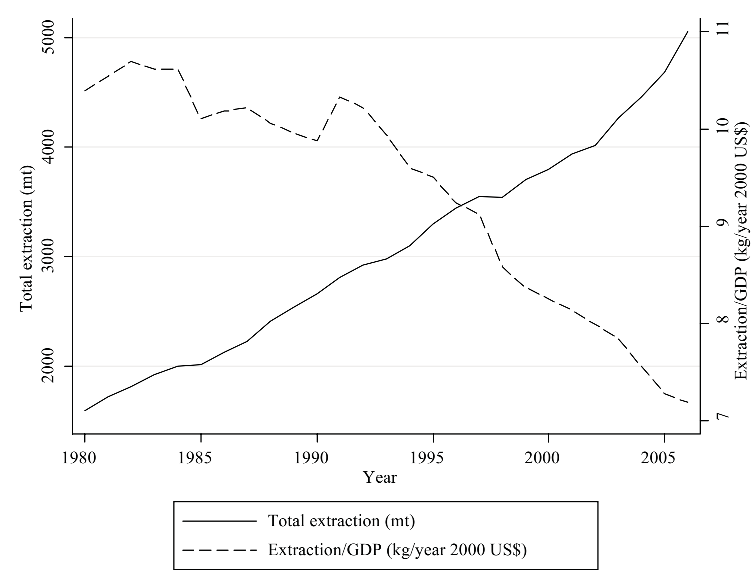

Figure 2 ■ India's total material extraction and extraction intensity (extraction/GDP), 1980–2006.

extracted rose more than three-fold in each nation over this same period, meaning that in an absolute sense, the economies of these nations hyper-materialized, the opposite of dematerializing. Clearly, declining economic material intensity (i.e., rising economic material efficiency) does not necessarily lead to an absolute decline in material extraction, even within a nation's borders. Indonesia exhibited a quite different pattern, where, after a decline in material intensity in the early 1980s, the material intensity of its economy rose steadily along with its total material extraction (see Figure 3). In Japan, while the material intensity of its economy declined steadily throughout this period, its total material extraction increased throughout the 1980s, and then declined slowly afterwards (see Figure 4). However, the changes in both total extraction and material intensity in Japan are quite modest compared to those in the other three nations examined here.

Japan's break from the pattern of the Jevons paradox is likely due to its relatively slow growth over the past two decades and to the structure of the world-system, in which Japan developed its economy without relying primarily on its own natural resources. The fact that Indonesia does not exhibit the Jevons paradox pattern is probably due to its more peripheral position in the global economy, where material intensification during the early stages of development is not uncom-

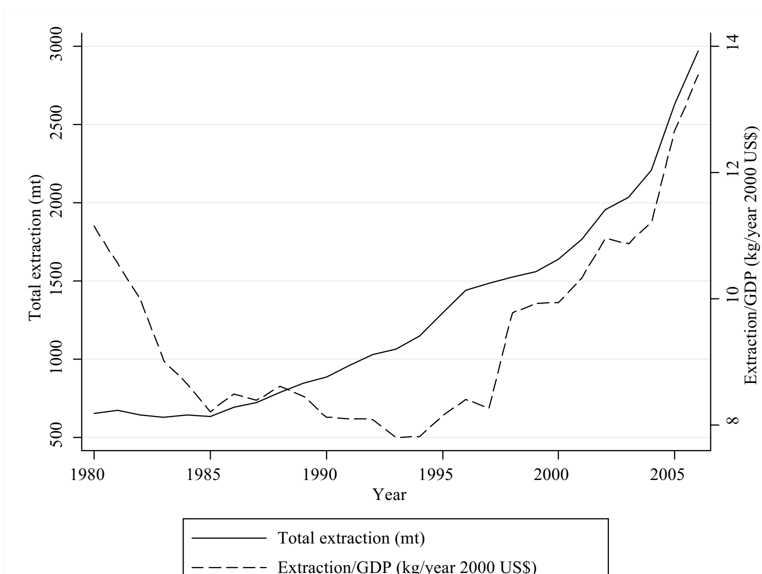

Figure 3 ■ Indonesia's total material extraction and extraction intensity (extraction/GDP), 1980–2006.

