Linking Population Growth Reduction to Climate Change

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I understand that my essay will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my essay to any reader upon request.

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1.0 Introduction

Global warming and climate change are hot topics anywhere you look today. They have reached popular magazines, made headlines in newspapers, and become a major political topic. More recent public awareness of global warming was stimulated by the former vice president Al Gore's documentary "An Inconvenient Truth" in 2006, and with extreme weather events such as the hurricane Katrina disaster of in 2007. Although the following paper will use the terms climate change and global warming interchangeably, a clear defining difference should be understood. Global warming is simply the measured increasing of the mean temperature of the earth's atmosphere while climate change refers to the impact of the warming on global climates (Maslin, 2009). Although the scientific community has reached a consensus that global warming is real and is influenced by human activities, there are still debates on how serious the problem is and will be in the future (Schneider, 2009). Furthermore, a debate on how to deal with climate change seems to be in a stalemate as the developed world has built its economy and infrastructure on fossil fuel resources including coal, oil, and natural gas. These resources are the leading cause of greenhouse gases (GHG) that lead to global warming and result in climate change (U.S. NASA, 2010 and PEW Center, 2009). There is significant evidence that the industrialized nations, since the dawn of the industrial revolution, are the nations that are primarily responsible for the current build up of GHG's in the atmosphere. Furthermore, there are concerns that the industrialization of nations such as

China and India are intensifying GHG accumulation in the atmosphere (PEW Center, 2009). These developing nations are building their economies based on the model of North America, Europe, and Japan, mainly on the use of fossil fuels for the growth of their economy. If this trend continues, and other less developed countries (LDC) pick up the pace of development using cheap, readily available fossil fuels, then the attempts of the industrialized nations to move away from fossil fuels may be moot in terms of the continued buildup of GHG's in the atmosphere. Global warming is not a national issue, although some nations may benefit from the effects whereas others may suffer more, it is instead a global issue that could change the face of the planet and the global economy.

Unlike climate change, population growth has rarely reached a critical level of public attention or open debate outside of immigration issues and third-world economic development (Baurelein and Jeffery, 2010; Whitty, 2010). Although the concern over population growth and its impacts on the environment and society is older than climate change, the topic has rarely reached beyond the scientific and academic conversation table. The hesitancy to an expanded dialogue and debate on population growth is unclear, yet likely stems from a variety of cultural, political, and economic points of view. China is the one nation in modern times that has taken an aggressive stance on population growth by institutional fertility policies to restrict fertility rates at an individual level and has received much criticism in regards to human rights violations as a result (Committee on International

Relations, 2004; Hesketh and Xing Xhu, 1997). With the projection of the world's population reaching seven billion in coming years and nine billion by 2050 (U.S. Census Bureau, 2010), the topic of population growth as a concern may well become an increasing focus in the media and in political circles in the near future.

This paper will discuss the linkage or correlation between population growth and climate change. Studies (Population Reference Bureau, 2007) have demonstrated that fertility rates and development have a negative correlation, that decreased fertility rates are correlated with positive economic development and that increased economic development has a positive correlation with greenhouse gas emissions. The following literature review will present the history and science of global warming and climate change. This will be followed by a review of demographic principles associated with population growth and finally a discussion of the theoretical link between populations and climate change. Following the literature review will be a discussion of the quantitative method of the study and its analysis. Finally, a discussion and analysis of policies of both climate change and population growth will be provided.

2.0 LITERATURE REVIEW

Climate change and human population growth are often treated as independent issues with specialized fields of studies such as demography and climatology. This paper takes a multi-disciplinary approach to investigate a hypothesis that an interaction between these two issues exists. Below are three sections that will introduce climate change and population growth and then bring the two issues together to illustrate the importance of merging these issues in scientific studies as they may have interactions that should be understood in order to address them in policy making decisions.

2.1 Background on Global Warming

The first hypothesis proposed on the greenhouse effect, the predecessor to the global warming hypothesis, was introduced in 1896 by Svante Arrhenius of Sweden and independently confirmed by Thomas Chamberlin, a geologist from the United States (Maslin, 2009 p. 23). The hypothesis was simple: carbon dioxide in the atmosphere acts as a blanket that warms the earth by retaining the long-wave radiation from the sun that is reflected off the earth's surface and back into the atmosphere. By the 1890s, the Industrial Revolution was well on its way and coal was the primary fuel for energy in the industrialized nations, and national and global economies were heavily reliant on it (Roberts, 2004). In 1938 English engineer Guy Callendar investigated the relationship between carbon dioxide and its warming effect and found that from the 19th century onward, there had been a 10 percent increase in CO_2 in the atmosphere and a corresponding rise in global temperatures (Sample, 2005; Weart, 2009). Despite this correlation, through much of the 1940s scientific minds felt that the earth's climate was largely regulated by the earth's cycle around the sun, sunspots, and geological and oceanic processes and that human influences were not significant enough to counter the forces of nature. Later that decade, advancements in infrared spectroscopy, which measures long-wave radiation, started a shift in the greenhouse hypothesis and water vapor in the atmosphere was added as a GHG. The new technology still failed to demonstrate a significant enough impact by greenhouse gases to issue an alarm that these substances could indeed alter the earth's mean temperature and affect global and regional climate. Furthermore, by the end of World War I crude oil, a luxury item for centuries, was emerging as the leading resource for energy markets.

The era of the Second World War saw significant advancements in technology that began a revitalization in the greenhouse effect hypothesis. These technologies, mainly in electronics that could measure and store data, allowed for further understanding that atmospheric pressure played a key role in CO_2's ability to absorb the long-wave radiation and that water vapor had the capacity to absorb other forms of radiation that could add to the warming effects (Masslin, 2009). In 1955 Gilbert Plass, a U.S. physicist, confirmed that CO_2 buildup in the atmosphere by industrialization was contributing to global warming and calculated that a temperature rise of 1 degree Celsius per century could occur (Sample, 2005). Plass and other scientists began warning government officials that global warming was real and should be taken seriously and they published in *Scientific America* in 1959 an article titled "Carbon Dioxide and Climate" arguing their case. They adjusted the argument that global mean temperature could reach 3 degrees Celsius by the end of the century and alter global and regional climates, threatening the status quo of socio-economic conditions dependent on climactic conditions. By this time the U.S. government and the governments of other industrialized nations were more aware of the global warming issue than many academics and scientists had been aware. U.S. Navel submarines operating in the arctic had been reporting that sea ice was becoming thinner, caused by the warming of surface temperatures in the region (Maslin, 2009).

The Cold War instigated development in technology and pushed man into space, which gave researchers a valuable tool for studying the earth's processes and conditions in the near future: satellites. Even before satellites would play a valuable role, scientific inquiry into global warming and climate change continued in the 1960s leading to additional support for the theories that there was a warming of the earth, that increased greenhouse gases were a likely contributor to the warming, and that regional climates would be altered by the warming. In the 1970s the global warming theory experienced a set back that would take a decade to resolve. In 1975 the National Academy of Science was expressing a new concern of a cooling trend and warnings of a new ice age were being presented (Maslin, 2009). A new study of palaeoceanography was showing that the number of glacial- interglacial periods was much higher than previously believed. Lowell Ponte, a decorated and influential radio personality was espousing this new ice age hypothesis and published a book *The Cooling: Has the Next Ice Age Already*

Begun? in 1976. To this day, Ponte's book is used by global warming deniers and skeptics, although continued scientific studies and data have largely discredited the hypothesis of a coming ice age and supports continued global mean temperature rise.

Satellite technologies developed for the Cold War and national defense became more available for scientific studies into the 1980s; data in oceanic, atmospheric, and terrestrial temperatures as well as ecological and weather systems made vast improvements to climate modeling (U.S. NASA, 2010). A growing consensus among scientists around the world was that there is significant evidence of global warming, that the world's climates will be transformed by the rise in the mean global temperatures and that changes in the earth's climates may alter regional environments. Furthermore, it would take an international effort to combat climate change, and that the economic needs to combat climate change may be less than the economic costs to mitigate change and adapt (Hallegatte, Dumas, and Hourcade, 2010).

In 1988, a joint effort by the World Meteorological Organization and the United Nations Environmental Panel formed the International Panel on Climate Change (IPCC) (Maslin, 2009: 13-15). The purpose of the IPCC is to compile scientific evidence from around the world by researchers, assess the data, and report; it is not an independent research group. The IPCC has published four assessment reports, the first in 1990, then 1995, 2001, and the latest in 2007 (IPCC, 2010). Each report has discussed the issues and severity of global warming and its connection to human activities that include industrial processes and the burning of fossil fuels. Today there is a general consensus among experts in many scientific fields on global warming and the rhetoric of the global warming deniers has changed course several times from its complete denial origins to a dialogue on severity.

Today scientists recognize greenhouse gases that include water (H_20), carbon dioxide (CO_2), ozone (O_3), methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO) and the chlorofluorocarbons, compounds of chlorine (Cl), fluorine (F), and carbon (C), the most common being Freon-11 $CFCl_3$ (CFC-11) and Freon-dichlorodifluoromethane CF_2Cl_2 (CFC-12) (Wallace and Hobbs, 2006). Chlorofluorocarbons are exclusively anthropocentric in nature and can have a residence time of hundreds of years in the atmosphere. Although chlorofluorocarbons are of concern, the most recognized greenhouse gas, CO_2, is the focus of scientific inquiry due to its high concentration in the atmosphere and other greenhouse gases are often reported in relation to CO_2. A significant difference between CO_2 and other greenhouse gases such as methane and nitrous oxide and chlorofluorocarbons is that besides anthropogenic sources such as industrial processes, there are several natural sources. Many of these natural sources are the newest concerns by climatologists in terms of feedback loops. Climate feedback loops are natural responses to additional GHG's and warming that are either positive or negative (Wallace and Hobbs, 2006). Positive feedbacks are those that amplify the direction of the system while negative feedbacks diminish the direction of the system (Walter, *et al,* 2006).

Continuing work is on feedback loops, both positive and negative, that interact as a natural process in response to increased greenhouse gases. Oceanographers have been studying the carbon cycle between the atmosphere and the oceans, as well as studying the carbon uptake by aquatic vegetation (U.S. NOAA, 2004). The oceans were once hailed as a safety net for global warming but are becoming a concern as a positive feedback loop that could continue to pump CO_2 into the atmosphere for many years to come (Friedman, 2008). Another feedback concern is the melting of permafrost in the cryoshere, or frozen landscapes, caused by the already warming temperatures (Field, C. *et al*, 2009). This permafrost has trapped carbon dioxide and methane that is being released into the atmosphere. A final feedback loop to note, is carbon dioxide that is being released and will continue to be released from dying forests caused by climate changes. Foresters and other scientists have been reporting on the release of carbon dioxide by forestry practices, mainly the cutting down of forests (Cramer *et al,* 2004). Additional atmospheric carbon dioxide will come from the loss of forests and their productivity without human intervention in the form of climactic changes of temperature and precipitation that may lead to further deforestation.

