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The Impacts of Climate Change on the World's Economic, Political, and Demographic Structures

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WASHINGTON UNIVERSITY IN ST. LOUIS

University College
International Affairs

The Impacts of Climate Change on the World's Economic, Political,
and Demographic Structures

By

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A thesis presented to the
Graduate School of Arts & Sciences
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partial fulfillment of the
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Dedication

This thesis is dedicated to my mother and to my father from whom I have learned, and will continue to learn, much.

ABSTRACT OF THE THESIS

The Impacts of Climate Change on the World's Economic, Political,
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by

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Master of Arts in International Affairs

Washington University in St. Louis, 2014

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Climate change will have negative impacts on the political, economic, and demographic structures of society. These include a rise in ethnic tensions in the Indian Sub Continent, massive immigration to Europe, regional economic collapse and political destabilization in Africa, the inundation of island nations and economic losses in the Americas among many other changes which will combine to destabilize humanity for generations. International affairs has failed to come up with a solution because global warming is a universal prevention focused problem that trades short term gains for long term losses. Global warming will be solved by the onset of grid parity within the next few decades, but it will be too late to avert drastic consequences. Humanity is resilient and civilization will ultimately find a way to cope in an age of global warming.

Introduction

The global warming debate is interesting in several respects. First off it is not even much of a debate as many of its major players actively acknowledge the facts behind climate change if only passively; after all it is hard to argue with a thermometer. Second the ultimate outcome of the global warming issue is also known. By the 22nd Century the majority of the world's energy supply will move beyond fossil fuels since there will simply be fewer fossil fuels left and mostly in harder to reach places. Furthermore it is highly probable that dramatic moves away from fossil fuels will occur even before the last barrel of oil is burned as the true costs of climate change become more visible. And therein lies the paradox. If fossil fuel consumption has negative effects on the wellbeing of people and if humanity must move to sustainable energy eventually then why delay.

While a lot has been written on climate change dealing with the scientific aspect of the issue, and rightfully so, there are relatively few works that deal with the potential demographic and political changes that would occur if there is a widespread failure to avert climate change. It is the goal of this thesis to present a global survey of how the political, economic, and demographic fate of regions will be affected by the changes in the climate. Afterwards a series of solutions will be presented that have the potential to avert the brunt of the consequences outlined.

The United Nations Intergovernmental Panel on Climate Change is the world's leading institution devoted to global warming. Their formal reports represent the consensus among the world's leading climate scientists on what the causes, effects, and solutions to global warming are. This report is also, rightfully or not, a compromise between everything from the influences

of powerful lobbies, wide ranging scientific views and national politics. The reports have a supreme amount of credibility, and therefore are the main source of facts and figures used throughout this thesis.

How Climate Influences Humanity

As a species, human beings have been relatively unchanged for the past 150,000 years. In other words, a person living 70,000 years ago had all of the mental capabilities needed to build buildings, grow crops, and even create airplanes. However it is only in the last 10,000 years that what would be classified as civilization by most came into fruition. What is remarkable is that within a span of a few thousand years human civilizations emerged simultaneously on all parts of the globe. In Mesopotamia, the Indus Valley, China, Mesoamerica and elsewhere civilizations began to form independently of each other. It seemed that during 200,000 years of human evolution writing, agriculture, and towns all suddenly decided to appear simultaneously across the globe at an arbitrary point in time that dates back to roughly 10,000 years ago. However it is not a coincidence that this is precisely when the current interglacial period began.

It turns out that the needed requirement for civilization, and not just human civilization, is agriculture at least in the example of planet Earth. Before the advent of agriculture, nomadic societies were not too different in their lifestyles than other groups of animals. An alien visitor

would likely not have differentiated a group of Neanderthals as being anything special when compared to a pack of wolves. What changed is the process through which people gained food and water. No longer was there a need to time one's life and activities to the movements of animal herds. People could simply stay in one spot and grow their own food. This was a drastic change. A stable food supply allowed populations to grow and settlements turned into villages which turned into towns. New types of problems emerged such as keeping an inventory of the crops, maintaining order on the streets, and protecting one's town from neighboring towns with well-organized warriors. As a result writing, government, and militaries were invented. Living in close quarters meant that the efforts of people could be organized and that the specialization of labor could develop. This manifested into art, science, technology and everything else that put humanity on the path to the prominence it enjoys today.

All of this began with a secure food and water supply. While the ice age was in full swing, temperatures, sea levels, and precipitation would change regularly and dramatically. This was not too much of a problem for small groups of people who would simply just move to a more favorable area. However remaining in one place too long was usually not an option. For example, as the shoreline of the Persian Gulf began to move farther and farther inland due to warming temperatures, the peoples along the shoreline were constantly forced to abandon any permanent settlements and move further inland. Once the climate stabilized 10,000 years ago, people were able to settle in one place for longer than a generation and as a result the first known permanent settlements emerged along with all of the possibilities that this entailed. Of course life would continue to be a challenge, but humanity was directly put on the road to civilization by a

stable climate. Had this fifth interglacial been postponed by 10,000 years due to the nature of the Earth's spin or Sun's alignment, the year 2014 would have been well within the Stone Age.

The assertion that the climate is responsible for human civilization has important implications for climate change and this thesis. If the climate can make a civilization then perhaps an unstable climate can undo the progress that stability created. Within the 10,000 years of human civilization, even the relatively stable climate has had many inconsistencies within it. Droughts, floods, famines, and storms have all had major effects on human societies. The fall of every major empire has been partly due climate either through a lacking in food availability due to drought or the migration of new groups due to food instability within their homelands. With some exceptions, no civilization ever fell during times of great bounty. Even with all of the technology that exists in the 21st Century, humanity is still heavily vulnerable to the weather, something that almost every news report can attest to. Therefore the drastic changes that are predicted by climate change models will greatly alter a human civilization that is overpopulated and overstretched in the use of resources.

There are several counter arguments to this theory of the importance of climate for civilization that first need to be addressed before the implications of this view are discussed. First, if climactic stability creates civilizations, then why had there never been advanced civilizations on planet Earth before? Certainly in the 500 million years since the Cambrian Explosion there have been many eras with stable climates. If humans managed to go from 'zero to sixty' almost instantaneously once the climate stabilized, then why have there not been advanced civilizations before? The answer is that humans had within them already the tools

needed to become a civilized species even before the interglacial period. These included an advanced larynx for speech, opposable thumbs for tool making, and a large brain among other features. Ironically, a lot of the features human beings have are adaptations developed to live in a changing landscape. So even before Homo sapiens, the human family tree was developing features that humanity would inherit.

One could also argue that even though the climate has had dramatic importance to human society in the past, the extent to which our fate is tied to weather is lessening as technology is increasing. For example people are already controlling the weather in certain areas, cloud seeding being an example. However while certain pockets of humanity are lessening their connection with weather events, society is now more susceptible to climate than perhaps at any time during the past few thousand years. The reason for this is simply that there are seven billion people on this planet and every storm, flood, drought, and sea level rise that happens on the planet will impact somebody, and perhaps a large number of people. Furthermore the structures humans build in the 21st century to shield them from the elements are not nearly as sufficient as they need to be to withstand the blunt forces of global warming. The massive hurricanes and cyclones that are forecast by climate change scientists will do unsalvageable damage to many areas and their economies. Humanity is about to fight a one-sided war with the weather and the outcome is already both known and unchangeable.

Finally one can argue while most of humanity will be adversely affected, not everyone will suffer the negative effects of climate change and therefore humanity as a collective will remain intact and unaffected. This is partly true. No matter how bad the effects of climate change

are, it is highly probable that some elements of humanity and society will be able to withstand the warming temperatures and rising sea levels by themselves. However these environmental events will not be isolated. Human society is so interconnected that these events will set into motion others within the political, economic, and social spheres that no part of human civilization will stay immune from.

There are many tangible examples of the weather influencing political events even within the time of 'climactic stability'. In 1783 a volcano in Iceland called Laki became active spewing 14 cubic kilometers of lava and huge amounts of sulfur dioxide into the atmosphere. The subsequent clouds of ash and chemicals were picked up by the jet stream and carried towards Europe and the rest of the world, causing considerable global cooling and a reduction in the amount of sunlight that reached the ground.¹ What resulted was crop failure and famine throughout much of northern Europe, including France. In some places the famine lasted for a time and many people lost their lives, but life and society went on. In France it was a different story. When the decrease in food supply combined with other factors such as high taxation, enlightenment ideas, and a perhaps too visibly affluent nobility, an uprising resulted. Other factors allowed this simple revolt to become a revolution and other factors unrelated to climate allowed this revolution to change all of human society. It is hard to pinpoint the exact chain of causality and whether or not the events of the French Revolution would have eventually occurred even if there wasn't a reduction of sunlight that hit the ground in 1783. But what can be said is

¹ Bressan, David. *June 8, 1783: How the 'Laki-eruptions' changed History*. Scientific American, 8 Jun. 2013. Web. 4 Apr. 2014.

that the Revolution happened when it did by events that were started by a natural phenomenon in Iceland.

Human society is as complex as the natural cycles behind climate and weather. Therefore it is often foolish to take the conclusions from specific events and apply them to other far removed instances. However even if these systems do not lend themselves to predictions, the underlying cause and effect relationships can be derived. If stresses such as food instability are applied over a long period of time and with ever increasing severities then the entire global order is subject to unprecedented change and collapse, even if a lot of this is self-inflicted by people themselves. Food and water instability will lead to wars and economic hardships, which will likely create more wars and once chaos finds a foothold it will take decades to reverse, especially if the underlying problems have not been addressed.

There are an innumerable about of other examples where natural climatic processes influenced human society. The dynasties of China would often fall as a result of great floods which people took to mean that their Emperor has lost his natural privilege to rule. The Bronze Age Collapse is often attributed to a change in climate, as is the fall of the Mayan civilization and well known cities in the Americas. The big difference is that these events were due to natural climate changes and weather patterns. A favorite argument of global warming skeptics is that climate change is a natural phenomenon that has always occurred. Therefore it is silly to try and influence the weather when this has and always will be out of humanities' control. Part of this argument is sound. However fundamentally it really does not matter what causes climate change. Whether a crop failure is the result of a volcano disrupting sunlight or a drought caused by

carbon dioxide emissions makes no difference to the farmer who lost his livelihood. The difference is that humanity can choose to avert one, while as of now be forced to live with the other.

There is another difference as well and one that is perhaps more selfish. Natural climate changes often happen slowly over hundreds of years which gives most species enough time to adapt. However, human induced climate change is happening much more rapidly and has the potential to create drastic changes in the lifetime of a single human being. While natural climate patterns might be a concern for generations far off into the future, the changes brought about by global warming are an immediate threat to those alive today and their future children. The reality that the climate is affecting humanity has been a fact since the dawn of our species. However for the first time, the relationship is now going both ways and humanity is affecting the climate.