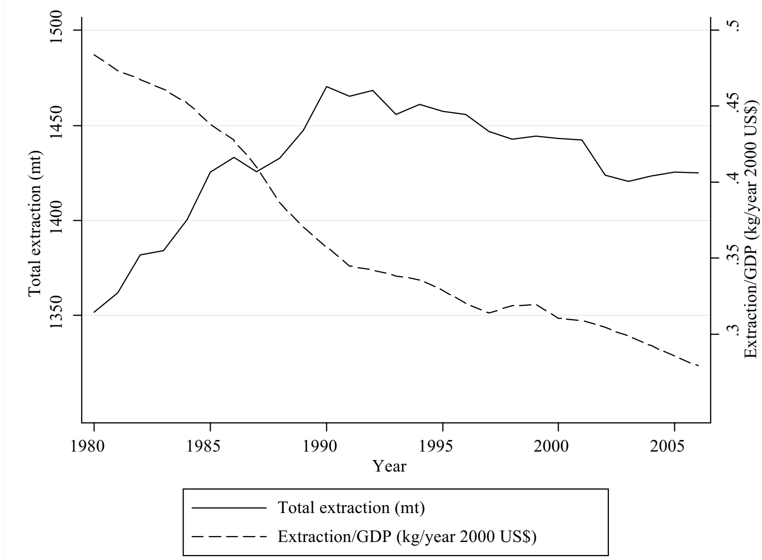

Figure 4 ■ Japan's total material extraction and extraction intensity (extraction/GDP), 1980–2006.

mon. For example, Roberts, Grimes, and Manale (2003) note that the carbon intensity of economies typically rises in the early stages of development but levels off and declines in the later stages. This occurs because once they become affluent, nations shift their economies away from dirty industries (which are often moved to poorer nations) and because they have disproportionate access to the cleanest technologies often not readily available to low-income nations.

Although the growth in material extraction in the large industrializing nations of Asia is remarkable, it is equally remarkable that, despite this extraordinary growth, China's, India's, and Indonesia's shares of global material extraction remain below each of their shares of the global population (see Table 2). In other words, these nations have levels of per capita material extraction below the world average. For example, India in 2006 had 17% of the world population, but only accounted for 5% of material extraction (see Table 2). In contrast, the United States had less than 5% of the world population but accounted for over 18% of material extraction (see Table 2).

The per capita material extraction for China, India, Indonesia, and Japan from 1980 to 2006 is presented in Figure 5. India's per capita extraction almost doubled over this period, reaching 4.39 tonnes in 2006. China's per capita extraction rose steadily, accelerating around

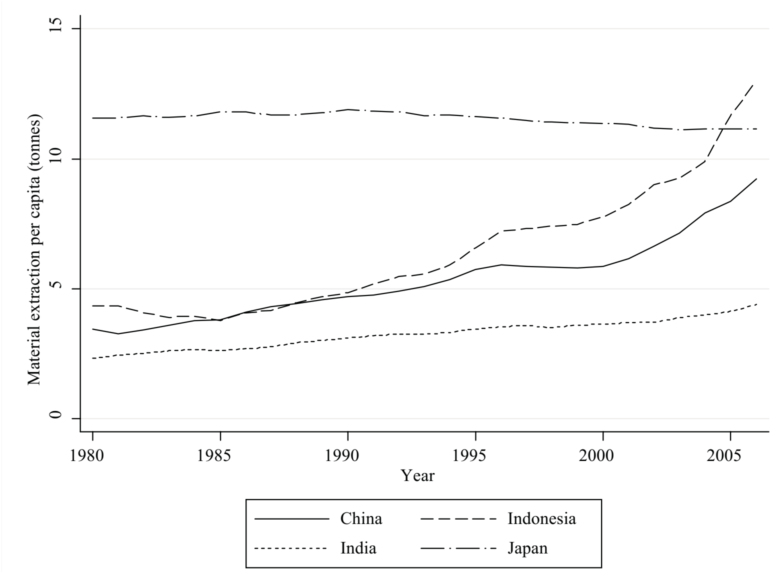

Figure 5 ■ Per capita material extraction for China, India, Indonesia, and Japan, 1980–2006.