Not all feedback loops involve greenhouse gases. Another significant concern is the melting of the cryoshere in the Arctic and Antarctic landscapes that alter the albedo or reflectivity of the earth's surface (Wallace and Hobbs, 2006). The dissipating ice sheets that once reflected the rays from the sun are now being absorbed by the dark rock and dirt. The Russian government has acknowledged this phenomenon for some time, but found the condition favorable for further gas and oil exploration in their arctic regions (Roberts, 2004). Other nations that harbor arctic landscapes such as Canada and Greenland may also feel that a future with warmer temperatures and less ice will have economic benefits. The shrinking of the ice sheets over the oceans also allows for an increase in absorption of the suns rays and is increasing ocean temperatures. This in turn could alter the oceanic currents that dictate the earth's climates worldwide (Overland and Wang, 2010).

With the mean global temperature rising in correlation with the increase in greenhouse gases since the industrial revolution, we are seeing signs of change from increased average rainfall in some regions to increased drought in others (U.S. NASA, 2010). Seasons are also changing in length and severity. Landscapes are being transformed by the climate changes and sea levels are on the rise (IPCC, 2007). Although there is significant uncertainty in climate modeling for the future, there is increasing evidence that without significant changes in first world energy production, industrial processes, and transportation technologies, the earth will see a continued increase in the average global temperature. Furthermore emerging economies such as China and India are building their economies on the same model the industrialized world had done. Even if the models are only moderately correct, and we began significantly reducing the global industrial system that is emitting GHG's, we can expect some economic impacts in many developed and developing countries based on losses in natural resources and infrastructure (Staudt, A, N. Huddleston and I. Kraucunas, 2008). Today, research is beginning a focus on adaptation to changes on a regional and global scale (Lim *et al,* 2004). Yet adaptation may be a challenge when the world houses seven billion people and is expected to reach nine billion in roughly a half century.

2.2 Population Growth and Development

Populations of most species including humans have the capacity to multiply exponentially but are restricted by complex interactions with their environment, other living organisms, as well as by limited resources. Limited resources for humans include food and water, oxygen, and geographical space; the most notable of these limiting factors are food and water. Man has spent the better part of his existence finding ways to improve access to these two fundamental resources. Today, food and water resources are heavily controlled and influenced by mankind's modern markets and aqueduct systems that transfer water to regions that lack water resources and can afford to have it imported. Through progressive achievements in improved water resource management and agricultural technologies as well as a global transportation system for resource flows, we have challenged our natural limitations. The world is now on the brink of reaching a worldwide population of 7 billion; an increase from a population of around 3 billion in the late 1950s and even more interesting considering it took roughly 118 years, between 1804 and 1922, to reach two billion from one billion as illustrated in figure 1 below (U.S. Census Bureau, 2004). The scientific advancements made during the Agricultural Revolution, the Industrial Revolution, the Green Revolution, and today's Genetic Revolution as well as the modernization and globalization of the agricultural food system, has significantly improved much of the world's access to food and improved the living standards of many, but not everyone has benefitted (Roberts, 2009). Today nearly 1 billion of the world's population, mostly in LDC's, are malnourished. There is a current trend in decreasing yields of major food crops worldwide and water resources are now becoming a major concern for much of the global population (Roberts, 2009; Bozzo 2009).

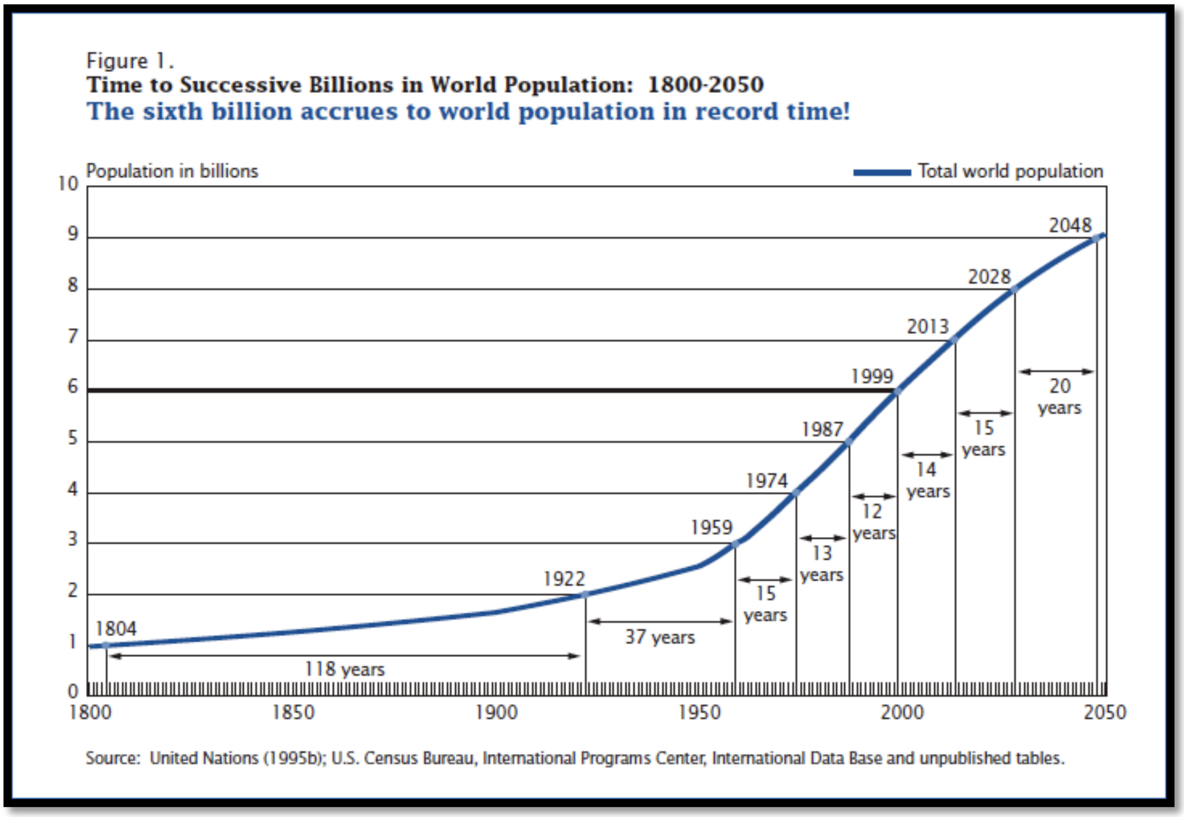

Figure 1: Shows world populations between 1800 to present and projections to 2050. This illustrates the non-linear growth of the global population and shows the shorter time frames for the addition of each billion from 1800 to 2000. (U.S. Census Bureau, 2004)

It was Thomas Malthus, a political economist from England in the late 1700s and early 1800s that first developed and articulated a clear theory on the dangers of population growth in his 1798 publication of *Essay on the Principle of Population as it Affects the Future Improvements of Society.* Malthus understood that populations could grow past their capacity to grow food in the agricultural system of the time. He warned that without proper measures against growth, hunger could increase nationwide as history had shown in previous societies. Critics of Malthus such as Julian Simon who published *The Ultimate Resource* in 1981 (Harris-Jones, 1999) and Bjorn

Lomborg in his *The Skeptical Environmentalist* (2001), argue against Malthus and point out that his doomsday scenario never played out and that technological advancements would continue to break ground for future generations. Where Malthus failed was in the understanding of how the new world would create a population sink and how technological advancements would factor into expanding crop yields (Grant, 1996). What he also failed to grasp was how the colonial period would create a global food trade that would largely benefit England and other more developed nations while repressing the colonized states. This global trade system, which continues today, supplied more food resources to countries that had already maximized much of their agricultural capacity and removed food resources from populations that were growing more rapidly (Freedman, 2008).

Today water and food resources are stressed under natural limitations (Roberts, 2009; Bozzo, 2009) and demands from a growing world population mainly in the less developed nations (Angenendt, 2009). Increased demand comes from more individuals and the increasing consumption in developing nations such as India and China (Hubacek, Guan, and Barua, 2007; Harper 2008) and high consumption rates in industrialized and post industrialized societies (Harper, 2008; Grant 2000). Although the growth rate of the world's population may be declining and some may argue growth itself is coming to an end by the end of the century (Lutz, Sanderson, and Scherbov, 2001), it is important to remember that as of 2009 the world's total fertility rate was 2.6 and the annual natural growth number, births minus deaths, was 82,866,000 (Population Reference Bureau). In short, population growth is still positive, meaning more people that will require more resources, and with such large numbers a decline to a zero growth rate would not equal a steady population size for some time. Our species is unique, we are cognitive reproducers with no predators and have advanced to a state that we challenge nature's capacity to keep our population in check with improved medical services and living standards. Although there are natural factors in controlling our growth, most of our reproductive influences are social and decreasing national and global fertility rates to reduce population based stressors will require either social will and self-control or political force.

Mathematically, national population growth is a function of (births- deaths) + (immigration- emigration) (Weeks, 1989). Demographers often report on national births and deaths as rates, which are expressed as fertility rates and mortality rates. Fertility rates are usually the expression of the average number of live births a woman gives in her lifetime and mortality rates are the number of deaths per 1000 in a given year. A stable population, one that is neither naturally increasing nor decreasing has a replacement fertility rate that is equal to 2.1 (Grant, 1996). This simply means that the average family has 2.1 children and that, over the population in time, this replaces the loss upon the deaths of both parents. Demographers have for some time acknowledged a correlation between high death rates and larger fertility rates; in particular in societies experiencing high infant and youth mortality.

In 1929, Warren Thompson first acknowledged a transition from high to low birth rates with complementary death rates in the developed country's histories (Weeks, 1989: 72- 79). This developing theory, the demographic transition, illustrated in figure 2, was expanded by Frank Notestein in 1945 and is defined as a transitional period when a developing nation with stabilized ratio of high birth rates and high death rates begins to transition into a stabilized low birth rate and low death rate. Theoretically the death rates decline first and the period before the birth rates complement the death rates is a period of rapid population growth. Although there have been many examples of the demographic transition occurring in developing societies there was room for criticism and the demographic transition was reformulated between the 1960s and 1980s. This reformulation acknowledged that the transition to lower fertility rates was not caused by declining death rates but instead the two rates transition as a result of modernization and economic development. Either way, there is a period in which death rates decline prior to birth rates and a population grows rapidly before stabilizing.

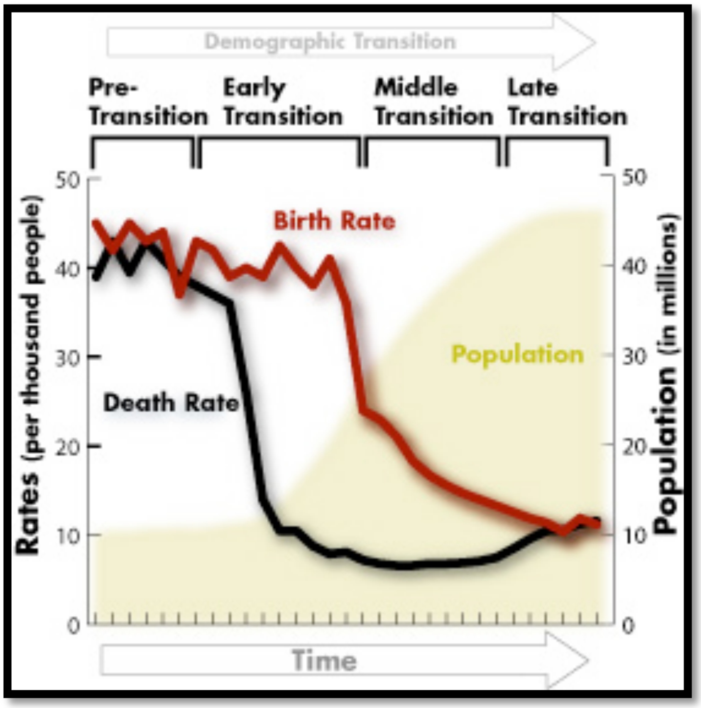

Figure 2: Shows the changes in birth and death rates in demographic transition and the corresponding growth in the population. The time frame with low death rates (in black) and high birth rates (in red) is the period of most rapid growth. (Population Action International, 2007)

Although there are biological factors that give humans the capability of rapidly reproducing, as a cognitive and social species we have choice and it is often social and cultural institutions that encourage growth and present barriers to constraint. Women are often seen as the deciding factor in fertility rates, and when empowered economically, socially, and politically, fertility rates often decline (Jaquette and Summerfield, 2006). The following discussion presents several important socio-economic and cultural factors that encourage high fertility rates and population growth. It should be noted that this is not an exhaustive list but rather a sample of factors.

