The Two Worlds Approach to Mitigating Climate Change: The Top One Billion and the Bottom Three Billion

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The work presented here is based on series of papers presented by the author at the Pontifical Academy of Sciences and the Pontifical Academy of Social Science. It benefited immensely from workshops and summits held by the two Pontifical Academies over the last 4 years at the Vatican, notably:

2015: Protect the Earth, Dignify Humanity. The Moral Dimensions of Climate Change and Sustainable Humanity. URL for the Proceedings.
(http://www.casinapioiv.va/content/accademia/en/events/2015/protectearth.html).
2014: Sustainable Humanity Sustainable Nature our Responsibility, Proceedings of the Joint Workshop, 2014. URL for the Proceedings
(http://www.casinapioiv.va/content/accademia/en/publications/extraseries/sustainable.html).
2012: The Global Quest for Tranquillitas Ordinis. Pacem in Terris, Fifty Years Later. URL for Proceedings. (http://www.pass.va/content/scienzesociali/en/publications/acta/pacem.html)
2011. Fate of Mountain Glaciers in the Anthropocene, 2011. URL for Proceedings
(http://www.casinapioiv.va/content/accademia/en/events/2011/glaciers.html).

By mid-century, our planet's climate under business as usual pollution is highly likely to have undergone dramatic transformation. The average temperature of the climate would have shot past the UN-defined safety threshold of 2^0C above pre-Industrial temperatures, and along with it the chronic trends in the other physical and natural systems would have exceeded the experience of most ecological systems over at least the past 800,000 years. Each decade will be much warmer and unlike any that had been experienced before. Mountain glaciers and snow packs worldwide would be visibly diminished and their ability to provide water for the warmer seasons would be severely compromised. Intense hurricanes, violent storms, flooding and heat waves would be more intense and mega droughts would be more frequent. Sea level would have risen visibly. Many of these changes are already occurring and are being recorded by instruments. By 2050 however, we would not need to read scientific papers to become aware of these changes and argue about their causes. Each and every citizen of the world will be experiencing the climate disruption, as many are already, especially the poorest and most vulnerable among us. Change, disruption and uncertainty would settle in as the norm. Our institutions from global to local domains would no longer be able to plan for the future based on the natural systems of the past. There would be overwhelming acceptance of human induced climate change and demand for urgent actions at scale, but if we wait for that moment of universal acceptance, it would be already too late to protect a large proportion of society, particularly the poorest three billion, who will suffer the worst consequences in spite of having a minimal role in the carbon pollution that is warming the planet.

The slowness with which nations and society are responding to scientific warnings of climate change is raising grave ethical and moral issues related to intergenerational as well as intra-generational equity. I will consider in this exposition just the issue of intra-generational equity. About one billion people consume more than 50% of available fossil energy and emit as much as 60% of the warming pollutants that lead to climate change. On the other hand the bottom three billion living mostly in developing nations cannot afford modern fossil fuels and live on rudimentary technologies of the 18^{th} century… burning firewood and dung for basic needs such as cooking. The solutions for limiting climate change are clear and have been prescribed by numerous scientific and government bodies: Decarbonize the economy and provide sustainable energy for all. The cost of cutting carbon pollution by 50% by 2050 as required by policy makers would have a net cost of only about $450 per person among the top one billion. It will cost them another $250 per capita to provide renewable energy access to the bottom three billion. The text describes why the world of the Top One Billion must make these investments to protect their own wellbeing. Religious institutions and faith leaders of the world can exert a transformational impact in raising the intra-generational equity and morality issue and amass public opinion for taking the necessary policy actions. They can also have a large impact in distributing scalable technologies to the world of the Bottom Three Billion.

I. What is the Scientific Basis of Climate Change?

The Greenhouse Blanket: The first question I am asked by the public is:

How does the colorless gas from the tail pipe of my car lead to heat waves, droughts, floods, severe storms, melting glaciers and finally sea level rise worldwide?