Indian Sub-Continent: Ethnic Divisions Refueled

Throughout history two forces have led to the fall of countless nations; famine and human migrations. While the 21st Century is different and perhaps unique, the changes brought about by unmitigated global warming would have dramatic implications on international politics. With all the literature that exists on global warming there is surprisingly little attention given to this dimension of the issue.

While climate change is a global problem from which no country or individual is completely immune, some regions will be more dramatically affected than others. And in few

places will global warming hit harder than Bangladesh. Climate change is on a nonstop course to deal four blows to this already poverty stricken country. The first comes in the disruption of rainfall. Droughts will become longer and more severe causing heavy losses in a country where a large segment of the population relies on subsistence agriculture. On the other hand, the rain that does arrive will be more extreme. The monsoons which have for centuries brought floods and destroyed settlements in Bangladesh will become more intense and once-in-a-century storms would become yearly events.

Third, the water supply that comes from Himalayan glaciers will be cut off as the ice would melt adding dramatic instabilities in the water available for both agriculture and drinking supply². The negative impacts of this will stretch far beyond Bangladesh. The list of rivers that originate from Himalayan glaciers is impressive. Included are the Indus, the Ganges, the Yangtze, and the Mekong which together are literally the lifeline for two billion people. However the fourth consequence, sea level rise, would be the most damaging to Bangladesh. Vast areas of Bangladesh are set to become flooded by sea water even using conservative climate change models. The vast majority of the country's 150 million people live on the coastline or near the Ganges delta, both being low lying areas.

Perhaps Bangladesh could adapt to these changes if only in limited ways. The cyclone warning system, which has been in place for over four decades, is being improved. According to Oxfam over 100,000 people were saved by the government's warning system and evacuation

² Fletcher, Mark. "The Himalayas." Nature. PBS. KETCW, Saint Louis, MO, n.d. Television.

plans when an unusually heavy storm hit in 2007³ However a poverty stricken nation like Bangladesh would not be able to cope with the realities of climate change if trends continue.

Millions of people would be forced to move. When forced migration does occur be it because of conflict, economics, or environmental issues cities are usually the end destinations. Millions of Bangladeshis from the coast and the Ganges delta would likely move into the nearest urban centers. Inland Kolkata, currently the world's 12th most populous city, in neighboring India would be a prime candidate city. Other cities in India which would be appealing targets include Dumka, Bhubaneswar, Patna and for those who could afford the journey, the larger centers like Deli and Hyderabad.

The state of Assam would also see an influx of Bangladeshi migrants. Even since the partition Assam has had a big problem with illegal immigration from Bangladesh and it is here that religious and ethnic rivalries are among their highest. Assam would be an even more attractive corridor for climate change refugees since there is an already established Bangladeshi community there. Also Assam is inland and yet supplied with water through the Ganges. Emigrating east into Myanmar would be an alternative path. The central cities such as Mandalay would probably be attractive targets.

However there are vast problems involved with emigrating to other countries. First, the vast majority of the Bangladesh population is Muslim which contrasts greatly with Hindu India and Buddhist Myanmar. In Assam in particular there is a history and precedence of ethnic unrest.

³ Yee, Amy. "In Bangladesh, More Shelter From the Storms." *New York Times*, 24 June 2013. Web. 05 Feb. 2014.

In 1983 fourteen villages in Assam were attacked and as many as 5,000 Bangladeshi Muslims were killed in the Nellie massacre. Furthermore the violence in Assam does not have a history of staying contained within troubled areas. First, with identification papers being hard to come by, it is hard to tell who is an illegal immigrant and who is a native inhabitant. Second, Muslims throughout India and the Sub Continent see the people in Assam not as illegal immigrants from Bangladesh but as fellow Muslims who are being oppressed by Hindus. Even relatively small events can lead to protests in Mumbai and elsewhere. ⁴

Then it is unclear how the Indian government would respond to climate refugees. And even if immigrants could safely settle in India, finding work and making a living would be a monumental task especially because India herself would be uprooted by climate change in major ways. It is therefore not likely that those at or near the poverty line in the Bangladeshi coastal cities would end up in India or Myanmar due to climate change. Rather they would make for the world's sixth largest city; Dhaka in the heart of Bangladesh. With as many as 24 million people in its urban area Dhaka is a mega-city. Already those displaced by localized flooding are moving into the city and the slums are rapidly growing. The city could become the world's largest if the southern plains of Bangladesh are flooded by sea water.

As a result people already in Dhaka and those of middle and upper class status would find it appealing to emigrate and therefore emigration from Bangladesh could in part be fueled not by those individuals living in Chittagong, Chandpur or Latachapli whose homes would flood, but

⁴ Hasan, Anjum. "Why the violence in Assam is not communal." BBC World News, 2 September 2012. Web. 05 Feb. 2014.

those who would be looking for greater economic and political stability. Likewise people living in Kolkata or the state of Assam would perhaps have new incentives to move from their homes to America or Europe due to instabilities. It would be a messy domino effect in a way without clear patterns.

India herself is just as prone to climate change as her eastern neighbor. India is a country where many live in poverty and, like Bangladesh, subsistence agriculture is the livelihood for millions of people. The yearly monsoons are therefore vital to India's economy as a large part of the nation literally depends on them for basic resources. The monsoon has been nicknamed India's Real Finance Minister.⁵ Climate change will have drastic effects to their cycle. Some seasons will be abnormally active creating widespread flooding and damage. Others will be lifeless causing crippling droughts that could send a country of over a billion people into a humanitarian disaster.

The cyclones that follow monsoon season would also become more extreme. In 1999 the Odisha Cyclone was the strongest storm in recorded history to make landfall in India. A close second was cyclone Phailin in 2013. In addition the Indian coastline will be just as heavily affected by sea level rise as Bangladesh, especially the larger cities. Among the most troubling is Mumbai, a mega-polis with 14 million that is surrounded by water from three sides. India's lack of infrastructure and a relatively weak centralized government will combine to create a worst case scenario with climate change.

⁵ Colvin, Ross, and Jatindra Dash. "Indian Scientists Try to Crack Monsoon Source Code." *Reuters*. Thomson Reuters, 20 July 2012. Web. 09 Feb. 2014.

It is important to mention that India is the world's largest democracy. As a country she has never invaded another nation beyond her borders. And yet the staggering ethnic, religious and linguistic diversity within India and the subcontinent create the potential for major political unrest. As many as three million civilians were killed in the Bangladesh war of liberation.⁶ In 1984 the Indian Government sanctioned an operation that led to the murder of as many as 20,000 Sikh civilians and the destruction of sacred Sikh sites.⁷ Even in the year 2014 many internal military conflicts are ongoing including a military uprising in Asom, a Maoist insurgency in the east, and the dispute over Kashmir not.

The seeds of unrest, however small, are within India. Famine, displacement, heat waves, and droughts might prove sufficient to bring them to fruition. This will be greatly magnified by thousands if not millions of immigrants crossing the border from Bangladesh. The good news is that India is relatively stable. But that cannot be said of her western neighbor.

Climate change does not rank among Pakistan's most pressing problems. As of 2014 the war with the Taliban and other antigovernment forces has displaced over three million people and resulted in over 11,000 deaths. To the south the Baluchistan Insurgency has never subsided and calls for independence are as powerful as ever. In a very real sense, Pakistan might break up into three or even four independent states during the 21st Century. Peace and stability (both economic and political) will be required to prevent this from happening. However climate

⁶ Anam, Tahmima. "Pakistan's State of Denial." *New York Times*, December 26, 2013. Web. 09 Feb. 2014.

⁷ Kaur, Gunisha. "Remembering the Massacre of Sikhs in June of 1984." *The Huffington Post*. *TheHuffingtonPost.com*, 03 June 2013. Web. 09 Feb. 2014.

change models will make this into an even greater challenge than it already appears to be.

Karachi, the most populous city, is threatened by sea level rise while the agricultural sector will be hampered both by drought, heat, and the loss of Himalayan glaciers as water sources.

Finally Sri Lanka, a country which dramatically ended a three decade long civil war in 2009, will be battered by the same forces of sea level rise and agricultural instability. Colombo is just three feet above sea level and one of the most susceptible large cities on the subcontinent to sea level rise. By centuries end, the IPCC's range for sea level rise is up to 3 feet from thermal expansion alone, meaning that Colombo would be lost to the Indian Ocean unless the Sri Lankan government created dykes and barriers, something unlikely for a relatively poor nation. Finally there is one nation near the Indian sub-continent that could literally disappear off the map; Maldives.

Oceania and Islands: The Threats from the Ocean

The Republic of the Maldives is the lowest country on Earth having an average elevation of only 4 feet. Inundation due to climate change has placed great fear into its entire population. There is a sense of a ticking clock, a time bomb that will within a century destroy the republic.⁸ They share this concern with the island nations of the South Pacific, the Caribbean, and other far flung islands of the world which humans call home.

⁸ Fogarty, David. "Q+A-How Will the Maldives Fight Climate Change?" *Reuters*. Reuters, 18 Feb. 2010. Web. 09 Feb. 2014.

Even Australia and New Zealand face droughts, and increasingly severe bush fires. Malaria is threatening to spread to Australia with the Great Barrier Reef, one of the world's most remarkable natural features and Australia's major tourist draw, faces destruction due to the rising acidity of oceans. Sea level rises also pose a risk and to the smaller surrounding islands such as New Caledonia in particular.

However rising sea levels are just one of many often unique problems island countries face with climate change. Some island nations, like Jamaica, rise as much as 2,000 meters above the ocean and so even though coastal cities might be lost it would not mean total inundation as it would with low lying atolls. However being surrounded by an ocean gives rise to unique problems when it comes to climate change.

One of the most devastating effects of climate change has to do with what will happen to the oceans themselves. As the ocean absorbs CO², acidity levels are making it more difficult for mollusks to build calcium based shells. As a result the food web is being drastically altered since the fish that humans consume eat the fish that eat the mollusks. Also alarming is the loss of coral reefs due to bleaching which is destroying the nurseries many fish species depend upon. As a result not only are island nations losing the beauty of their coral reefs and the tourists that come to see them, but also their fish stocks, which are often the major source of food. According to the IPCC, most corals would die if the global mean temperature rose by 4 degrees at the end of the century.⁹ This would almost qualify as the fifth mass extinction event since the Cambrian

⁹ Kirby, Alex. *Climate in Peril: A Popular Guide to the Latest IPCC Reports*. Arendal, Norway: UNEP/GRID-Arendal, 2009. Print. p. 29

Explosion as whole genera and families of species that depend on coral reefs would die off as well.