the year 2000, reaching over 9 tonnes by 2006. Indonesia exhibited the sharpest rise, with per capita extraction reaching 13 tonnes per capita in 2006, triple the level in 1980. In contrast, throughout this period, Japan's per capita extraction remained roughly constant at slightly over 11 tonnes annually. Even given the rapid growth in extraction in China, India, and Indonesia and the high level of affluence in Japan, the per capita levels of material extraction in each of these nations was below the worldwide average of 14.54 tonnes in 2006 (up from 13.09 tonnes in 1980), and well below that of the United States, with 57.49 tonnes in 2006 (up from 55.79 tonnes in 1980).

Insights from the world-system perspective help explain why Japan's resource extraction is so low and Indonesia's is so high. As we have already noted, the site of extraction is not the same as the site of consumption. Japan's resource extraction is low because it is the regional hegemon, maintaining control via trade of resource flows in the region. Much like the Netherlands, Japan can protect its own environment by using resources from other nations. In contrast, Indonesia has become an extraction center, much like the Brazilian Amazon has been, as detailed by Bunker (1984), due to its relatively weak position in the global economy. Indonesia supplies resources to other countries, even as its internal consumption remains fairly low.

The Future is Open

The hierarchical structure of the world system, as with any systemic structure, seems a durable entity that may be expected to persist into the foreseeable future. Recurrent patterns over the past five thousand years can be read to suggest that, not only capitalism, but perhaps civilization itself, as embodied in states with centralized power, is unsustainable (Chew 2001, 2007). The various world-systems that have emerged throughout history have shared some common dynamics that, much like the modern capitalist system, generate and perpetuate inequality and ecological destruction (Chew 2001, 2007). Thus, the environmental crises facing the world today have deep roots and autocatalytic processes. Hence, we cannot be excessively sanguine about the potential to alter such long-established trajectories.

Nonetheless, contingency reigns throughout history, and all historical moments contain the potential for change. While we should temper any optimism about a global restructuring in the short run, we should not assume that we are locked into the current global power structure that drives the exploitation of people and environments around the world. Although durable, this structure is not ossified. The modern world-system embeds dynamic elements that can lead to modifications in that structure. A central location of that dynamic is among the semi-peripheral nations, especially the countries of Asia with large populations, where the manner in which they "develop" over the coming century will have profound global implications. These nations have a variety of pathways to follow, and we should not assume that any one of them sets the future. Here we examined the historical trends of the three Asian nations with the largest populations—China, India, and Indonesia—and the most affluent Asian nation, Japan, to not only understand how the present patterns emerged, but also to highlight the importance of where these nations go from here.

Viewing recent trends in these nations from an ecological point of view leads to an unassailable point; the economic and population growth occurring in the developing economies of Asia and their key role in driving the remarkable increase in material extraction (and other attendant environmental impacts) is alarming. China, India, and Indonesia each have more than tripled their rate of material extraction since 1980, and, particularly in the case of China, the overall environmental impact of each of these nations is approaching that of affluent nations in the core. It is difficult to imagine that the ecosystems of the world can long sustain the rapid expansion of environmental exploitation now underway. If we are to maintain the ecological integrity of the planet, it appears clear that the nations of the world will need to take a different path than the one on which they now find themselves. We suggest that an alternative path is possible, one that allows for both reducing human impact on the global environment and for improving human quality of life. However, this path represents a dramatic break from how "development" is currently conceived.

As our results demonstrate here, the traditional modernization notion that technological "advances" will solve our environmental problems by improving the efficiency with which resources are used seems terribly misguided. In both China and India, the material intensity of the economy declined dramatically since 1980, while total material extraction increased rapidly. Clearly, as William Stanley Jevons noted a century-and-a-half ago, improvements in efficiency do not necessarily lead to an absolute decline in resource consumption, and, in fact, quite often lead to an escalation. The route modernization theorists point to is clearly a path that seriously endangers global sustainability.

