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Fair Plan 8: Earth's Climate Future—Pope Francis' Population Mistake

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Abstract

Pope Francis wrote in his Encyclical Letter *Laudato Si'*: *On Care for Our Common Home*: "*Instead of resolving the problems of the poor and thinking of how the world can be different, some can only propose a reduction in the birth rate.*" … "*To blame population growth instead of extreme and selective consumerism on the part of some is one way of refusing to face the issues.*" Here, we test the hypothesis that population size does not matter. We do so in terms of the effect of the size of the human population on its emission of greenhouse gases. We find that the hypothesis is false = POPULATION MATTERS. *Ceteris paribus*, the larger the population of human beings on Planet Earth, the more difficult it will be to reduce, and finally eliminate, the emission of greenhouse gases by humanity and, thereby, constrain human-caused climate change = Anthropogenic Global Warming.

Keywords

Earth's Climate Future, Population Matters

1. Introduction

In his Encyclical Letter, *Laudato Si'* (Praise Be to You) [1], Pope Francis wrote in Paragraph 50: "Instead of resolving the problems of the poor and thinking of how the world can be different, some can only propose a reduction in the birth rate." At times, developing countries face forms of international pressure which make economic assistance contingent on certain policies of "reproductive health". Yet "while it is true that an unequal distribution of the population and of available resources creates obstacles to development and a sustainable use of the environment, it must nonetheless be recognized that demographic growth is fully compatible with an integral and shared development". To blame population growth instead of extreme and selective consumerism on

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the part of some, is one way of refusing to face the issues. It is an attempt to legitimize the present model of distribution, where a minority believes that it has the right to consume in a way which can never be universalized, since the planet cannot even contain the waste products of such consumption. Besides, we know that approximately a third of all food produced is discarded, and "whenever food is thrown out it is as if it were stolen from the table of the poor". Still, attention needs to be paid to imbalances in population density, on both national and global levels, since a rise in consumption would lead to complex regional situations, as a result of the interplay between problems linked to environmental pollution, transport, waste treatment, loss of resources and quality of life.

Herein we show that human-caused (anthropogenic) emissions of carbon dioxide (CO_2) and, thus, Anthropogenic Global Warming (AGW), depend strongly on the number of human beings on Earth. From this we conclude that purposefully reducing the future growth of the human population will diminish the difficulty in preventing AGW from exceeding the 2˚C (3.6˚F) limit adopted by the UN Framework Convention on Climate Change "to prevent dangerous anthropogenic interference with the climate system" [2].

2. Past Greenhouse Gas Emissions and Population

The left-hand panel of **Figure 1** shows the concentrations of carbon dioxide (CO_2, in parts per million), methane (CH_4, in parts per billion) and nitrous oxide (N_2O, in parts per billion) over the past 10,000 years (the Holocene epoch, following the last ice age), as well as the concentrations of these greenhouse gases over the period of the industrial revolution beginning in 1750 (insets). This panel also shows the radiative forcing of these human-caused greenhouse gases—the change in the net incoming radiation at the top of Earth's atmosphere, in Watts per meter squared (Wm^{-2})—and is Figure SPM 1 of the Summary for Policymakers of Working Group I to the Fourth Assessment Report (2007) of the Intergovernmental Panel on Climate Change [3], wherein further details of these observations can be found. **Figure 1** shows that the concentrations of these three greenhouse gases were essentially constant over the Holocene until the beginning of the Industrial Revolution, circa 1750, when they skyrocketed upwards.

The right-hand panel of **Figure 1** shows the population of human beings during the Holocene from Figure 9 of the 1991 paper by Joseph A. McFalls Jr., "Population: A Lively Introduction" [4]. This panel shows that the human population was essentially constant over the Holocene until the beginning of the Industrial Revolution, circa 1750, when it skyrocketed upwards. In fact, since the lead author's birth in 1943, the number of human beings has more than tripled from 2.3 billion people to 7.4 billion people (31 October 2015) (http://www.worldometers.info/world-population/). There are now more people in China and India alone, 2.6 billion people, than existed on Earth when the lead author was born!

The nearly identical rise in the concentrations of human-caused greenhouse gases and the number of human beings on Earth is stunning and compelling. It is for this reason that the lead author constructed **Figure 1** some years ago for his introductory (100-level) Climate & Global Change course at the University of Illinois at Urbana-Champaign. Consequently, *POPULATION MATTERS*!