Additionally as temperatures increase species confined to certain climactic zones are being able to spread beyond their natural ranges. For example the IPCC predicts that malaria threatens to spread to areas like Texas and the Ukraine by 2050.¹⁰ For cut off island countries such outbreaks of new pathogens could be even more problematic and are already occurring in small numbers. For example the first case of Chikungunya, an African tropical disease spread by mosquitoes) has been recorded in Dominica in early 2014.¹¹ By the time of this publication in May of 2014, Chikungunya has managed to spread to many other islands and over 31,000 people are suspected of having become infected.¹²

Then there is the threat of stronger cyclones to which island nations are the most susceptible and especially those in the Caribbean and Western Pacific since they lie in the paths of Atlantic Hurricanes and Pacific Typhoons respectfully. However the main immediate threat from climate change to island countries is, ironically, water supply. Fresh drinking water, especially in small Pacific countries like Tonga and Vanuatu, is a hard to come by commodity with communities often relying on one underground source. As sea levels rise and storms

¹⁰ Kirby, Alex. "*Climate in Peril: A Popular Guide to the Latest IPCC Reports*". Arendal, Norway: UNEP/GRID-Arendal, 2009. Print. p. 36 + 38

¹¹ "Government Information Service." *Health Officials Confirm One Case of Chikungunya Disease on Dominica*. Dominica Republic Information Service. 17 Jan. 2014. Web. 10 Feb. 2014.

¹² McFadden, David. "Recently Arrived Chikungunya Virus Gains Foothold In Caribbean" The Huffington Post. 2 May 2014. Web. 6 May 2014.

become more severe, salt will enter these underwater aquifers and contaminate the drinking supply. Alternatives such as desalination or importing water would not always be practical due to remoteness and the economic scarcities of certain island settlements. Therefore the only option available would be relocation to larger island centers. This would effectively destroy an entire way of life and bring an end to human cultures that have existed thousands of years. This in turn would be a great loss for humanity as a collective since the existence and diversity of our species would be diminished and the answer to the question of what it means to be human will not be as vivid as it is today.

However, these people who stand to lose everything due to the direct effects of climate change will not stand idly by while the world continues a business as usual approach to global warming. The small island countries have always been an enigma in international affairs. Tuvalu's vote in the UN, with a population of 9,860 people, is just as powerful as the vote of India or Brazil. The sovereignty of such small places provides many loopholes in international relations. Billionaires the world over use Cayman Island Banks, the Bahamas and Marshall Islands have 12% of the world's shipping fleet thanks to flags of convenience, and South Ossetia is now an 'internationally recognized' country thanks to Nauru opening relations with them (after a 'deal' with the Russians). The presence of sovereignty gives these countries unique tools to pursue their agenda that is unavailable to other nongovernmental groups fighting climate change.

Moreover, many of these counties have populations under 150,000 and relatively strong centralized governments making unanimity easy to come by. It is therefore not surprising that

one of the strongest delegations when it comes to rallying the general assembly or the IPCC into taking action on climate change is this group of twenty or so oceanic countries. Their sovereignty ensures them a spot at the table for every important negotiation and treaty conference, and since their fate is tied to climate change in a very direct way it is probable that these island countries will have a large role to play in ultimately passing solutions for climate change in the international arena.

Africa: A Disconnect in Supply and Demand

As with all change, there are always winners and losers and a warmer planet will have its winners for sure. Certain plants will thrive in a CO² rich atmosphere and a warmer climate, provided water availability is not disrupted. Jellyfish will bloom in the acidic oceans to astonishing numbers. In certain areas of North America, Northern Asia and Europe farmers can expect an increase in rainfall and therefore more productive crop cycles. And almost everywhere in the world, deserts will thrive. This is perhaps most apparent with the Sahara which is expanding further and further south. However when it comes to climate change Africa as a whole stands the most to lose.

Throughout human history agrarian society was always dependent on a steady and predictable climate. When the climate is altered then catastrophe can ensure. There are few better examples of this in the 20th Century than Africa. In 1992 a drought combined with political instability in Somalia led to the deaths of 300,000. The same pattern was repeated in Sudan in 1998 where 70,000 people died. Perhaps most well-known was the Ethiopian famine in the early 1970s.

In all of these cases there was a disturbance in water supply which in itself is not a catastrophe. Droughts can be mitigated by good infrastructure and adequate governance. However most of Africa is lacking in both. Furthermore, as was the case with all three of the instances above, famine can create even more political instability and ethnic unrest which further disrupt food and water supplies becoming a positive feedback loop.

Some areas of the continent will be more negatively affected than others. Perhaps surprisingly, Egypt is set to become really hard hit by global warming. The main reason behind this is the area's millennia old reliance on the Nile River. The overwhelming majority of Egypt's population is centered on the Nile River. Satellite photos of North Africa show an almost uniform yellow desert landscape only broken by a thin line of extremely green vegetation flanking the Nile River to the Mediterranean Sea. As precipitation levels decrease throughout the region while the demand for water rises, countries below Egypt will use up more of the Nile's water and leaving less for Egypt's 86 million plus people. Furthermore the opposite problem might result due to the river overflowing its banks due to sea level rise and more severe storm events.

A rise in atmospheric temperatures in what is the hottest place on planet Earth would also push some agriculture beyond the breaking point. The few population centers in Egypt that are not on the Nile are centered on the Mediterranean and Red Sea coasts and are even more susceptible to climate change. Not only do they face threats from sea level rise, but also the loss of their major resource, fisheries. Acidic ocean levels and coral bleaching will lead to ecosystem collapse in the Red Sea. This area is home to some of the most pristine coral reefs in the world

and their loss would mean the end of tourism to this part of Egypt before it even had a chance to get going. These same patterns of sea level rise and water scarcity will play themselves out throughout the North Africa and the Middle East.

However, apart from the small oceanic islands, the area of the world which will be most negatively affected by climate change is Sub Saharan Africa. The major reason for this will be a dramatic imbalance between the supply of and the demand for basic resources like food and water. The decrease in supply will result from climate change. The increase in demand will come from the unparalleled population growth Africa is set to experience this century. Of course population growth is not a fundamentally negative phenomenon. In the right circumstances, Africa will be able to use her growing human population to great effect.

For example the population of America in 1800 was a little over 5.3 million people.¹³ Within a hundred years this number grew to over 76 million and set the stage for America's prominence in the 20th Century.¹⁴ However the Far East forms a better parallel with the African example. During the 20th Century East Asia was experiencing similar circumstances that plague Africa today. Post-colonial civil wars claimed the lives of millions of people in China, Cambodia, Vietnam, Korea and elsewhere. Improper governance was rampant and combined with environmental factors to produce some of the worst famines in human history. From 1959

¹³ Bureau of the Census. "History." *1800 Fast Facts*. Census.gov. Web. 10 Feb. 2014.

¹⁴ Bureau of the Census. "History." *1900 Fast Facts*. Census.gov. Web. 10 Feb. 2014.

to 1961 45 million people starved to death in the Great Famine under Mao.¹⁵ The lesser known Vietnamese famine of 1945 killed as many as 2 million people.¹⁶

The explosive economies and the military might that China and the Four Asian Tigers enjoy today were unfathomable to many in 1950. Even Japan, the relative powerhouse, was until the 1970s more synonymous with cheap knockoffs than quality products. And yet by the late 1990s two of the world's three largest economies were Asian. China is set to surpass America as the world's largest economy as early as late 2014, which would mean that America would relinquish a title she held since the late 19th Century when America surpassed the British Empire in terms of economic output. The point is that East Asia was able to leverage population growth to her advantage and use it help develop her economies. However, there is no correlation between population growth and development. South Asia is a good example of this. Rather a large population is just a potential resource that can aid a country in becoming prominent while it also has the potential to create problems for that society. In terms of coping with climate change, Africa's population growth will determine much. And within one hundred years countries like Nigeria and Tanzania are set to become the China and India of tomorrow.

The models are staggering. By the year 2050 Africa's population is expected to more than double what it is today in 2014.¹⁷ By 2090 it is expected to double yet again from where it

¹⁵ Branigan, Tania. "China's Great Famine: The True Story." *The Guardian*. Guardian News and Media, 02 Jan. 2013. Web. 09 Feb. 2014.

¹⁶ Marr, David G. *Vietnam 1945: The Quest for Power*. Berkeley, CA: University of California, 1995. Print.

will be in 2050. The population of Asia which is today 4.5 as large as that of Africa, will be by the year 2100 only about twice as numerous.¹⁸ By contrast, Africa is set to grow and grow. What America underwent in the 1800s and Asia in the 1900s in terms of population growth, Africa is expected to undergo in the next 100 years. By the year 2100, the population of Africa will break the 4 billion mark. Nigeria in particular is on the eve of undergoing one of the most dramatic population explosions in human history. Within three generations Nigeria is expected to grow by a factor of eight. This will place Nigeria at 914 million and make her the third most populous nation in the world, and just 100 million shy of overtaking a shrinking China.¹⁸

Tanzania, a country of just 44 million, is set to become the fourth most populous nation by breaking 300 million by 2100 and be a stone's throw from displacing America's third place position. The Democratic Republic of the Congo and Ethiopia will also grow exponentially as will smaller nations like Liberia, Zimbabwe and Burundi who currently have the world's largest population growth rates.

As mentioned previously, population alone does not guarantee success. For instance Japan with only ten percent of India's population has a GDP roughly three times larger than India's.¹⁹ The other factors that are required include a solid infrastructure and a culture of

¹⁷ Fisher, Max. "The amazing, surprising, Africa-driven demographic future of the Earth, in 9 charts." *The Washington Post*, July 16, 2013. Web. 09 Feb. 2014.

¹⁸ Department of Economic and Social Affairs. "World Population to 2300". United Nations. 2004. Web. 09 Feb. 2014.

¹⁹ Central Intelligence Agency. "Field Listing: GDP (official Exchange Rate)." *cia.gov*. Web. 10 Feb. 2014

academics and entrepreneurship. Both of these require political stability. And for political stability to be possible there has to be a sustainable source of the basic resources like food and water.

It is here that climate change threatens to turn Africa's population growth into a serious problem for the continent. The Sahara desert is expanding southward into the Sahel. Water tables are being depleted by a growing agricultural sector. Heat waves are becoming more common and more severe. And most critically, precipitation is decreasing. When this is combined with an explosion in population on which Africa is on the verge of experiencing, catastrophic conditions will arise.

The ethnic unrests that have plagued the continent ever since colonization will erupt as water and food shortages force massive migrations. The wars in Sudan, DR Congo, and the Central African Republic foreshadow how these new wars would play out. Furthermore, with increasing populations the situation would become even more volatile. Millions upon millions of young people would be without work and perhaps without food driving them into both national armies and renegade militias.