2.2.1 Individuals and Societalists

The modern demographic transition model emerged as a result of discovering social transitions that were occurring in unison with economic development (Weeks, 1989). This social transition, secularization, is a shift away from autonomy and personal responsibility. Although modernized, secularized, free and democratic societies relish their individualism; there are also those (societalists) that take a broader view of their place in the larger society, whether it is a geographically local society or a global society. The socialized attitudes of individualist and societalists (Grant, 1996: 226-230) plays a significant role in their perceptions of fertility. Although similar to the modern ideologies of conservatives and liberals, there are however distinct differences in viewpoints. Individualists, as used here are those whose viewpoint of society and governance is one that does not restrict the personal choices and freedoms of the individual. Furthermore, the individual is responsible for his or her wealth and position in society. Within this perspective there is little tolerance for policies that would address one's choice on family size regardless of the strains placed on society by an increasing population.

In opposition to the individualists lie the societalists that have a viewpoint that humans are social creatures (Grant, 1996). They value government as a responsible mediator for the well being of society by providing a basic standard of living and opportunity but understand there is a social contract between their government and the people. Here, there is recognition that if a population's growth is recognized as a threat to the society as a whole, and therefore to the individuals, then responsible action is needed.

2.2.2 Nationalism

Nationalism is the identity a person or people have to their nation, it is a sense of pride and often delivers a sense of duty to defend. Nationalism is not restricted to either a society dominated by individualists or by societalists, yet nationalism influences a population's growth rate in one of two ways. The first being: a nation's security is often defended by its military, which historically was dominated by manpower supplied by a growing and healthy population. In order to have power and security a nation had to have a good supply of able fightable men. This became more critical when one's neighbors were also an enemy (Freedman, 2008). Secondly, Nationalistic nations may often establish pro-growth policies for a sense of high national virility that symbolically expresses health and prosperity. In the modern and developed world, modern militaries are mechanized and technological, and a nation's health and prosperity are judged more on its markets and gross national product than its reproductive health. Yet the developed world is a smaller fraction of the overall nations of the world and some nationalistic values may well be relevant in some less developed nations even today.

2.2.3 Religion

Religion is a significant social and cultural factor that has shaped the world in which we live today. Every culture the world over has developed some sense of religious or spiritual belief and practice with the majority of the modern world falling into six major categorical beliefs (Burke, 2004). Although indigenous people in the Americas, Australia, and Africa, and Islanders of the Pacific, do have religious values individual to their societies and communities, the spread and conversion of Christianity and Islam throughout the world has largely marginalized these beliefs. The other major religions after Christianity and Islam are Buddhism, Judaism, Hindu, and the Chinese religions. In a special conference in Whistler British Columbia, Canada (1993), the world saw the first gathering of forty religious scholars and leaders from all over the globe and every major faith, as well as indigenous religions (Coward, 1995). The conference was intended to reach a better understanding of how the religions of the world viewed the environment, economy, law, and demography.

Out of this world religions conference emerged a consensus regarding demographics and environmental principles. The common values were a deep respect for human life and the understanding that the world's environment is something to be cherished both for its resources and for its own sake. In the religions of Abraham: Christianity, Judaism, and Islam, some fundamentalist views empower god as an active entity that will provide the environmental and subsistence needs for his followers who have faith in his will. Every religion had some level of discrepancy with abortion but differed on the debate of birth control. Islamic law dictates that fertility control of any kind is strictly forbidden but Judaic law acknowledges that some forms of birth control are permissible (Coward, 1995: 73- 107; 123- 136). Christianity on the other hand has become too diversified to have a consensus on biblical meaning on fertility control, yet Christian theology does connect population growth to justice. In an address before the Panel on Religious & Ethical Perspectives on Population Issues for the preparation of the U.N. International Conference Population and Development in 1994, Rev. Martin-Schramm stated that population issues are a matter of justice and justice is central to Christian theology. The Rev. went on to state (U.N.,1993):

> I believe that population growth today springs forth chiefly from poverty, which has its roots in injustice. Therefore, the primary Christian response should constitute an attack upon poverty and injustice. At the forefront of this effort must be the attempt to provide basic human needs. This will necessitate substantial social reform, and not just the path of Western economic development, since most conventional courses of development have only served the middle and upper classes in many developing countries. Alan Durning, citing Ghandi, rightly reminds us that "true development puts first those that society puts last."

The Eastern religions, which lack a single almighty god and any single divine canon, differ among the Western religions and among themselves. Hindus view fertility control as immoral on the ground that it denies the reincarnation of spiritual beings and a marriage that lacks children is grounds for divorce (Coward, 1995: 139- 140). The Chinese religions takes little to no stance on population growth and fertility control and China has a history of infanticide, abortion, and birth control and a modern national policy on fertility reduction, the One-Child Policy. Yet in traditional Chinese religion and culture, sons are of extreme value to the family and for traditions of securing the afterlife of all family members by rituals (Coward, 1995: 180- 181). Buddhism may well be the most liberal of the major religions in its stance on sexuality, which is an act of communication and bonding and not just an act of procreation as with other religions (Coward, 1995: 155- 172). Although abortion is not viewed as an option, fertility control is widely acceptable as long as it is not harmful or damaging to the woman. In fact from a Buddhist perspective, a population should not grow larger than it can live in harmony with its environment.

2.2.4 Culture

Although religion and culture are often tightly woven there are also cultural values that influence fertility rates, death rates, and population growth. Culture is communicated by personal relationships and by media and it would be hard to argue that modern media methods are not shaping our actions and lives especially in the industrialized world but globally as well (Lull, 2000). Although the world is shrinking through globalization and culture with it (Friedman, 2008), mass media gives us an opportunity to see how others live. This has given the less developed and developing societies the opportunity to see the developed nations and their lifestyle, which is often sought after and emulated. It is this emulation of developed nations that is increasing consumption of natural resources including fossil fuels for energy.

Japan, a small island nation illustrates how culture through media can influence family values and national fertility rates (Freedman, 2008). In post World War II Japan, the nation was facing crises of limited resources and a shattered economy. Demographers have noted for some time that conflict itself can be a powerful influence on raising fertility rates and Japan's government was fearful of what could happen if the nation went through a population explosion. The state established a policy utilizing mass media outlets such as popular magazines to advertise birth control methods (Freedman, 2008). The impact was effective, fertility rates declined and the population explosion was avoided but today the fertility rates are way below replacement level and Japan faces an aging population demographic challenge (Frauqee and Muhleisen, 2001).

In some cultures the family is the cornerstone of life itself but in post-industrialized societies, the role of family has shifted for a variety of reasons. This shift has resulted in new personalized freedoms for partners that can be compromised by the presence of children (Agrillo and Nelini, 2008; Kohler, Billari, and Ortega, 2006). In these societies fewer children equates to more financial security and more expenditures for each family member. Furthermore fewer children and even childless couples have more personal time as well as quality time as a couple. In cultures such as China and other developing states that have rich traditions of filial piety, the caring of the parents by the siblings, and agricultural communities where family farms are dependent on children for labor, larger families are often preferred (Deutsch, 2006). Given the prominent role local culture plays in understanding views toward family size, it may be beneficial that global studies account for such diversity of beliefs.

2.2.5 Gender Inequality and Healthcare Disparities

One of the most critical international demographic factors to emerge, not only due to increased human rights issues, but also to liberate high fertility rates, is the cultural value of women. Many cultures around the globe have developed from patriarchal societies (Therborn, 2004). In industrialized and post-industrialized societies women have increased their status in the community and in the family, but in many other cultures women have limited say in the decisions of the community and the household (Jaquette and Summerfield, 2006). A 2007 Population Reference Bureau report found that nations that had increased percentages of women who received an education also had lower fertility rates (Population Reference Bureau, 2007). Figure 3 below illustrates the lower fertility rates of woman with higher levels of education in LDC's. Likewise, when women are given choices on the number and spacing of their children they often choose to have fewer children and space them apart more so than when their choices are confined by parents or husbands (Ashford, L *et al*, 2000).

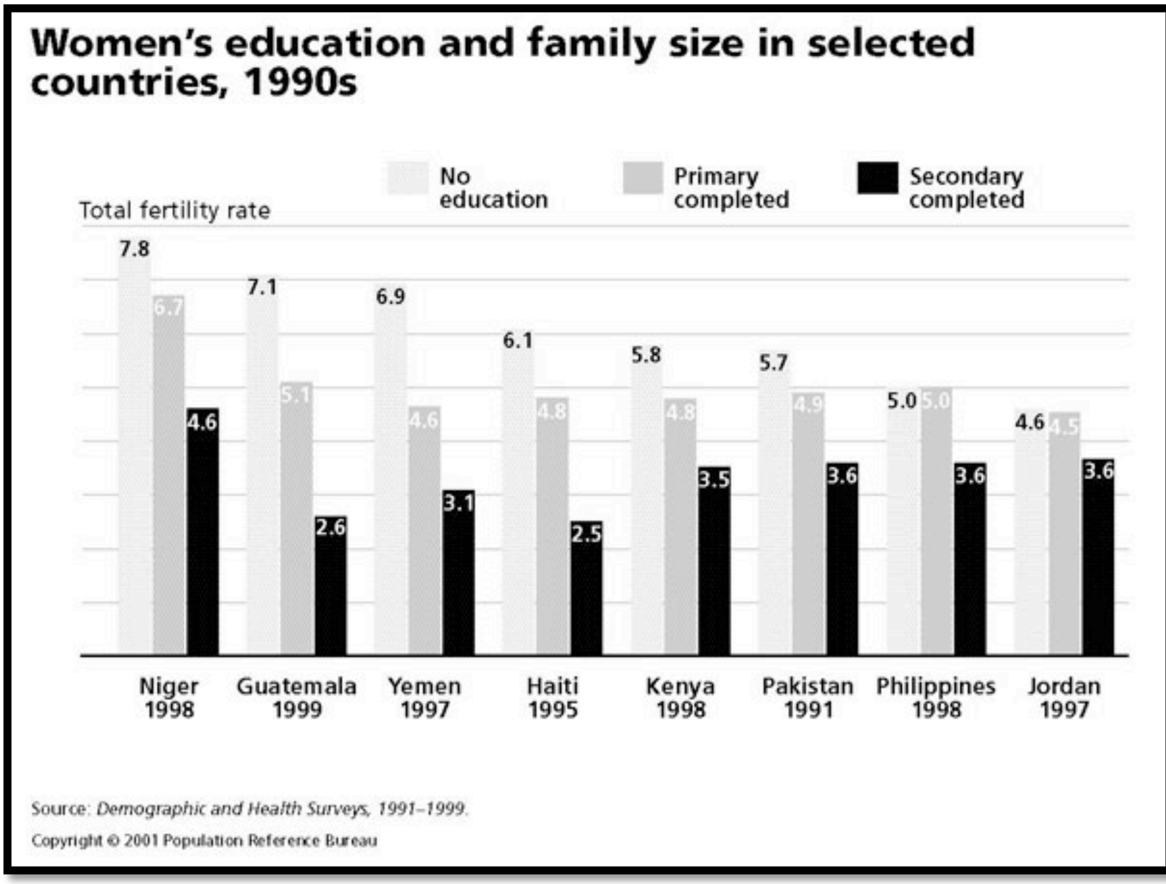

Figure 3: Examples of education levels and fertility rates. In each example there is distinct lower fertility rate in groups with completed secondary education (black bars) from completed primary (dark gray) and no education (light gray). (Population Reference Bureau, 2001)

