Population, Environment and Economic Development

Anthropogenic environmental change is as old as civilization.[1] Heroditus wrote of this relationship as did William the Conqueror and the well-known Malthus hypothesis that "geometric (exponential) growth in population would outstrip the arithmetic (linear) growth in the means of subsistence.[2] Over time, population has been linked to economic, social and environmental outcomes and has gained clarity though scientific investigation and attention in our world.

This paper supports the idea that population, its size and changes, impacts the environment. Also, this impacts are differential in developed versus developing nations. While population models and their relationships to outcomes is far from simple, we can point to some to some clear environmental outcomes from population changes.

As of June 14, 2011 world population was 6,924,897,458 showing a net increase of 2.4 people per second (see Table 1). The growth rates in developing nations show a rate of 0.10% per year. Developing nations show 1.5% per year. More than 98% of the world's population growth was occurring in development nations.[3] (See Figures 1 and 2)

The sheer size of the population represents only one important variable in the relationship of population and the natural environment. Other demographic dynamics include changes in population flows and densities which have dramatic impacts on the environment.[4] For example, one can point to impact from density dependent and density independent factors related to population growth. As population grows resources, air quality, water availability and land use patterns change dramatically. Dense populations are highly susceptible to density independent events as witnessed by the recent Tusami in Japan.

Other trends are noticeable as related to population, trends that impact the environment. For example, migration to cities is high -- there is a continuing trend towards ever-larger urban agglomerations. As of 2000, 261 cities in developing countries had populations over 1 million, compared with 213 in the mid-1990s. In 1994, there were14 so-called "mega-cities," defined as cities with at least 10 million inhabitants. Their number is expected to double by 2015. (see Figure 3)[5] the development of mega-cities is most prevalent in developing nations, a growth that will certainly increase environmental impacts in those nations.

According to the class notes, the causes of population growth are varied, including lack of accessible education which influences literacy rates and fertility rates, [6] need for financial security in old age, children as economic assets, lack of contraceptives, child mortality, status of women, and social dimensions such as national policies and religious beliefs.[7] Declining infant mortality rates, for example, lead to better nutrition due to increased agricultural production and better food distribution and storage. Also, clean drinking water and improved sanitation and mass inoculations and better medicine lead to these decreases.

The developing and developed nations have differential impacts from population changes. Hans Rosling illustrates these differences in an entertaining and informative talk.[8] His core message is that the key population impacts, social, economic or environmental, will depend on how we handle, as a developed world, the poorest people in our world.

The theories behind the link between population and environment have varied and are far from clear. The most popular and well known model is Environmental Impact=Population Size x Affluence and consumption patterns x level of technology of the society.[9] The IPAT formulation fits well with the concept of carrying capacity.[10] One alternative to this model shows refinements in the terms: Environmental Impacts = Population x Consumption x Technology resource use x technology waste management x amount by which the environment changes in response to a given amount of resource extraction or pollution.[11]

A third version is the pressure-state-response model.[12] This model is a systems theory showing pressures (population, consumption, technology, etc.) impacting the environment, gaining feedback through scarcity, hazard and loss of amenity such as loss of biodiversity, influenced by filters such as the legal and economic systems, leading to societal responses such as changes in behavior and regulatory responses.[13] Figure 5 shows some of important relationships among population levels, growth and various outcomes of these relationships, including the outcomes on the environment.

Most theorists agree, however, that human pressure on the natural environment is a product of population size and flows, consumption per person, and technology (i.e., how many resources are used and how much waste or pollution is produced for each unit of consumption.) Throughout history humans have improved their survival rate, increased their populations and increased their life spans by doing some things other organisms cannot do. For example, humans are limited by energy requirements yet the recovery and use of fossil fuels gave us new sources of energy; medical breakthroughs lowered child mortality.

Some researchers believe that technological impacts are infinite and we should not be concerned with population impacts on the environment.[14] These people believe that the value of the natural environment is as resources for humans. Thus, humans increase their carrying capacity in the short term while potentially making trade-offs that will be paid in the long-term.[15] Other believe, of course, that the earth is finite and out natural systems are being pushed to an ever closer limit that will compromise human existence.[16] One paper concluded that the Earth's carrying capacity is 7.7 billion people,[17] a limit we are likely to exceed in the next decade. (see Figures 1-3). I tend to subscribe to the later view.

