

GLOBAL CLIMATE CHANGE AND THE CHURCH IN THE MODERN WORLD: A SIGN OF THE TIMES

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Abstract

Forty Years Later: *Gaudium Et Spes* and Global Climate Change

Considered by many to be one of the most distinctive achievements of the Second Vatican Council, *Gaudium et Spes* signaled a pastoral and methodological shift in the Church's approach to the modern world. Perhaps best identified by the phrase, "signs of the times," arguably a primary expression of the focus and intent of this remarkable document, *Gaudium et Spes* punctuated a genuine shift toward the world and the Church's commitment "to cooperate in finding the solution to the outstanding problems of our time."

Nevertheless, when *Gaudium et Spes* was promulgated in 1965 the deterioration of earth's bio-physical environment was just beginning to emerge as a scientific concern and was not, consequently, identified by the Council as a "problem with special urgency." For example Part II, Chapter III, on Socio-Economic Life, is an insightful and critical anthropocentric analysis on the economic disparities and social inequalities of modern existence but makes no mention of the environmental impacts of economic growth with the exception of the observation that the "modern economy is marked by man's increasing domination over nature. . ." Forty years later, as humanity moves into the 21st century, it would be impossible to critically reflect on "The Common Purpose of Created Things" without a serious discussion of the range of environmental problems that threaten creation, chief among which is the critical concern over global climate change. Consequently, this paper will argue in the spirit of *Gaudium et Spes* that global climate change is a major sign of the times and must be given special urgency by the Church and the human community it serves if potential devastating consequences are to be avoided. From a perspective of interdisciplinary collaboration between Catholic theology and environmental science, this paper will provide a summary of the scientific basis for climate change, focus on the social and economic impacts of this phenomenon, and discuss how climate change and other environmental conditions have challenged Catholic Social Teaching to expand and re-define itself. It will conclude with the proposal that, given the complexity of climate change, a reasonable and successful response to this problem will require an interdisciplinary approach and the collaboration of many fields providing Catholic universities with a unique opportunity to assist humanity in facing this threat.

The Specter of Climate Change: Scientific Basis, Impacts and Vulnerability

In spite of its cautionary approach to contemporary science and technology, *Gaudium et Spes* recognized that “scientific study and strict fidelity toward truth in scientific research, the necessity of working together with others in technical groups, a sense of international solidarity. . .” were positive values of modernity. In light of this positive affirmation of scientific research and international collaboration, this section will draw upon the work of the Intergovernmental Panel on Climate Change (IPCC) established in 1988 by the World Meteorological Organization and the United Nations Environmental Programme. The IPCC, composed of three technical working groups of approximately 2000 international scientists, has produced the most comprehensive and current scientific and social analysis of global climate change to date. The most recent product of their research, The Third Assessment Report (TAR, 2001) provides a voluminous and detailed scientific basis for climate change and re-affirms the judgment that global warming and climate change are the result of anthropogenic causes. Moreover on the issues of impacts and vulnerability, the TAR is clear that the negative impacts will affect the most vulnerable populations (human and non-human) on the planet. In the Summary for Policymakers, Working Group II states that “Those with the least resources have the least capacity to adapt and are the most vulnerable,” particularly those communities “under pressure from forces such as population growth, resource depletion and poverty.” The impact and vulnerability scenarios projected by Working Group II clearly indicate that those human populations in developing nations will suffer disproportionately the negative effects of climate change. After summarizing the scientific basis for climate change and highlighting the most significant research on impacts and vulnerability, this section of the paper will make that case that, given the excessive consumption of energy resources by developed nations, the climate change issue presents us with an acute intersection of ecological and social justice.

Catholic Social Teaching and Climate Change: Expanding Perspectives on Human Dignity, the Common Good and Social Justice

The primary task of *Gaudium et Spes* was to scrutinize the signs of the times in light of the gospel and Catholic Social Teaching. In doing so the Pastoral Constitution emphasized the following key principles: human dignity, the common good and social justice. In recent years the Church, faithful to the intent of *Gaudium et Spes*, has responded to our environmental crisis indicating an expansion of Catholic Social Thought. A prime example of this is the U.S. Catholic Bishops’ statement, *Global Climate Change, A Plea for Dialogue, Prudence and the Common Good* (2002) wherein the Bishops utilize the term “universal common good” and state that “Global climate change is by its very nature part of the planetary commons.” Traditionally understood within the organic framework of human social-historical-economic existence, the concept of the common good has evolved into the “universal and planetary common good” due, in part, to the impact of ecology and the environmental crisis. This section of the paper will address several specific components of Catholic Social Teaching that are evolving and will interpret and refine them in light of global climate change. The following key concepts will be examined:

- Ecology, scientific inquiry and the “Signs of the Times,”

- The doctrine of the *imago Dei*, the role of biblical creation theology and stewardship,
- The common good, social justice and the expanding concept of ecological justice.

Climate Change and the Catholic University: The Need for Interdisciplinary Collaboration.

The final section of the paper will propose that, given the complex nature of current environmental conditions such as climate change, interdisciplinary collaboration is essential. In light of *Gaudium et Spes* and *Ex Corde Ecclesiae* (1990), the Catholic University has an opportunity to forge new models of interdisciplinary cooperation and research. This conclusion will propose an interdisciplinary method for analyzing and responding to the signs of the times that is consistent with the spirit and intent of *Gaudium et Spes*.

Introduction

Considered by many to be one of the most distinctive achievements of the Second Vatican Council, *Gaudium et Spes* signaled a pastoral and methodological shift in the Church's approach to the modern world. Perhaps best identified by the phrase, "signs of the times," a primary expression of the focus and intent of this remarkable document, *Gaudium et Spes* punctuated a genuine shift toward the world and the Church's commitment "to cooperate in finding the solution to the outstanding problems of our time." Nevertheless, when *Gaudium et Spes* was promulgated in 1965 the deterioration of earth's bio-physical environment was just beginning to emerge as a scientific concern and was not, consequently, identified by the Council as a "problem with special urgency." For example Part II, Chapter III, on Socio-Economic Life, an insightful and critical anthropocentric analysis on the economic disparities and social inequalities of modern existence, makes no mention of the environmental impacts of economic growth with the exception of the observation that the "modern economy is marked by man's increasing domination over nature. . ."

Forty years later, as humanity moves into the 21st century, it would be impossible to critically reflect on "The Common Purpose of Created Things" without a serious discussion of the range of environmental problems that threaten creation, chief among which is the critical and growing concern over global climate change. Consequently, this paper will argue in the spirit of *Gaudium et Spes* that global climate change is a major sign of the times and must be given special urgency by the Church and the human community it serves if potential devastating consequences are to be avoided. Within the global community, this issue is magnified by the continued refusal of the United States—the world's leader in fossil fuel consumption and producer of greenhouse gas pollution—to endorse the Kyoto Protocol and participate in the global effort to reduce greenhouse gas emissions.