Health care availability is a key to providing family planning services as well as pediatric services for existing children. In communities where children have a lower probability of surviving to adulthood, fertility rates are often higher in order to insure some survive (Hummel, 2006). In the developed nations health care services are often more readily available than in LDC's, yet in many LDC's healthcare, if available at all, is often a major task to receive. Often the costs of healthcare are out of reach and when provided by the state or through international non-governmental organizations

(INGO) their geographic locations can be hours or even days apart in travel time. Inadequate health care availability is not only a factor in the death of children but also may limit women's access to other family planning services, including prenatal care. Women who do not have family planning services available may resort to less healthy means of ending an unwanted pregnancy, and every year thousands of women around the globe die or are permanently disabled by their actions (Ahman, Dolea, and Shah, 2006). Healthcare and education are key services in countries that have the economic resources to supply them and in states where employment opportunities provide the economic resources for families to care for themselves.

2.2.6 Economics and Populations

When addressing the concerns of population growth, Newt Gingrich the prominent U.S. conservative and Terry Maple the former Atlanta Georgia Zoo president wrote in their *A Contract with the Earth,* "Overpopulation is a problem we can handle most effectively by targeting foreign aid and encouragement for emerging democracies with a stable rule of law and growing economies" (2007: p. 25). This illustrates a key ideology that has shaped the international aid efforts in addressing high fertility rates in LDC's; that if the states develop a modern and stable economy, the fertility rates in these states will fall. This vision has been supported by studies that have found a strong correlation between national GDP and fertility rates (Population Reference Bureau, 2007). Figure 4 below shows the relationship between national GDP and fertility rates. Yet the Neo-Liberal ideology that has dominated the international aide agencies such as the World Bank and International Monetary Fund since the 1980s has largely been based on a belief that this correlation is a cause and effect principle that will hold throughout the international community.

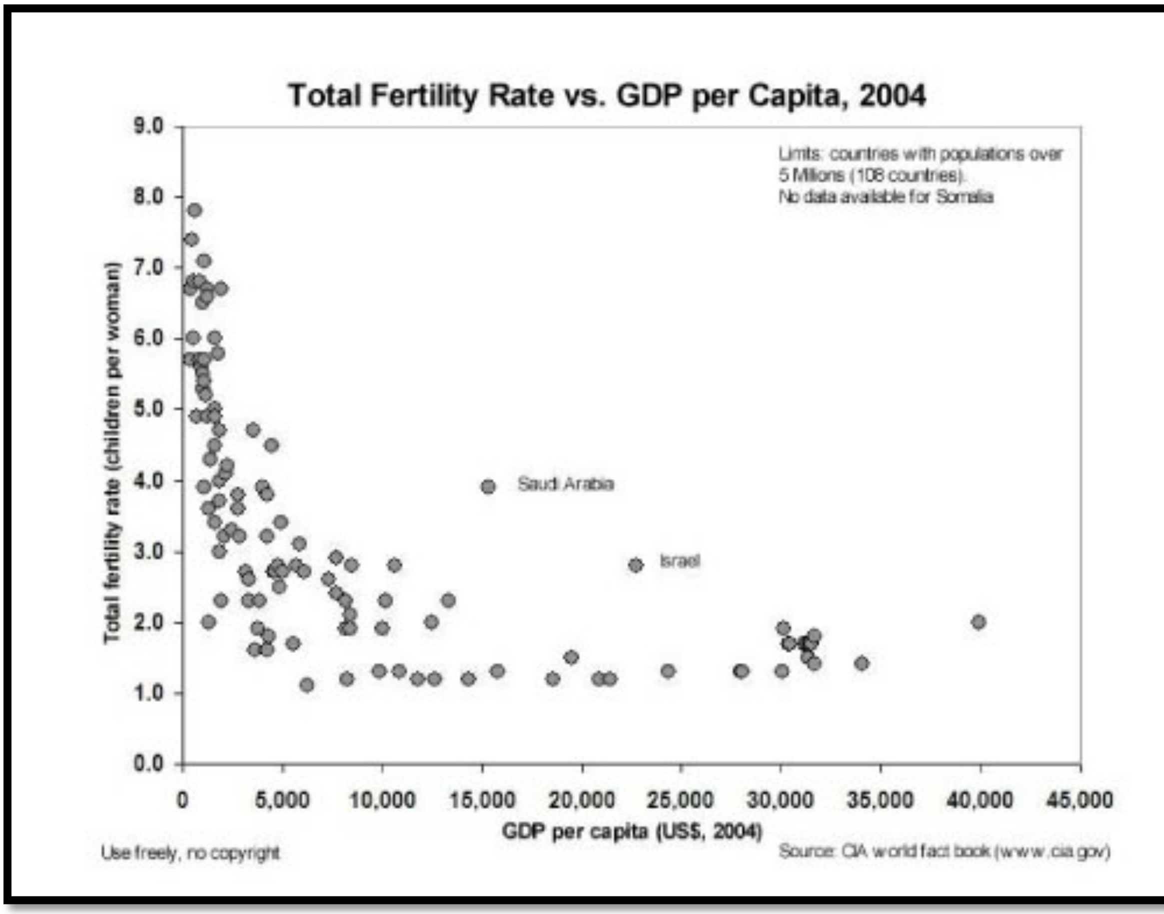

Figure 4: Showing national GDP per capita and correlating fertility rates. As fertility rates decline from 8 to 3 there is little improvement in GDP per capita but once fertility rates decline further than 3 there is a sharp improvement in GDP per capita (CIA)

Another relationship between economy and population growth is the supply-side economic principle to labor (Grant, 1996). A nation's Gross National Product is a measure of its production that is traditionally dependent on its labor force; the more workers the more production. This principle seems to hold relatively consistently across the modern political-economic philosophies of capitalism, communism, and socialism. Furthermore, a healthy economy is dependent not merely on the production of goods but on the flow of goods, services, and currency. A growing population can also be viewed as a growing consumer base, which channels the economic outputs of labor across geographic space and time. Yet a question for the modern era is how will technologies affect the labor force? Today we see a decrease in the need for human capital by increasing technological factors such as computers and robotics that have replaced customer service and production factories. Population growth has had its traditional economic purpose in that it supplies the work force, consumers and taxpayers for the future. Some countries such as the Germany, France, Sweden, the United States and others, have applied tax incentives and subsidies to families that encouraged a positive fertility rate to ensure economic security (Cohen, Dehejia, and Romanov, 2007).

2.2.7 Summary

The previous discussion of socio-economic and cultural factors is an illustration of the many complex factors affecting fertility and population growth. The complexity of the interactions of these factors within a community is exacerbated by local community contexts; each community interacts very differently from the others. This complexity challenges international efforts by agencies and NGO's at addressing population growth, as each community becomes a unique case and standardized efforts and policies are not often successful. Despite the complexity of addressing population growth, many NGO's and international agencies have made efforts to bring down population growth rates in many LDC's. Yet with efforts to reduce population growth under way, should or can these efforts be coupled with aiding LDC's development and utilization of clean energy?

2.3 The Theoretical Link between Populations and Impacts on Climate Change

Studies on how population dynamics interact with climate change have largely focused on how populations contribute to GHG buildup through increasing consumption rates. Recently, statistician Paul Murtaugh of Oregon State University investigated the carbon footprint legacy from mother to child (Whitty, 2010). His findings were that although both American's families and the overall population are smaller than India's, its carbon footprint legacy was 55-times-higher due to both America's high economy and its correlated high consumption. This analysis may be helpful in understanding individual scaled contributions to climate change through time and supports the hypothesis that larger economies produce increased consumption, contributing to rising levels of GHGs. This begs the questions of what can we anticipate about national population dynamics and national contributions to climate change as LDCs transition into MDCs? India and

China are both emerging economies, yet China represents a slightly divergent and unique perspective on the relationship between population growth, national economies, and national GHG contributions. Below is a case study of China that illustrates how macro scaled population dynamics interact with macro scaled GHG emissions.

Today China makes up nearly one-seventh of the world's population with 1.33 billion yet it is only the 4th largest country in land area (Population Reference Bureau, 2009 and CIA, 2010). This population is the result of high fertility rates prior to 1970 when Mao Zedong, the Chinese Communist Party Leader, was pressured to address fertility rates that were 5.9, over two times the replacement rate (Hesketh and Zhu, 1997). By 1970 China held one-fifth of the world's population, and had one-seventh of the world's arable lands. Under pressure from officials Mao reluctantly authorized the Late, Long, and Few Policy, a voluntary program established to encourage having children later in life, spacing them apart longer, and having fewer children. This policy was relatively successful in dropping the fertility rate to 2.9 by 1976. However growth concerns persisted and in 1979, under new leadership, China introduced the most aggressive regulatory policy on fertility rates in modern times, the One-Child Policy (OCP). To date China has had a positive but declining natural growth rate despite the OCP. With virtually no immigration, China represents a classic example of demographic transition as the increase in the economy has increased Chinese lifestyles and increased modern medicine leading to a declining death rate.

No matter what one's values and beliefs are on fertility policies and the OCP, the policy provides the first ever "controlled" environment to study the relationship between fertility rates, a significant factor to population growth, and national economies. In the *Review of Economics and Statistics*, Hongbin Li and Junsen Zhang analyzed this relationship in "Do High Birthrates Hamper Economic Growth" (2007). Their study collected data on fertility and economic variables over a twenty-year period in China from the time the OCP was established. They found that the OCP had not just a correlation with, but a causal relationship with China's economic boom as was desired by Chinese officials. If this study is valid and truly robust as they claim, it is significant to the fundamental principles of demographic and economic theories and supports neo-Malthusian principles. But what has this economic boom done in relation to China's environment and its role as a GHG emitter?