We now turn our attention to the future growth of the human population and its influence on greenhouse-gas emissions.

3. Future Population and CO_2 Emissions

To illustrate that *POPULATION MATTERS*, we use the scenarios developed in the Special Report on Emissions Scenarios (SRES) for the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC) [5]. We have used these scenarios in several of our papers published beginning in 2000 [6]-[9]. While we have used the more recently developed Reference Concentration Pathway (RCP) scenarios [10] in our more recent Fair Plan to Safeguard Earth's Climate papers [11]-[17], the SRES scenarios are ideally suitable for our present purpose.

The SRES scenarios can be expressed using the so-called Kaya Identity [5] [18]:

$$\dot{C} = N\left(\frac{GWP}{N}\right)\left(\frac{E}{GWP}\right)\left(\frac{\dot{C}}{E}\right)$$

where $\dot{C}$ is the emission rate of carbon in billions of metric tons (= tonnes) per year, N is the human population

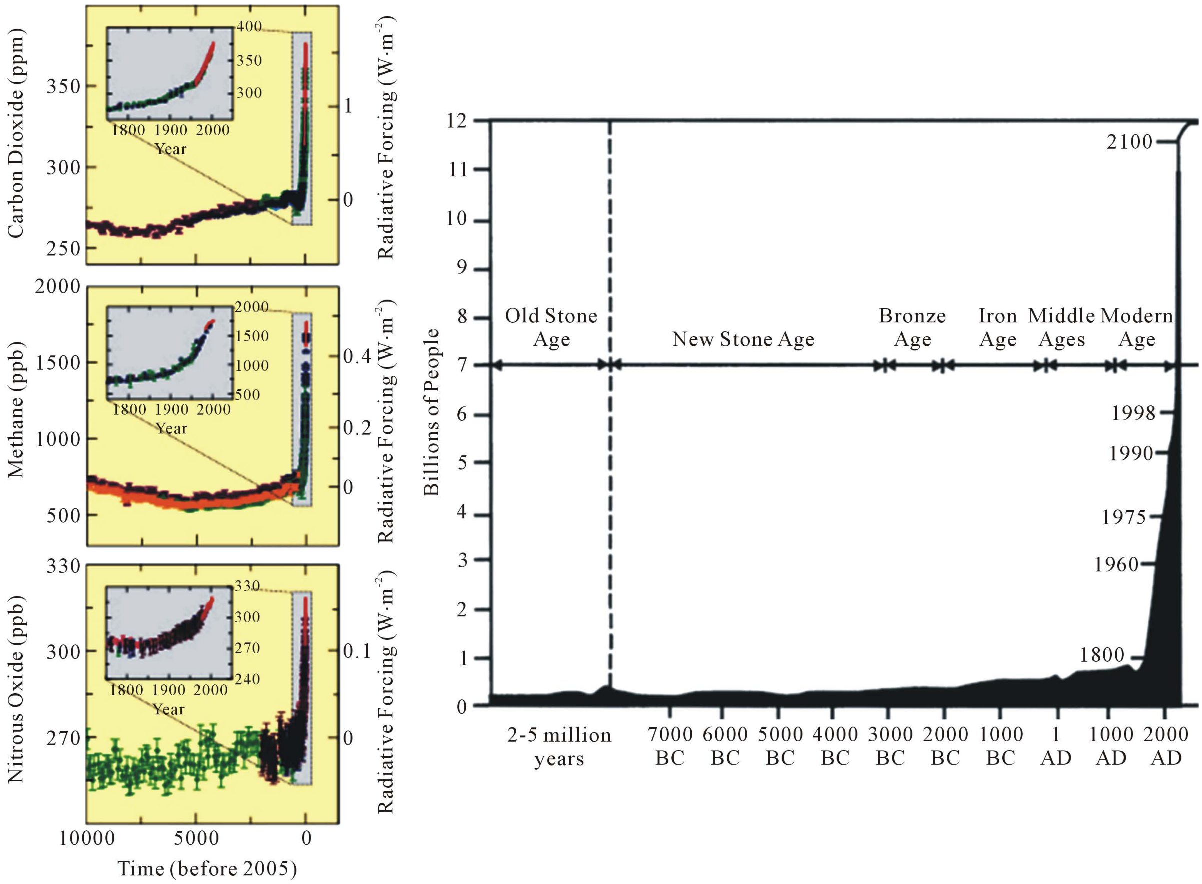

Figure 1. The left-hand panel shows the concentrations of carbon dioxide (CO_2, in parts per million), methane (CH_4, in parts per billion) and nitrous oxide (N_2O, in parts per billion) over the past 10,000 years (the Holocene epoch, following the last ice age), as well as the concentrations of these greenhouse gases over the period of the industrial revolution beginning in 1750 (insets). This panel also shows the radiative forcing of these greenhouse gases—the change in the net incoming radiation at the top of Earth's atmosphere, in Watts per meter squared (Wm^{-2}) [3] (Figure SPM 1). The right-hand panel shows the population of human beings during the Holocene from Figure 9 of the 1991 paper by Joseph A. McFalls Jr., "Population: A Lively Introduction" [4].

in billions of people, GWP is the Gross World Product in thousands of 1990 US dollars, and E is the energy used in a year in exajoules (EJ = 10^{18} joules).

The SRES scenarios consist of four families designated A1, A2, B1 and B2 which differ in their storylines for four possible futures absent any climate-change policy. Thus, these are non-intervention scenarios. **Figure 2** shows the annual carbon emission rate, $\dot{C}$, for the highest and lowest end-member scenarios, A2 and B1, respectively. These scenarios are described thusly in the SRES Summary for Policymakers report [19]:

"The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines."

"The B1 storyline and scenario family describes a convergent world with the same global population that peaks in midcentury and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives."

Figure 2 shows that in the A2 scenario, $\dot{C}$ increases across the 21st century to 27.6 billion tonnes of carbon (GtC) per year in 2100. In marked contrast, in the B1 scenario, $\dot{C}$ peaks at 11.5 GtC in 2050 and ends the century at 4.8 GtC.

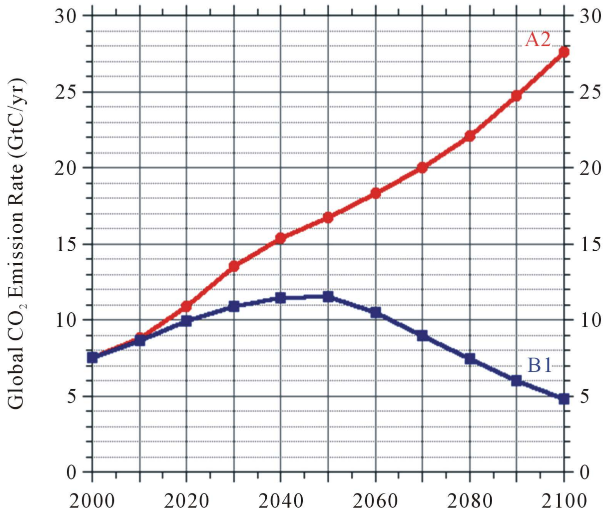

Figure 2. The annual carbon dioxide emission rate, $\dot{C}$, in billions of tonnes of carbon per year, for the highest (A2) and lowest (B1) end members of the SRES scenarios. SRES data from the SRES archive at http://sres.ciesin.org/final_data.html.

The four Kaya quantities for the A2 and B1 scenarios are presented in **Figure 3**. It can be seen that the wealth per person (GWP/N) increases across the century, while the energy intensity (E/GWP) and the carbon intensity ($\dot{C}$/E) both decrease. However, there is a marked difference in the trajectories for the human population (N) in the two scenarios. In the A2 scenario, N increases across the 21st century to 15.1 billion people in 2100. In the B1 scenario, N increases to 8.7 billion in 2050 and then decreases to 7.0 billion in 2100, which is slightly smaller than the current (31 October 2015) human population of 7.4 billion people (http://www.worldometers.info/world-population/).

To illustrate the importance of population, let us calculate the carbon emission rate for the A2 scenario using the B1 population scenario rather than the A2 population scenario. In this calculation we use the A2 scenarios for (GWP/N), (E/GWP) and ($\dot{C}$/E). The result is shown in **Figure 4**. It is seen that in the modified A2 scenario, the carbon emission rate increases to about 13.5 GtC/year in 2070 and thereafter remains quasi constant, ending the century at 12.9 GtC. This is 47% of 27.6 GtC emitted in 2100 in the unmodified A2 scenario. Consequently, *POPULATION MATTERS*!

