Has the World Really Survived the Population Bomb? (Commentary on "How the World Survived the Population Bomb: Lessons from 50 Years of Extraordinary Demographic History")

Key words: resources, water, population growth, deforestation, biodiversity, ecological economics

In his 2011 PAA presidential address David Lam (hereafter referred to as 'Lam') documented the phenomenal progress of human societies over the past half century–increases in levels of schooling, increases in food production and food per capita, lower proportions in poverty, and declining mortality and fertility rates. All of this in spite of the addition of three billion persons to the planet. However, Lam does not fully consider the environmental costs of these trends though he does admit "There are many less positive trends that I have not discussed." (Lam, 2011 p. 1257). Lam concludes that by the 2050 PAA "I expect that it [the world] will have improved in many ways, including lower poverty, higher levels of education, and plenty of food to go around." (Lam, 2011, p.1259). Though I have no argument with the data Lam presents, I am less sanguine about the outlook for the next 40 years. Lam's article was titled: "How the world survived the population bomb..." But actually 95% of the article focuses on *homo sapiens*, and the rest of the "world" and its ecosystems are relegated to the subsections on "food production" and one on "global warming and pollution".

I focus on two oversights of Lam's world model which are directly related to our recent demographic and development history, i.e. very rapid population increase and economic development. First is our nonsustainable use of the Earth's resources, essentially compromising the quality of life of future generations. Second, are our continued negative and often devastating effects on the planetary ecosystem. Each of these is covered in turn and then a possible framework to better integrate ecology and development is outlined.

Nonsustainable Use of Resources.

The increases in industrial and food production over the past century have required massive inputs of non-renewable resources. Consumption of fossil fuels increased faster than population for most years of the 20th century (Hook et al., 2011) and particularly after 1950. Though the amount of reserves can only be roughly estimated, energy experts tend to agree that we are at or not far from the peak of oil production (Hughes and Rudolph, 2011; Seljom and Rosenberg, 2011; Sorrell et al 2012; Aleklett et al 2010). Going forward there are likely to be nefarious consequences for the global economy of significantly increased oil prices and in particular rises in costs of foods like those seen in 2008 (Neff, Parker, Kirschenmann et al. 2011). Similarly, while huge natural gas reserves have been found recently in the USA, the environmental and energy costs of extracting it are large and an estimate is that even these reserves may only last 60 years (Weijermars, 2012). Though renewable energy resources are being used increasingly, replacement fuels for heavy vehicles and air transport have yet to be discovered and historical experience shows that the lag time from discovery to extensive use of a new resource typically is several decades (Hook et al. 2011, Mediavilla et al. 2012.).

Increases in food production have required immense inputs of fertilizer, typically produced from fossil fuel (natural gas) and non-renewable minerals (phosphorus). In addition, much of the increase in food production has been due to a combination of high yield varieties of wheat with rice and massive irrigation. To provide water for irrigation, farmers around the world have tapped rivers and underground aquifers such that outflow exceeds inflow. Each aquifer has its own rate of recharge depending on depth, rock formations above it and so on. The stock of underground water in the world is very difficult to quantify but the amount of withdrawal and the depletion (when withdrawal exceeds recharge) are better estimated. Global groundwater overdraft is about 160 billion cubic meters per year or about twice the annual flow of the Nile river (Giordano, 2009). 1.7 billion people live in areas where groundwater resources and/or groundwater-dependent ecosystems are under threat from depletion (Gleeson et al. 2012). Only a small fraction (3%) of depleted groundwater returns to the groundwater store by recharge and the remainder ends up in the ocean and contributes to sea level rise (Wada et al, 2012)

Groundwater use is higher than recharge in large parts of India and China. Half of the wheat production of the North China Plain is threatened because of aquifer overdraft (Giordano, 2009). India is now the biggest user of groundwater for agriculture in the world–nearly 90% of the rural water supply there is from groundwater (Shankar, Kulkarni, and Krishnan, 2011). One quarter of India's food crop is at risk as water tables have been falling at rates of one meter or more per year over the last 20 or more years in some states (Giordano, 2009). The security of drinking water is also threatened since the source is the same for both irrigation and drinking. It has been scarcely reported in the Western media, but about 250,000 Indian farmers have committed suicide in the last 16 years, with a great number of these precipitated by financial ruin–the inability to afford the digging of deeper wells (for irrigation) as the water table receded (Gruere and Debdatta 2011; Center for Human Rights and Global Justice, 2011). In the USA, water from the Ogallala aquifer in the Midwest is also being used faster than it can be replenished–the US Geological Service estimates that its levels have dropped by an average of 14 feet over the entire region (USGS, 2013a). This, combined with an expected drier climate in the Midwest due to climate change, as well as demand for agricultural land for cultivation of biofuels, could lead to a significant negative impact on food production (Wada et al. 2012). Also, note that groundwater below 'my' land is not 'mine' because it may flow from somewhere quite distant; thus both surface water and groundwater are in the commons and cooperative management is essential.