The theory that an increase in an economy has a negative relationship with the environment has been understood for some time and is a significant concern in both developed and developing nations (Field and Field, 2002: 412- 434). China and India are today's common examples of rising economies with devastating environmental responses. Decreasing water quality and availability, increasing smog and air pollution, deforestation and desertification are major concerns in these emerging economies, yet it is their greenhouse gases caused by their newly emerged industrialization that is significant for the hypothesis of this paper. In 2008 it was reported that

China had taken the lead as the largest CO_2 emitting nation with the United States second (Harrabin, 2008 & Rosenthal, 2008). Yet due to China's extensive population size, the United States still holds the title for largest greenhouse gas emitter per capita. Figure 5 below shows China's as the dominant GHG emitter and the U.S. resting just below followed by the European Union.

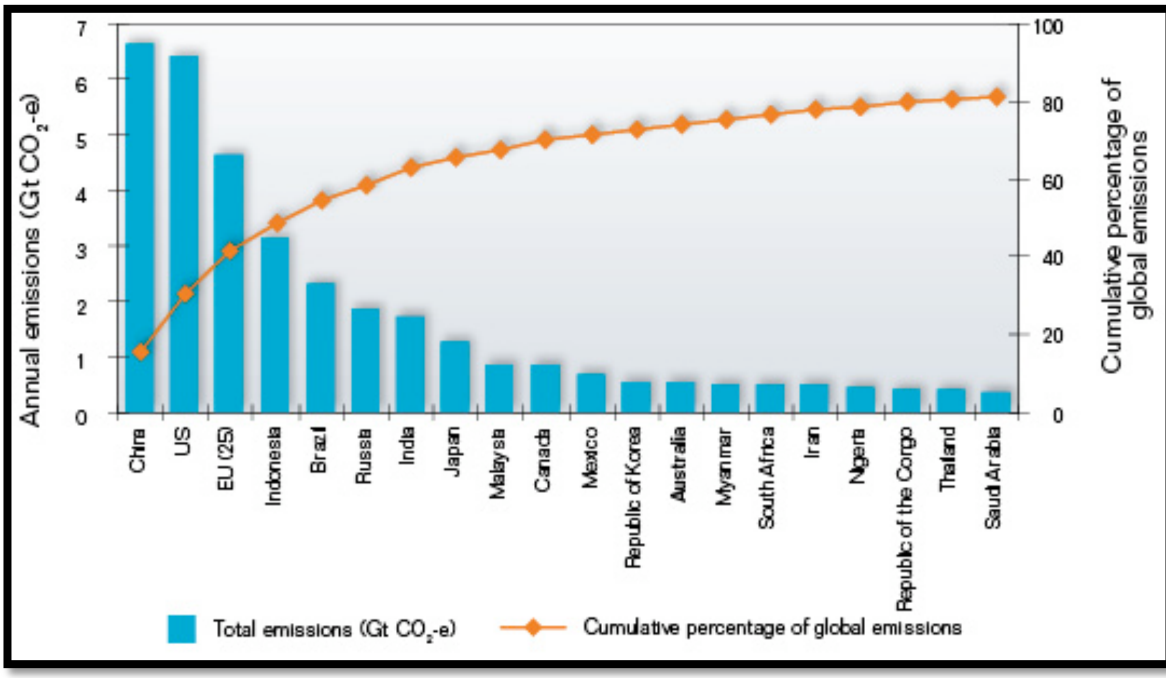

Figure 5: The graph illustrates the global accumulation of CO_2 and shows the top emitters in 2004 with China, the U.S. and the E.U. as the top three. This graph also illustrates the reasoning for tension between the LDC's and the industrialized world when accounting for responsibility in regards to current CO_2 accumulation and the impact of less developed nations on anthropogenic climate change (Garnaut Climate Change Review, 2008)

In China, the decrease in fertility has lead to an increased economy and industrialization, which has lead to a significant increase in the burning of fossil fuels to power the economy, thereby leading to a dramatic increase in GHG emissions. Although the data supports this cause and effect relationship in China, the pending research question is: can we illustrate this relationship across nations?

It is generally accepted by many academic disciplines that human population growth leads to environmental degradation. In the late 1960's and early 1970's an outspoken biologist on population growth, Paul Ehrlich and physicist and environmental scientist, John Holdren, currently the science and technology advisor to U.S. President Barrack Obama, published a number of articles on population growth and the environment. This raised a debate on whether or not population growth or a society's consumption activity was the true culprit for environmental degradation. They eventually developed a simple equation to illustrate the nature of populations on the environment:

I=PAT

Here, the (I)mpact of a society on its environment is a product of the (P)opulation, its (A)ffluence ([C]onsumption is also used) and its (T)echnological choices (Harper, 2008 and Grant, 1996). Using the IPAT model as a base, the China case study discussed above, and available literature, it is hypothesized in this paper that national fertility rates and population growth will have a negative relationship with nations' greenhouse gas emissions, thereby impacting global climate warming and climate change. More specifically, as a shift in demographic factors to a reduced fertility rate and growth rate occur, it will lead to an increase in the consumption of fossil fuels.

In figure 6 below, the theoretical model is presented. The illustration shows the positive and negative hypothesized relationships that have been derived from the previous discussion. It is hypothesized that as economic development increases, fertility rates decrease (negative sign). As economic development increases, energy and industry demand increases (positive sign). With increased energy demand and development, using current fossil fuel systems, as well as industrialization, there is an increase in greenhouse gases including carbon dioxide. Finally, based on current scientific understandings, the increase in greenhouse gases increase the mean average temperature (global warming), causing changes to the climates around the globe.

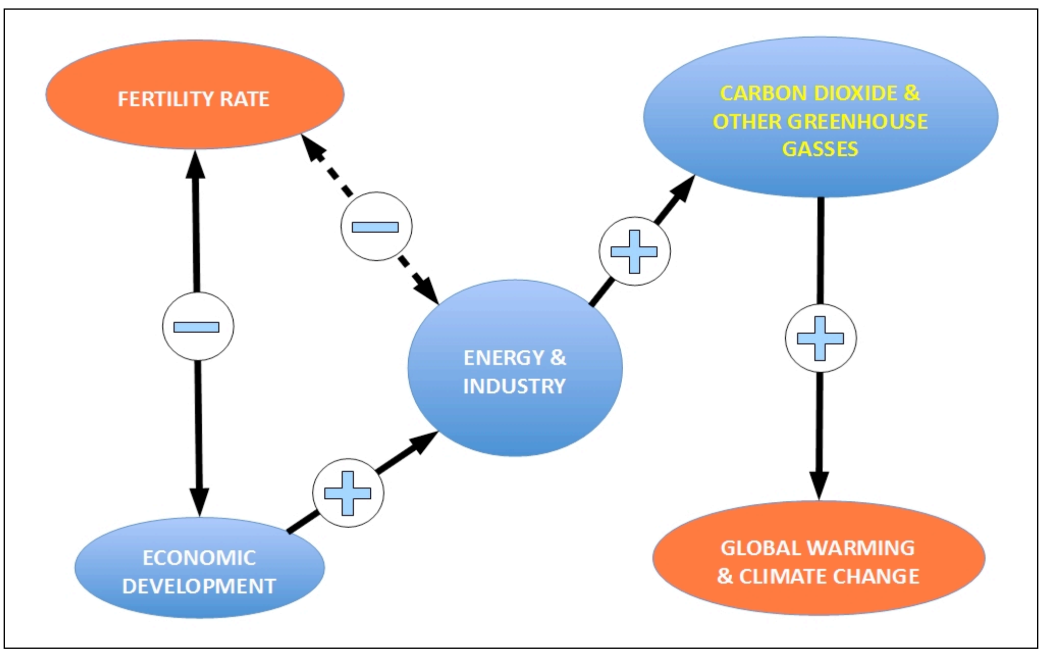

Figure 6: The theoretical model showing linkages from fertility rates to global warming.

3.0 Methods

To test the hypotheses, data were collected from sources that include U.S. national agencies, NGO's, and the United Nations. These data were used because their sources are reputable institutions that maintain and provide raw data for public information and scientific purposes. Table 3.1 and 3.2 display the variables, the variable ID, any transformations made and their sources. Once the data were obtained, four statistical regressions were run using SPSS to test the hypothesized relationships.

Table 3.1: Variables, Transformation and Source for Regression 1
Regression on CO_2, sample size (n)= 160 countries:

Variable I.D.	Variable	Transformed	Source
CO_2 Emissions	CO_2 Emissions	Natural Log	Population Reference Bureau (2007)
TFR	Total Fertility Rate	Natural Log	Population Reference Bureau (2007)
GNI PPP	Gross National Income in Purchasing Power Parity	None	Population Reference Bureau (2007)

Table 3.2: Variables, Sample Size, Transformation, and Source for Regressions 2-4. Regressions on Fossil Fuels, sample nize (n)= dependent variable restricted:

Variable I.D.	Variable/ units	N	Transformed	Source/ Year
LnOil	Oil Consumption (bbl/day)	153	Natural Log	CIA World Factbook (2007)
LnNG	Natural Gas Consumption (cu m)	83	Natural Log	CIA World Factbook (2007)
LnCL	Coal Consumption (thousand short tons)	83	Natural Log	U.S. EIA (2007)
LnGDPPPP	Gross Domestic Product in Purchasing Power Parity	**	Natural Log	CIA WorldFactbook (2007)
LnTFR	Total Fertility Rate	**	Natural Log	Population Reference Bureau (2008)
LnRNI	Rate of Natural Increase	**	Natural Log	Population Reference Bureau (2008)
LnMIG	In Migration	**	Natural Log	U.N. Economic & Social Affairs (2007)
HDI	Human Development Index	**	None	U.N. Development Programme's (2007/2008)

*** denotes independent variables and n is dependent variable restricted*

The first regression is used to test a relationship between fertility rates and CO_2 emissions and the remaining three are identically modeled regressions on three fossil fuels. These three models explore the relationship between demographic factors and consumption. These are extremely important, as it is the consumption of fossil fuels that emit the greenhouse gases. If there is a significant relationship between demographic factors and fossil fuel consumption then there is support for the IPAT model for climate change. Similarly, if there is a significant link from population factors to consumption of fossil fuels with increased economies and industrialization, this would lead to an impact on global warming.

The first regression to be analyzed is CO_2 Emissions Per Capita= B_1 + B_2(True Fertility Rate) + B_3(Gross National Income in Purchasing Power Parity). The data for the first regression comes from the Population Reference Bureau's (PRB) *2007 World Population Data Sheet*. This regression has a sample size of 160 countries based on the availability of data for all variables. This gives us a sample size of 76.9% of the total sovereign states or nations given by the PRB. The dependent variable *Carbon Dioxide Emissions per capita* is measured as the amount of CO_2 in metric tons, produced or emitted per capita in a nation. The PRB report only reported in per capita and not overall national emissions. In the subsequent 2008 PRB annual data sheet, CO_2 factors were not included. The independent variable *Total Fertility Rates* (TFR) is defined as the average number of children a woman would have assuming that current age-specific birth rates remain constant throughout her childbearing years (15 to 49) and is a significant indicator for population growth. The second independent variable *GNI PPP per capita (2006)* is defined as gross national income in purchasing power parity divided by midyear population and is reported in international dollars (U.S. dollars). GNI differs from Gross Domestic Product (GDP) that is used below by its ability to capture incoming investments and outflow of wealth by a nation's economy whereas GDP measures a nation's generation of wealth but does not account for wealth that flows outward, such as incomes to migrant workers that transfer their earnings to their home land or wealth generated by international businesses located in a particular country (OECD, 2004). The Use of GNI in this case is used as a matter of convenience, the PRB reported in GNI and not GDP. In either case purchasing power parity is vital for comparing GNI or GDP across nations as it levels out the value of foreign currency and in the case below it transfers all value to the U.S. dollar. The variables CO_2 emissions and TFR are transformed using natural logs due to non-linearity (Studenmund, 2006). The reformulated statistical model used is:

$$\ln (CO_2 \text{ Emissions}) = B_1 + B_2(\ln [TFR]) + B_3(\text{GNI PPP})$$

The dependent variables for the three remaining regression equations are the national consumption of fossil fuels: coal, oil, and natural gas. The *Consumption of Oil*, measured in barrels per day (bbl/day), and *Consumption of Natural Gas*, measured in cubic meters (cu m) are taken from the U.S. Central Intelligence Agencies (CIA) "World Factbook" (2009), a reputable source for international information and readily available. The consumption information is dated 2006 and 2007 depending on the year the estimates were reported last on the individual nation. The *Consumption of Coal* in thousand short tons, was taken from the U.S. Energy Information

Administration "World Coal Consumption, Most Recent Annual Estimates, 1980-2007" (2008). The coal consumption data that is used is for the 2007 year. The reason EIA was chosen for coal was that the CIA "World Factbook" did not offer this information and the EIA offered the data as public access.