4. Earth's Climate Future = Humanity's Choice

We now examine in the light of the above, two more recent scenarios for carbon emission rate, one a Reference scenario for unmitigated carbon emission, and the other our Fair Plan to Safeguard Earth's Climate.

4.1. Emissions

Figure 5 shows two scenarios for the future emission rate of CO_2, a Reference scenario in which there is no emissions abatement, and the scenario for the Fair Plan to Safeguard Earth's Climate, wherein there is emissions abatement.

The Reference emission scenario for CO_2, and other human-caused greenhouse gases, is that of the Reference Concentration Path 8.5 (RCP-8.5) [10]. This is the way the world would likely emit GHGs if either there were no consequent climate change or if we were completely ignorant thereof. The RCP-8.5 was developed at the International Institute for Applied Systems Analysis in Laxenburg, Austria, to be one of four emission scenarios developed for the fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) [20]. RCP-8.5 is the highest of these scenarios and leads to a radiative forcing (the change in the net incoming radiation, net incoming solar minus outgoing infrared radiation, at the top of Earth's atmosphere) of about 8.5 $W \cdot m^{-2}$ in 2100.

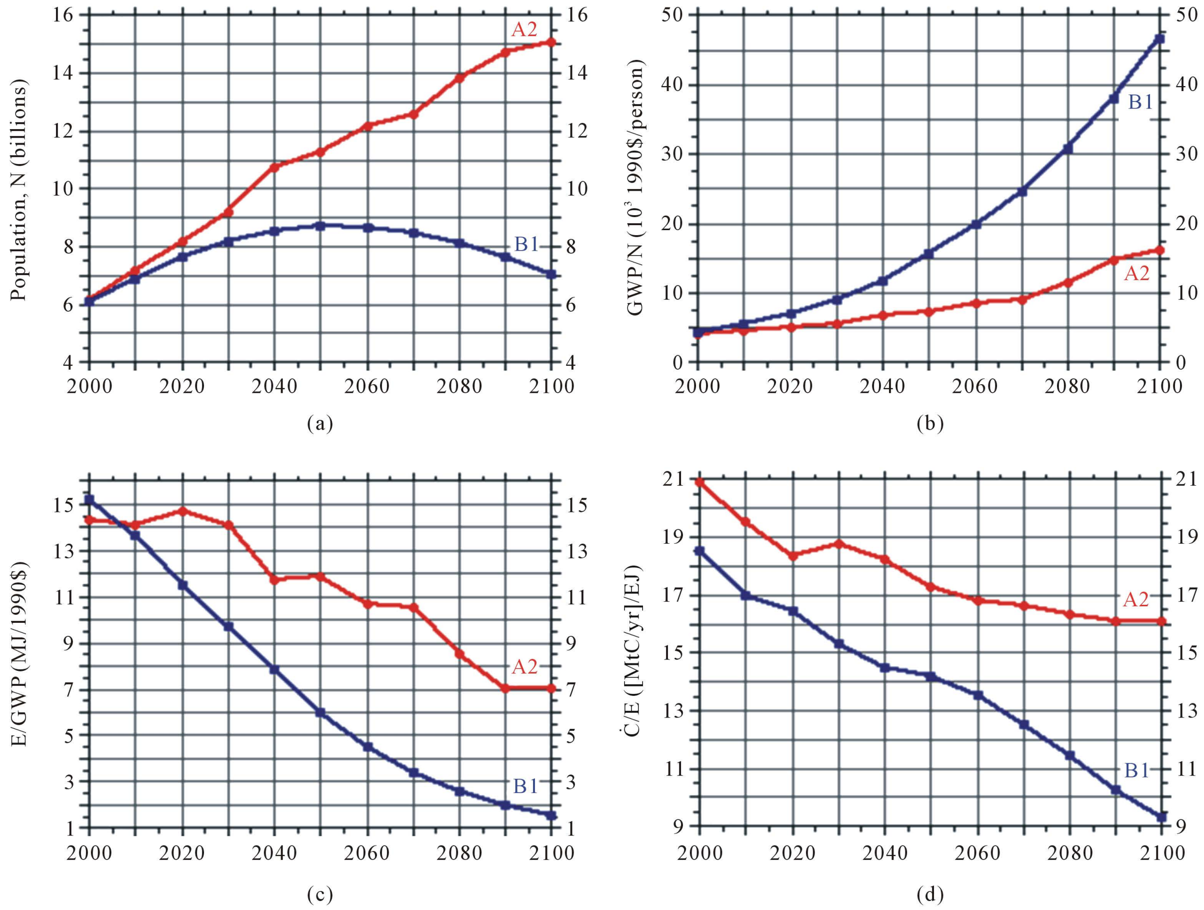

Figure 3. The four quantities of the Kaya identity for the highest (A2) and lowest (B1) end members of the SRES scenarios: (a) population, N, in billions of human beings; (b) wealth per person (GWP/N), where GWP = Gross World Productivity, in thousands of 1990 US dollars (10^3 1990$) per person; (c) energy intensity (E/GWP), where E is energy in 10^{18} Joules (EJ), in MJ/1990$; (d) carbon intensity (Ċ/E) in MtC/yr/EJ. SRES data from the SRES archive at http://sres.ciesin.org/final_data.html.

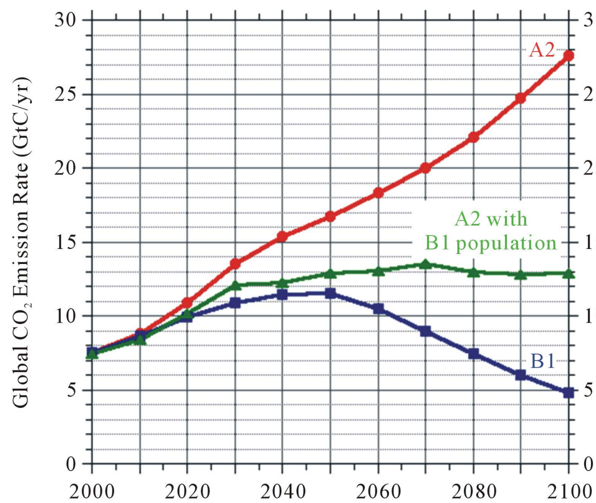

Figure 4. The annual carbon dioxide emission rate, Ċ, in billions of tonnes of carbon per year, for the modified A2 scenario = the A2 scenario for (GWP/N), (E/GWP) and (Ċ/E) and the B1 scenario for N. The annual carbon emission rates for the A2 and B1 scenarios are shown for comparison. SRES data from the SRES archive at http://sres.ciesin.org/final_data.html.

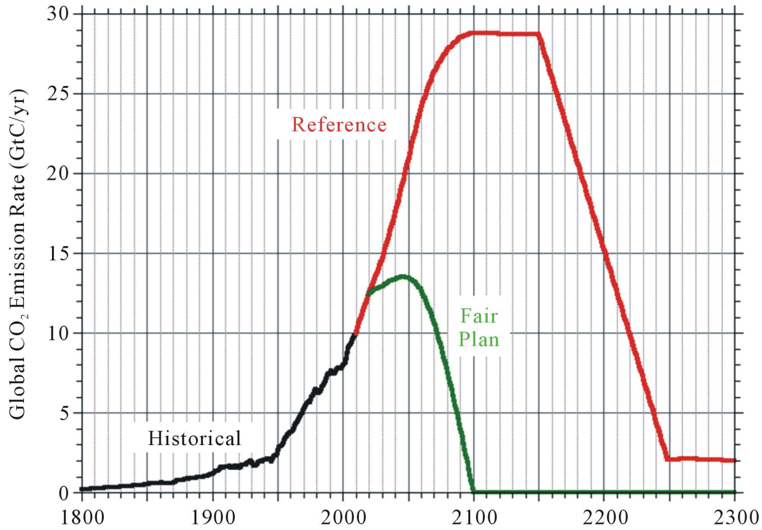

Figure 5. The annual carbon dioxide emission rate, in billions of tonnes of carbon per year, for the Reference (RCP-8.5) scenario (red line) and for the Fair Plan to Safeguard Earth's Climate (green line). The historical CO_2 emission rate is shown by the black line.