Are environmental impacts caused by population growth different in developing countries and developed countries? Developed countries are industrial countries and industrially advanced countries). These are high-income countries, in which most people have a high standard of living. They are sometimes defined as countries with a large stock of physical capital, in which most people undertake highly specialized activities.[18] Developing countries, according to the World Bank classification, are countries with low or middle levels of GNP per capita as well as five high-income developing economies -- Hong Kong (China), Israel, Kuwait, Singapore, and the United Arab Emirates. These five economies are classified as developing despite their high per capita income because of their economic structure or the official opinion of their governments.[19]

We can compare and contrast these two types of countries using the model Environmental Impacts = Population x Consumption x Technology resource use x technology waste management x amount by which the environment changes in response to a given amount of resource extraction or pollution.[20] (see Table 2).

Although fertility rates have declined in most world areas, population growth continues to be fueled by high levels of fertility, particularly in Asia and Africa. The average number of children a women would be expected to have given current fertility levels remains high for some nations, e.g., as high as 7.5 children in Niger. Even in areas where fertility rates have declined to near replacement levels (2.1children per couple) population continues to grow because of "population momentum" which occurs when a high proportion of the population is young.[21]

The higher the population size the more we can expect limits on such global resources as arable land, water, forests, fisheries, and fossil fuels. Decreasing farmland contribute to growing concern of the limits of global food production. Global water consumption rose six-fold between 1900 and 1995, more than double the rate of population growth. The impact of the size of population will clearly be more impactful on developing nations than developed nations.

Figure 6 shows a poverty cycle and Figure 7 shows the consequences of a population explosion in developing countries. The following commentary highlights the important aspects of these impacts.

The distribution of population has three impacts on the environment. Less developed regions cope with a growing share of population pressures on dwindling resources; per capita availability declines as population increases. Second, migration shifts put pressures on local environments, easing the strain in some areas and increasing problems in others such as cities and develop nation immigration. Finally, urbanization, particularly in less developed nations, frequently outpaces the development of infrastructure and environmental regulations leading to haphazard and large environmental impacts.

The composition of population impacts the environment and differential compositions can be found in developed and developing nations. Overall, our world has the largest cohort of young people (age 24 and under) and the largest proportion of elderly in history.[22] Migration patterns vary by age. Young people are more likely to move, thus, we can expect increasing levels of migration and urbanization by this group, and therefore intensified urban environmental concerns. This migration pattern is most intense in developing nations.

The relationship between economic develop and environmental pressure resembles an inverted U-shaped curve; middle income nations are likely to have the most powerful pressures on the natural environment. Least developed nations have very low impacts. Highly advance countries can mitigate environmental impacts with technology and efficiencies.

Thus, technology, policy contexts and cultural factors mediate the relationship between population and the environment. For example, learning to obtain fossil fuels increased their use; the current trend with natural gas in the United States is similar, with fracking a controversial process.[23] Cultural variables are important. For example, attitudes toward the environment, conservation, population control, and so many other factors are culturally-based. Culture includes how societies resolve issues common to all humans. Developed and developing nations tend to have different cultures in addition to their nation-specific characteristics.[24]

Other differential impacts of population on environment include:

- Climate change is extremely important and differentially impactful on nations. The impact of population on climate change varies between developed and developing nations, as well (see Figures 8 and 9).
- High density with higher wealth creates a wide environmental footprint. For example, Americans place at least 20 times the demand on Earth's resources as does a person in Bangladesh. This means that population increases do not necessarily push societies to the limits. Yet, as developing nations increase their wealth we can expect greater environmental challenges. These challenges will be coupled with population growth impacts.
- Developed nations are more likely to practice stewardship having the resources to do so.
- Wealthy nations can pass on environmental problems to developing nations, such as transporting waste to these countries. For example, developed nations can locate production facilities in developing nations to avoid polluting their home locations. Some developed nations have bought land in developing nations to use as waste dumping grounds.[25]
- Rapid population growth in developing nations impacts need for food production and environmental impacts, as a result. For example, as developing nations increase in population, the families subdivide their lands. These makes difficult adequate food supply and new land for agriculture may not be well suited and lend to soil erosion, deforestation, and loss of biodiversity.
- Nonpoint water source pollution increases and irrigation increases become problematic with population increases. 70% of the world's use of water is for irrigation. If food production continues to increase in the developing world, more water will go toward this activity and less will be available for direct human consumption.