The independent variables comprise three dimensions of a society: the demographic factors, the social, and the economic. The demographic variables include the *Total Fertility Rates*, defined above, and the *Rate of Natural Increase*, defined as the percent of growth including births minus deaths and leaving out migration. These two variables come from the Population Reference Bureau's *2008 World Population Data Sheet*, available to the public online. The *Migration* variable is taken from the United Nations Economic and Social Affairs "World Population Policies 2007" report and is the number of migrants in thousands. The values are captured as the year the data was collected, 2005. This U.N. report is available to the public and covers demographic factors as well as political views on population growth and polices.

The socio-economic variables include *Gross Domestic Product in Purchasing Power Parity (GDPPPP) and the Human Development Index (HDI)*. The GDPPPP was also derived from the CIA "World Factbook" and reported in differing years as early as 2001 and most commonly 2008. National GDP's are available from a variety of agencies, the CIA was chosen as other factors were collected from this source and the report is updated often. Finally the social variable, The *Human Development Index* is "a composite index measuring average achievements in three basic dimensions of human development- a long and healthy life, knowledge and a decent standard of living" (UNDP, 2007). Due to HDI's expansive coverage including gender disparities and socio-economic factors that are related to fertility rates, this variable was chosen to reduce the amount of possible variables, using one that incorporates many. The HDI is taken from the United Nations Development Programme's (UNDP) "Human Development Report 2007/2008." The HDI values were issued by the UNDP in 2005. As with the first regression, the dependent variables proved to be non-linear and were transformed using natural logs. TFR, RNI, MIG, and GDP were also transformed using natural logs based on errors in linearity and heteroskedasticity that were found. The model for these three regressions is:

$$\ln(\text{Fossil Fuel}) = B_1 + B_2(\ln[TFR]) + B_3(\ln[RNI]) + B_4(\ln[MIG]) + B_5(\ln[GDPPPP]) + B_6(HDI)$$

4.0 Results and Discussion

The results from the four regressions above support the hypothesis that there is a negative relationship between a nation's total fertility rate, a key indicator for population growth, and the nation's CO_2 emissions. Figure 7 below illustrates the results and shows fertility rates and GDP impacting CO_2 emissions and fossil fuel consumption, leading to impacts on global warming and climate change. Regression 1 looks at the CO_2 emissions per capita and total fertility rate directly. Regressions 2, 3 and 4 look at total fertility rates on the consumption of fossil fuels, which are the key source of CO_2 emissions and a leading factor in anthropocentric climate change. Oil, the world's leading fossil fuel for energy is the only resource that showed a significant negative relationship with fertility rates. In the Figure 7 below, the red highlights the focus of this paper. It shows that fertility is significantly correlated with oil and carbon dioxide and therefore linked to global warming and climate changer.

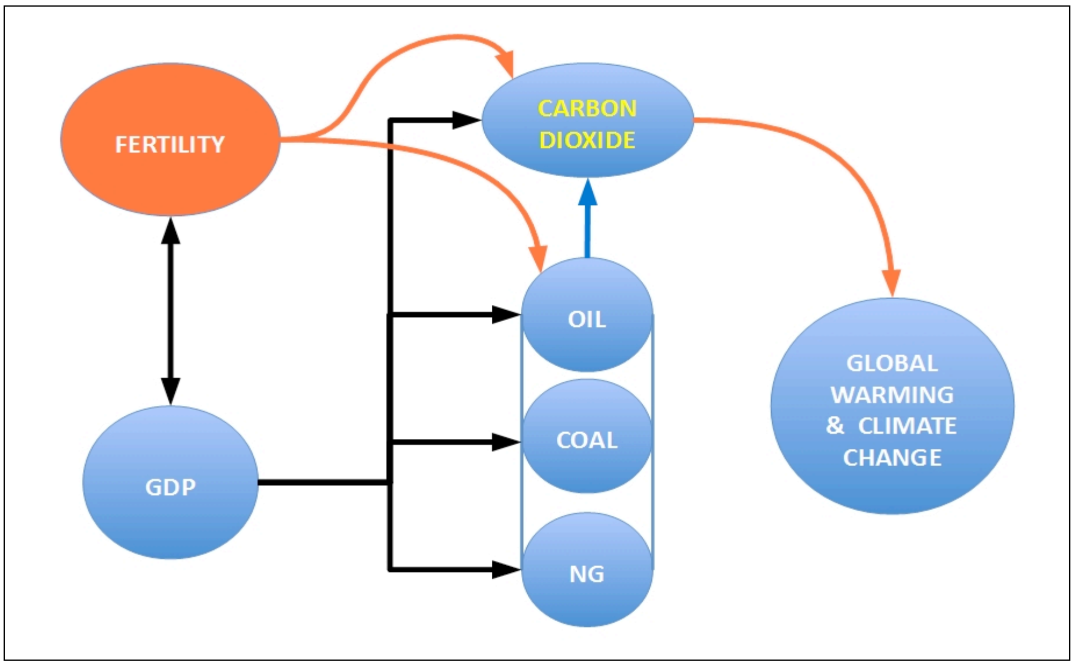

Figure 7: A graphic illustration of the results showing the connections fertility rates and GDP have to fossil fuels consumption and CO_s emissions and its link to global warming and climate change.

The regressions on the consumption of coal, natural gas and oil show that there are some complex interactions between socio-economic and demographic factors with regard to fossil fuel use. The economic factor based on GDP PPP behaved as expected, highly correlated and significant in all four models. Not all regression models share similar sample sizes (*n* values) due to missing information on a specific country from the reporting agencies. The smallest sample size is 83 countries, for both the consumption of coal and consumption of natural gas, yet this represents more than 35% of the nations. The Pearson correlation values are objective valued (Robson, 2002), for the purpose of this paper any relationship with a value lower than 0.10 will be regarded as no-relationship and a value of 0.80 will be considered highly correlated. All statistical significance levels are shown as 99%, 95%, and 90% levels.

4.1 Regression 1: Fertility Rate's and GDP on CO_2

Recall that the first regression was to examine the relationship between total fertility rates and CO_2. Regression 1 shows that TFR and GNI PPP are both significant variables explaining CO_2 emissions on a per capita basis in a country. Table 4.1 shows the strength of the correlations between the variables: TFR and GNI PPP have a slightly above average correlation that is inversed (-0.613). This supports both the literature and the hypothesis that fertility rates affect the economy and more specifically that as fertility rates decline there is a positive relationship with economies. The adjusted R^2 (0.709) informs us that roughly 70% of CO_2 emissions per capita in a specific country are explained by the independent variables of GNI PPP and TFR. Furthermore, based on the high F value of 194.683 which is greater than the critical F value of 4.61, we reject the null hypothesis that there is no effect of TFR and GNI PPP on CO_2 emissions per capita.

The model's coefficient's beta values explaining CO_2 emissions are found in Table 4.3. The three beta coefficients share significance levels of 99% with p-values of less than 0.001. The beta for TFR in its natural log transformation -1.154, states that as national fertility rates decline there is an increase in CO_2 emissions, in tons, per capita. For GNI PPP, for every dollar increase there is a corresponding increase in tons of CO_2 emissions per capita. The resulting model is:

Ln(CO_2 Emissions in tons)= 1.431 – 1.545(Ln[TFR]) + 0.00005848(GDP PPP)

Table 4.1: Pearsons Correlations on CO_2 emissions per capita

	Ln CO_2 Emissions	**Ln (Fertility)**	**GNIPPP**
Ln CO_2 Emissions	1.000	-0.770***	0.745***
Ln (Fertility)	-0.770***	1.000	-0.613***
GNI_PPP	0.745***	-0.613***	1.000

Significance, 1-tailed test: ***= 99%, **= 95%, *= 90%

Table 4.2: Model & ANOVA statistics on CO_2 emissions per capita

Model	**B**	**Std. Error**	**Beta**	**t**
Constant	1.431***	0.233		6.135
Ln Fertility	-1.545***	0.167	-0.501	-9.262
GNI PPP	5.848 E-5***	0.000	0.438	8.099

Significance, 1-tailed test: ***= 99%, **= 95%, *= 90%; Adj. R^2 = 0.709; F-stat = 194.7***

4.2 Regression 2: HDI, GDP, TFR, RNI, and Migration on Oil Consumption

The first regression based on fossil fuel consumption of oil is observed in Tables 4.4, 4.5, and 4.6. Based on Table 4.4, we see that all the independent variables are significantly correlated to the consumption of oil and to national GDP PPP. Except for TFR and MIG, all other variables are correlated with a significance level of either the 99% or the 95%. In migration carries a small correlation with the independent variables of fertility rates, rate of natural increases, and the Human Development Index. The model's F-test has a 99% significant level and the F-value of 370.067 is greater than the critical F-value of 3.32 so we reject the null hypothesis that the list factors do not affect the consumption of oil. The R^2 of 0.926 tells us the model is explaining roughly 92% of the consumption of oil.

In Table 4.6 the beta coefficients for the model are presented. The independent coefficients of the constant, the GDP PPP, the TFR, RNI, are all statistically significant at 99%, MIG is significant at a 95% level and HDI shows little significance in this model. The model's constant is a negative (-9.926), which may be explained by oil exportation. Once again the GDP PPP is positive as would be expected, an increase in GDP leads to more consumption of oil and the TFR is once again negative which coincides with the hypothesis that decreased fertility rates would increase the fossil fuel consumption. The RNI and MIG both have positive coefficients meaning that as the RNI and MIG increase so does the consumption of oil. Both of these variables are additive factors to a population, resulting in an additive affect on consumer numbers if the fossil fuel resources are available and cost effective.