Fortunately, however, the traditional conception of modernization is not the sole theoretical frame for nations seeking to improve their citizens' standard of living. Reconceptualizing "development" as improving human quality of life, rather than as expanding the scale of economic production, opens up a new direction for societies that is not as ecologically destructive as "modernization." We would like to stress an important point: there is *not* a strong connection between economic development in a nation, as measured by GDP per capita, and measures of subjective well-being of the populous, particularly once nations are out of absolute poverty (Leiserowitz et al. 2005). This observation points to the fact that relentlessly pursuing economic growth is not an effective strategy for improving people's lives as they experience them. Likewise, high levels of resource consumption do not appear to be associated with high levels of human well-being, variously measured. For example, in a classic study, Mazur and Rosa (1974) found that higher levels of energy consumption did not correspond with a variety of indicators of quality of life. Likewise, Rosa (1997) found that high levels of carbon dioxide emissions were not associated with high levels of societal well-being. More recent research found that there is no direct connection between environmental impacts and human well-being as measured by education and life expectancy (Dietz, Rosa, and York 2007; Knight and Rosa 2009), and that measures of well-being are decoupling from GDP in general (Brady et al. 2007).

Some scholars suggest that a better way to evaluate sustainable development is by assessing the degree to which nations maximize the well-being of their citizens relative to the impact they have on the environment (Dietz, Rosa, and York 2009; Knight and Rosa 2010). Nations that produce high levels of well-being with relatively low levels of environmental impact can be seen as successfully moving toward sustainable development. The New Economics Foundation (NEF) developed the Happy Planet Index (HPI) as a useful alternative to taking GDP as the principal or sole measure of well-being. The HPI uses "happy life years"—a combination of life satisfaction levels reported by individuals and life expectancy—as a measure of human well-being and divides this by the per capita ecological footprint of a nation, a measure of the demands placed on the environment. The nations that score the highest on the HPI, most of which are in Latin America, with Costa Rica having the highest HPI in the world, have relatively long life expectancies and high reported levels of happiness while having relatively low ecological footprints per capita. Both China and India saw their scores on the HPI decline between 1990 and 2005, as their happy life years declined while their footprints rose (particularly in the case of China) (NEF 2009: 34–35).[2] Clearly, the process of development currently underway in the most populous nations in the world is not an ecologically sustainable one, nor is it one that is proving itself to be especially effective at improving people's lives. We concur with the conclusions of the NEF (2009) and suggest that the best way out of our ecological crisis is to focus on improving human well-being rather than focusing on endlessly expanding the scale of economic production and consumption.

We also note that, just as shifting away from development based on economic growth (and the high levels of consumption that accompany affluence) does not require abandoning the goal of improving human well-being (and in fact may serve to enhance it), curtailing population growth does not require socially detrimental actions. To the contrary, the goal of curtailing population growth is consistent with a program to improve quality of life, since the most effective ways to reduce fertility rates include improving women's status and education, reducing infant mortality, eliminating absolute poverty, and providing all people with access to safe, effective, and affordable birth control (Cohen 1995). Therefore, what is necessary to protect the global environment—the curbing of economic growth and the reduction of fertility rates—fits well with an agenda aimed at *improving* human well-being.

It is important to recognize that, despite the rise of resource extraction in the developing economies of Asia, it is generally still the affluent nations of the world, particularly the United States, that have the largest impacts on global ecosystems. It is important not to lose sight of the fact that the scale of material extraction in the United States, both in absolute and per capita terms, is considerably greater than in any of the four nations we examine here. This is also true in terms of ecological footprints (York, Rosa, and Dietz 2009). In fact, the United States scores very poorly on the HPI, ranking 114th out of 143 nations, whereas Indonesia, China, India, and Japan rank 16th, 20th, 35th, and 75th respectively. This is due to the fact that the United States has a very high per capita footprint, while not enjoying a particularly long life expectancy or reported life satisfaction compared to other affluent nations—or even compared to many poorer nations (such as Costa Rica). Thus, if we are to overcome the global ecological crisis, it is not only necessary that the dramatic rise in resource consumption in developing nations be curtailed, it is essential that affluent nations drastically scale back their impact on the environment as part of a move toward global equity. Achieving sustainability on the global scale will require a convergence across nations on a lifestyle that does not rely on high levels of consumption to bring about human well-being.