All of this will be going on while the population continues to rise. It is well documented that childbirth rates are higher where life expectancy is lower since parents rely on their kids to help create an income.²⁰ So, in an unfortunate twist, the demand for basic resources will dramatically increase while the supply will decrease and even collapse in certain places like the

²⁰ Gore, Albert. *Our Choice: A Plan to Solve the Climate Crisis*. Emmaus, PA: Rodale, 2009. Print. p. 229

eastern and central Sahel. In this scenario, in the next two hundred years, Africa will become a catastrophe with widespread civil war, malnutrition, economic depression and ecosystem collapse. Global biodiversity will decrease exponentially as the tropical forests and savannas of Africa, which are home to millions of endemic species, will be overrun by a population looking for the basic necessities needed to survive.

These two versions of Africa's future hinge on climate change. Without a stable climate to provide food and water resources all of Africa's aspirations will be delayed while the problems that have plagued the continent throughout history will multiply. It is therefore that Africa has the most to lose from climate change, especially in the long term.

Europe: Adapting to Climate Refugees

When it comes to the problems currently facing Europe in the early 21st Century, climate change does not rank high on the list of immediate concerns. Perhaps this is ironic as most of the carbon emissions that have historically taken place were a result of either the industrialization of European countries or the use of European machinery and inventions. Rather it is the economic woes collectively referred to as the Great Recession and the Eurozone Crisis that are a real threat to the very fabric of the European Union and to Europe's position in the world. Something that is not often talked about is the relatively short time it took for Europe to lose her place on top of the global hegemony. With possibly three exceptions, every inhabitable part of planet Earth has been under European control at one point or another in its history and in some cases this was the entire

time period from 1600 to 1900. However after two suicidal world wars, the prestige and power most European countries held for centuries were eroded, with perhaps the Russia being an exception.

Rather the global balance of power is shifting east where it has historically belonged. China, Japan, and the 'Four Tigers' are the first wave of Asian countries that have already overtaken Europe in terms of economic and military power. Behind them are the Southeast Asian countries and then the Indian Subcontinent. However when climate change is taken into the equation then the predictions change.

Europe will also experience the adverse effects of climate change but in ways much different from the developing world. Relative to places like India and South China, European food security would not be threatened. The single market insures that even if Greece experiences a prolonged drought, agriculture from France and Poland could supplement the difference. Relative economic wealth, world class infrastructure, and the relatively stable political systems of Europe would always insure that food and water could be obtained, even if measures such as desalination would need to be implemented.

However, other than in the absolute worst case sensations of climate change, measures such as these are highly unlikely to be necessary. In fact the IPCC expects rainfall amounts to greatly increase in many parts of Europe due to climate change, since there will be more water vapor in the atmosphere.²¹ This combined with milder winters will lead to an increase of food

²¹ Kirby, Alex. *Climate in Peril: A Popular Guide to the Latest IPCC Reports*. Arendal, Norway: UNEP/GRID-Arendal, 2009. Print. p. 36

production in Europe as a whole; a positive impact of climate change which ironically benefits those who are most responsible for it.

However it is not all good news. The Netherlands and the UK will have to spend billions of dollars to protect their cities against rising sea levels. One of the seven wonders of the modern world are the Delta Works projects of the Netherlands created to protect and even reclaim the coastline. The Dutch have increased the size of their country and made brand new municipalities by literally pushing back the Atlantic Ocean to create new towns, farms, and communities on what was the ocean floor a few decades ago. This is something that could not easily happen in a country like India or the Philippines. Now new preparations are being made in the Netherlands to increase the efforts to be ready for climate change. Venice, Istanbul and Hamburg are also threatened even by a modest rise.

Europe will also not be immune from the other effects of climate change. Permafrost will disappear from much of Scandinavia and northern Russia. For the Sami people and other native Ulrich and Turkic groups this will spell the end for a traditional way of life that they have lived for thousands of years. The loss of permafrost will collapse the foundations of houses for groups that live in communities, while it will also threaten nomadic groups who depend on reindeer populations. In Greenland, climate change has already arrived and is in full swing. The Inuit who make up a majority of Greenland's population depend upon sea ice for their income and well-being. No ice means they cannot go out to hunt for seals. Furthermore tourist hunters who bring a lot of income to the small communities of Greenland are not arriving since hunting visas for animals like polar bears will not be sustainable.

On mainland Europe the glaciers and snow slopes of the Alps will disappear and with them the cultural identity of an entire region.²² Millions of dollars are being spent to try and preserve the world famous sky resorts but as the temperature rises warmer winters will mean that places like alpine Switzerland and Slovenia will become forever changed. Other threats include malaria spreading north from Africa and increasing forest fires from Spain to Bosnia and Herzegovina. But again, Europe has vast resources available to mitigate the effects of climate change. For example in Switzerland entire mountains and glaciers are covered during the summer to keep the snow and ice on them from melting.²³ Therefore the most drastic impacts of climate change on Europe will be indirect. However these indirect changes have the potential to be just as destabilizing as any flood or drought and they could hit Europe in a very real and uncompromising way.

The major indirect consequence of climate change involves an increase in immigration. The number of climate refugees will likely grow exponentially as the century continues and the focus of this exodus will be from the Indian Subcontinent and Sub-Saharan Africa, as well as other places like oceanic islands. As mentioned earlier, those leaving for European shores will not necessarily be those whose homes have been flooded or whose fields have been destroyed by drought, although many of these people will surely find their way to Europe as well. Rather the

²² Haeberli, Wilfried and Beniston, Martin. "Climate Change and Its Impacts on Glaciers and Permafrost in the Alps." *Ambio*. Vol. 27, No. 4. Print.

²³ Tagliabue, John. "GLETSCHE JOURNAL; Frozen in Memories, but Melting Before Their Eyes." *The New York Times*. The New York Times, 24 Oct. 2006. Web. 10 Feb. 2014.

floods and droughts and heat waves will create economic and political instabilities that will destabilize these entire regions and render them void of opportunities to easily have a productive life. As a result people will find it worthwhile to undertake great risks to move to a more promising area, and one where the political structure as well as the climate is more stable.

Of course immigration to Europe is not a new phenomenon. For those who are unfamiliar, the numbers are staggering. In 2012 there were 66,930 documented illegal border crossings into Europe, many of which were through Africa and the Middle East.²⁴ In 2010, 21.5% of Switzerland's citizens who hold Swiss passports were born outside of the country.²⁵ For tiny Luxembourg that number is 43.5 %. Moreover the motivations to get to Europe are so intense that thousands upon thousands of people willingly risk their lives just for a chance at getting to European shores. Since 1988, at least 19,142 people are documented to have died on the journey, with the real number expected to be much higher.²⁶ Furthermore the rates of immigration and the deaths that result from the voyages are increasing, with the recent tragedies off Lampedusa being an example. However, this is just the early stage of a catastrophe that is slowly unfolding. All of the recent emigration numbers and data are from what is still an age of climactic stability. Currently it is as if all of the variables and factors are slowly falling into place over time to form a problem that has the potential to forever change European society.

²⁴ "Illegal immigration into Europe in numbers". BBC. 4 Oct. 2013. Web. 6 May 2014.

²⁵ Rogers, Simon. "Immigration to Europe: how many foreign citizens live in each country?". The Guardian. 7 Sept. 2010. Web. 6 May 2014.

²⁶ "Illegal immigration into Europe in numbers". BBC. 4 Oct. 2013. Web. 6 May 2014.

The first of these is the doubling of Africa's population in the next four decades and the greater demand for natural resources that goes along with this. Second is widespread decrease of food and water availability due to changes in the climate that will happen even with a very conservative 2° Celsius rise in global mean air temperature by the century's end. Third are the economic repercussions that will arise from a lack of vital resources in Africa. Finally fourth is the political instability that will result from economic hardship, competition between resources and desperation.

These will combine in the following ways. Millions of young Africans will move to the cities as farms and pastures throughout the Sahel and Central Africa will be rendered unusable due to desertification. Cities such as Lagos, Khartoum, Abidjan, and Kinshasa will be filled with millions of young people unable to find work and support themselves economically. Simultaneously the ethnic unrests Africa is infamous for will spread as governments will lose credibility due to the hardships while militias will grow helped by a large pool of unemployed youth. This has been happening in Africa for decades, but as climate change worsens and populations grow it will increase exponentially. Millions of Africans, literally, will choose to pursue their right to a better life and there will be massive movement to the closest areas of stability.

One will be the cone of Africa, which is southerly enough to where the Hadley air cells will carry the increased water vapor from the tropics and drop rain onto this temperate zone of the African continent. Another will be the Middle East and specifically the Arabian Peninsula especially for those living in Somalia, Eritrea, and other countries in the horn of Africa. This is

because the Middle East is relatively cushioned from climate change since the society there evolved within a desert region and there is sufficient infrastructure to accommodate large numbers of migrants. The United Arab Emirates are a prime example of this as 70% of the country is made up of migrant workers. There will also be movement to the Americas and even China perhaps. However Europe will likely be higher on the list than any other location.

European plans regarding climate change don't deal with the inevitable increase in immigration from Africa and elsewhere as a result of global warming. In the minds of most European lawmakers, the issues are separate and the idea that one greatly influences the other does not even figure into their calculus. However the demographic changes brought about by climate change will have dramatic implications for Europe and the very fabric European society. At stake are literally the lives of millions of people and the forecasts, both political and climate related, are not good. However one would struggle greatly to find an article regarding global warming and the resulting demographic changes to Europe that would result. When these events do occur people will not connect the dots. The inevitable tragedy will be taken by many as something that was unforeseen and unpreventable just like the boats sinking off of Lampedusa are today. However a sound European Union climate change management policy that takes into account immigration and one that is taken seriously is badly needed. Such a thing does not yet exist and because of this the lives of millions of people, some of them not yet born, are put at risk. Furthermore the very future of Europe at least for the next few centuries will be determined in large part by this one issue.

The pathways from Africa to Europe already exist and as the century unravels a few key pieces of infrastructure across Africa will likely fall into place allowing for even greater mobility across the continent. Chief among these is the Trans-African Highway Network being constructed by the UN and the African Union in partnership with the African Development Bank. Crossing the Sahara will become quicker, cheaper, and safer which will increase the traffic to the Mediterranean Coast. More importantly many African communities are already well established within Europe and knowing that they will have somebody of their nationality, if not even their family, there plays a huge part for any immigrant. Also many Africans already know a European language and therefore someone emigrating from Gabon would likely find France a more preferable option compared to Arab speaking Qatar or English speaking South Africa. It is for these reasons that immigration to Europe will increase exponentially.