As was done in the first regression, several variables needed natural log transformations and because the HDI was not significant it was removed. Based on the significant model coefficients in their natural log transformations we get the following model:

Ln(Oil Consumption)= -9.926 + 0.85(Ln[GDPPPP]) – 1.056(Ln[TFR]) + 0.392(Ln[RNI]) + 0.085(Ln[MIG])

Table 4.3: Pearson Correlations for regression on oil

	LnOil	LnGDPP	LnTFR	LnRNI	LnMIG	HDI
LnOil	1.000	0.949***	-0.481***	-0.360***	0.740***	0.503***
LnGDP	0.949***	1.000	-0.388***	-0.342***	0.780***	0.414***
LnTFR	-0.481***	-0.388***	1.000	0.802***	-0.125*	-0.856***
LnRNI	-0.360***	-0.342***	0.802***	1.000	-0.153**	-0.662***
LnMig	0.740***	0.780***	-0.125*	-0.153**	1.000	0.163**
HDI	0.503***	0.414***	-0.856***	-0.662***	0.163**	1.000

Significance, 1-tailed test: ***= 99%, **= 95%, *= 90%

Table 4.4: Model and ANOVA statistics for regression on oil

Model	B	Std. Error	Beta	t
Constant	-9.926***	1.037		-9.571
LnGDP	0.850***	0.042	0.831	20.314
LnTFR	-1.056***	0.264	-0.220	-3.996
LnRNI	0.392***	0.098	0.151	4.006
LnMIG	0.085**	0.041	0.078	2.055
HDI	0.729	0.550	0.058	1.324

Significance, 1-tailed test: ***= 99%, **= 95%, *= 90%; Adj. R^2 = 0.924; F-stat = 370.1***

4.3 Regression 3: HDI, GDP, TFR, RNI, and Migration on Coal Consumption

The consumption of coal has very different statistical results than oil consumption. In Table 4.7, all the independent variables are significantly correlated with coal consumption and between independent variables; the only correlation that is not significant at the 99% or 95% level is between the TFR and MIG. The model statistics show that the model is significant with a F-value of 22.667, which is greater than the critical F-value of 3.65, suggesting that the null hypothesis should be rejected. The adjusted R^2 suggests that the model explains 56.9% of the consumption of coal, but the only significant independent variable is GDP PPP. In Table 4.9 the constant coefficient, as with oil is negative and may be interpreted by nations that have coal reserves but export them and nations that have significant economies but do not consume coal. With only two statistically significant coefficients, both at 99%, the final model is:

Ln(Coal Consumption)= -27.672 + 1.291(Ln[GDP PPP])

Coal is not as energy dense as oil or natural gas (Roberts, 2005), and due to its bulk, it is not as efficient to transport as oil. Despite its lack of energy density, coal technology is well established and affordable unlike natural gas, nuclear, and other alternative energy sources. It may be the case that coal is used within a country or region rather than extensively traded or sold between countries. If a nation has an existing infrastructure that is based on coal fired power plants due to a historical supply of coal within its borders, it may be advantageous to import coal until a new energy infrastructure can be developed based on a different resource. This inefficient transportation factor may be the cause for such a small sample size compared to oil.

Table 4.5: Pearson Correlations for regression on coal

	LnCL	LnGDPPP	LnTFR	LnRNI	LnMIG	HDI
LnCL	1.000	0.740***	-0.455***	-0.379***	0.492***	0.429***
LnGDP	0.740***	1.000	-0.379***	-0.283**	0.715***	0.464***
LnTFR	-0.455***	-0.379***	1.000	0.830***	-0.113	-0.842***
LnRNI	-0.379***	-0.283**	0.830***	1.000	-0.179*	-0.711***
LnMig	0.492***	0.715***	-0.113	-0.179*	1.000	0.237*
HDI	0.429***	0.464***	-0.842***	-0.711***	0.237**	1.000

Significance, 1-tailed test: ***= 99%, **= 95%, *= 99%

Table 4.6: Model and ANOVA statistics for regression on coal

Model	B	Std. Error	Beta	T
Constant	-27.672***	5.519		-5.014
LnGDP	1.291***	0.216	0.717	5.961
LnTFR	-2.078	1.387	-0.270	-1.498
LnRNI	-0.324	0.471	-0.094	-0.688
LnMIG	-0.044	0.216	-0.023	-0.204
HDI	-3.907	2.853	-0.193	-1.370

Significance, 1-tailed test: ***= 99%, **= 95%, *= 90%; Adj. R^2 = 0.569; F-stat = 22.7***

4.4 Regression 4: HDI, GDP, TFR, RNG, and Migration on Natural Gas Consumption

Natural gas is similar to coal in that its import/export factors are highly expensive based on technological and infrastructural requirements (Roberts, 2004). Despite this expense, natural gas may well be the fuel of the near future. It is cleaner to burn, reducing green house emissions from currently used coal plants, and it is relatively abundant compared to oil that is believed to either have already peaked or will peak in the near future (Hook *et al,* 2009; Roberts, 2004). The expense of natural gas transportation may well create a similar situation that is seen with coal, the nations that have it or can afford to have it imported are the consumers.

In Table 4.10, the Pearson correlations of the independent variables on natural gas consumption were all significant except the RNI. The correlations between the independent variables showed significance at either the 95% or 99% level except the correlations between MIG and TFR, and between MIG and RNI, which had no statistical significance. As with the other consumption variables the GDP PPP has the highest correlated relationship with natural gas consumption. The TFR correlation is negative showing the inverse relationship as predicted, yet the correlation is not as high (-0.264) as the correlations between TFR and Coal and Oil consumption which are -0.455 (Table 4.7) and -0.481 (Table 4.4) respectively.

The model is significant at α= 0.001 and the F-value of 26.404 is greater than the critical F-value of 3.34 suggesting that the rejection of the null hypothesis is warranted. The R^2 suggests that the independent variables of the specified model explain 60.8% of natural gas consumption. The betas for the model that have statistical significance are GDP PPP, RNI and MIG, all other factors fail to meet a statistical significance level of 90%. Due to the fact that TFR and HDI do not carry significant betas the model is left at:

Ln(Natural Gas Consumption)= 1.318 + 0.719(Ln[GDP PPP]) + 0.877(Ln[RNI]) + 0.380(Ln[MIG])

Table 4.7: Pearson Correlations of regression on natural gas

	LnNG	LnGDPP	LnTFR	LnRNI	LnMIG	HDI
LnNG	1.000	0.732***	-0.264**	-0.088**	0.603***	0.353**
LnGDP	0.732***	1.000	-0.301**	-0.218**	0.610***	0.325**
LnTFR	-0.264**	-0.301**	1.000	0.822***	-0.085	-0.764***
LnRNI	-0.088	-0.218**	0.822***	1.000	-0.095	-0.616***
LnMig	0.603***	0.610***	-0.085	-0.095	1.000	0.224**
HDI	0.353***	0.325***	-0.764***	-0.616***	0.224**	1.000

Significance, 1-tailed test: ***= 99%, **= 95%, *= 90%

Table 4.8: Model & ANOVA statistics of regression on natural gas

Model	B	Std. Error	Beta	t
Constant	1.318	3.516		0.375
LnGDP	0.719***	0.128	0.520	5.625
LnTFR	-1.614*	0.859	-0.289	-1.878
LnRNI	0.877**	0.291	0.369	3.010
LnMIG	0.380**	0.128	0.267	2.959
HDI	1.975	1.691	0.129	1.168

Significance, 1-tailed test: ***= 99%, **= 95%, *= 90%; Adj. R^2 = 0.608; F-stat = 26.4***

4.5 Summary

The results of the four regressions give some credence to the hypothesis that a decreasing fertility rate is positively correlated with the economy based on GDP or GNI in purchasing power parities; therefore positively correlated with greenhouse gas emissions that contribute to global warming. The complex issues and expenses related to coal and natural gas transportation and utilization may explain the loss of statistical significance with TFR in explaining national consumption rates. If a nation has coal, it is easy to consume because it does not require expensive technologies and infrastructure that natural gas needs. Natural gas is a relatively new fuel to the international markets and use as a primary fuel. This is not to say that it has not been used historically, but it was not until recently that technological techniques have been made available for natural gas to be shipped and utilized in primary energy production. Oil is the fuel of the world, it is used for transportation and electricity production all over the globe, in rich and poor countries. As long as the markets are not including externalities, costs that are not included in prices, that are associated with the burning of oil such as climate change, its costs will remain artificially low. As long as oil and its products are relatively cheap, they will be available to both MDC's as well as LDC's and will be used to fuel these countries socio-economic needs.

The analysis in this paper is done using data from individual years. Although this analysis illustrates with some confidence that there is a relationship that can be drawn from decreasing fertility rates to increasing CO_2 emissions resulting in impacts to global warming and climate change, future analysis could benefit from a time series analysis. Using data from multiple years can measure changes in national fertility rates and the national contributions to greenhouse gases. Furthermore, CO_2 may be the quantifiably dominant greenhouse gas in the atmosphere, it is not the dominant greenhouse gas in terms of energy or heat trapping capacities.

Methane gas, discussed above in its relation to increasing emissions from melting permafrost is a much more potent greenhouse gas than CO_2. A further analysis that measures changes in nation fertility rates to other national greenhouse gases emissions could also be beneficial to the understanding this complex relational system. Finally, only a small sample of contributing factors from a cultural and political- economic nature that influence fertility rates, economies, and consumption rates where used in this analysis. Any further research could benefit from analyzing any number of the other factors that influence national behaviors that include reproduction and consumption, and by using a best model selection such as the Akaike Information Criterion application offered by some software packages.

5.0 Policy Discussions and Implications

The analysis above indicates that a negative relationship between a nation's total fertility rate (TFR), a key variable in overall population growth, and CO_2 emissions per capita and oil consumption exists. Although the analysis does not support a relationship between TFR or any other population growth factor and the consumption of coal and/ or natural gas, a nation's Gross Domestic Product in Purchasing Power Parity does.

Furthermore, several studies have lead to widespread opinion that a nation's economy and fertility rates are significantly and negatively correlated, that as fertility rates decline there is an associated increase in the economy. Although scientific studies often inform the public and policy makers what is or is not, it is what we choose to do or not do that dictate what may occur in the future.

Below is a discussion on climate change and population growth policies. It acts in an informative manner on what policies have or currently occur and where the policy-making communities are in terms of any further policy actions. In addition there are some recommendations based on the analysis performed in this paper. Policies addressing climate change and population growth are contentious and very complicated and efforts to mitigate threats should not compromise overall decency, respect and compassion for human rights and wellbeing. Yet respect and compassion for human rights and wellbeing may demand mitigation in order to reduce significant risks to populations associated with high rates of population growth and threats associated with increasing degrees of global temperature.

5.1 Climate Change Policy

Protecting the environment means protecting the people that inhabit the planet not just today but into the future as well. It would not be far reaching to say that failing to address climate change today could have a significant impact on future populations and their capacity to grow. This was historically illustrated by Jared Diamonds *Collapse, How Societies Choose to Fail or Succeed* (2008); as civilizations experienced climactic and environmental changes they were unable to adapt; they often collapsed under the weight of their populations. Yet it should be inexplicably expressed that we are on a course with climate change that most of the species, including our own, have not experienced. As we wade into uncharted territories with CO_2 concentrations, we are in essence running a planetary scientific experiment (Schnider, 2009). The earth has not seen the level of carbon dioxide concentrations in the atmosphere that we are capturing today, 385 parts per mission (ppm) in 2009 (Schnider, 2009), and in over 670,000 years of historical ice-core data, the highs and lows have been between 180 ppm and 300 ppm with a steady concentration of 280 in the last 10,000 years (Friedman, 2008, and Maslin 2008).