The emission of CO_2 under RCP-8.5 is shown by the red curve in **Figure 5**. The CO_2 emission rises from about 10.0 billion tonnes of carbon dioxide per year (GtC/year) in 2010 to 28.8 GtC/year in 2100, remains essentially constant until 2150, and then decreases to 2.0 GtC/year in 2300, where it remains essentially constant throughout the remainder of the millennium (not shown).

The Fair Plan to Safeguard Earth's Climate [11]-[17] was crafted by us to satisfy three objectives:

Objective 1: The cumulative trade-adjusted CO_2 emissions by the developing countries equal the cumulative trade-adjusted CO_2 emissions by the developed countries. Trade-adjusted emissions mean the emissions incurred by country A to export goods and/or services to country B are debited to country B, not country A.

Objective 2: The maximum global warming above preindustrial temperature does not exceed the 2˚C (3.6˚F) chosen by the United Nations Framework Convention on Climate Change (UNFCCC) "to prevent dangerous anthropogenic interference with the climate system" [2].

Objective 3: The phaseout of CO_2 and other greenhouse-gas emissions is begun as late as possible in the 21^{st} century and proceeds at the slowest possible pace, consistent with Objectives 1 and 2, to minimize the disruption of the global economy.

The global annual CO_2 emissions for the Fair Plan are shown by the green curve in **Figure 5**. The CO_2 emissions for the Fair Plan increase slowly from 12.4 GtC in 2020 to 13.5 GtC2046, and thereafter decrease to zero in 2100.

4.2. Concentrations

Figure 6 shows the CO_2 concentration for the Reference case (red curve) and Fair Plan (green curve). The CO_2 concentration for the Reference case rises to 1928 parts per million by volume (ppmv) in 2237 and then, as a result of the natural sinks, decreases to 1875 ppmv in 2300. The CO_2 concentration continues to decrease to about 1750 ppmv in 2600 and remains there over the last 400 years of the third millennium (see Fair Plan 7 [17]). This CO_2 concentration is more than six times the preindustrial concentration of 277 ppmv. It is also about 500 ppmv larger than the CO_2 concentration was during the Late Eocene, 35 million years ago. Then there was no ice on Earth and sea level was 73 meters (240 feet) higher than at the beginning of the Industrial Revolution. Clearly, this is an outcome that humanity should not create by continuing its unabated emission of greenhouse gases.

The CO_2 concentration for the Fair Plan rises to 612 ppmv in 2087, a bit more than twice the preindustrial CO_2 concentration of 554 ppmv, decreases to 484 ppmv in 2300, and further decreases to 406 ppmv by the end of the third millennium (not shown).

4.3. Global Warming

Figure 7 shows the expected value of the change in global-mean near-surface temperature from pre-industrial temperature for the Reference case (red curve) and the Fair Plan (green curve) (see Fair Plan 7 [11] for details).

In 2054 the Anthropogenic Global Warming (AGW) for the Reference case exceeds the 2˚C (3.6˚F) limit adopted by the UN Framework Convention on Climate Change (UNFCCC) "to prevent dangerous anthropogenic interference with the climate system" [2]. The AGW increases then to 5.3˚C (9.5˚F) in 2240 where it remains for the remainder of the third millennium. This human-caused future AGW is comparable to the nature-caused