Regarding rivers, "peak renewable water" limits have already been reached for a number of major river basins including the Nile, the Jordan, and the Yellow rivers (Gleick and Palaniappan, 2010). The Colorado River is also in this category (Gleick, 2010); demand for its water has become so large that river flow rarely reaches the Pacific Ocean (Cintra-Buenrostro, Flessa and Dettman, 2012). The Rio Grande also suffers severe water scarcity during seven months of the year (Hoekstra et al. 2012). The United Nations anticipates that in 2025, 1.8 billion people will live in countries or regions with absolute water scarcity (United Nations, 2013a). Though a potential solution to the problem of water scarcity is desalination of sea water, its practical use on a large scale may be years off because it still requires large energy inputs and has a nontrivial carbon footprint (Elimelech and Philliip, 2011).

Lam showed prices of 5 metals (chromium, copper, nikel, tin and tungsten) from 1960 to 2010 including the period during which Simon and Ehrlich had their bet about prices of these metals. In the past several years prices of these non-renewable resources have been volatile but definitely higher than they were in recent decades (USGS, 2013b, 2013c) while ore grades are declining (May et al. 2012). Further, it is estimated that, at current rates of use and assuming upper bounds on resource stocks, several minerals (zinc, lead, tin and silver) will last less than fifty years, though presumably recycling can avoid total depletion (Perman et al. 2012). Substitutes for these minerals may be found but in the meantime exploration for and exploitation of these and other minerals continues apace in places like Mongolia and Afghanistan. Feeding the population has obviously been the priority, but "surviving the population bomb" while leaving reduced stores of minerals and scarce water supplies to future generations is poor stewardship.

Negative Effects on the Planetary Ecosystem.

Lam does briefly discuss global climate change and correctly identifies the problem that markets do not include costs of externalities, stating that: "In domains without markets and resource ownership, problems are much more likely"(Lam, p. 1257). We need to consider how nonsustainable externalities affect future generations–for example, with regard to climate change, flooding of coastal cities or complete submersion of some island nations in the South Pacific.

Lam gives two examples where negative effects of human activities have been markedly reduced–the decline of sulfur dioxide through emissions standards and the decline in ozonedestructive CFCs by international agreement. However, nowhere does Lam mention deforestation nor species loss which are two major problems confronting us. Below is documentation of the extent of these two problems due in large part to human population growth in combination with the progress Lam described.

Deforestation.

The Food and Agriculture Organization estimates that the world forest area covers approximately 4 billion hectares (31% of total land area) but that clearing of forests has been occurring at the rate of about 13 million hectares per year during the past decade (FAO, 2013). This deforestation accounts for as much as 10% of our greenhouse gas emissions. Brazil and Indonesia account for nearly 30% of the deforestation and a major reason is conversion of the forest to farming land to feed our growing population (e.g. for soybean production in Brazil). To give perspective on the rapidity of deforestation, a 5000-word article in *National Geographic* on the Amazon forests states: "In the time it takes to read this article, an area of Brazil's rain forest larger than 200 football fields will have been destroyed." (Wallace, 2007, p.40). This seems a heavy price to pay for the increases in food production that Lam describes and the situation will only worsen with the additional deforestation that will occur by midcentury in order to feed the added two to three billion persons projected for 2050 (United Nations, 2013b).

Other Species.

Scientists have estimated that the rate of extinction of species in the past century has been on the order of 100 to 1000 times the rates before humans became dominant in the world (Pereira et al, 2010; Ricketts, Brooks, and Hoffmann 2005). This is largely due to quadrupling of the number of *homo sapiens* over the past century and our altering in one way or another of virtually every ecological niche on the planet (e.g. the effects of air or water pollution are measurable almost everywhere). The range of extinction rates is wide partly because the number of species on the planet is unknown. Only about 1.5 million species have been classified whereas a recent estimate of the number of species on Earth is 8.7 ± 1.3 million (Mora et al, 2011). To illustrate the problem, consider beetles--there are species of beetles that may only exist on a few acres of the Amazon forest, and when those acres of forest are cut down, that species goes extinct without ever being classified.