From a perspective of interdisciplinary collaboration between Catholic theology and environmental science, this paper will provide a summary of the scientific foundation for climate change based on the most recent scientific data available. Secondly, this analysis will focus on the social and economic impacts of this phenomenon with special attention to those human populations considered most vulnerable and least able to mitigate and adapt to the negative and rapid changes in global climate. Thirdly, this paper will discuss how climate change and other environmental conditions have challenged Catholic Social Teaching to expand and re-define key aspects of this social theology. Finally the paper will conclude with the proposal that, given the complexity of climate change, a reasonable and successful response to this problem will require an interdisciplinary approach and the collaboration of many fields providing Catholic universities with a unique opportunity to assist humanity in facing this threat.

The Specter of Climate Change: The Current Scientific Basis

In spite of its cautionary approach to contemporary science and technology, *Gaudium et Spes* recognized that “scientific study and strict fidelity toward truth in scientific research, the necessity of working together with others in technical groups, a sense of international solidarity. . .” were positive values of modernity. In light of this positive affirmation of scientific research and international collaboration, this section will draw upon the work of the Intergovernmental Panel on Climate Change (IPCC) established in 1988 by the World Meteorological Organization and the United Nations Environmental Programme, and upon recent analyses of the technical literature by other authoritative sources.

The IPCC, composed of three technical working groups of approximately 2000 international scientists, has produced the most comprehensive and current scientific and social analysis of global climate change to date. Their Third Assessment Report (TAR, 2001) provides a voluminous and detailed scientific basis to understand climate change, and re-affirms the judgment that global warming and climate change are the result of anthropogenic causes. More recent IPCC documents¹ that are additionally informative include the IPCC Working Group I Workshop on Climate Sensitivity, Workshop Report (held in Paris, France, 26–29 July 2004) and the IPCC Workshop on Describing Scientific Uncertainties in Climate Change to Support Analysis of Risk and of Options Workshop Report (held in Maynooth, Ireland, 11–13 May 2004). Although details of the more recent publications will be worth referring to, everything subsequent to the TAR has been consistent with its conclusions and supportive rather than calling for revisions. The challenging findings of the TAR are standing the test of further scrutiny; anthropogenic climate change is pollution-initiated, accelerating, and threatening to the conditions we depend on to support our civilization.

“Pollution” is a term that encompasses several things, including: (1) production and either intentional or unintentional release of novel human-invented materials (industrial chemicals, synthetic organic pesticides, cosmetics and pharmaceuticals which increasingly are accumulating in freshwater ecosystems), (2) physical products of an

increasing human population (biological waste materials), and (3) augmented levels of naturally occurring materials well beyond levels previously seen (increasing atmospheric levels of natural gases, salinization of soil, soot from fires). Global climate change is being driven to a small extent by human-invented chemicals (chlorofluorocarbons in the atmosphere, which should decrease in concentration gradually due to the CFC ban following the Montreal Protocol) but primarily by anthropogenic augmentation of naturally occurring gases beyond historical levels (carbon dioxide, methane). Global climate change goes beyond what we typically think of as pollution, because the gases released initiate processes of amplification that is called positive feedback loops. These positive feedback loops further accelerate climatic destabilization, much like the growth of a cancer from an initially small number of aberrant cells can develop into a widespread and ultimately fatal biological process.

The principle gas driving global climate change is carbon dioxide (CO₂), which is the major product of combustion for all fossil fuels, wood, and biofuels (such as ethanol and biodiesel). The ever accelerating rate of fossil fuel consumption over the last 150 years, combined with extensive burning of wood (both as the commonest fuel used by humans for heating their homes and cooking, and as part of slash-and-burn agriculture and tropical deforestation) has raised atmospheric CO₂ levels from 280 parts per million (ppm) to roughly 375 ppm. This increases global heat retention, since CO₂ (like all greenhouse gases) allows incident solar radiation to reach the earth's surface from the sun, but as its atmospheric concentration increases, it increasingly blocks the natural escape of infrared radiation re-radiated from the earth's surface back into space. More energy arriving and less energy escaping results in a steady buildup of energy on the earth, which we experience as climatic destabilization and overall warming.

Human economic activity is producing CO₂ in an accelerating fashion, and despite the efforts made by some nations to reduce CO₂ output in compliance with the Kyoto Protocol, at this point in time more CO₂ is released into the atmosphere every year by human economic activities than was released in the preceding year. Despite what we already know about the perils of excessive CO₂ emissions, we are still in an era of increasingly accelerating CO₂ release. Nevertheless, even though the matter of accelerating CO₂ concentrations is cause for concern, the prospects are even more alarming when one considers the reality of positive feedback loops, processes that make global climate change a self-accelerating de-stabilization of our planet. The nature of positive feedback loops impact the planet in the following ways: (1) as the planet warms, ice melts to expose dark surfaces beneath it on mountain ranges and in Antarctica, and the dark surfaces absorb more heat than the reflective ice did, which causes further warming driven by this new change to occur. (2) As the oceans warm, more water evaporates from them into atmospheric water vapor, which is itself a greenhouse gas, and this begins a self-perpetuating cycle of warmer air making more evaporation occur making moister air which means there is an additional increase in the greenhouse effect. (3 and 4) Clouds might either retard or accelerate global climate change; if they eventually form high in the atmosphere they will add to the greenhouse effect by trapping heat beneath them; if they form low in the atmosphere they might shade the surface of the earth like a thick cloud passing overhead on a hot summer day casting a cool shadow.

This scenario might slow CO₂ driven global climate change (the latter is the one possible negative feedback loop that has been described, and far from the likeliest one to occur). We have no way of being certain which of these processes will occur and with what strength, since we have never destabilized a planet's climate before, but in common parlance we are "playing with fire." Very few scientists are comfortable relying on chance to protect us from potentially catastrophic consequences, or at least consequences catastrophic to those humans with the least capacity to protect them.

Methane is a less prevalent greenhouse gas than carbon dioxide, but it is 23 times as effective in promoting global warming molecule-by-molecule. The concentration of methane in the atmosphere has approximately doubled since high levels of human economic activity began to impact our planet. The methane produced by human activities has as its main sources cattle and sheep rearing, rice growing because of the biological processes in marshes, and forest burning in slash-and-burn agriculture. Cattle and sheep produce methane gas in their digestive processes, and the enormous number of cattle now reared globally means that the gaseous products of their digestion are a significant element in global methane levels (approximately 20% of global methane emissions are due to farm animals). Efforts are underway to remediate the problems caused by farm animals². A team from the Commonwealth Scientific and Industrial Research Organisation in Perth, Western Australia, is developing a vaccine against the microbes that produce methane in sheep rumens. Vaccinated sheep have been shown to burp 8 per cent less methane over a 13-hour period³. Future vaccine development will attempt to reduce methane production even more by including more of the offending microbes in the protection they afford. Rice production and slash-and-burn agriculture are methane sources that it is more difficult to see a technological "fix" for. Methane has a short atmospheric residence time of about 12 years (as opposed to periods measured in centuries for carbon dioxide) and so there may be a relatively rapid payback to anything we can do to reduce methane emissions.