In sum, this paper developed the relationship between population dynamics and environmental impact. It presented some documented and not so well documented ideas about the relationship. I then extended the

analysis to discuss differential impacts on developing and developed nations. All said, this important area of study must be continued, yet needs interdisciplinary research for it to create clarity of the relationships and for developing public policy to meet these challenges. The Rand report "Population and Environment" ends with

> Disciplinary boundaries between social and natural scientists have hindered the study of the interrelationships between demographics and the environment. These barriers, however, are beginning to fall. The trend toward interdisciplinary environmental research must be encouraged…[26]

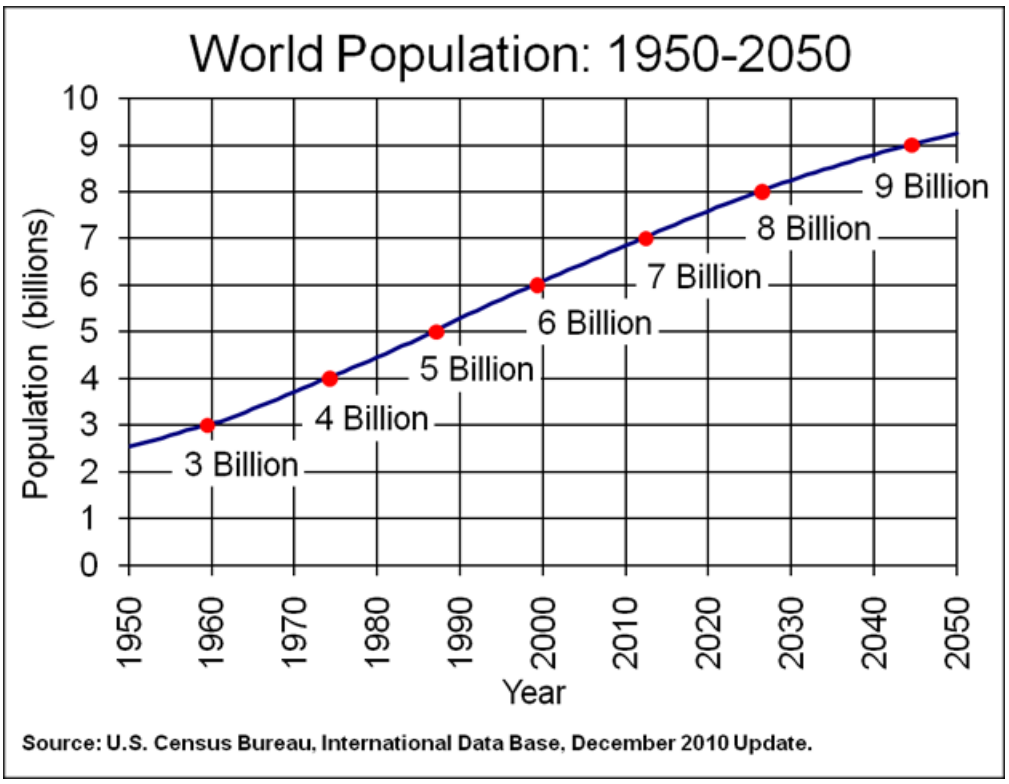
T**able 1: World Vital Events Per Time Unit: 2011**[27]
(Figures may not add to totals due to rounding)

Time unit	Births	Deaths	Natural increase
Year	132,697,074	56,260,324	76,436,750
Month	11,058,090	4,688,360	6,369,729
Day	363,554	154,138	209,416
Hour	15,148	6,422	8,726
Minute	252	107	145
Second	4.2	1.8	2.4

Table 2: Comparison of Developing and Developed Nations Using the I=PxAxT Model

	Developed (greater or less) Developing
Population size	<
Population growth	<
Fertility rates	<
Death rates	<
Consumption	>
Technology resource use	>
Technology waste management	>
Amount by which the environment changes in response to a given amount of resource extraction or pollution	?

Figure 1: World Population 1950 to project 2050.[28]