But there are many different ways for this to play out in practice. The first model, an unrealistic one, would be one where Europe opens her borders and allows everyone to enter at will in order to peruse a better life. Furthermore there is evidence that such a model would work and would produce beneficial results for Europe. Consider America in the late 19th and early 20th Centuries. There were more Irish and German people in New York than in Dublin and Hamburg respectfully. At the start ethnic and religious tensions were high, and most immigrants lived in what amounted to slums. Life was not easy for them and many hardships were endured. However it would be inconceivable to imagine American hegemony today without the many waves of immigrants that made their way to America's shores. People, regardless of economic status, add to a country's economic, political, and social potential. Of course people alone aren't enough. What is also needed are sound educational institutions, solid infrastructure, and a stable

political climate. Europe has all three and so would be able to eventually integrate immigrant communities no matter how large the size.

Europe could use the many millions of immigrants from Africa and other places around the world to regain the place she once held on the global political stage. Walking through London today in the year 2014, one would see just as many immigrants as native English inhabitants, and London is still one of the world's greatest economic and cultural cities. If Europe adopted this open arms immigration policy then cities like Stuttgart, Riga, and Liverpool would become 'Londons' in their own right. Europe could become a continent dotted with Tokyo sized megacities and grow considerably in economic might, especially since she is experiencing an aging native population herself.

Of course there is no shortage of arguments against this type of policy. One is that Europe would lose her cultural identity. This is true in a way. The cultural identity of today's London is not the same as it was 1497, before Great Britain started to turn out towards the world. Similarly the cultural identity of a Puritan America has long ago vanished in no small part due to the waves of immigrants that came to America's shores. However neither of these changes was necessarily bad. In some cases culture almost seems to undergo a type of Darwinian evolution. Most people want a productive life and a well-off society and this is a goal shared across religious, ethnic, and linguistic lines. Perhaps cultural values that best promote these are the ones that survive and become part of a society long-term. It is sort of like the Roman Empire taking the best traits from conquered Greece. However this only happens in times of prosperity, as other

forces such as war and economic hardship often outweigh and disrupt this positive cultural evolution process.

Another argument against an open door European immigration policy is sounder. When immigrants enter a region there are often initial strains to the society in terms of providing basic needs for its new inhabitants. This is especially true when the people coming are of a lower income and have to start their life over from scratch. The best contemporary example might be Lebanon and Jordan in terms of accepting Syrian refugees. However these are usually short term situations. No one wants to live in a life of poverty and if society provides a way to rise to prosperity people often take it. For example most of Jordan's population is composed of Palestinian refugees who arrived decades ago. Today Jordan is a more powerful country and has a stronger economy because of these once refugees who are now well integrated into Jordanian society. Going back to the American precedent, the slums of Brooklyn in the late 19th Century were in no better condition than many of the refugee camps today in terms of standards of living. However universal education, political stability, and other factors allowed immigrants to naturally rise in the community over time and play a big part in propelling Brooklyn forward economically.

However this approach to a European climate refugee emigration policy is unlikely. The first reason is that people and politicians will be unwilling to pay the short term costs of immigration which include fewer jobs, costlier social programs, and higher poverty rates. Second, xenophobia is prevalent throughout Europe and divisions among ethnic lines are real. The French ban on headscarves and the Swiss ban on minarets are two examples of this. Even

though an open door immigration policy makes sense in theory, in practice it likely would not as anti-immigrant feelings in Europe are sufficient enough to spoil the chances of a peaceful evolution of cultures. Rather it is more likely that politicians will find it not in their best interest to promote such an immigration policy while local xenophobic elements will clash with immigrant communities creating a culture of exclusion rather than integration.

To go to the other extreme, Europe might choose to close its borders down altogether and just allow a symbolic number of well to do immigrants in from Africa and Asia. The European Union could choose to take drastic steps to crack down on illegal immigration and deport many individuals already in Europe. To Europe the cost of this would come mainly in the form of lost opportunities to reap the long term benefits of large scale immigration. To millions of would be immigrants it would likely mean disaster. However the most likely scenario of events would probably be somewhere between the two extremes, and this would not necessarily go well for Europe.

In a way a climate refugee policy that takes in some while denying entry to others is not consistent with the integration model needed to fully realize the benefits of a new large population. And not being committed to this would give xenophobia room to expand, creating dangerous and potentially destabilizing rifts between the immigrant and native communities. As a result events such as the 2013 Stockholm riots will probably become more commonplace throughout Europe as climate refugees start showing up on the coasts in greater numbers.

As mentioned previously, those coming to Europe will not necessarily be those whose homes will be flooded in India or those who suffer droughts and desertification in Africa. Rather,

emigration to Europe will increase just because instability in these regions will rise and even well to do families will decide to move. Immigration has both positive and negative impacts. However if economic conditions in Europe undergo hardships while immigration rises then the possibilities for ethnic unrest will surely grow.

Climate Change in the Americas

The United States and Canada will undergo many similar stresses due to climate change as Europe. First both regions occupy roughly the same temperate latitudes which means that climactic changes will be somewhat synchronized between them. Additionally North America and Europe have high GDP levels, advanced economies, and relatively stable governments which make them less vulnerable to droughts, food shortages, and rising sea levels. For example, New York City is contemplating the creation of massive multibillion dollar sea walls to protect Manhattan from flooding, a project that would be unthinkable in Bangladesh or the Maldives. Other efforts by the city include reinstating native marshland habitats on shorelines along stretches of Brooklyn and Staten Island to help absorb storm surges and imposing greater safety standards on infrastructure built within the potential floodplains.

The cities most at risk from sea level rise across the US and Canada, which include New Orleans, Los Angeles, Vancouver and Miami as well New York will likely be preserved since the economic costs of combating climate change in these areas, however high they may be, will always be greater than losing large parts of these cities to the sea. However that cannot be said

for the many thousands of smaller coastal communities that stand to be inundated by rising sea levels within the next century or two. These include the many coastal settlements along the Mississippi Delta, fishing villages along Alaska's southern coast, settlements in New England and Canada's Atlantic Provinces, and southern Florida among other places. Furthermore more intensive hurricanes will batter the Atlantic and Gulf Coasts with ever increasing ferocity and cause many billions of dollars in economic losses.

However ironically a lack of water rather than an abundance of it might be what cause most of North America's climate change woes. The areas west of the Rocky Mountains will be the hardest hit. For example, California's Great Central Valley which stretches for nearly five hundred miles from Redding to Bakersfield in one of the world's most productive agricultural regions. A yearlong warm climate combined with fertile soils and an abundance of agricultural equipment has created a Mecca for food production whose existence is now threatened by climate change. In early 2014 California suffered one of the worst droughts ever recorded in the region. Decreased rainfall as well as shorter lived and diminished ice and snow packs in the Rocky Mountains due to milder winters are decreasing the supply of water to the valley. Furthermore this is happening at a time when the population of America's Southwest is rapidly growing and the demand for water is rising while supply is diminishing. Even without climate change, the 'water wars' of the American Southwest have been problematic for the region for the past few decades. A decrease, even a slight one, in the availability of water would be disastrous for the region's agricultural potential as well as her general economic growth. Climate change predictions almost guarantee that this slight increase will occur while leaving the door open for much more ominous scenarios. Efforts such as massive desalination could be a costly solution

for cities such as Los Angeles, but other communities away from the ocean might find it hard to survive climate change.

Las Vegas is the ultimate example of this. It is a city in a desert, literally in the middle of nowhere, that is indecently the proud home of some of the world's largest water fountains. The only reason Las Vegas can exist is because of Lake Meade, a reservoir created by the Hoover Dam. Lake Meade is exclusively comprised of the waters of the Colorado River which in turn is fed by ice and snow from the Rocky Mountains. If climate change alters the water levels of the Colorado River the very existence of Las Vegas, currently one of the country's fastest growing cities, is put at risk.

A lack of water creates many other environmental problems other than just the obvious effects of droughts. Wildfires, which have always been a threat to developed areas of the West, will increase dramatically in a world altered by climate change. Higher temperatures combined with drier landscapes create the perfect conditions for more frequent and more severe fires. This will not only cause damage to land and properties but also worsen the air quality far away from the site of the fires which will lead to adverse health effects for the population.

The ecology of the American West will also change, as water will be diverted from natural areas to help feed the reservoirs that provide cities and agricultural regions with water. A warmer climate would also result in the migration of species from the tropics into what is now the temperate region of the Americas. This does not only include animals such as neotropical birds and bats, but also insects including some that are harmful to humans. According to the IPCC, malaria carrying mosquitoes will populate large areas of the United States stretching from North

Carolina to Washington State.²⁷ Other tropical diseases such as Chikungunya which is already affecting Caribbean islands, are also threatening to move north. However, not all the effects of climate change will be negative for the US and Canada.

IPCC projections suggest that average amounts of precipitation will greatly increase for the eastern and northern areas of North America.²⁷ This is a result of increased water vapor in the atmosphere due to higher temperatures creating more evaporation. So while areas of the west might be threatened with chronic droughts, areas in the east and north might face problems such as flash floods and more intensive snowfall. However more precipitation combined with warmer temperatures and an increase in atmospheric carbon dioxide is a near perfect recipe for plant growth including crops. Areas of Canada that are currently covered by permafrost and that have carbon rich soils might become arable for parts of the year, a significant development due to the enormous size Canada's and Alaska's undeveloped lands. At the same time, a loss in permafrost would mean the release of large amounts of methane into the atmosphere, a nightmarish scenario for climate scientists which will be discussed later in this thesis.

However, as is the case with Europe, some of the most dramatic effects of climate change on Canada and the United States might come from indirect consequences rather than the climatic changes themselves. In a world that is more connected than ever, what happens on one side of the planet often has implications well beyond the immediate area. If the Indian Subcontinent descends into political and economic chaos brought about by resource scarcity due to climatic

²⁷ Kirby, Alex. *Climate in Peril: A Popular Guide to the Latest IPCC Reports*. Arendal, Norway UNEP/GRID-Arendal, 2009. Print. p.38.

instability, the whole world would feel the effects. And as climate change threatens areas as diverse as California, Sun Sahara Africa, and Indonesia the global, the economic and the political instability brought about by climate change will reverberate throughout the planet. While it is hard to predict certain examples due to the complexity of society, certain scenarios can be imagined.