Soot is a complex combination of carbon black and various organic compounds that is involved in various processes that might influence climate, but on overall balance soot contributes to global warming and loss of ice.⁴ Soot settles from the air onto snow or ice and makes it dark, which causes the darkened surface to trap more solar energy than reflective white snow. This contributes to global climate change, by shifting the global energy balance towards increasing temperatures. It also contributes specifically to heating the snow or ice, which helps explain why sea ice and glaciers are melting even faster than expected as surface temperatures increase. Soot emissions may be easier to reduce than carbon dioxide emissions. Increasing efficiency of equipment to more cleanly burn fossil fuels without releasing large amounts of soot would provide one avenue to help slow global climate change, while we attempt to find ways to reduce the more intractable carbon dioxide gas emissions. Greenhouse gases are certainly the primary cause of global warming, but soot also contributes to the process.

According to Working Group I (WGI) of the IPCC, the most recent scientific analysis indicates that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."⁵ This assertion is based, in part,

on scientific observation and analysis during the later part of the 20th century and indicates the following changes:

- Global average surface temperature has increased since 1861, when record keeping began, and during the 20th century the increase has been 0.6°C +/- 0.2°C.
- Globally the 1990's were the warmest decade and 1998 was the warmest year since 1891.
- Data analysis indicates that for the Northern Hemisphere temperature increase during the 20th century is likely to have been the largest during the last 1000 years.
- Snow cover, ice extent and glacier coverage has decreased during the 20th century.
- Global average sea level has risen between 0.1 and 0.2 meters and ocean heat content has increased.
- During the 20th century precipitation has increased by 0.5 to 1% per decade over most mid and high latitudes of Northern Hemisphere continents and has likely increased by 0.2 to 0.3 % per decade over tropical land area.⁶

In addition to observed changes during the 20th century, Working Group I analysis indicates that concentrations of greenhouse gases (e.g. carbon dioxide, methane, nitrous oxide, CFC's) have continued to rise and that these anthropogenic emissions will "continue to alter the atmosphere in ways that are expected to affect the climate."⁷ This assertion is partly based on the increased confidence in computer generated climate models and their capacity to project future climate scenarios. Accordingly WGI asserts that human activities—particularly the burning of fossil fuel—will continue to alter atmosphere composition throughout the 21 century and consequently contribute to increase global warming and accelerate climate change. In other words, according to the IPCC Special Report on Emission Scenarios (SRES) global average temperature and sea level are expected to increase in the future. On the matter of temperature the projections are significant. In the Second Assessment Report (1994), WGI predicted that average global temperature would likely rise in the future between 1.0 to 3.5°C. That projection was upgraded in the TAR to reflect a range of increase from 1.4 to 5.8°C over the period of time between 1990 and 2100. Consequently WGI concluded that "The projected rate of warming is much larger than the observed changes during the 20th century and is very likely to be without precedent during at least the last 10,000 years. . ."⁸ In addition to rising average global temperature, WGI expects precipitation to increase, snow and ice to decrease with retreating glaciers and ice caps accompanied by rising sea levels. It is expected that between 1990-2100 sea level is projected to rise by 0.09 to 0.88 meters.⁹ WGI's level of confidence on the cumulative impacts of these changes on extreme weather and climate events during the 21st century is shown in the following table:¹⁰

Confidence in Observed changes (latter 20 th century)	Changes in Phenomenon	Confidence in projected changes (during 21 st century)
Likely	Higher maximum temperatures and more hot hot days over nearly all land areas	Very Likely

Very Likely	Higher minimum temperatures, fewer cold days and frost days over nearly all land area	Very Likely
Very Likely	Reduced diurnal temperatures range over most land areas	Very Likely
Likely, over many areas	Increase of heat index over land areas	Very Likely, over most areas
Likely, over many Northern mid to high latitude land areas	More intense precipitation events	Very Likely, over many areas
Likely, in a few areas	Increased summer continental drying and associated risk of drought	Likely, over most mid-latitude continental interiors
Not observed in the few analyses available	Increase in tropical cyclone peak wind	Likely, over some areas
Insufficient data for assessment	Increase in tropical cyclone mean and peak precipitation intensities	Likely, over some areas

A more recent assessment of the possible range of temperatures that make up the reasonable range of possibilities as the planet warms was published by climateprediction.net¹¹, a unique distributed computing approach to climate change modeling in which tens of thousand of volunteers have downloaded software that makes their home computers part of a vast network running climate change scenarios when not otherwise fully in use by their owners. The climatechange.net article reported 2,017 unique simulations of future climates, representing over 100,000 simulated years. Their results expanded the range of climate sensitivities beyond the previously reported 2-6°C, to between 2 and 11°C. The upper end of this range of temperature increases cannot be ruled out as a real possibility according to their calculations, and it represents a scenario that would involve a truly apocalyptic sea level rise. The climatechange.net project continues to calculate constantly worldwide, and their results will be incorporated into the Quantifying Uncertainty in Model Predictions (QUMP) project that will form part of the UK contribution to the IPCC Fourth assessment report.

The level of consensus among the scientific community about the reality of global climate change cannot be overstated. In a recent article in the most widely read scientific journal in North America, *Science*, Naomi Oreskes analyzed 928 abstracts of papers published in refereed scientific journals between 1993 and 2003 that were listed in the ISI database with the keywords “global climate change”¹². She categorized the papers into six groups. The first three groups combined (“explicit endorsement of the consensus position; evaluation of impacts; mitigation proposals”) accounted for 75% of the published works. The next two categories (“methods; paleoclimate analysis”) accounted for the remaining 25% of the publications, and these categories are technical ones that take no stand on the reality of global climate change. Dr. Oreskes sixth and last category (“rejection of the consensus position”) contained no publications. There are a small group

of people who speak loudly as “greenhouse skeptics”, but not one of them has mustered arguments sufficient to merit a publication in a refereed journal over that ten year span, and the best known of them have not actually published any scientifically refereed article on climate change for decades.

In the critical analysis published in *Science* by Dr. Oreskes, she noted that other scientific organizations have also published reports concluding that global climate change is occurring due to anthropogenic atmospheric modifications and include the National Academy of Sciences of the United States, the American Meteorological Society, the American Geophysical Union, and the American Association for the Advancement of Science. Global climate change is real, and the time has come for the United States to take responsibility for the potential consequences instead of hiding behind the prevarication of uncertainty. We have destabilized the global climate and we understand the physical processes of the greenhouse effect clearly. We are uncertain if the consequences will be uniformly catastrophic or merely damaging to those least able to afford the result.