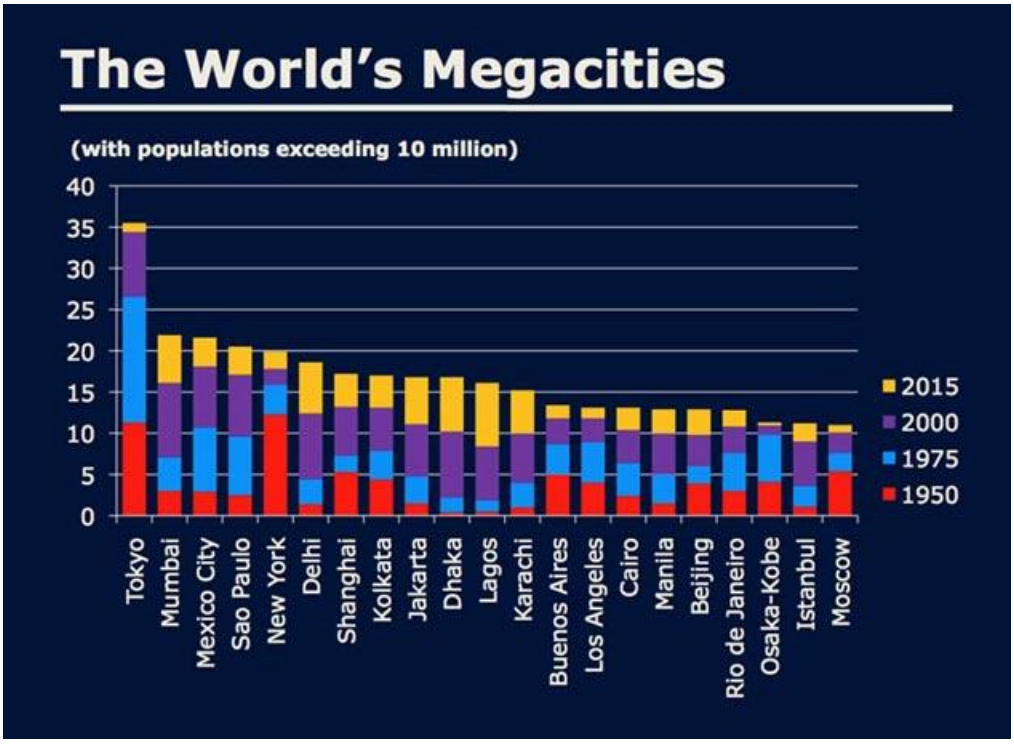


This figure shows that by 2020 we are likely to exceed our carrying capacity.

Figure 2: World Population Growth Rates[29]

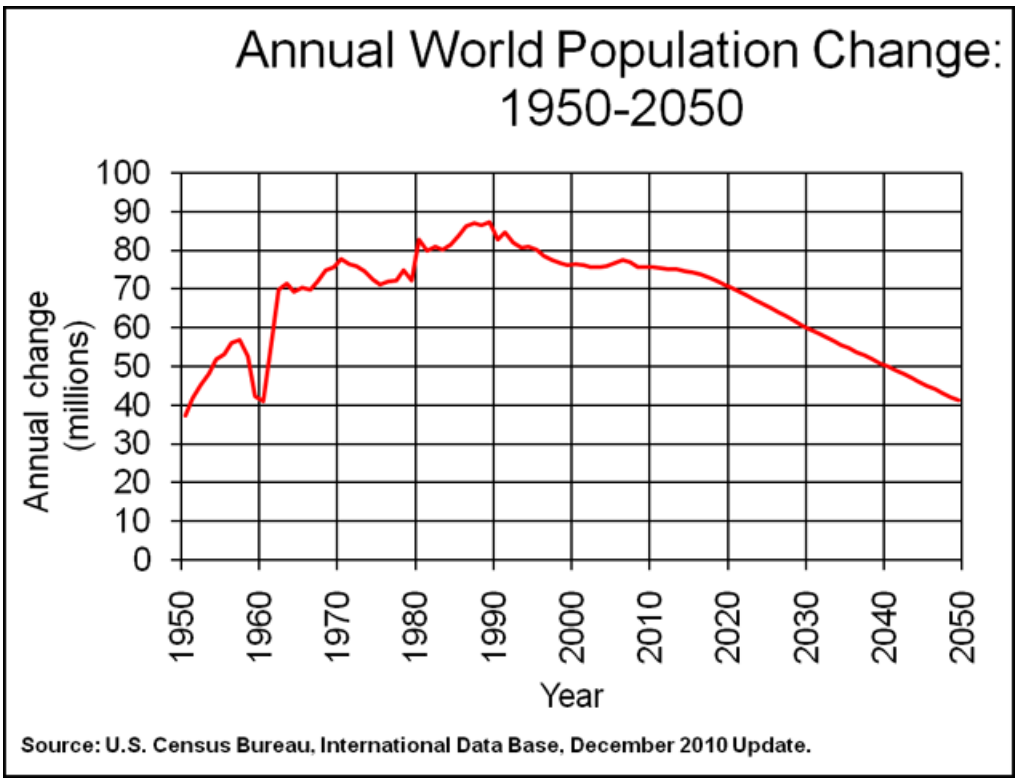
Growth rates have varied over time yet show a steady decline from 1950 through today.

Figure 3: Mea-Cities[30]



The evidence shows that mega-cities will continue to increase, especially in developing nations. These are cities with 10 million people or more.

Figure 4: Annual World Population Change: 1950-2050[31]



This figure supplements Figures 1 and 2.