On the political side, tensions between ethnicities in India might be reenergized by massive migrations, unemployment levels, and food scarcities brought about by climatic changes. As a result frozen conflicts in India's northern and eastern regions might be reenergized. With the underlying reasons for the instability (economic hardships, food scarcity and over population due to migrations among other things) not reversing but only worsening with time, conflicts would only grow and spread. Independence movements would erupt throughout the subcontinent in places such as Baluchistan and Nagaland. The nuclear stockpiles of both countries could become compromised and nuclear weapons could be used either by a resourceful insurgency or a desperate government. This would greatly alter the global political environment. One scenario would be that counter proliferation efforts increase due to the reminder of what nuclear weapons can do, and international calls for nuclear disarmament would be reenergized. A more probable scenario would be that countries become more threatened and seek to develop nuclear weapons themselves. Advances in lasers that could be used in uranium enrichment and other technologies that would be widely available by 2050 would make creating nuclear weapons much simpler and an increase in their need would lead to many neighboring states, and even perhaps nonstate actors, to develop nuclear weapons, be it Iran, Myanmar, Thailand or Indonesia. The old fear that nuclear states might lead to more nuclear states would

be realized as a nuclear Iran might lead to a nuclear Saudi Arabia and a nuclear Indonesia to a nuclear Malaysia. By 2050, the United States will share global hegemony with other countries and the decision set before global powers then would be frightening; whether to stand by or take drastic actions to prevent nuclear proliferation which themselves could be greatly destabilizing. In either scenario, such a chain of events would knock the entire political order off balance.

While it is hard to predict specific events, general trends are far easier. At the most basic level, societies are composed of people who need food, water, and shelter to survive. Climate change will decrease the availability of these for millions and societies will degrade. As climate change will outstrip the efforts of people to reverse and cope with the stresses, the situation will only get worse as time goes on. Furthermore instability will feed further instability and chaos will result. This trend will only reverse when the underlying cause of basic resource scarcity is addressed. And this in itself would take generations. As mentioned earlier, the effects of climate change or really any large event on society cannot be generalized. Some areas will flourish, and there will be pockets and periods of stability and even prosperity. But on the whole, human society and the natural systems of planet Earth will suffer greatly due to climate change whether it be in Africa, Canada, or Latin America.

The Americas south of the United States border will also feel the blunt forces of climate change though to a lesser direct extent than the Indian Subcontinent and Sub Saharan Africa. The same general patterns would again be repeated. Rainfall would decrease where it is needed most leading to rising food prices and economic hardships. Coastal cities such as Buenos Aires, Recife, Rio de Janeiro and Lima would be threatened with sea level rise along with hundreds of

smaller coastal communities along the La Plata and Amazon deltas and other low lying areas. And the oceans around South and Central America would undergo major changes due to coral reef die offs, increasing acidity levels, and warmer waters.

Latin America harbors the greatest biodiversity on the planet and the IPCC warns of massive extinctions of birds, butterflies, frogs and reptiles by 2050 in Mesoamerica and the Amazon. The Cerrado region of Brazil is expected to suffer a 24% loss of tree species from just a 2 degrees rise in atmospheric temperatures. In a real way, climate change threatens to turn the crown of the natural world that is Latin America into just another piece of land on planet Earth.

The impact on human societies will be strongest in Patagonia, northern Chile and Argentina, southern Mexico, and Southern Peru. Snow packs and glaciers in the Andes will diminish resulting in great water stress for Patagonia. Deserts on the east side of the Andes will expand into fertile areas. This is particularly true of the Monte desert in Northern Argentina and to a smaller extent the Atacama of Peru and Bolivia. Water will become a key point of contention in these areas, even more so than it is today. Governments will be blamed for not providing people with the key necessities of life and political instability might grow.

Climate Change in Asia and Polar Regions

As the realities of global warming continue to come to fruition, one weapon against climate change will be strong centralized governments. And democracy is not necessarily a requirement or even a benefit in this instance. For example the American policy on climate

change and energy has shifted with every administration. Carter put solar panels on the White House roof just to have them be taken down by Regan. The Clinton Administration did much to further the Kyoto Protocol even though a republican congress never ratified it. And in a twist of fate, under Obama the US became one of the first countries to reach their goal under the Kyoto protocol, even though the US did not officially ratify the treaty. ²⁸ This is largely due to the increase of natural gas use in America.

However a more authoritative government can take action to further the agenda of their county is a matter of hours. An excellent example of this is the People's Republic of China. While China is often regarded as the worst culprit when it comes to greenhouse gas emissions, the government has taken dramatic steps in the right direction. Having thousands of people die in Beijing due to air pollution every year and having to deal with the spreading of the Gobi desert has caused the government to set a surprisingly green agenda that is being carried out without distractions.

Every able bodied Chinese citizen is required by law to plant new trees, which has led to China adding over a billion new trees. During the past decade, China has planted two and a half times more trees every year than the rest of the world combined. ²⁹ To reduce carbon pollution in cities, China regulates which cars can drive on the road and at what times which in effect cuts

²⁸ LeBlanc, Allan. "Is the US About to Accidentally Meet Kyoto Protocol Targets?" *Berkeley Energy & Resource Collaborative.*, 4 Sept. 2012. Web. 10 Feb. 2014.

²⁹ Gore, Albert. *Our Choice: A Plan to Solve the Climate Crisis*. Emmaus, PA: Rodale, 2009. Print. p. 194

traffic in half.³⁰ China is also leading the world in sustainable energy development. Few other countries could have undergone and successfully completed a project as vast and controversial as the three gorges dam which nearly produces a staggering 100 terra watt hours of emission free renewable energy every year. China has also invested fully in solar and wind technology and now leads the world in the production of solar panels and wind turbines.³¹

However these steps won't be enough to spare China from the negative effects of climate change. While not as severe as the impacts the Indian Sub Continent and Africa are set to suffer, China and the rest of the Far East will still face problems. Malaria is expected to spread to the south coasts of China from Vietnam and Laos. The Tibetan Plateau will lose most of her permafrost which will change the region greatly. For instance railroads will be damaged as the hard permafrost ground they sit on give way to softer land. Tibet's fundamental cultural and natural identity will also undergo a major shift and the 'roof of the world' will not be the same in a world of climate change.³² Shanghai and Tianjin will be threatened by sea level rise as will

³⁰ "Beijing to Restrict Private Car Use to Tackle Pollution." *BBC News*. BBC, 17 Oct. 2013. Web. 12 Feb. 2014

³¹ Bradsher, Keith. "China Leading Global Race to Make Clean Energy." *New York Times*, 30 January 2010. Web. 05 Feb. 2014.

³² Lustgarten, Abraham. "Will Global Warming Melt the Permafrost Supporting the China-Tibet Railway?" *Scientific American Global RSS*. Scientific American, 21 July 2009. Web. 12 Feb. 2014.

neighboring Seoul, Osaka and Tokyo. For Japan in particular typhoons will become more severe and droughts more common.³³

Stronger storms will be even more problematic in Southeast Asia due to the overcrowded islands and poor infrastructure. In late 2013 Typhoon Haiyan, one of the most intense cyclones ever recorded on Earth, literally destroyed the city of Tacloban and killed at least 6,201 people in the Philippines alone.³⁴ Indonesia has as much to lose due to climate change as India or Africa. Jakarta, a city of over ten million, lies six feet below sea level in certain places. The coral reefs that provide shelters for Indonesia's fisheries will almost certainly die off due to coral bleaching by the end of the century if trends continue.³⁵ The vast ethnic diversity of Indonesia combined with climactic instability and migration could feed the fires on the many insurgencies and independence movements throughout the country.

However Indonesia can do more than most when it comes to influencing climate change. Surprisingly, Indonesia is the world's third largest emitter of greenhouse gasses. This is not due to cars and factories, but rather the unique nature of her landscape. Indonesia's tropical peatlands are very carbon rich. As a result when they are burned the amount of carbon released into the atmosphere is staggering. Deforestation is particularly harmful for climate change because in

³³ Kirby, Alex. *Climate in Peril: A Popular Guide to the Latest IPCC Reports*. Arendal, Norway: UNEP/GRID-Arendal, 2009. Print. p. 34.

³⁴ Visser, Nick. "Super Typhoon Haiyan Could Be One Of The Strongest Storms In World History." *The Huffington Post*. TheHuffingtonPost.com, 07 Nov. 2013. Web. 12 Feb. 2014.

³⁵ Kirby, Alex. *Climate in Peril: A Popular Guide to the Latest IPCC Reports*. Arendal, Norway: UNEP/GRID-Arendal, 2009. Print. p. 28.

addition to adding to atmospheric carbon due to the initial burning, it also destroys the capacity of the land to soak up carbon from the atmosphere. Surprisingly China is almost single handedly helping the Earth keep up with the losses of forests. In effect, trees planted within China make up for a third of all of the trees cut down in Indonesia and Brazil each year. ³⁶

Even though Brazil destroys twice as much forest every year, Indonesia produces twice as much green house gas emissions due to the nature of the peatlands. In a foul twist, American taxpayer money set aside for combating climate change was actually used to clear these Indonesian forests, to make way for palm plantations which would be a source of ‘green’ biofuels. ³⁷

However other parts of Asia will benefit from climate change, at least as most people are concerned. The extent of Siberia’s permafrost will retreat northward while precipitation will increase for most of Northern Asia stretching southward from the Arctic to Manchuria. When combined with warmer climates, the agricultural potential of this vast stretch of land will be enormous. ³⁸

³⁶ Gore, Albert. *Our Choice: A Plan to Solve the Climate Crisis*. Emmaus, PA: Rodale, 2009. Print. p. 194.

³⁷ Gore, Albert. *Our Choice: A Plan to Solve the Climate Crisis*. Emmaus, PA: Rodale, 2009. Print. p. 182.

³⁸ Kirby, Alex. *Climate in Peril: A Popular Guide to the Latest IPCC Reports*. Arendal, Norway: UNEP/GRID-Arendal, 2009. Print. p. 28.

However as the permafrost melts large amounts of methane are expected to be released into the atmosphere.³⁹ This is a worst case scenario for many climate scientists since methane is twenty times more potent than carbon dioxide as a greenhouse gas. The changes to the Arctic are perhaps the most dramatic since they are occurring now. This is the canary in the coal mine for climate change and it is through studying the Arctic that climate scientists first realized the implications of global warming. The extent of Arctic sea ice cover is shrinking by a staggering 3% every year and the rate of decline is steepening.⁴⁰ By midcentury the North Pole could be free of ice during summer, something that has not happened for close to a million years.

There are a few benefits to this. A new shipping lane would open, drastically cutting sea voyage distances from Europe, Asia and North America. Furthermore Arctic nations such as Russia and Canada would be better positioned to use the abundant energy resources of the Arctic Ocean. However an ice free Arctic would also mean even higher sea levels throughout the world than what the IPCC forecasts, since only sea level rise due to thermal expansion is included in calculations and not from ice melt. For the small number of inhabitants it would mean disaster. Polar bears, ribbon seals, and walrus would all face extinction in the wild while the traditional ways of life for the Inuit and neighboring civilizations would be shattered.