Moreover on the issues of impacts and vulnerability, the TAR is clear that the negative impacts will affect the most vulnerable populations (human and non-human) on the planet. In the Summary for Policymakers, Working Group II (WGII) states that “Those with the least resources have the least capacity to adapt and are the most vulnerable,” particularly those communities “under pressure from forces such as population growth, resource depletion and poverty.” The impact and vulnerability scenarios projected by WG II indicate that human populations in developing nations will suffer disproportionately the negative affects of climate change and, given the excessive consumption of energy resources by developed nations, the climate change issue presents humanity with an acute intersection of ecological and social justice.

Climate Change: Impacts and Vulnerability

Building on the scientific basis for global warming and climate change, WGII was assigned the daunting task of assessing the sensitivity, vulnerability and adaptive capacity of natural and human systems to climate change and the projected consequences to these systems. In their analysis *sensitivity* refers to “the degree to which a system is affected, either adversely or beneficially;” *vulnerability* refers to “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change,” and *adaptive capacity* refers to “the ability of a system to adjust to climate change.”¹³ It is expected that both natural and human systems will be impacted by global climate change. According to WGII, natural systems are particularly vulnerable and some will be irreversibly damaged.”¹⁴ Furthermore it is projected that many human systems will be sensitive to climate change and some will be vulnerable. What is important to remember is that the WGII impact projection on natural and human systems is grounded in the expected range of average global temperature increase. As noted above WG I projected an increase in global mean temperature from 1.4 to 5.8 °C by 2100. The future impact scenarios of WG II are based on a lower range of temperature increase, in large measure

because the literature investigating impacts of climate change at the higher range of warming is unavailable. In spite of this lack of research the TAR “Synthesis Report” argues that “the larger the change and rate of change in climate, the more the adverse effects predominate.”¹⁵ In other words, should global average temperature increase to the high end of the projected range—say to 5.8 °C—the adverse impacts on many natural and human systems could be catastrophic. As in natural systems, the impact of climate change on human systems should be considered a positive feedback loop. In other words social instability and environmental degradation constitute a positive feedback loop for human societies. As a society destabilizes, a scramble for scarce resources, not moderated by prior social controls, accelerates. This in turn will lead to greater resource depletion, and eventually the further disintegration of any society reliant on those resources. This feedback loop is as problematic as any described under the auspices of the natural sciences.

WGII assessed the sensitivity of climate change to human systems in six areas: 1) Hydrology and water resources, 2) Agriculture and food security, 3) Coastal zones and marine ecosystems (fisheries), 4) Human health, 5) Human settlements energy and industry, and 6) Insurance and financial services. While limited beneficial impacts are expected for specific regions (e.g. potential increase in crop yields in some mid-latitude regions, reduced energy demand for heating due to higher winter temperatures, etc.), the following represents a summary of adverse affects:

- A general reduction in potential crop yields in most tropical and sub-tropical regions for most projected increases in temperature.
- A general reduction in potential crop yields in most mid-latitude regions for increases in annual average temperature of more than a few °C.
- Decreased water availability for populations in many water scarce regions, especially the sub-tropics.
- An increase in the number of people exposed to vector borne (e.g. malaria) and water borne diseases (e.g. cholera), and an increase in heat stress mortality.
- A widespread increase in the risk of flooding for many human settlements from heavy precipitation and rising sea level.
- Increased energy demand for cooling due to higher summer temperature.¹⁶

A key component of WGII’s analysis is that increased global warming and climate change will render human settlements more vulnerable to extreme weather events. The following table¹⁷ provides a sample of the largely negative impacts of simple and complex weather extremes in WGII’s impact assessment:

Projected Changes during the 21 st Century in Extreme Climate Phenomena and their Likelihood	Representative Examples of Projected Impacts
Simple Extremes	
Higher maximum temperatures; more hot days and heat waves over nearly all land areas (very likely)	<ul style="list-style-type: none"> • Increased incidence of death and serious illness in older age groups and urban poor • Increased heat stress in livestock and wildlife • Shift in tourist destinations

	<ul style="list-style-type: none"> • Increased risk of damage to a number of crops • Increased electric cooling demand and reduced energy supply reliability
More intense precipitation events (very likely over many areas)	<ul style="list-style-type: none"> • Increased flood, landslide, avalanche, and mudslide damage • Increased soil erosion • Increased flood runoff could increase recharge of some floodplain aquifers • Increased pressure on government and private flood insurance systems and disaster relief
Complex Extremes	
Increased summer drying over most	<ul style="list-style-type: none"> • Decreased crop yields mid-latitude continental interiors and • Increased damage to building foundations associated risk of drought (likely) caused by ground shrinkage • Decreased water resource quantity and quality • Increased risk of forest fire
Increase in tropical cyclone peak wind intensities, mean and peak precipitation intensities (likely over many areas)	<ul style="list-style-type: none"> • Increased risks to human life, risk of infectious disease epidemics, and many other risks • Increased coastal erosion and damage to coastal buildings and infrastructure • Increased damage to coastal ecosystems such as coral reefs and mangroves
Increased Asian summer monsoon precipitation variability (likely)	<ul style="list-style-type: none"> • Increased flood and drought magnitude and damage in temperate and tropical Asia

While all societies are expected to be sensitive to climate change those considered especially vulnerable are human communities where population density is greatest and economic development is weakest—what the world usually refers to as developing nations. The TAR demonstrates vulnerability and adaptive capacity in direct proportion to a society’s social, economic and technological infrastructure. Consequently a weak socio-economic infrastructure means greater vulnerability and lesser adaptive capacity to global warming. Accordingly WGII states that

Populations and communities are highly variable in their endowments with these attributes, and the developing countries, are generally poorest in this regard. As a result, they have lesser capacity to adapt and are more vulnerable to climate change damages, just as they are more vulnerable to other stresses. This condition is most extreme among the poorest people.¹⁸

Regarding this assessment of vulnerability and adaptive capacity among developing nations, four consequential points should be considered: (1) Increases in average global temperature will likely produce net economic losses in many developing societies and the greater the degrees of increase the greater the potential for economic damage. (2) It is likely that the expected economic impacts of climate change will exacerbate the existing

disparity between developed and developing nations with the caveat that global mean temperature at the higher end of the projected spectrum (e.g. 4-5.8°C) will further increase economic disparity. (3) Due to weaker resources for adaptive capacity, developing countries will suffer more adverse impacts than developed nations and within developing nations many more people are expected to be harmed rather than benefited from climate change. (4) Finally it is projected that developing countries will suffer the greatest loss of human life.¹⁹