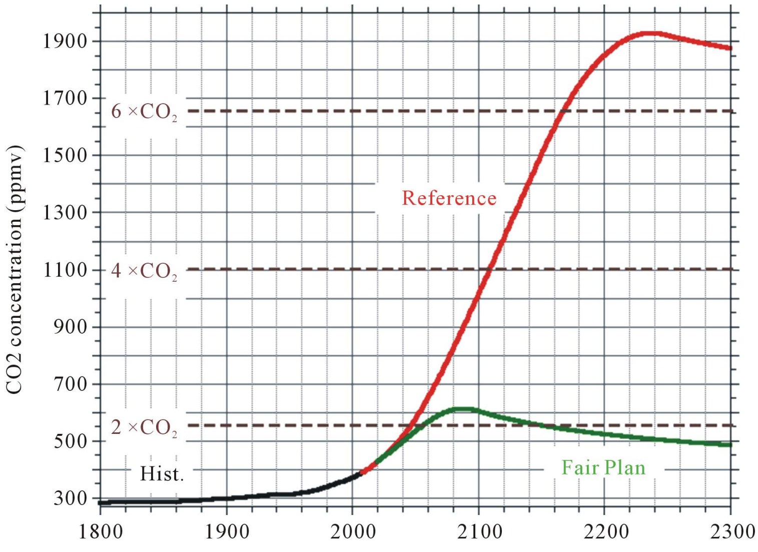

Figure 6. The CO_2 concentration for the Reference case (red line) and Fair Plan (green line). The brown dashed lines show two times, four times and 6 times the preindustrial CO_2 of 277 parts per million by volume (ppmv).

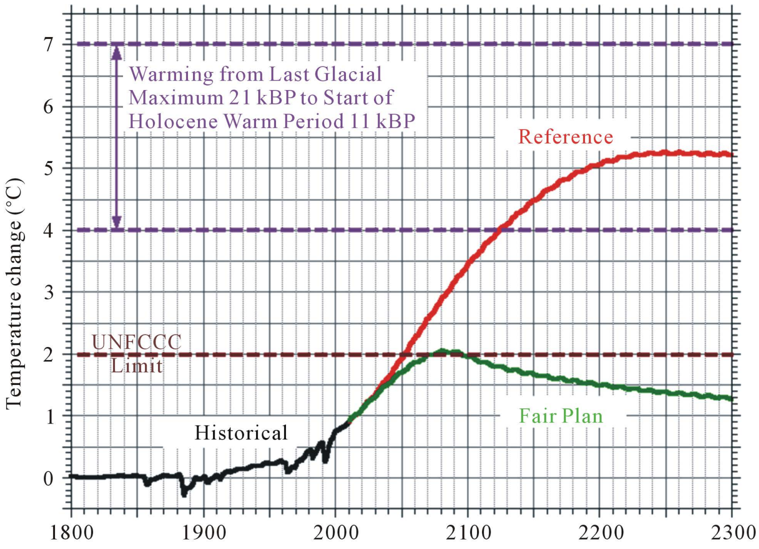

Figure 7. The expected value of the change in global-mean near-surface temperature from pre-industrial temperature for the Reference case (red curve) and Fair Plan (green curve). The historical temperature change is shown by the black line. The UNFCCC limit of 2˚C is shown by the dashed brown line. The estimated range of the warming from Last Glacial Maximum 21,000 before the present (21 kBP) to the start of the Holocene Warm Period 11 kBP is shown by the dashed purple lines.

past Global Warming from the Last Glacial Maximum climate of the Wisconsin ice age about 21,000 years ago to the succeeding Holocene interglacial climate 11,000 years ago [21] (page 435). Thus the human-caused future warming of the Reference case, if unabated, would be 50 times faster than the nature-caused past Global Warming from the last Ice Age to its successor non Ice Age.

In marked contrast, the AGW for the Fair Plan peaks at 2.04˚C (3.7˚F) in 2082, just above the 2˚C (3.6˚F) UNFCCC limit, and then decreases throughout the remainder of the millennium to 0.9˚C (1.6˚F) in year 3000.

5. Conclusion

We have shown herein that in the matter of the emission of greenhouse gases by humanity and the consequent human-caused climate change = AGW, *POPULATION MATTERS*! **Figure 4** shows that, *ceteris paribus*, reducing the growth of the human population reduces the growth of the emission of greenhouse gases by humanity. Does this require some Draconian, Orwellian, Logan's-Run/Soylent-Green solution? No, it does not. Rather it requires only that the birth rate be decreased to below the mortality rate so that Senior Citizens, such as the lead author, pass away without replacement until the desired level of the human population (N_{max}) is achieved. What is this desired value of N_{max}? The answer to this question depends on three things: 1) the desired quality of human life (QoL); 2) the desired distribution of QoL among the various peoples of the world (DiST); and 3) the desired sustainability of QoL and DiST on Planet Earth (SuS). Clearly, the lower N_{max}, the higher the *potential* for: a) enhanced QoL; b) more uniform DiST—a principal goal of Pope Francis' Encyclical Letter, *Laudato Si'*: *On Care for Our Common Home*; and c) enhanced SuS. It is for humanity to decide collectively the desired value of N_{max} and structure human civilization to make it so.

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