Figure 5: Some population relationships

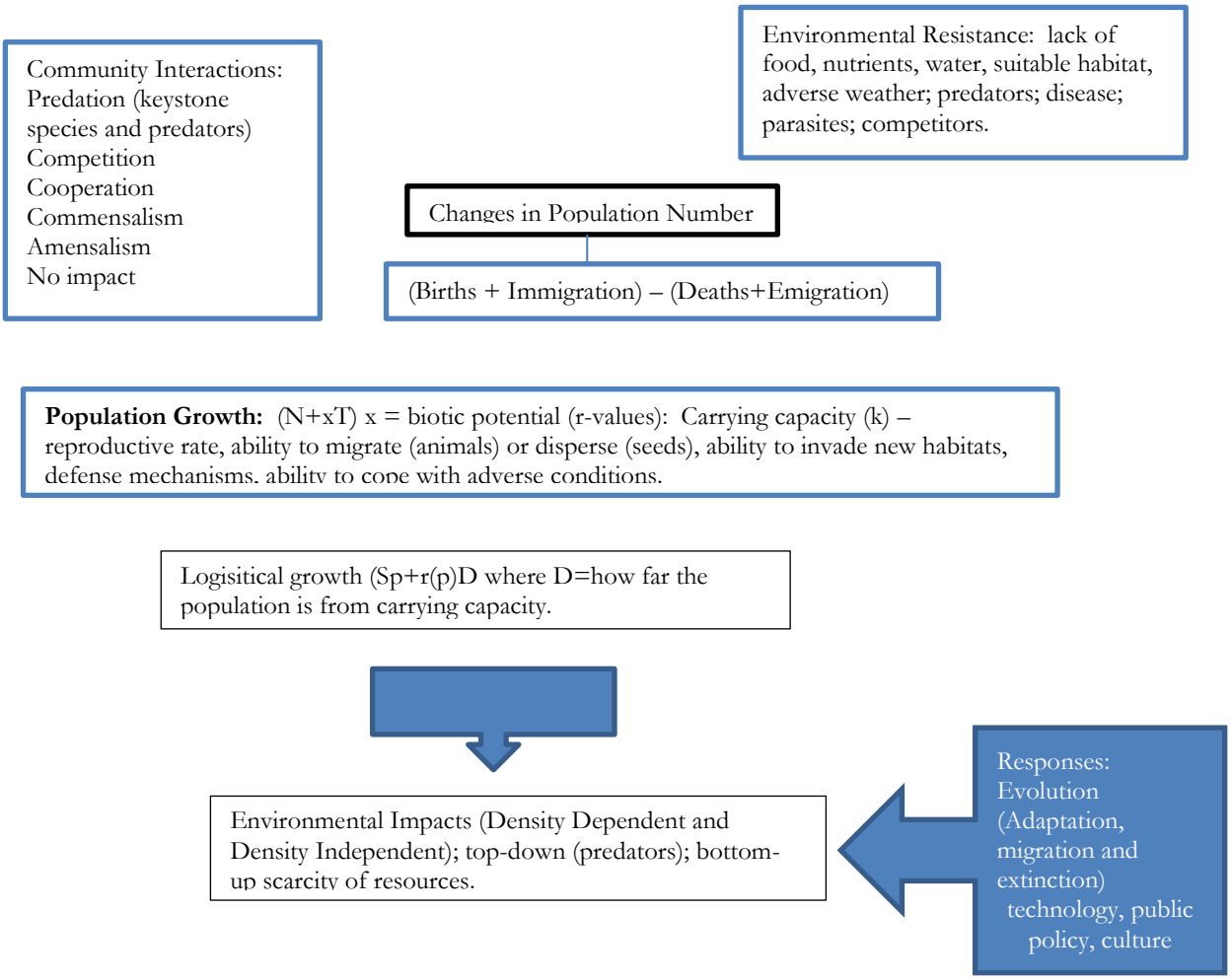


Figure 6: Poverty Cycle[32]