In their regional assessment of impacts, vulnerability and adaptive capacity, Working Group II identified three continental areas that are particularly worrisome: Africa, Asia and Latin America. The following table²⁰ is a representative sample of impacts and key concerns in those regions:

Region	Adaptive Capacity, Vulnerability, and Key Concerns
Africa	<ul style="list-style-type: none"> • Adaptive capacity of human systems in Africa is low due to lack of economic resources and vulnerability high as a result of heavy reliance on rain-fed agriculture, frequent droughts and floods, and poverty. • Grain yields are projected to decrease for many scenarios, diminishing food security, particularly in small food importing countries. • Extension of ranges of infectious disease vectors would adversely affect human health in Africa. • Desertification would be exacerbated by reductions in average rainfall, runoff, and soil moisture, especially in southern, North, and West Africa. • Increases in droughts, floods, and other extreme events would add to stresses on water resources, food security, human health, and infrastructures, and would constrain development in Africa.
Asia	<ul style="list-style-type: none"> • Adaptive capacity of human systems is low and vulnerability is high in the developing countries of Asia; the developed countries of Asia are more able to adapt and less vulnerable. • Extreme events have increased in temperate and tropical Asia, including floods, droughts, forest fires, and tropical cyclones. • Decreases in agricultural productivity and aquaculture due to thermal and water stress, sea level rise, floods and droughts, and tropical cyclones would diminish food security in many countries of arid, tropical and temperate Asia. • Human health would be threatened by possible increased exposure to vector-borne infectious diseases and heat stress in parts of Asia. • Sea level rise and an increase in the intensity of tropical cyclones would displace millions of people in low-lying coastal areas of temperate and tropical Asia; increased intensity of rainfall would increase flood risks in temperate and tropical Asia. • Climate change would increase energy demand, decrease tourism attraction, and influence transportation in some regions of Asia. • Climate change would exacerbate threats to biodiversity due to land use and land coverage and population pressure in Asia. Sea level rise would put ecological security at risk, including mangroves and coral reefs. • Poleward movement of the southern boundary of the permafrost zones of Asia would result in a change in thermokarst and thermal erosion with negative impacts on social infrastructure and industries.
Latin America	<ul style="list-style-type: none"> • Adaptive capacity of human systems in Latin America is low, particularly to extreme climate events, and vulnerability is high.

- Loss and retreat of glaciers would adversely impact runoff and water supply in areas where glacier melt is an important water source.
- Floods and droughts would become more frequent with floods increasing sediment loads and degrading water quality in some areas.
- Increases in intensity of tropical cyclones would alter risks to life, property, and ecosystems from heavy rain, flooding, storm surges, and wind damages.
- Yields of important crops are projected to decrease in many locations in Latin America, even with the effects of carbon dioxide taken into account; subsistence farming in some regions of Latin America could be threatened.
- The geographical distribution of vector-borne infectious diseases would expand poleward and to higher elevations, and exposures to diseases such as malaria, dengue fever, and cholera will increase.
- Coastal human settlements, productive activities, infrastructure, and mangrove ecosystems would be negatively affected by sea level rise.
- The rate of biodiversity loss would increase.

The impacts of climate change in developing nations—particularly those in Africa, Asia, and Latin America—are potentially staggering. The overall damage to social, economic and technological infrastructure appears to be co-dependent on the rate and range of increase in average global warming and climate change, the greater the increase in global mean temperature the greater the adverse impacts on developing countries. By their very nature developing nations are already stressed due to generally weak social and economic institutions and their vulnerability and adaptive capacity to climate change is a function of such factors as wealth, technology, education, information, skills, access to resources and management all of which are in relatively short supply.²¹ The projected impacts of climate change in developing nations are highlighted in the assessment of WGII that the poor in these countries will suffer the greatest. In their analysis “impacts are expected to fall most heavily, in relative terms, on impoverished persons. The poorest members of society can be inferred to be the most vulnerable to climate change because of their lack of resources with which to cope and adapt to impacts. . .”²²

A recent example of the potential devastating impact of climate change on food production in developing nations has been reported by the journal *New Scientist*. In its February 9, 2005 web report, *New Scientist* states that “Rice yields are crashing as a result of global warming at twice the rate predicted,” according to research performed at the Rice Research Institute at Los Banos, Philippines.²³ The results of the detailed study suggest that “global rice yields could potentially fall by a catastrophic 50 percent during this century.”²⁴ Researchers at Los Banos found that “mean temperature rose by 0.7 °C over the past 25 years,” and “while maximum temperatures rose by 0.35 °C, night minima have risen by 1.1 °C.”²⁵ The end result was that rice plants expended so much nighttime energy for respiration, due to elevated temperatures, less energy remained as a product of photosynthesis when grain was produced. Bearing in mind that rice is the most widely eaten food worldwide—the major staple of more than 2 billion people in Asia and hundreds of millions of people in Africa and Latin America—a 50 percent reduction in rice production would be devastating.

This, along with other projected impact scenarios on developing nations and the poor is an egregious affront to distributive, social and ecological justice and a potentially serious

threat to world peace. The de-stabilizing potential of unabated and rapid climate change is obvious. Among a wide spectrum of negative affects, the world could witness the displacement of millions of people from deltaic regions such as Bangladesh (estimates project the possible loss of 17% of their habitable land) as well as the permanent loss of low lying island nations such as the Maldives. The certainty of ecological refugees will impact migration and immigration patterns, further compounding the adverse impacts of climate change. Unless a serious commitment to mitigation by developed countries occurs, including the strategic necessity of buttressing the adaptive capacity of developing nations, the outlook appears bleak for many. The developed nations ought to consider that socio-economic suffering often gives way to anger and desperation and desperation is often the step-parent of conflict, violence and war.

One strategic response, proposed by the TAR is to enhance the adaptive capacity of developing societies by promoting sustainable development. Accordingly, WGII states that “Policies that lessen pressures on resources, improve management of environmental risks, and increase the welfare of the poorest members of society can simultaneously advance sustainable development and equity, enhance adaptive capacity, and reduce vulnerability to climate and other stresses.”²⁶ In other words, WGII understands the project of improving adaptive capacity to climate change as equivalent to promoting sustainable development, a concept that has received a great deal of attention in the last decade. The concept has a great deal of merit, at least in theory, for producing the desired foundation for a just and sustainable society. The central question, however, for this analysis is: How do the scientific-ecological realities such as global climate change impact and frame a contemporary interpretation of *Gaudium et Spes* and How does *Gaudium et Spes* shed light on the serious impacts of global climate change, particularly on the most vulnerable human populations?