In a dark way climate change may well be the cure to overpopulation. This statement comes from a pessimistic, although realistic view, that we have in large part failed to address green house gas emissions with historical attempts such as the Kyoto Protocol and are failing to come together in a united front against this issue even today (Schnider, 2009). The Copenhagen climate talks in 2009 were debatably a failure as reported in countless articles in the New York Times, BBC, and U.K. Guardian, as well as other media outlets. In short the rich nations blame the poor and the poor blame the rich and Europe blames the U.S. and China and so on and so on (Kanter, 2009, Black, 2010 and Vidal, 2009). Yet we cannot blame politics and national leaders for the failures; we need to blame our societies, in essence ourselves, for the lack in social and political will to deal with our economy that is driven by fossil fuels. Stephen Schnider, Stanford University Physicist, claims there are "simple and complicated" answers as to why we have failed to address climate change (2009, p.4):

> The simple can be summed up in five easy pieces: ignorance, greed, denial, tribalism, and short-term thinking. Let's face it- with so many billions of people to feed, house, and help to be productive, we focus on the immediate, not what is sustainable over decades to centuries. The Complicated aspects will require most of this the chapters in [*Science as a Contact Sport*]. But answer we must to prevent most of the looming danger. We must first see what held back beneficial changes from being implemented and then fashion strategies to overcome these constraints.

It may be that a series of events so horrific, they capture the public's attention and cannot be ignored, need to take place to lift the public's will and set the motion for social change that light's the fire for political change to take place. Historically, it is negative events that capture the attention of the people who, even under oppressive governments, lead the cause of change. Even under Mao's communist dictatorship did a series of local and regional starvations capture the attention of individuals in Mao's government to push for policies to address population growth. So far there have been two devastating events, the 2005 Hurricane Katrina and the 2003 heat wave, which killed some 50,000 people in Europe, yet these are only the big events that have captured media attention (Friedman, 2008 and Schneider, 2009). There have also been highly unusual weather events associated with climate change that have cost lives and caused economic damage that have not hit mainstream media, including heavy floods, ocean storms driving high waves into island nations, droughts, and unusual snow falls. As long as climate change effects are sparsely timed and less dramatic, people have a hard time making the connection. Furthermore, even when a significant majority of "experts" identify a connection, it is virtually impossible to make an absolute causal claim between a specific weather event and climate change, and this and other uncertainties becomes a tool by the political and cultural powers that wish to maintain the status quo.

In order to deal with climate change, it is universally recognized that the U.S. needs to participate and even more so take the lead (Friedman, 2008). The U.S. and China are the leaders in greenhouse gas emissions. China takes the medal for overall emissions and the U.S. for per capita; yet China is the new comer and the U.S. has been *the* polluter for several decades. The lack of the U.S.'s accountability for its role in green house gas emissions makes it virtually impossible to discuss and compromise on change. The international community *needs* the U.S. to step forward and to date the U.S. is showing little sign of change. To make matters worse, recent Gallup Polls show that 1) for the first time in a decade the U.S. is prioritizing energy production over the environment (Jones, 2010), 2) "Climate Gate" may have been successful in damaging American's faith in the science of climate change (Newport, 2010) and 3) President Obama announced opening off shore drilling for oil along the east coast.

With or without U.S. leadership and/or any mandate, the wheels of the human minds have begun to turn on how to deal with climate change. From technological efforts to decrease fossil fuel consumption with alternative energy sources and elaborate infrastructure planning for decentralized power (Friedman, 2008) to macro-scale geo-engineering theories (Morello, 2009), to yes, birth control and family planning (Hymas, 2010 & Murtaugh and Schlax, 2009). But all these require vast sums of capital and time and if the data and models are accurate it may be more prudent to establish policies and actions to adapt to climate change as well as find ways to reduce green house gas emissions and CO_2 in the air. The issue here is we are already seeing the signs of climate change and yet we have not begun to decrease the annual worldwide emissions of green house gases. Adaptation is going to be essential.

In short, climate scientists need to step forward, get into the debate, make their arguments and counter the attacks against them with science (Freidman, 2010). After all the overwhelming evidence is in the favor of anthropogenic climate change. If the U.S. is such a vital element to international climate change policy then the international community must find a way to pressure U.S. interests. This may be one of most difficult challenges ahead and any effort to bully a hegemonic power such as the U.S. is bound to have some level of consequence to the international community and the participating nations. For the time being, as long as the world is focused on issues that range from terror to energy demand and the devastated international economy, climate change policy will surely take a back seat and continued increases in green house gas emissions will rise, unabated, for the benefit of future generations.

5.2 Population Policy

International policies to assist in decreasing global fertility rates are as difficult to implement and maintain as international policies to address climate change. Although there is a high level of acceptance and concern over the rate of population growth, dealing with high fertility rates challenges complex culture traditions. Most of the world's high fertility rates are located in LDC's; whereas, most MDC's have seen a significant decline in fertility rates over the last several decades. Given the large number of women in their child-bearing years in LCDs, the world's net population is projected to continue to increase through 2050 (U.N. D.E.S.A., 2006). This means that international policies must be directed toward the nations that have little resources in dealing with their population growth and are heavily reliant on aid from wealthier nations.

In 1976 the first "World Population Plan of Action" was adopted by 137 nations out of the United Nations World Population Conference at Bucharest, August 1974 (Mumford, 2010). This plan of action acknowledged the link between development and population growth and established a directive for the nations to work together to increase economic and social development in the least developed nations in hopes of bringing down their population growth. The plan also established a directive to aid in the information and methods of reproductive choice through modern methods of birth control. In the second conference in Mexico City, 1984, the delegates reviewed the plan that was established previously, endorsed it again, added some amendments and highlighted the need to intensify international cooperation and policy efficiency (United Nations, 1984). At this time a new political paradigm was in motion with a conservative ideology, lead by U.S. President Reagan and U.K. Prime Minister Margret Thatcher.

During the early 1960s and into the early 1970s a division in the values and ideologies regarding women, sex, contraception, and abortion was brewing in the U.S. (Luker, 1984). Forming under an umbrella of pro-life vs. pro-choice, and seemingly focused as a debate on the medical practice of abortion and its morality, these movements formed as a result of ideological differences between 19th century laws and more recent liberal state laws. While legally settled under the *Roe v. Wade* and *Doe v. Bolton* in 1973, the ideological differences of the two sides have yet to be reconciled (Luker, 1984). As a staunch conservative Reagan as California's Governor and later as the President of the U.S, championed the values endeared by pro-life advocates: that sexuality is for procreation, that woman and men are intrinsically different and that these differences prepare each for a given role in the home and society, that contraception devalues sexuality, and that abortion is immoral under most circumstances (Luker, 1984).

As an expression of his pro-life values, President Reagan responded to the second population conference in Mexico City by enacting the "Mexico City

Policy", also known as the "Global Gag Rule" (Baker, 2009). This policy was directed toward USAID, the U.N. Population Fund and NGO's that received federal grants and funds. The policy removed any funding from programs that provided any sort of resources or information on abortion as part of family planning efforts. The policy essentially crippled many family planning programs around the world. During the U.S. Clinton Administration, the policy was lifted, reinstated again during the U.S. G.W. Bush Administration, and lifted again when U.S. President Obama was elected in 2009 (Clinton, 2009; Meckler, 2009).

A third conference in 1994, held in Cairo, once again reiterated the need for international cooperation on the population issue. At this meeting there was a shift in direction from focusing on the regional, national, and community level to an emphasis on individual needs and more generally, the needs of women (U.N. 1995 and Finkle, 2005). In 2000, the United Nations launched the Millennium Declaration, that set goals that cover many of the underlying causes and negative circumstances surrounding unwanted pregnancies, such as ending poverty and hunger, empowering women, providing education, reducing child mortality and improving maternal health, to name a few (U.N., 2008). All this effort has not been in vain; family planning programs and aide have reduced unwanted pregnancies and in many regions fertility rates have declined. Unfortunately the long-term objective of flattening the overall global population growth has not been met.

There is an interesting pattern emerging between population policies and international climate change policies. International efforts at addressing both climate change and population growth have failed as of 2010. For more than a few decades of climate change awareness and a decade since the Kyoto Protocol there are still no enforceable policies on climate change. In more than three decades of population conferences the international community is still in a locked debate on how to tackle such a monumental task and respect sovereignty. If we wish to achieve any significant goal on these issues, enforceable policies will need to be enacted and the threat to sovereignty will need to be overcome and compromises made. Until then, the world will wait; leaders will meet, talk and strategize: and we watch as little to nothing emerges until the consequence of failure occurs and the people look to their leaders and ask why.

6.0 Conclusion

This paper investigated the hypothesis that population growth impacts climate change. That as national population growth rates decrease, the consumption of fossil fuels and CO_2 emissions increases. This hypothesis is supported in the analysis of CO_2 emissions and oil consumption. However, with coal consumption neither the total fertility rate (TFR) nor rate of natural increase (RNI) were significant. Furthermore, with natural gas consumption the TFR was not significant and the RNI was significant at the 95% confidence level. The nature of fossil fuels, their price, their geographic locations, transferability, and technological requirements may play a significant factor in national consumption. Yet with oil, the world's primary fossil fuel, which is cheap, easy to transport, and not technologically challenging, TFR and the RNI do affect consumption. A question here is whether or not changes in technologies and prices around coal and natural gas would change the relationship they share with population growth factors to resemble a country's consumption behavior of oil?

Regardless of what the world's primary fossil fuel is, it is evident from recent events that the world is far from reaching a social and political drive to rapidly transform the world's energy system from fossil fuels. The availability, reliability, and efficiency of fossil fuels have made international corporations in the production, transference, and refinement wealthy and powerful. This power has made them very influential in policy implementation or lack thereof. Furthermore, the capital invested into the fossil fuel infrastructure around the globe and the high costs and uncertainty of alternatives energy sources make changing out of fossil fuel use very concerning. Yet without rapid reductions in the emissions from fossil fuels, our future is left with the complex and expensive adaptations to climate changes, and with global population growth continuing into the future, there is potential for increased human suffering from larger populations that will become displaced and in need of aide.

Policies that have had success in reducing fertility rates and overall population growth have been focused on increasing development, national economies, and women's rights and access to health care. The first two form a paradox with concerns in climate change, mainly that increasing economies and developing a nation to modern market economies means developing energy resources and as China and India have illustrated, without significant investment in developing these nations on alternative energy systems, they are bound to develop on the cheap and available fossil fuels such as oil. What is important here is that the industrialized world has it in their interest to develop and market cheap, reliable, and efficient alternative energy technologies not just for their national interests but as investments into the LDC's. These investments of alternative energy technologies can allow the LDC's to increase development, reduce their fertility rates therefore reduce the stressors on the world's other natural resources.

In conclusion, it is hard to remain optimistic about the future for following generations. It is not that the future of the planet under modeled climate change is non-livable, but it is a world that will require significant changes in our ways of life. Whether or not we have grown past a sustainable population with relation to our environment, our biological carrying capacity, is debatable and climate change adds complexity to the debate for the future. If we want to live the consumptive lifestyles of today and allow others to catch up, we may need to reduce the world's population and/ or find alternative means for energy production not based on finite resources that contribute to climate change.

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