³⁹ Christensen, T. R., T. Johansson, J. Åkerman, M. Mastepanov, N. Malmer, T. Friborg, P. Crill, and B. H. Svensson .” Thawing sub-arctic permafrost: Effects on vegetation and methane emissions.” *Geophys. Res. Lett.*, 31, L04501, doi:10.1029/2003GL018680. 2004. Web. 12 Feb. 2014.

⁴⁰ "World of Change: Arctic Sea Ice: Feature Articles." *World of Change: Arctic Sea Ice: Feature Articles*. NASA Earth Observatory, n.d. Web. 12 Feb. 2014.

On the other side of the world, the effects of climate change would be different. Remarkably, as the planet warms, Antarctica is cooling and the ice that covers her is expanding. The reason for this phenomenon has to do with water vapor. As the planet warms and more water is held by the atmosphere precipitation is increasing in temperate and polar areas. Since Antarctica is land, the ice and glaciers there are hundreds of thousands of years old. More snowfall just piles onto this mass of frozen water and the ice sheets grow. As they do the air around them is cooled and hence the process enters a positive feedback loop.

This effect appears to be localized to certain parts of the continent however. As a collective, Antarctica has warmed together with the rest of the planet. The most dramatic example of this was the disintegration of the Larsen B Ice Shelf, a chunk of ice larger than Rhode Island. As is the case with the Arctic, Antarctic wildlife is threatened with extinction.

How to Solve Global Warming

Scientifically, climate change is a straightforward problem understand and to solve. In a nutshell, CO² and methane trap energy from the sun and therefore heat the planet. The more of these gases are released as a result of human activities, the more the planet warms. Global warming is often thought of as a problem of science. However in a way it is really not. All of the solutions are known and can be effectively implemented almost immediately, saving each region of the globe from the adverse effects of climate change outlined above. There are many solutions that would reduce the amount of greenhouse gas emissions while simultaneously meeting humanities' energy needs and even saving money.

The fundamental question that is at the heart of climate change is how does one stop the burning of carbon. There are two solutions; make it expensive or make something else cheaper. Both of these are happening already. Since fossil fuels are finite their supply is decreasing while at the same time demand is going up causing prices to rise. Simultaneously renewable technologies are obtaining and even surpassing grid parity with coal. Even if there were no concerns regarding the environmental consequences of climate change society would still move towards renewable energy sources for economic reasons alone. However this will take a sufficiently long time to make the consequences of climate change irreversible for many generations. So it falls on governments to make this transition faster in order to avoid the perils of climate change.

If humanity ceased releasing greenhouse gases into the atmosphere tomorrow then global warming would in effect be solved. The reason why this is unrealistic is not because of science, but rather because of economics, politics, and psychology. Furthermore solving the climate crisis is not really a technical problem either. The solutions exist and can be implemented immediately. In many cases these solutions would even save money. In all cases, they would save the planet and civilization from the perils of climate change. It is common sense. And yet it is not happening. Climate change is a political and psychological problem and while science and technology might be necessary to provide alternative solutions, they are not sufficient.

For climate change to be averted, the vast majority of people need to do things that are on the surface at least not directly beneficial to them. To solve the climate crisis people need to switch their light bulbs, stop driving gasoline cars, install solar panels, produce less waste, buy

fewer imported materials, and heat and cool their homes to a smaller degree. And they need to do these things all the while knowing that these sacrifices will do nothing towards the big picture of climate change if their neighbors don't follow their lead.

Not reducing one's carbon footprint in this sense is a logical move. It is very Hobbesian in a way. As rational beings people always do what is best for themselves. In a world without government engaging in stealing and violence makes sense. However when people surrender certain rights to a central guiding authority then the benefits to society as a whole are great enough to even benefit individuals by a greater degree than what they gave up. Therefore in this sense the logical move can be to cede personal power to a greater authority.

However this is not a simple manner, for if it was then other species would have complex political structures as well. There are enormous logistical obstacles to get 7 billion people to do something even very simple let alone shift their lives to help solve the climate crisis. However there is good news here. First the psychological infrastructure is already in place. A central authority can tell people to do something and it is done. The world's human population must somehow take the same action either indirectly or consciously. And this is where international politics needs to step in. There is no better example of this than telling 7 billion people to set their clocks back an hour during daylight savings time and then have it happen successfully; no other species in the world has the social infrastructure to get every one of its members to do something even as simple as this.

Second, to solve the climate crisis one doesn't need to convince 7 billion people. In reality 6,500 of the right people would be enough. To pass laws one needs to get the backing of just a certain amount of key individuals. However, this statement is vague and ambiguous as there are no ways to know who needs to be won over and when. Therefore activists and scientists often turn to a blanket approach; spread the message to everybody and hopefully the key people will also be caught up in this net. In lieu of another approach this seems to be the best option, but it is a waste of time and resources.

What complicates matters greatly is that climate change is not a problem of national policy or politics. If country like the Maldives were told that their island nation would be saved if everyone who lived there installed solar panels on their roofs then they would have done so a long time ago. Similarly, if legislators in California knew that putting a tax on industries that emit carbon would solve the droughts that threaten to destroy the state's agricultural output then that legislation would likely have been passed without delay. However climate change is a global phenomenon. California can become the greenest state in America and yet they will see very few direct benefits of this in terms of negating the effects of climate change if Chinese factories continue emitting carbon dioxide in record levels. The droughts will still come and the sea level will still rise. Therefore there is little incentive for anyone to take unilateral action against global warming especially if there are short term costs associated with those actions. Either everyone acts or no one does.

It is therefore that climate change is at its very heart a problem of international affairs more than anything else. When it comes to climate change, everyone is in the same boat. Even though some regions are more vulnerable to climate change than others, all will suffer the negative consequences of sea level rise, food shortages, heat waves, ecosystem collapse, extreme weather events, and the political and economic instability that results from these factors. So how does one get a community of 195 independent entities to agree on anything?

The international community has come together to solve transnational issues in the past even in the environmental arena. One of the most successful examples of this was the effort undertaken to stop the ozone layer from being depleted. In the 1970s it was discovered that the anthropogenic release of chlorofluorocarbons was creating a hole in stratospheric ozone above Antarctica and that this could have adverse health effects for the human population all over the globe⁴¹. As a result the Montreal Protocol was passed and eventually ratified by every UN member state. Under the treaty the emissions of certain chemicals were banned and the ozone layer started to recover. Another good example for international cooperation regarding ecological preservation is the moratorium on commercial whaling which prevented the extinction of whale species throughout the oceans. Furthermore the countries of the world were successful in putting together the Antarctic Treaty System, which spared Antarctica from becoming a waste disposal site or a nuclear firing range. Outside of the environmental sphere, the mechanisms of

⁴¹ Green, Bryan A. "Lessons from the Montreal Protocol: guidance for the next international climate change agreement." *The Free Library* 01 January 2009. 24 September 2013. Web.

international affairs have been largely successful in many other aspects including containing the spread of weapons of mass destruction, increasing global GDP and preventing widespread warfare. So the precedent on global action is strong. But climate change is different, and for the first time since World War Two, the international community seems destined to fail in preventing a foreseeable and avoidable global calamity of epic proportions.

So why does international affairs fail when it comes to climate change while being successful in the aforementioned causes? One reason is that the scales really aren't comparable. It is one thing to outlaw the use of chlorofluorocarbons and a different thing entirely to go after coal and oil. If fossil fuels disappeared overnight humanity would reenter the Stone Age and literally millions if not billions of people would die. On the other hand, not being able to use certain aerosols or purchase whale meat would not seem as the end of the world for most people. Climate change is an issue because human society is built around coal and oil. In most places, every cup of water and bite of food is made possible by the burning of a carbon based fuel at some part of the production process. Almost all transportation, industry, and really any other aspect of human life in the 20th and 21st Centuries is made possible by carbon based fuels either directly or indirectly. The logistics of changing human society are therefore immense. But they are not unparalleled.

Society has undergone great changes in even smaller periods of time. The most obvious example is the information revolution. Putting sophisticated computers and cell phones in the majority of the world's homes and creating the architecture to support these vast information networks within the span of two decades was no small task. Furthermore nearly every

cooperation fundamentally changed the way it conducts business in order to make the most out of these new technologies. Integrating computer technologies into society is more complex of a task than changing to carbon neutral fuels and yet this took place without any subsidies or elaborate international efforts. So if billions of people can be equipped with rather sophisticated cell phone and internet technology than why can't coal be replaced with solar?

The international community is a sum of its parts, with the parts being individual human beings. And it is here that the basic nature of people plays an important part in the climate change problem. Acting to obtain success has always less resistance and more excitement than acting to avoid failure. Furthermore, people prefer activities that yield immediate gains for small costs, and avoid things with immediate costs with a potential long term gain. Tackling climate change is made more difficult because the problem entails the worst of both worlds. It is a problem of avoiding failure rather than creating success, and it has short term costs with long term gains. A real solution to climate change must in a way alter the problem to one that is easier for humans to solve. This does not refer to the difficulty of the solution, but rather the excitement level of taking it on. If a solution to climate change can be presented that people actively want to pursue, it will be adopted as naturally as the internet.

As mentioned previously, the most effective current solutions against climate change that are being pursued are putting a tax on carbon, creating subsidies for clean energy, and paying countries to keep their forests intact. All of these are uphill battles because they will not happen naturally in a population that favors immediate gain over long term gains, and perhaps logically so. However with time, regardless of how the governments of the world choose to act, the

problem of climate change will fundamentally change. Instead of it being about avoiding negative consequences it will be about pursuing positive benefits. Solar power generation will surpass fossil fuels in price within this decade. This will occur because people will be able to save money and as more solar installations are created there will be an enormous impetus to calibrate other aspects of the energy market to the changing conditions. The supergrid and electraneet will become realities and power companies will be pressured to come up with alternative ways to produce electricity. By the year 2050 most new cars on American roads will be electric not because that is good for the environment, but rather because the benefits of having an electric car will outstrip those of driving a gasoline or diesel vehicle chief among those being not having to endure the rising costs of gasoline.

It is doubtful that the international community will come together to combat climate change in a meaningful way because the problem is not in a form that human beings are collectively good at solving. Even if a handful of western countries become carbon neutral and a number of other symbolic victories are achieved, events are now in motion that cannot be easily undone. Methane will be released from the arctic tundra, growing populations in Africa and Asia will result in more deforestation, oceans will become more acidic leading to widespread mortality among species, and weather events will wreck havoc on global food and water supplies. Conflicts will result, economic collapse will occur, and millions of people will lose their lives. However life will go on.