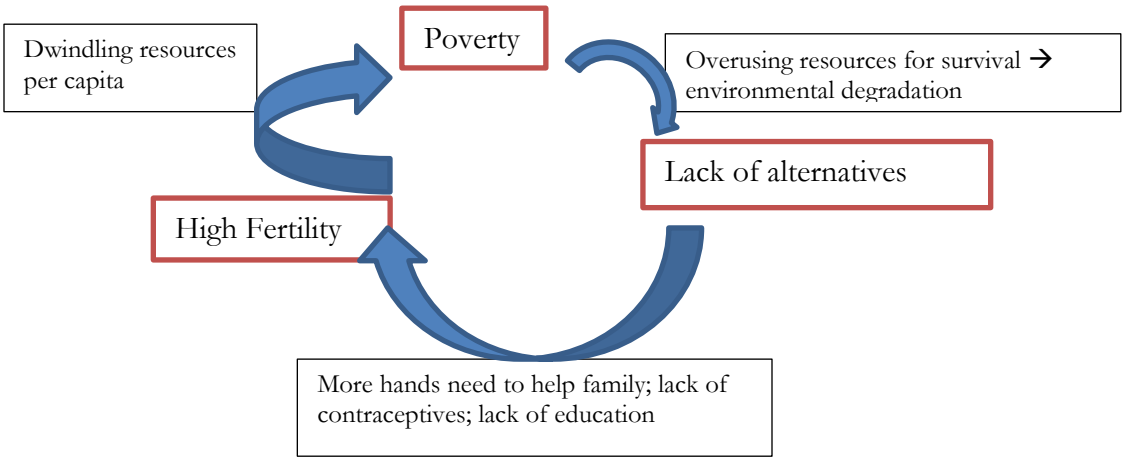


Figure 7: Consequences of a Population Explosion in Developing Countries.[33]

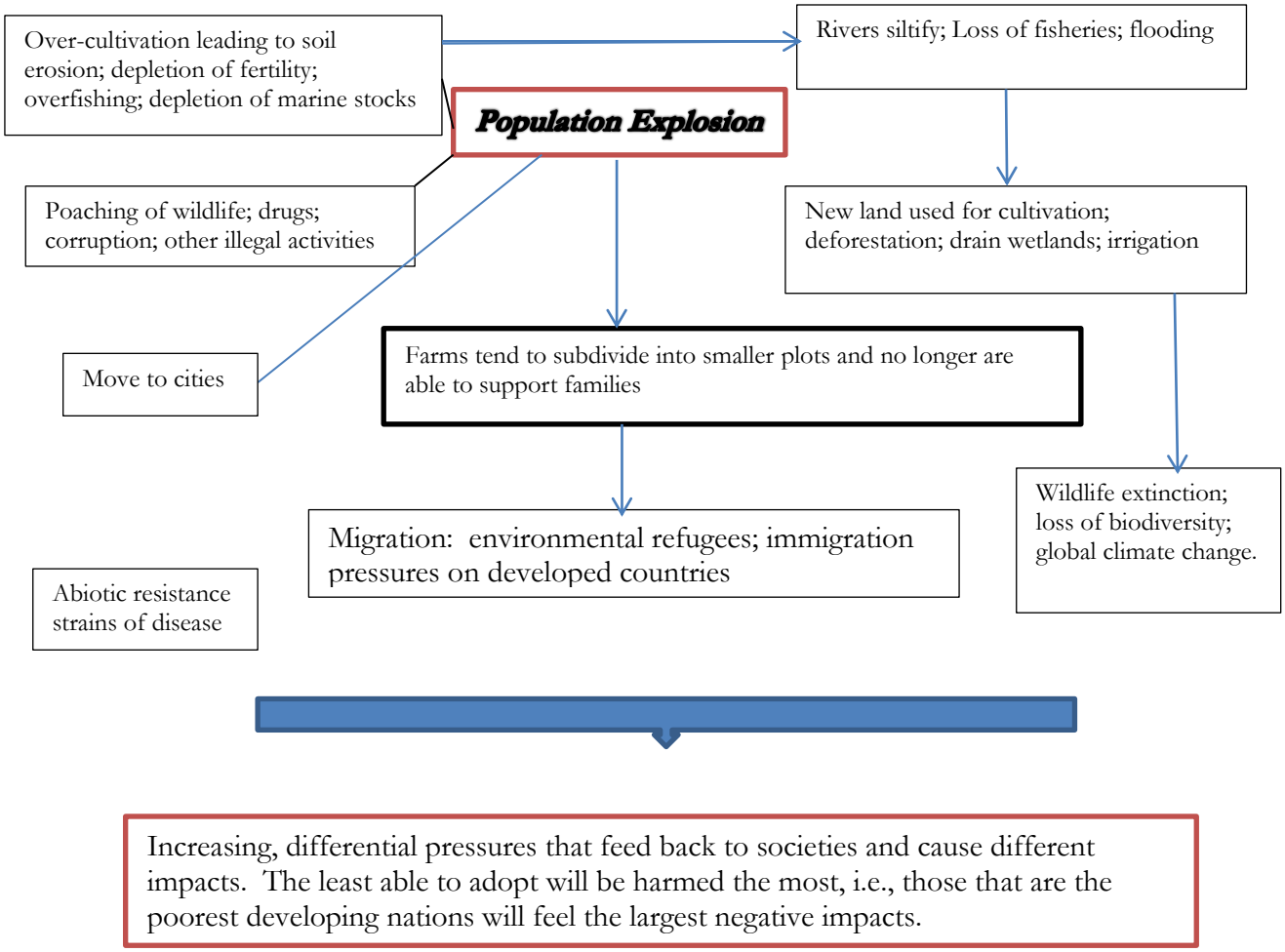


Figure 8: CO_2 Emissions in the World[34]