When we burn fossil fuels, the carbon in the fuel combines with oxygen in the air to form carbon dioxide. Once in the air, about half of the tailpipe emissions stay in the air for 100 years and about a quarter stays for over a thousand years. Because of this long life of the potent carbon dioxide molecule, it covers the planet like a blanket. This has been going on since the ushering of the fossil fuel age by James Watts through his improved steam engine in the 1770s. About 1000 billion tons (Trillion) of this gas has accumulated in the blanket by now. This likely is one of the most lasting and damaging legacies of the Anthropocene (Crutzen, 2002). Just like a blanket keeps us warm on a cold night by trapping our body heat, this blanket traps the heat from the surface and the atmosphere and warms both the surface and the atmosphere. Beyond tail pipes of cars, almost all human activities require energy released by the burning of fossil fuels. One notable exception is the world of the Bottom Three Billion, where the people still cannot afford modern fossil fuels even for basic activities such as cooking and heating.

The Physics of Global Warming: The amount of heat trapped is determined by the quantum mechanics of the carbon dioxide molecule and by the thickness of the blanket, which is about 1000 billion tons now. The Swedish Nobelist, Svante Arrehnius, worked out the science of the greenhouse effect of the carbon-dioxide molecule and its global warming in detail 119 years ago. A detailed review of Arrehnius' work to mark the hundredth anniversary of this path-breaking study was commissioned by the Swedish Academy of Sciences (Ramanathan and Vogelmann, 1997; all references to published literature are listed at the end). Many refinements to the Arrhenius' theory have been made in the intervening century but the underlying science of Arrhenius work still stands firm, which is, that the climate system is very sensitive to increases in carbon dioxide.

For nearly 75 years scientists believed that carbon dioxide was the only climate warming pollutant. This view changed dramatically with the publication of a study in 1975 (Ramanathan, 1975), which identified the refrigerant CFCs as a super greenhouse gas. This study showed that addition of one molecule has the same warming effect as the addition of over 10,000 molecules of carbon dioxide. Soon, many other man made warming gases were identified, and as of now CFCs and the other warming pollutants are contributing as much as carbon dioxide. These other warming pollutants include the short-lived climate pollutants, which are: black carbon aerosols (soot), tropospheric ozone (pollutant in smog), methane (natural gas), and HFCs (a compound that replaced CFCs). In short, the global warming problem became doubly more important and required a more sophisticated approach that integrates air pollution with climate change.

The Scientific Predictions: By early 1980s, studies predicted that the warming will be accompanied by increased humidity in the air, get amplified in the polar regions, melt sea ice and

continental glaciers and would penetrate to the deeper oceans and increase sea level, among other changes (Charney, 1979). The famous Charney report was followed by a prediction that the warming due to manmade greenhouse gases would become discernible by 2000 (Ramanathan and Madden 1980), which indeed was verified by a team of about 500 scientists assembled by the United Nations (IPCC, 2001). This 2001 report concluded: *An increasing body of observations gives a collective picture of a warming world and other changes in the climate system', and 'There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.'* The predictions about polar amplification of the warming, melting of arctic sea ice and sea level rise were all confirmed by actual measurements.

Is it Climate Change or Climate Disruption? The only difference was that in most instances the observed changes were much larger than the predicted changes. The strongest warming was observed since the 1970s. The planet has warmed by about than 0.8^0C (1.5^0F) and the last decade was the warmest decade since James Watt's time. The Arctic warming is three times as much, threatening thee ecology of the region. The warming was accompanied by increasing occurrences of severe weather such as heat waves, intense hurricanes, mega droughts and floods, which came as a surprise to the climate science community for it had not predicted the intensity of the extreme events. This has led to the emerging view that we should think of it not as global warming or climate change but as climate disruption (a preferred term now for some policy makers).