Catholic Social Teaching and Climate Change: Expanding Perspectives on Human Dignity, Social Justice and the Common Good

The primary task of *Gaudium et Spes* was to scrutinize the signs of the times in light of the gospel and Catholic Social Teaching. In doing so the Pastoral Constitution emphasized the following key principles: human dignity, social justice, and the common good. In recent years the U. S. Church, faithful to the intent of *Gaudium et Spes*, has responded to the environmental crisis indicating an expansion of Catholic Social Thought. A prime example of this is the U.S. Catholic Bishops’ statement, *Global Climate Change, A Plea for Dialogue, Prudence and the Common Good* (2002). This significant document represents an initial foray into the science and seriousness of climate change and the implications of applying Catholic Social Teaching to this global phenomenon for the purpose of providing an ethical basis for Christian response. Nevertheless, given the on-going scientific research discussed above, and the gravity of the impact scenarios of climate change on the world’s poor, a more thorough and systematic analysis of Catholic Social Teaching in light of the world’s deteriorating ecological health is required. The modest aim of this section is to offer a preliminary

sketch of the work to be done utilizing *Gaudium et Spes* as a heuristic baseline for reflection beginning with the question: What is humanity?

What is Humanity?

In response to modernity the introductory reflection of *Gaudium et Spes* addressed the primary anthropological question. It stated that “in the face of the modern development of the world, an ever increasing number of people are raising the most basic questions or recognizing them with a new sharpness: What is Man?”²⁷ Although a timeless question, the Pastoral Constitution sought to address this query with a fresh historical consciousness declaring that human personhood is constituted by its historical context. Moreover, while acknowledging the value and meaning of personhood from a deeply personalist perspective, the Pastoral Constitution embraced the modern idea that human persons are also constituted by social processes and concomitant economic and political realities. It stated that

In our era, for various reasons, reciprocal ties and mutual dependencies increase day by day and give rise to a variety of associations and organizations, both public and private. This development, which is called socialization, while certainly not without its dangers, brings with it many advantages with respect to consolidating and increasing the qualities of the human person and safeguarding his rights.²⁸

Defined by historical and communitarian existence, the Pastoral Constitution subsequently acknowledged that the human person is also constituted by culture and a plurality of cultures. It is from this perspective that the document declared that the human person “can come to an authentic and full humanity only through culture” and that “Wherever human life is involved, nature and culture are quite intimately connected.”²⁹ Moreover, *Gaudium et Spes* also argued that “human culture has a historical and social aspect” taking on a “sociological and ethnological” meaning and it is in this perspective that the document “speaks of a plurality of cultures.”³⁰

These insights into the nature of humanity signaled an important methodological and anthropological shift in the Church’s definition of human personhood. The acknowledgement that the human person is shaped by historical, social and cultural factors still has merit today and the key linkage in this anthropological recognition is the interrelated and interdependent aspect of human historical existence. In other words the constitution of the human person is a dynamic process whereby humanity creates history, society and culture and is, dialectically, shaped by this handiwork. Nevertheless, significant as this development was in *Gaudium et Spes*, what more must be said in response to the question, “What is humanity?” 40 years later?

The answer is framed, in large measure by the ecological exigencies of our time with the prospects of global climate change and the concomitant impact scenarios highlighting a spectrum of additional environmental concerns. Due to the discipline of ecology and related environmental sciences, the ecological dimension of human existence has been

raised to a level of understanding never before encountered in human history. The specter of global climate change exemplifies this awareness in an unprecedented fashion as humanity continues to conduct an uncontrolled experiment on the earth's atmosphere producing a range of possible positive feedback loops. In stark fashion, global climate change illustrates the human dependence on and interdependence with the earth's biosphere. In other words, the ecological signs of our time force us to acknowledge that humanity, the human person, is fundamentally constituted by its biological interrelationship with the biophysical world. From an evolutionary point of view, the ecological relatedness and dependency of the human person is primary to the making of history, the building of societies and the creation of culture. In fact the ecological horizon of the 21st century is already impacting the way we think about society and culture to the point where some are entertaining a re-design of fundamental social institutions—such as economic life—along the basis of ecological sustainability. Visionaries and strategists such as Karl Henrik Robert, Paul Hawkin, Amory Lovins, William McDonough and Michael Braungart are leading the way to the future re-design of human artifacts and economies. While these are significant and hopeful developments, the question remains: What do the ecological signs of our time mean for the hallmark of Catholic Social Teaching, that human beings are created in the image and likeness of God?

Human Dignity and the Right to a Healthy Environment

Human beings, by virtue of the fact they are earth creatures in both scientific and theological perspective, are fundamentally constituted by their ecological relationships with and dependency on the earth's biosphere. Theologically these should be understood as primary associations within the community of creation—a point to be emphasized—in reflecting on the meaning of human dignity. In other words, the doctrine of the *imago Dei*—the linchpin of modern Catholic Social Teaching and rights theory—arises from the Church's interpretation of the priestly (P) author's version of creation (Gen. 1: 26-28) wherein God created humanity in God's image and likeness. Hermeneutically, from the genesis of modern Catholic Social Teaching, the Church has interpreted these verses in an ontological fashion as a theological validation of the inherent dignity and worth of the human person. Stated differently, the doctrine of the *imago Dei* is an axiological statement declaring that human beings are endowed with intrinsic value, but this intrinsic value occurs within creation not apart from it. The Yahwist (J) author of creation (Gen. 2:4b-25) knew this intuitively when s/he portrayed all life—human, botanical and zoological—coming “out of the ground.”

It is clear that *Gaudium et Spes* embraced the transcendental worth and dignity of the human person as the centerpiece of its approach to modernity. Nevertheless, in keeping with its historical perspective, the Pastoral Constitution sought to interpret the meaning of human dignity from a historical, social and cultural context. Consequently the document states,

But God did not create man as a solitary. From the beginning “male and female he created them” (Gen. 1:27). Their companionship produces the primary form of interpersonal communion. For by his innermost nature man

is a social being, and unless he relates himself to others he can neither live nor develop his potential.³¹

David Hollenbach writes that “The Council’s most important contribution to the human rights tradition was its important new acknowledgement that the demands of human dignity are historically conditioned ones.”³² We agree and would add to that, in keeping with the focus of this paper, that the demands of human dignity are also ecologically conditioned. Adapting the above language of the Pastoral Constitution, we propose that “by their innermost nature human beings are ecological beings, and unless they relate to the earth correctly they can neither live nor develop their potential.” This ecological interpretation of human dignity is, in our view, consistent with the Pastoral Constitution’s approach of historicity in defining the human person on one hand, and its desire to elaborate on the meaning of human dignity within the context of the signs of the times. Ethically, therefore, what are the implications for Catholic Social Teaching for an ecological interpretation of human dignity? One answer immediately raises the issue of human rights, defined here as the minimal conditions necessary to protect and promote human dignity. If, as we have argued, that human dignity is ecologically conditioned, then it requires the expansion of Catholic rights theory to include a full array of environmental rights chief among which is the right to a safe environment.