Richard York is Associate Professor of Sociology and Environmental Studies at the University of Oregon and co-editor of the journal *Organization & Environment.* He has twice won the Outstanding Publication Award from the Environment and Technology Section of the *American Sociological Association*. His most recent book is *The Science and Humanism of Stephen Jay Gould* (with Brett Clark, Monthly Review Press, 2011). Address: Department of Sociology, University of Oregon, Eugene, OR 97403-1291, USA. E-mail: rfyork@uoregon.edu.

Christina Ergas is a doctoral student in the Sociology Department at the University of Oregon. Her research interests include the environment, gender, and social movements. Address: Department of Sociology, University of Oregon, Eugene, OR 97403-1291, USA.

Eugene (Gene) Rosa is the Edward R. Meyer Distinguished Professor of Natural Resource and Environmental Policy and Professor of Sociology at Washington State University, Visiting Scholar at the Woods Institute for the Environment at Stanford University, and founding member of the STIRPAT research program. He is currently on the American Sociological Association

Task Force on Climate Change and has work in process on the drivers of climate change. His other current research interests are on global environmental change, including climate change, on grand environmental and other risks, such as nuclear waste, and on science policy. With Ortwin Renn and Aaron McCright he has a book in preparation on *Risk Theory and Governance*. At Stanford he is a member of the executive team of the MAHB, the *Millennium Assessment of Human Behavior*, an initiative to galvanize the social sciences and humanities around the challenges of environmental sustainability. Address: Department of Sociology, Washington State University, Pullman, WA 99164-4020, USA.

Thomas Dietz is a Professor of Sociology and Environmental Science and Policy and Assistant Vice President for Environmental Research at Michigan State University. He holds a Ph.D. in Ecology from the University of California, Davis, and a Bachelor of General Studies from Kent State University. He has co-authored or co-edited eleven books and more than 100 papers and book chapters. His current research examines the human driving forces of environmental change, environmental values, and the interplay between science and democracy in environmental issues. Address: Department of Sociology and Environmental Science and Policy Program, Michigan State University, East Lansing, MI 48824, USA.

Notes

1. SERI (2008) notes that the data for unused materials are less reliable than those for used materials. We chose to use the combined values (i.e., total material extraction) nonetheless, since 1) total extraction takes into account the full range of anthropogenic impact on the environment, which would be missed by focusing on used materials alone and 2) total material extraction and used material extraction are very highly correlated, so the substantive conclusions we research are not appreciably affected by which measure is examined. The data on population and GDP that we use come from the SERI dataset, which originate from FAO and World Bank sources. Values for all factors for the world as a whole are based on summing the values for all nations in the dataset.

2. Japan saw its HPI increase slightly over this period. Although its ecological footprint per capita increased, its happy life years increased as well, giving it a net gain on the HPI. Indonesia's 1990 score on the HPI was not reported.

References

Alcott, Blake. 2005. "Jevons' Paradox." *Ecological Economics* 54 (1): 9–21.

Andersen, Mikael Skou. 2002. "Ecological Modernization or Subversion? The Effects of Europeanization on Eastern Europe." *American Behavioral Scientist* 45 (9): 1394–1416.

Arrighi, Giovanni. 2009. *Adam Smith in Beijing: Lineages of the Twenty-First Century.* London: Verso.

Ausubel, Jesse H. 1996. "Can Technology Spare the Earth?" *American Scientist* 84: 166–178.

Brady, David, Yunus Kaya, and Jason Beckfield. 2007. "Reassessing the Effects of Economic Growth on Well-being in Less-Developed Countries, 1980–2003." *Studies in Comparative International Development* 42: 1–35.

Bunker, Stephen G. 1984. "Modes of Extraction, Unequal Exchange and the Progressive Underdevelopment of an Extreme Periphery: The Brazilian Amazon, 1600–1980." *American Journal of Sociology* 89 (5): 1017–1064.

Bunker, Stephen G. 1996. "Raw Material and the Global Economy: Oversights and Distortions in Industrial Ecology." *Society and Natural Resources* 9: 419–429.