II. What Is In Store For Us and For Generations To Be Born?

Ocean data have revealed that the added heat trapped by the thousand billion tons of greenhouse blanket has penetrated to a depth of more than 1000 meters in the ocean (Roemmich et al, 2015). The heat stored in the ocean will influence the climate for millennia even if we stop polluting the planet today. On the contrary we are continuing with the pollution at a faster rate. Roughly 45 billion tons of carbon dioxide and other warming gases are being added every year. If the current rate of pollution continues, the planet can warm by as much as 2^0C (3.5^0F) by 2050 and as much as 4^0C (7^0F) by end of century (Schellnhuber, 2013). Such temperatures have not been witnessed in the last million years and the probability of tripping over many tipping points that can set off irreversible changes of the ecosystem is high {Schellnhuber, 2013}. The damages to natural ecology, human health, water and food security due to drastic changes in iconic climate systems such as the Greenland glaciers, much of coastal systems, wetlands, Himalayan-Tibetan glaciers and rivers are incalculable. One major obstacle in estimating the damages is that the predictions of the future climate are subject to large uncertainty. The changes could be smaller than the predictions by a factor of 2 but could just as well be larger by a factor of 2. Already, the 4^0C (7^0F) warming predicted for 2100 would be unprecedented but if it is larger than the predicted by a factor of 2 or more (albeit a low probability event), it could be catastrophic. For example to find a past analogue to a world warmer than the present by 8C (14^0F), we have to go back more than 50 million years. Economists are beginning to recommend that such catastrophic warming, even if it is a low probability event, should govern our policy responses (Weitzman, 2011).

III. Who are Responsible?

Almost everyone and every industry are responsible for polluting the planet with carbon dioxide and numerous other climate pollutants. But some are disproportionately more responsible than the

others. As of today, about one billion people are consuming about 50% of the fossil fuel and contributing about 60% of the greenhouse gas pollution (Ramanathan, 2014). With the business as usual scenario, they will also be contributing about 60% to the increase in the emissions. About 75% of this Top One Billion live in industrialized nations and the rest are distributed among the developing nations of the world (Chakravarty et al, 2012). The bottom three billion, contribute only about 5% to the emissions. Their emissions are mainly for basic needs such as cooking, heating and lighting. The balance of 25% of the emissions is due to the middle low-income population of about three billion.

IV: How Soon and How large is the Change going to be?

It has become clear to most scientists that about 2^0C warming is unavoidable because of the thousand billion tons of greenhouse blanket which is already up there from past emissions (Ramanathan and Feng, 2008). There is a 50% probability that this warming can happen as early as 2050 (Ramanathan and Xu, 2010).

V. The Ethics of Intra-Generational Equity

The disproportionate and unsustainable consumption by the top one billion in conjunction with the likely imminence of the warming raises major ethical issues since the Bottom Three Billion are least equipped to deal with climate change resulting from a 2^0C warming. To give but one example, most of them survive on subsistence farming with few acres of land. A mega-drought of the sort that is visiting California the last five years would destroy their only source of income. In spite of having a minimal role in causing global warming they will disproportionately bear the brunt of the likely devastations of climate disruption.

VI. The World of the Bottom Three Billion

We must prepare people for adapting to such a rapid climate change with unprecedented rise of storms, droughts, sea level rise, and depleted water storage in our snow packs and glaciers. Adaptation has to happen from local to global scales and requires new institutions (Kennel, 2014). Above all adaptation requires access to energy, water and modern technologies and all three are pose challenges and opportunities for the bottom three billion who still are coping with 18^{th} century technologies. They pay a huge price in terms of health. Every year the smoke from solid biomass cooking and heating alone leads to about 4 million premature deaths. The first task is to provide access to energy to the bottom three billion as called for by the UN under the new sustainable development goals (Sachs, 2015). The cost of providing renewable energy access to meet basic needs for the bottom three billion is estimated by the IIASA institute in Austria to be $250 billion (Pachauri, 2013), which is about $250 per capita among the Top One Billion. Why should the Top One Billion bear this cost? Because the carbon footprint in the Bottom Three Billion world otherwise could climb to 15 billion tons per year if they adopt the outdated fossil fuel technologies of the other four billion people of the world. Mini – and Micro- grids of solar and renewable biofuel are attractive alternatives for rural areas of S. Asia, sub-Saharan Africa and South America where most of the Bottom Three Billion live. These smaller grids do not requite the massive infrastructure of large giga watts power plants of cities. Such distributed micro to mini grids will

enable them to leapfrog the Top One Billion world into sophisticated and climate friendly ways of energy generation and consumption.