Of species that have been classified, the International Union for the Conservation of Nature (IUCN) documents their status as: 1. Critically endangered; 2. Endangered; 3. Vulnerable, 4. Near threatened, 5. Lower risk, and 6. Least concern (IUCN, 2013). The continuously updated compilation of IUCN shows that the number of species at risk of extinction (groups 1-3) continues to grow each year.(See Table 2 in the IUCN citation.) Human activity (especially development) is the major threat. Among the large primate species (n=9) all except *homo sapiens* are endangered at this time. (*Homo sapiens* is grouped by IUCN along with mice, rats, cottontail rabbits, white-tailed deer, etc. in the category of “Least concern”.) Of all mammalian species (n=5501), 21% are in categories 1-3 and 4% are critically endangered. The situation is becoming dire and is very likely to become worse in the years ahead (Periera et al. 2010) unless preservation of biodiversity is given greater emphasis (Rands et al, 2010). Unfortunately when a species is gone, it is gone forever.

Several Other Negative Effects of Humans on Ecosystems

Deforestation and species loss are only two of quite a number of major negative effects of humans on the environment we inhabit. Briefly, three others are:

a. Overfishing. Depletion of stocks of cod, haddock, herring etc. have occurred because of lack of regulation (until recently) of the commons that is the ocean (Petitgas, et al. 2010).

b. Nitrogen pollution of streams, estuaries and the seas. 'Dead zones' in coastal oceans are where dissolved oxygen levels are so low that most life dies; these zones exist mainly due to nitrogen runoff predominately from fertilizers. Dead zones are present in more than 400 areas covering over 245,000 square kilometers (Diaz and Rosenberg, 2008).

c. Mountaintop removal in Appalachia. Scores of mountaintops have been and are being blown off in West Virginia, Kentucky and elsewhere to obtain coal relatively easily; entire local ecosystems are irreparably destroyed (Mitchell, 2006).

Though *homo sapiens* has done well as Lam describes, the rest of "the world" has suffered from the success of our species. In fact, some scientists label the current geological age the "anthropocene" or "homocene" since our species has altered the Earth on a planetary scale (Myers, 2003; Steffan et al. 2011). Recently 2012 was shown to be the hottest year on record in the US (Gillis,. 2013), extreme weather events are occurring with increasing frequency all over the world (Lyall, 2013) and groups of scientists say we are approaching a tipping point in the biosphere (Barnosky et al. 2012; Rockstrom et al, 2009). On another front, humans appropriate approximately 30-40% of net primary production of the planet (Erb et al. 2009, Haberl et al. 2007) As another example, the mass of water impounded behind reservoirs--estimated at 8300 km^3 (Hoff, 2009)--has significantly (albeit slightly) altered the tilt and rotation of the Earth (Chao, 1995).

Potential Framework to Integrate Ecology and Development

Ecological economics provides a good framework for considering these matters and what to expect between now and 2050; it is a transdisciplinary field that addresses the relationships between ecosystems and economic systems (Costanza, Daly and Bartholomew 1991; Shmelev, 2012). Some key propositions from ecological economics are:

First, the natural world provides our life support systems and the human economy is not separate from but embedded within nature (Ropke, 2005). These life-support systems include: the hydrological cycle, renewable and non-renewable resources, photosynthesis, atmosphere and climate, pollination, waste absorption, the nitrogen cycle, etc. We must establish safe minimum standards and precautionary principles for protecting these systems (Ehrlich, 1994; Saltelli and Funtowicz, 2004).

Second, sustainable development "is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987 p.41). Note that if a single process is unsustainable, the whole system is unsustainable (Schilling and Chiang, 2011). A necessary condition for sustainability is that future generations do not forfeit freedom of choice as a result of the activities of the present generation. It is prudent to assume that future generations' needs for natural resources (soil, air, water, forests, fisheries, plant and animal species, energy and minerals) will not be markedly less than ours (Goodland and Ledec 1987). In operational terms, sustainability means that: a) human scale must be limited within the carrying capacity of the global ecosystem so in particular physical (and population) growth cannot continue indefinitely; b) "harvesting rates of renewable natural resources should not exceed regeneration rates; c) waste emissions should not exceed the assimilative capacity of the environment; d) non-renewable resources should be exploited, but at a rate equal to the creation of renewable substitutes" (Berkes and Folke, 1994, p.130).

Third, ecosystems typically respond nonlinearly to perturbation–for example, gradual increases in salinity may go unnoticed by farmers for years but then reach crisis levels. Biological resources that we presently take for granted could become subject to rapid and unpredictable transformations within the span of a few generations (Barnosky et al. 2012). Thus, because of the uncertainty in our understanding of ecological processes it is prudent to avoid courses of action that could lead to dramatic and irreversible consequences (Daily et al, 2000).

In conclusion, Lam provided a nice overview of human progress from 1960 to 2010 and he is optimistic about the next 50 years. However he does not do justice to the looming major ecological problems that have been the result of this human progress. Will birth cohorts of 2040-50 look back and wish our generation had done more to preserve the world that was bequeathed to us? I do believe so.

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