Chase-Dunn, Christopher, Yukio Kawano, and Benjamin Brewer. 2000. "Trade Globalization Since 1795: Waves of Integration in the World System." *American Sociological Review* 65: 77–95.

Chase-Dunn, Christopher, and Salvatore J. Babones. 2006. *Global Social Change: Comparative and Historical Perspectives.* Baltimore: Johns Hopkins University Press.

Chew, Sing C. 2001. *World Ecological Degradation: Accumulation, Urbanization, and Deforestation 3000 B.C. – A.D. 2000.* Walnut Creek, CA: Altamira.

Chew, Sing C. 2007. *The Recurring Dark Ages: Ecological Stress, Climate Changes, and System Transformation.* Lanham, MD: Altamira.

Clark, Brett, and John Bellamy Foster. 2001. "William Stanley Jevons and the Coal Question: An Introduction to Jevons's 'Of the Economy of Fuel.'" *Organization & Environment* 14(1): 93–98.

Cohen, Joel E. 1995. *How Many People Can the Earth Support?* New York: Norton & Co.

Cyranoski, David. 2007. "China Struggles to Square Growth and Emissions." *Nature* 446: 954–955.

Dietz, Thomas, Eugene A. Rosa, and Richard York. 2007. "Driving the Human Ecological Footprint." *Frontiers in Ecology and the Environment* 5(1): 13–18.

Dietz, Thomas, Eugene A. Rosa, and Richard York. 2009. "Environmentally Efficient Well-Being: Rethinking Sustainability as the Relationship Between Human Well-Being and Environmental Impacts." *Human Ecology Review* 16(1): 114–123.

Ehrlich, Paul, and John Holdren. 1971. "Impact of Population Growth." *Science* 171: 1212–1217.

Fan, Ying, Lan-Cui Liu, Gang Wu, Hsien-Tang Tsai, and Yi-Ming Wei. 2007. "Changes in Carbon Intensity in China: Empirical Findings from 1980–2003." *Ecological Economics* 62 (3–4): 683–691.

Frey, R. Scott. 1998. "The Export of Hazardous Industries to the Peripheral Zones of the World-System." *Journal of Developing Societies* 14(1): 66–81.

Frey, R. Scott. 2003. "The Transfer of Core-Based Hazardous Production Processes to the Export Processing Zones of the Periphery: The Maquiladora Centers of Northern Mexico." *Journal of World-Systems Research* 9 (2): 317–354.

Grossman, Gene, and Alan Krueger. 1995. "Economic Growth and the Environment." *Quarterly Journal of Economics* 110 (2): 353–377.

Hawken, Paul, Amory Lovins, and L. Hunter Lovins. 1999. *Natural Capitalism: Creating the Next Industrial Revolution.* New York: Little, Brown and Company.

Jevons, William Stanley. 2001 [1865]. "Of the Economy of Fuel." *Organization & Environment* 14 (1): 99–104.

Jorgenson, Andrew K., and Brett Clark. 2009. "The Economy, Military, and Ecologically Unequal Relationships in Comparative Perspective: A Panel Study of the Ecological Footprints of Nations, 1975–2000." *Social Problems* 56 (4): 621–646.

Knight, Kyle W., and Eugene A. Rosa. 2009. "The Environmental Cost of Life Satisfaction." Paper presented at the SCORAI (Sustainable Consumption Research and Action Network) workshop, Clark University, Worcester, MA, 16 October.

Knight, Kyle W., and Eugene A. Rosa. 2010. "Sustainability and Human Well-Being: Explaining Cross-National Variation in the Environmental Efficiency of Well-Being." Paper resented at the annual meeting of the Pacific Sociological Association, Oakland, California, April 9.

Leiserowitz, Anthony A., Robert W. Kates, and Thomas M. Parris. 2005. "Do Global Attitudes and Behaviors Support Sustainable Development?" *Environment* 47 (9): 23–38.

Liu, Jianguo, and Jared Diamond. 2005. "China's Environment in a Globalizing World." *Nature* 435: 1179–1186.

Liu, Jianguo, and Jared Diamond. 2008. "Revolutionizing China's Environmental Protection." *Science* 319: 37–38.