VII. Dialing Down Climate Change: Who and How?

This is a well-established area with numerous international reports. Basically we have to decarbonize the economy, that is, reduce the dependency of fossil fuels for energy access. To keep the warming below 2^0C, we have to cut carbon emissions by 50% by 2050 and to eliminate emissions by 2100. The cost of this has been estimated to be about one Trillion Dollars per year (IPCC, 2013). But fossil fuel subsidies is estimated to be about $550 billion, and so the net cost is about $450 billion per year, which amounts to about an annual cost of about $450 capita among those in the world of Top One Billion. The situation for the Top One Billion may be even much better since a new study published this month by the International Monetary Fund concludes [http://www.imf.org/external/pubs/ft/wp/2015/wp15105.pdf] *"Post-tax energy subsidies are dramatically higher than previously estimated—$4.9 trillion (6.5 percent of global GDP) in 2013."* Hence my estimated cost of $450 for the Top One Billion is likely an upper limit. I am not implying it is straightforward to channel the fossil fuel subsidies to climate mitigation. It is a monumental governance issue best left to national leaders. The main point of the hypothetical exercise is that the cost of mitigation is not unaffordable.

There is one remaining important issue with respect to protecting the current generation. Because of the century to millennial lifetimes of the Carbon Dioxide molecule, it will take decades for the effect of Carbon Dioxide mitigation on climate to manifest. So we need another strategy to slow the warming in the coming decades. Fortunately, the lifetime of the other warming pollutants know as "short-lived climate pollutants" range from only weeks to about 15 years. We have proven technologies to mitigate these short-lived climate pollutants and these can reduce the rate of warming from now until 2050 by almost 50% (Ramanathan and Xu, 2010; UNEP_WMO, 2011; Zaelke & Ramanathan, 2012).

The objectives of climate policy, as stated in the UN Framework on Climate Change are two fold: to stabilize the concentrations of climate pollutants at a safe level for long-term climate protection, and to cut the rate of climate change quickly enough to allow ecosystems to adapt naturally to climate change, to ensure food security, and to allow economic development to proceed in a sustainable manner: Cutting short-lived climate pollutants is essential for near-term protection, and cutting both short-term and long-term carbon dioxide is essential for long-term climate protection. It is also essential to achieve sustainable development goals since these pollutants directly harm air quality, crops, ecosystem and human health.

Role of the Church and Other Religions in Protecting Humanity and Ecosystems

I will conclude with what I now consider to be the most important issue in the debate on climate chang**e.** The ethics of intra-generational and inter-generational equity as well as the responsibility to protect nature has catapulted the climate change problem into a major moral and ethical issue. In considering our present world, and the great challenge we face as humanity to correct our development path towards one that considers the limits of Nature and one that avoids severe damage to the most vulnerable ones, we must reflect on the moral necessity of acting on climate change. The logical domain of the moral and ethical issue is religion with responsibility placed on

religious leaders. But science has to be a synergistic partner in this venture. In this regard, the Pontifical Academy of Science (PAS) and the Pontifical Academy of Social Sciences (PASS) has a unique role to play since these prestigious science academies operate under the domain of the Catholic Church. The academies have organized several trend-setting workshops and summits on the climate change and sustainability issues and have released several documents and declarations (see citations in the cover page). The overwhelming conclusions from these reports (as summarized in Dasgupta and Ramanathan, 2014; also see *The Climate Change and the Common Good* document in the website of PAS and PASS) are two fold (direct quotes):

- *There is a need to reorient our attitude toward nature and, thereby, toward ourselves.*
- *The transformational step may well be a massive mobilization of public opinion by the Vatican and other religions for collective action to safeguard the well being of both humanity and the environment.*

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