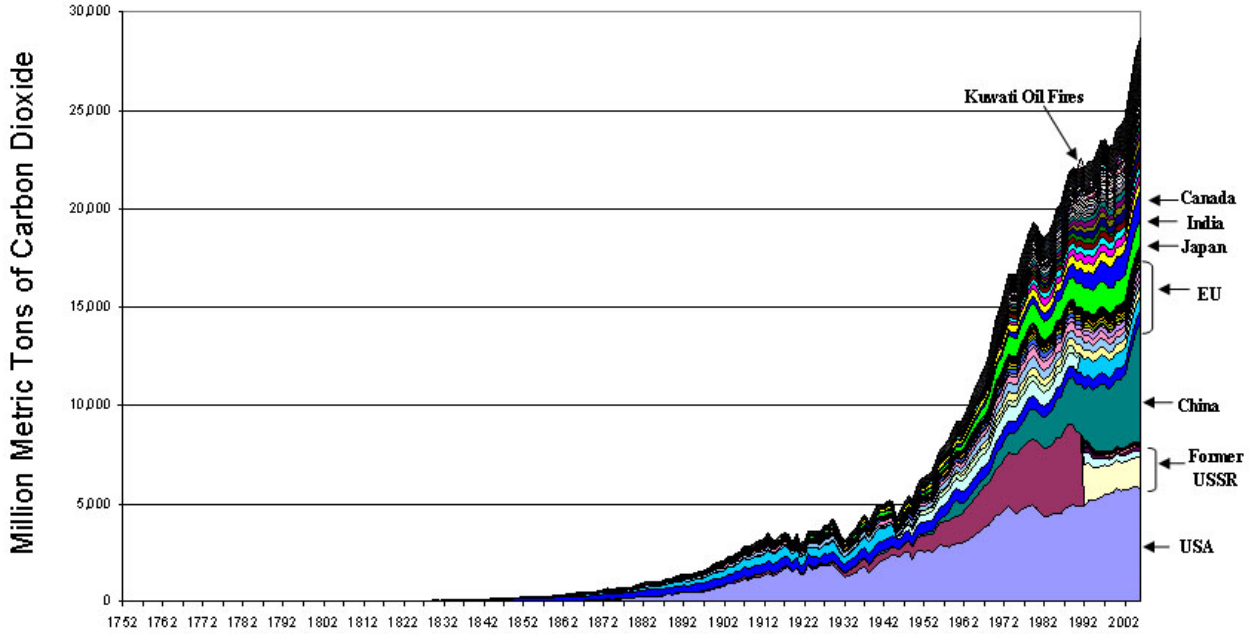
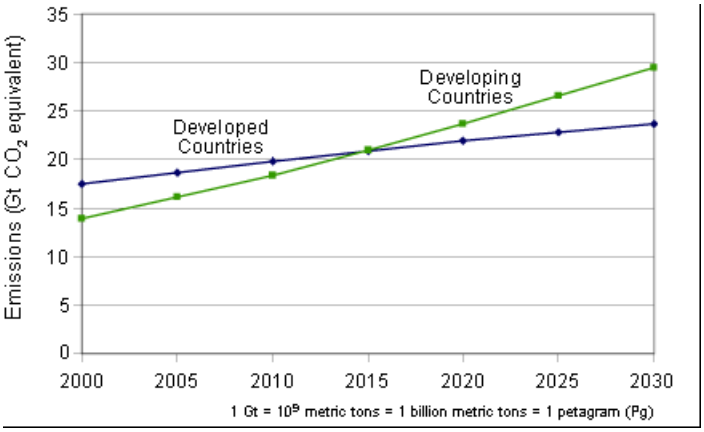


Figure 9: Total Greenhouse Gas Emissions by Region



These two figures show the dramatic and recent rise of CO_2 causing global warming. Also, Figure 9 shows how developing countries will exceed developed nations in producing CO_2.

ENDNOTES

[1] T. Dietz and E.A. Rosa (1994). Rethinking the environmental impacts of population, affluence and technology. Human Ecology Review. Summer: 277-300.

[2] Herodotus. 1952 [464-447 B.C.] The History. PP 1-341 in R.M. Hutchins (ed) Great books of the western world. Vol. 6 Chicago: Encyclopedia Britannica. J.R. Weeks (1986). Population: An introduction to concepts and issues. Belmont, California: Wadsworth. T.R. Malthus (1960) [1798]. On population. New York: Modern Library.

[3] A population is a group of members of the same species living together in an area; community is populations of different species living together in an area.

[4] L. M. Hunter (2000). The environmental implications of population dynamics. Santa Monica, CA: Rand.