Mazur, Allan, and Eugene Rosa. 1974. "Energy and Life-Style." *Science* 186: 607–610.

Mol, Arthur P. J. 2001. *Globalization and Environmental Reform.* Cambridge, MA: MIT Press.

Mol, Arthur P. J., and David A. Sonnenfeld, eds. 2000. *Ecological Modernization Around the World: Perspectives and Critical Debates.* London: Frank Cass.

New Economics Foundation. 2009. *The Happy Planet Index 2.0.* London: NEF.

Polimeni, John M., Kozo Mayumi, Mario Giampietro, and Blake Alcott. 2008. *The Jevons Paradox and the Myth of Resource Efficiency Improvements.* London: Earthscan.

Roberts, J. Timmons, Peter E. Grimes, and Jodie L. Manale. 2003. "Social Roots of Global Environmental Change: A World-Systems Analysis of Carbon Dioxide Emissions." *Journal of World-Systems Research* 9 (2): 277–315.

Roberts, J. Timmons, and Bradley Parks. 2007. *A Climate of Injustice: Global Inequality, North South Politics, and Climate Policy.* Cambridge, MA: MIT Press.

Rosa, Eugene A. 1997. "Cross National Trends in Fossil Fuel Consumption, Societal Well-Being and Carbon Releases." Pp. 100–109 in *Environmentally Significant Consumption: Research Directions,* eds. Paul C. Stern, Thomas Dietz, Vernon W. Ruttan, Robert H. Socolow, and James L. Sweeney. Washington, D.C.: National Academy Press.

Rosa, Eugene A., Richard York, and Thomas Dietz. 2004. "Tracking the Anthropogenic Drivers of Ecological Impacts." *Ambio* 33 (8): 509–512.

SERI [Sustainable European Research Institute]. 2008. *Technical Report of the Compilation of the Material Flow Database for www.materialflows.net.* Vienna: SERI. Available at http://www.materialflows.net.

Wallerstein, Immanuel. 1997. *The Capitalist World Economy.* Cambridge, UK: Cambridge University Press.

Wallerstein, Immanuel. 2004. *World-Systems Analysis: An Introduction.* Durham, NC: Duke University Press.

York, Richard. 2006. "Ecological Paradoxes: William Stanley Jevons and the Paperless Office." *Human Ecology Review* 13 (2): 143–147.

York, Richard. 2007. "Structural Influences on Energy Production in South and East Asia, 1971–2002." *Sociological Forum* 22 (4): 532–554.

York, Richard. 2010a. "The Paradox at the Heart of Modernity: The Carbon Efficiency of the Global Economy." *International Journal of Sociology* 40 (2): 6–22.

York, Richard. 2010b. "Three Lessons from Trends in CO_2 Emissions and Energy Use in the United States." *Society and Natural Resources* 23 (12): 1244–1252.

York, Richard, and Eugene A. Rosa. 2003. "Key Challenges to Ecological Modernization Theory: Institutional Efficacy, Case Study Evidence, Units of Analysis, and the Pace of Eco-Efficiency." *Organization & Environment* 16 (3): 273–288.

York, Richard, Eugene A. Rosa, and Thomas Dietz. 2003. "Footprints on the Earth: The Environmental Consequences of Modernity." *American Sociological Review* 68 (2): 279–300.

York, Richard, Eugene A. Rosa, and Thomas Dietz. 2004. "The Ecological Footprint Intensity of National Economies." *Journal of Industrial Ecology* 8 (4): 139–154.

York, Richard, Eugene A. Rosa, and Thomas Dietz. 2009. "A Tale of Contrasting Trends: Three Measures of the Ecological Footprint in China, India, Japan and the United States, 1961–2003." *Journal of World-Systems Research* 15 (2): 134–146.

York, Richard, Eugene A. Rosa, and Thomas Dietz. 2010. "Ecological Modernization Theory: Theoretical and Empirical Challenges." Pp. 77–90 in *The International Handbook of Environmental Sociology, Second Edition,* eds. Michael Redclift and Graham Woodgate. Cheltenham, UK: Elgar.