Pope John Paul II anticipated this necessity when he declared in 1990 that “The right to a safe environment is ever more insistently presented today as a right that must be included in an updated Charter of Human Rights.”³³ It is our position that, in the face of global climate change and the impact scenarios outlined above, that human dignity, particularly of the most vulnerable human persons, cannot be promoted, protected or maintained under the current ecological conditions of increasing global mean temperatures, destabilization of the earth’s climate system and the potentially devastating impacts on human societies. Within the framework of Catholic Social Teaching, however, the notion of human rights—as the primary conditions whereby human dignity is ensured—is inherently related to a theory and concept of justice.

Social and Ecological Justice

The concept of justice is a longstanding aspect of Catholic Social Teaching. Justice—whether in its commutative, distributive or social dimensions—has been primarily defined in relationship to rights and the mitigation of rights conflicts among human actors. Hollenbach claims that

Rights represent claims to those things that are due individuals. The notion of justice is an indispensable means in the process of judging which of these claims take priority over others in situations of conflict.³⁴

The operative notion of justice in *Gaudium et Spes* is social justice. Given the document as a whole and its place in the evolving tradition of Catholic Social Teaching, relatively minor space and attention is devoted to social justice and its theoretical meaning. Essentially *Gaudium et Spes* embraces and ratifies the notion of social justice from

Quadragesimo Anno (1931), the papal encyclical that introduced the concept. In keeping with its overall approach of historicity however, the Pastoral Constitution sought to apply the principle of social justice “according to the circumstances of the times” and, consequently, focused on economic development as one problem of special urgency.³⁵ The document declared that

Moreover, although rightful differences exist between men, the equal dignity of persons demands that a more humane and just condition of life be brought about. For excessive economic and social differences between members of the one human family or populations groups cause scandal, and militate against social justice, equity, the dignity of the human person, as well as social and international peace.³⁶

The moral norm of social justice makes claims on both personal and corporate institutional actors (e.g. governments). On one hand it requires that individuals assist in creating social institutions that guarantee everyone’s rights. On the other hand it also requires corporate actors, such as governments and economic institutions, to ensure—through such means as legislation—that the rights of all are protected. Hollenbach makes the case that

Social justice is a measure or ordering principle which seeks to bring into existence those social relationships which will guarantee the possibility of realizing the demands of distributive justice. . . In other words, social justice demands that the institutions of society be ordered in a way that makes it possible to protect the social and personal rights of all.³⁷

As an “ordering principle,” the unique feature of social justice is that it directly assumes the necessity of institutional reform and social transformation in order to protect human rights and promote the common good. When applied to the impact and vulnerability scenarios of climate change, it is obvious that this is a matter of social justice on a global level. Poorer developing nations will experience the worst impacts of climate change—even though they use less fossil fuel and produce less atmospheric pollution—to a far greater degree than developed nations who consume the most fossil fuel and produce the largest amount of greenhouse gases. The United States, by itself, consumes 26% of the world’s fossil fuels (measured in BTUs) and produces 24% of the world’s excess carbon dioxide. The Kyoto Protocol—a example of the type of international legislation dictated by the norm of social justice—designed to reduce greenhouse gas emissions, has never been ratified by the U. S. In fact the treaty was abandoned by the U.S. government in 2001.

Unfortunately, applying the norm of social justice to global climate change also reveals its limitations. Social justice focuses on the social and institutional relationships that are necessary to protect human rights and promote the common welfare of citizens. It does not, however, address the ecological relationships that constitute human dignity and the ecological goods and services upon which all human societies and cultures depend. The phenomenon of anthropogenically produced climate change—in addition to the entire

spectrum of environmental problems—reveals the fractured ecological relationship between human societies and the natural world. Moreover, global climate change does not only threaten the quality of human existence, it endangers the support structures of life, that is, the biosphere, and the existence of other species with whom humanity shares this planet. If we are faithful to the spirit and intent of *Gaudium et Spes*, we must entertain the concept of ecological justice as an extension of Catholic Social Teaching. Ecological justice, as a permutation of commutative, distributive and social justice, is the measuring rod or standard whereby social, economic and political institutions are held bound to the primary relationships all living beings share with creation. In other words, ecological justice is the faithful response to the demands and responsibilities of our relationships with humans, creation and God, through restoring and preserving the integrity and orderliness of creation. Ecological justice is based on the profound and life giving relationships we share with the rest of creation and acknowledges that human well being—what Catholic Social Teaching calls the common good—is inextricably connected with the well being of the biotic and abiotic aspects of Earth’s biosphere.

The Universal-Planetary Common Good

The ultimate aim of justice in all its forms is the creation and maintenance of the common good. Along with the concept of justice, this is also a longstanding aspect of Catholic Social Teaching. *Gaudium et Spes* defined the common good as the “sum of those conditions of social life which allow social groups and their individual members relatively thorough and ready access to their own fulfillment. . .”³⁸ Consistent with its historical interpretation of Catholic Social Teaching, the Pastoral Constitution recognized the complexity of applying this principle to the “general welfare of the entire human family”³⁹ In other words, the notion of the common good takes on a distinct international meaning in *Gaudium et Spes* that embraces the reality of human interdependence.

In recent years there have been additional interpretations of the common good that reflect an expanding definition. For example in *Centesimus Annus* (1989), Pope John Paul II briefly addressed the “ecological question” and indicated that governments have an important role to play in preserving “the common good such as the natural and human environment, which can not be safeguarded simply by market forces.”⁴⁰ In the United States the bishops’ pastoral statement on the environment, *Renewing the Earth* (1991) speaks of the planetary and universal common good. Most recently, in *Global Climate Change, A Plea for Dialogue, Prudence, and the Common Good* (2001), the U.S. bishops refer to the universal common good by stating that “Global climate change is by its very nature part of the planetary commons. The earth’s atmosphere encompasses all people, creatures, and habitats.”⁴¹ The bishops have accurately and appropriately enlarged the meaning of the common good in the face of the compelling signs of the times. The global phenomenon of climate change underscores the necessity of proposing a definition of the common good that incorporates the entire biosphere. After all what real existential meaning does “the general welfare of the entire human family” have when all of earth’s ecosystems are in a process of deterioration? The environmental damage of the present age is global in proportion and highlights the necessity of restoring and maintaining the ecological relationships that make life possible for all beings. Consequently the

appropriate domain for defining the common good is the entire commonwealth of creation. This would emphasize, from a scientific and theological point of view, the deep genetic, ecological and organic bonds of creatureliness that the human species shares with all creation.