[5] The Mega-Cities Project. http://www.megacitiesproject.org/

[6] http://data.worldbank.org/indicator/SP.ADO.TFRT/countries

[7] Class 3 notes, University of Massachusetts, Boston.

[8] Hans Rosling on global population growth (2010). http://www.ted.com/talks/hans_rosling_on_global_population_growth.html

[9] R.T. Wrigth and D.F. Boorse (2010). Environmental science: Toward a sustainable future. Eleventh Edition. Upper Saddle River, NJ: PHL Learning:201.

[10] Carrying capacity is the maximum population of a species that a given habitat can support without being degraded long-term.

[11] American Association for the Advancement of Science. (2001) The theory of population-environmental links. Los Angeles, CA: The University of California Press:7 http://atlas.aaas.org/index.php?part=1&sec=theory

[12] Ibid.: 10.

[13] **Rand Corporation (2000). Population and Environment: A Complex Relationship. Santa Monica, CA: Rand Corporation**. http://www.rand.org/pubs/research_briefs/RB5045/index1.html

[14] J. Smith (1983). The ultimate resource. Princeton, NJ: Princeton University Press.

[15] J. Cohen (1995). How many people can the earth support? NY, NY: Norton.

[16] Population Summit of the World's Scientific Academics (1993). National Academy of Sciences, National academy of Engineering, Institute of Medicine (SEM) http://www.nap.edu/openbook.php?record_id=9148

[17] J. Van Den Bergh and P. Rietveld (2004). Reconsidering the limits to world population: Meta-analysis and meta production. Bioscience. 54(3): 195.

[18] According to the World Bank classification, these include all high-income economies except Hong Kong (China), Israel, Kuwait, Singapore, and the United Arab Emirates. Depending on who defines them, developed countries may also include middle-income countries with transition economies, because these countries are highly industrialized. Developed countries contain about 15 percent of the world's population. They are also sometimes referred to as "the North.". http://www.worldbank.org/depweb/english/beyond/global/glossary.html .

[19] Several countries with transition economies are sometimes grouped with developing countries based on their low or middle levels of per capita income, and sometimes with developed countries based on their high industrialization. More than 80 percent of the world's population lives in the more than 100 developing countries. http://www.worldbank.org/depweb/english/beyond/global/glossary.html

[20] American Association for the Advancement of Science. (2001) The theory of population-environmental links. Los Angeles, CA: The University of California Press:7 http://atlas.aaas.org/index.php?part=1&sec=theory

[21] Rand (2000) op cit.

[22] Wright and Boorse, op cit: 210-216.

[23] Fracking. Source Watch (2011). http://www.sourcewatch.org/index.php?title=Fracking . Union of Concerned Scientists (2010). EPA Findings on Hydraulic Fracturing Deemed "Unsupportable" http://www.ucsusa.org/scientific_integrity/abuses_of_science/oil-extraction.html

[24] This is evidenced by world organizations such as the World Bank, UN, WTO and others classifying these nations into developed and developing nations.

[25] Granger, T (2010). Study Shows E-waste in Developing Countries is on the Rise. Earth911.com http://earth911.com/news/2010/05/11/study-shows-e-waste-in-developing-countries-is-on-the-rise/

[26] Rand Corporation (2000) op cit.

[27] World Vital Events. U.S. Census Bureau. International Data Base. http://www.census.gov/cgi-bin/ipc/pcwe.

[28] http://www.census.gov/ipc/www/idb/worldpopgraph.php

[29] The world population growth rate rose from about 1.5 percent per year from 1950-51 to a peak of over 2 percent in the early 1960s due to reductions in mortality. Growth rates thereafter started to decline due to rising age at marriage as well as increasing availability and use of effective contraceptive methods. Note that changes in population growth have

not always been steady. A dip in the growth rate from 1959-1960, for instance, was due to the Great Leap Forward in China. During that time, both natural disasters and decreased agricultural output in the wake of massive social reorganization caused China's death rate to rise sharply and its fertility rate to fall by almost half. http://www.census.gov/ipc/www/idb/worldgrgraph.php

[30] Mega-Cities Project. http://www.megacitiesproject.org/

[31] http://www.census.gov/ipc/www/idb/worldpopchggraph.php In addition to growth rates, another way to look at population growth is to consider annual changes in the total population. The annual increase in world population peaked at about 87 million in the late 1980s. The peak occurred then, even though annual growth rates were past their peak in the late 1960s, because the world population was higher in the 1980s than in the 1960s.

[32] Adapted from Class 3 notes. Op cit.

[33] Class 3 notes. Op cit.

[34] http://www.epa.gov/climatechange/emissions/globalghg.html