Conclusion

Climate Change and the Catholic University: The Need for Interdisciplinary Collaboration

Given the complex nature of current environmental conditions related to climate change, interdisciplinary collaboration is essential. Science, theology, the other humanities, and the social sciences must all bring their methods and perspectives to bear. As it states in *Ex Corde Ecclesiae* (1990)

In the world today, characterized by such rapid developments in science and technology, the tasks of a Catholic University assume an ever greater importance and urgency. Scientific and technological discoveries create enormous economic and industrial growth, but they also inescapably require the correspondingly necessary *search for meaning* in order to guarantee that the new discoveries are used for the authentic good of individuals and of human society as a whole.⁴²

We are urgently called to discern what it will mean to be human and humane on an altered planet, how we can prevent further alterations whose negative impacts will be felt most keenly by the vulnerable and poor, and what activities social justice demands that we recognize the consequences of, acknowledge, and repent from. In light of *Gaudium et Spes* and *Ex Corde Ecclesiae* the Catholic University has an opportunity to forge new models of interdisciplinary cooperation and research.

In *Ex Corde Ecclesiae*, the call to social justice and interdisciplinarity is explicit. It says

A Catholic University, as any University, is immersed in human society; as an extension of its service to the Church, and always within its proper competence, it is called to become an ever more effective instrument of cultural progress for individuals as well as for society. Included among its research activities, therefore, will be a study of *serious contemporary problems* in areas such as the dignity of human life, the promotion of justice for all, the quality of personal and family life, the protection of nature, the search for peace and political stability, a more just sharing of the world's resources, and a new economic and political order that will better serve the human community at a national and international level.⁴³

The call for integration of Academic disciplines, crucial to assessing the causes, impacts, and possibilities for mitigation of global climatic destabilization, is clear in *Ex Corde Ecclesiae* when it states "In a Catholic University, research necessarily includes (a) the

search for *an integration of knowledge*, (b) a *dialogue between faith and reason*, (c) an *ethical concern*, and (d) a *theological perspective*."⁴⁴

It is sometimes said that deviating from the fossil fuel consuming economic course upon which our society has embarked would be too costly, too difficult, to disruptive. We must acknowledge that year after year we are releasing an ever greater and greater amount of excess CO₂, that the impacts will be enormous and disproportionately felt by the poor. The single minded impetus towards excesses of affluence often seen in modern societies is tinged with unacknowledged heartaches imposed on the powerless. As *Ex Corde Ecclesiae* states, "If need be, a Catholic University must have the courage to speak uncomfortable truths which do not please public opinion, but which are necessary to safeguard the authentic good of society."⁴⁵

¹ IPCC documents are available at <http://www.ipcc.ch/>

² *New Scientist* magazine, 25 September 2004, page 18.

³ See the sheep vaccine project website at

<http://www.csiro.au/index.asp?type=activity&id=Methanevaccine&stylesheet=aboutCSIROActivity> or *Vaccine*, vol 22, p 3976

⁴ see <http://www.newscientist.com/channel/earth/climate-change/dn4508> or *Proceedings of the National Academy of Sciences* (DOI: 10.1073/pnas.2237157100)

⁵ *Climate Change 2001: The Scientific Basis*, "Summary for Policymakers," 10.

⁶ *Ibid.* 2-4.

⁷ *Ibid.* 5.

⁸ *Ibid.* 13.

⁹ *Ibid.* 16.

¹⁰ *Ibid.* 15. In its Technical Summary and Summary for Policymakers, WGI uses a confidence scale for the occurrence of certain weather scenarios the range of which is—Virtually Certain (99% chance), very likely (90-99% chance), likely (66-90% chance), medium likelihood (33-66% chance), unlikely (10-33% chance), etc.

¹¹ D. A. Stainforth, T. Aina, C. Christensen, M. Collins, N. Faull, D.J. Frame, J.A. Kettleborough, S. Knight, A. Martin, J.M. Murphey, C. Piani, D. Sexton, L.A. Smith, R.A. Spicer, A.J. Thorpe, and M.R. Allen, "Uncertainty in predictions of the climate response to rising levels of greenhouse gases," *Nature* 433, 2005, 403-406.

¹² Naomi Oreskes, "The Scientific Consensus on Climate Change," *Science*, 306, 2004, 1686.

¹³ *Climate Change 2001: Impacts, Adaptation and Vulnerability*, "Summary for Policymakers," 6.

¹⁴ *Ibid.* 4. Ethically the vulnerability to natural systems is important to consider as all ecosystems are essential to themselves and all living organisms that dwell therein and many ecosystems are essential to human wellbeing. Nevertheless due to the focus of this paper the impact on natural systems will not be extensively developed..

¹⁵ *Climate Change 2001: Synthesis Report*, "Summary for Policymakers," 9.

¹⁶ *Climate change 2001: Impacts, Adaptation, and Vulnerability*, "Summary for Policymakers," 5.

¹⁷ *Ibid.* 7. The information provided here is taken from Table SPM-1 of WGII's "Summary for Policymakers."

¹⁸ *Ibid.* 8.

¹⁹ *Ibid.*

²⁰ *Ibid.* 14-15. The information provided here is taken from Table SPM-2 of the "Summary for Policymakers."

²¹ *Ibid.* 8.

²² *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, "Technical Summary," (Cambridge University Press, 2001), 71.

²³ <http://www.newscientist.com/article.ns?id=dn6082>.

²⁴ *Ibid.*

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- ²⁵ Ibid.
- ²⁶ *Climate Change 2001: Impacts, Adaptation and Vulnerability*, “Summary for Policymakers,” 8.
- ²⁷ *Gaudium et Spes (GS)*, no. 10.
- ²⁸ *GS*, no. 25.
- ²⁹ *GS*, no 53.
- ³⁰ Ibid.
- ³¹ *GS*, no. 12.
- ³² David Hollenbach, S.J., *Claims in Conflict, Retrieving and Renewing the Catholic Human Rights Tradition*, (Paulist Press, 1979), 69-70.
- ³³ Pope John Paul II, *The Ecological Crisis: A Common Responsibility*, (U. S. Catholic Conference, 1999), 9.
- ³⁴ Hollenbach, 144.
- ³⁵ *GS*, no. 63.
- ³⁶ *GS*, no, 29.
- ³⁷ Hollenbach, 152.
- ³⁸ *GS*, no. 26.
- ³⁹ Ibid.
- ⁴⁰ *Centesimus Annus*, no. 40. Also see no. 37.
- ⁴¹ *Global Climate Change, A Plea for Dialogue, Prudence, and the Common Good*, (United States Catholic Conference, 2001) 7.
- ⁴² *Ex Corde Ecclesiae (EE)*, no. 7
- ⁴³ *EE* no. 32
- ⁴⁴ *EE* no. 15
- ⁴⁵ *EE* no. 32