The story of humanity has rarely been one free from trouble. Wars, epidemics, droughts, and storms have been part of the human experience since our species first emerged. Humans

have survived on every habitat on Earth. People have been to the deepest oceanic trenches and have traveled to the moon. And by the year 2025, the first people will leave this planet for Mars and humanity will start a path which will be more important and significant in terms of our own evolution than even the advent of agriculture or language itself. The effects of climate change will be severe, perhaps much more than this thesis predicts. However the human spirit will endure and some people will find ways to adapt and even flourish in this new normal.

As for other species, the effects of climate change will be more detrimental. Corals will die off in massive numbers, polar ecosystems will collapse, and taxa across the tree of life will disappear. It is probable that life is currently experiencing the sixth mass extinction event within its history on this planet. However life is extremely resilient and nothing humanity can do, including total nuclear war, will put too much of a dent in the long term evolution of life on Earth. Even after most species on the planet died out during the P-T extinction, life still managed to recover and later thrive⁴². Life will recover and adapt again in response to this new challenge, even perhaps in the short term. In a world of global warming, jellyfish are expected to rule the oceans, trees are projected to grow in the Arctic and desert animals are expected to spread well beyond their normal ranges. The world will be transformed and species that are generalists will thrive while those that are specialists that rely on very specific conditions will suffer the worst from climate change.⁴³ The history of life and the history of planet Earth is that of change.

⁴² White, Rosalind V. "Earth's biggest 'Whodunnit': Unravelling the clues in the case of the end-Permian mass extinction." *Philosophical Transactions of The Royal Society A: Mathematical, Physical and Engineering Sciences* 360 (Dec. 15, 2002): 2963-2985. Web.

⁴³ Associated Press. "Scientists predict animal climate change winners and losers." *One News*. TV New Zealand, 10 April. 2014. Web. 14 April 2014.

Humans are not aliens that have come to this planet as outsiders. We are a part of this world and a part of its natural system. Fundamentally in the scheme of this planet, there is no difference between greenhouse gases being emitted by a volcano or by a factory.

Climate change will enter history books as a dramatic failure in international affairs when in fact it is a failure of the nature of the human condition. Future generations will take climate change to be a part of life and not blame our generation as much as we deserve to be blamed. Other events that will dominate the 21st Century will come to fruition and take attention away from the negative effects of global warming. These include the advent of interplanetary travel, the promises and perils of genetic engineering, a formal understanding of consciousness, and perhaps the discovery of life beyond Earth.

The negative effects of climate change will fall on those who are least deserving of them. For the people of the Indian Subcontinent and Sub Saharan Africa, life will become more difficult with climate change. However these societies will cope, and recover for there is no other alternative. As for the lives of ordinary individuals, climate change will be a side note to their lives much like wars and natural disasters are to people today. The personal details of their lives that have meaning only to them will be what define the experiences of individuals living in an age of global warming.

Annotated Bibliography

Anam, Tahmima. "Pakistan's State of Denial." *New York Times*, December 26, 2013. Web. 09 Feb. 2014.

This New York Times article underscores the complexities of the Indian Subcontinent. Specifically, it deals with the Bangladeshi War of Liberation and the atrocities that the Pakistani army committed against fellow Muslims at that time. This underscored the danger global warming poses to this part of the world in that there are deep divisions and frozen conflicts that can easily erupt once basic resources become scarcer.

Archer, David. "*Global Warming: Understanding the Forecast*". Malden, MA: Blackwell Pub, 2007. Print.

A great book whose influence on this work comes second only to the IPCC reports. It is as if *A Brief History of Time* met the *Principia Mathematica* as the book is both marketed to a wide audience and is a formal proof. If the purpose of this thesis was to explain climate change than writing anything would be irrelevant as one could just be directed to David Archer's book and confidently gain a solid understanding of the issue. The book's main benefit is in its scientific approach and yet it is a fun read for anyone with an interest in the climate.

Associated Press. "Scientists predict animal climate change winners and losers." *One News*. TV New Zealand, 10 April. 2014. Web. 14 April 2014.

This short story published by TV New Zealand news gives publicity to an often neglected side of the global warming debate. Just like with any change, global warming will have its winners as well as its losers. This story does a good job in economically highlighting who stands to gain the most from global warming, specifically focusing on the animal world. This article is a good reminder of the complexities behind climate change and serves to show that not everything is always black and white.

"Beijing to Restrict Private Car Use to Tackle Pollution." *BBC News*. BBC, 17 Oct. 2013. Web. 12 Feb. 2014

This article by the BBC is cited only once in the thesis, but provides a good overview of one of the strategies China is employing to combat air pollution. The journalist provides a good background of the problem and does an effective job in giving the reader an understanding of how China deals with ecological issues.

Bradsher, Keith. "China Leading Global Race to Make Clean Energy." *New York Times*, 30 January 2010. Web. 05 Feb. 2014.

This New York Times article is well written and to the point. It wastes no time in telling the reader the state of the clean energy market and why China has been so successful in dominating this sector. Furthermore Bradsher exposes the hierarchy many have towards China in that other countries simultaneously slam China for undermining their clean energy initiatives while reaping the full benefits of the low cost technologies developed in China. I recommend this read to anyone who has an interest in clean energy or US-China relations.

Branigan, Tania. "China's Great Famine: The True Story." *The Guardian*. Guardian News and Media, 02 Jan. 2013. Web. 09 Feb. 2014.

This article from The Guardian gives a good and compact account of the causes behind the Great Chinese Famine and the effects it had on Chinese society. For this thesis, the article provided hard figures that were used in citing the number of casualties caused by the famine. More importantly it outlines the mechanisms through which poor governance can combine with unfavorable weather to create great catastrophes.

Bressan, David. “ *June 8, 1783: How the ‘Laki-eruptions’ changed History*”. Scientific American, 8 Jun. 2013. Web. 4 Apr. 2014.

This article gives a thought provoking account of how natural events seemingly unrelated to political and economic events can change the world. It specifically deals with a volcano that erupted in Iceland during the 18th Century and argues that it caused a chain of events that ultimately led to the French Revolution and therefore the modern era. The ideas presented in this article serve as a reminder of how humanity is at the mercy of mother nature and heightens ones concerns about the impacts climate change can have.

Bureau of the Census. "History." *1800 Fast Facts*. Census.gov. Web. 10 Feb. 2014.

This official US government census data was used to cite population growth within America during the 19th Century. The website is easy to use and has data and facts that are indispensable due to their reputation and scope.

Bureau of the Census. "History." *1900 Fast Facts*. Census.gov. Web. 10 Feb. 2014.

This official US government census data was used to cite population growth within America during the 20th Century.

Central Intelligence Agency. "Field Listing: GDP (official Exchange Rate)." cia.gov. Web. 10 Feb. 2014

This CIA run website has long been treated as a credible source that is easy to navigate and that contains useful and accurate information. This thesis referred to its data throughout and used it to site things such as GDP levels.

Christensen, T. R., T. Johansson, J. Åkerman, M. Mastepanov, N. Malmer, T. Friborg, P. Crill, and B. H. Svensson .” Thawing sub-arctic permafrost: Effects on vegetation and methane emissions.” *Geophys. Res. Lett.*, 31, L04501, doi:10.1029/2003GL018680. 2004. Web. Web. 12 Feb. 2014.

This scholarly article deals with the hard science of global warming and those who have an interest in biology will find it most interesting. T gives a very thorough explanation of how warmer temperature could melt permafrost which in turn would greatly increase the amounts of methane in the atmosphere, a greenhouse gas twenty times more potent that carbon dioxide. The terminology and concepts used in the publication are targeted towards readers with a working understanding of this field.

Colvin, Ross, and Jatindra Dash. "Indian Scientists Try to Crack Monsoon Source Code." *Reuters*. Thomson Reuters, 20 July 2012. Web. 09 Feb. 2014.

This Reuters article serves as a reminder of the importance of the monsoon to India. It is humbling to realize that most of the nation’s GDP is directly tied to the weather and that monsoon is the true ‘finance minister of India’. This underscores the vulnerability the entire sub-continent faces from climate change.

Department of Economic and Social Affairs. "World Population to 2300". United Nations. 2004. Web. 09 Feb. 2014.

These official United Nations figures were used to supplement the Washington Post article by Max Fisher and cite population growth in Asia and Africa. The website presented information in an easy to read manner and I recommend it to anyone who wants to look up predictions on future demographic data.

Douma, Wybe T, L. Massai, and Massimiliano Montini, ed. "*The Kyoto Protocol and Beyond: Legal and Policy Challenges of Climate Change*". The Hague, the Netherlands: TMC Asser Press, 2007. Print.

This book was only briefly used for this thesis. However it does provide excellent information on how individual EU countries have implemented the Kyoto Protocol. The text is not attractive to read however and there is much technical information that is not on immediate relevance to the goals of this thesis. The introduction of the book however was somewhat profound and is cited in the thesis. A recommended read for anyone who has an interest in EU countries' implementation of the Kyoto Agreement.

Dow, Kirstin, and Thomas E. Downing. "*The Atlas of Climate Change: Mapping the World's Greatest Challenge*". Berkeley: University of California Press, 2006. Print.

Similar to *Climate in Peril* but more reader friendly. Its small size and beautiful illustrations make it a perfect book for someone who is new to the issue of global warming. However it was also useful for this thesis in two ways. First, its limited size insures that only the most immediate issues and data are included and this has the benefit of streamlining the thesis away from deviations. Second, the ease of finding information within it made it a great work to use for confirming the data presented in other works.

Fisher, Max. "The amazing, surprising, Africa-driven demographic future of the Earth, in 9 charts." *The Washington Post*, July 16, 2013. Web. 09 Feb. 2014

This Washington Post article greatly influenced the Africa section of this thesis. It should be read by anyone who has an interest in how the world will change in the next hundred years. It presents data using charts that make it apparent that the world is about to go a monumental shift in terms of the human population of this planet. In short, Africa is projected to become the main demographic event of the 21st Century. For example, Nigeria is expected to overtake the United States in terms of population size by 2040 and be on the verge of catching China by 2100. The implications of this for climate change are immense and are given thorough analysis within this thesis.

Fletcher, Mark. "The Himalayas." *Nature*. PBS. KETCW, Saint Louis, MO, n.d. Television.

I came across this PBS TV documentary by accident but it proved to be a worthy asset for this thesis. While books and articles are the best sources for information, sometimes it can be worthwhile to be exposed to a subject in a more visually engaging way. Seeing aerial panoramas of the Tibetan landscape and interviews with people who are studying the changes taking place there was perhaps the best way to get a sense of the actual events on the ground short of actually being there oneself. The time lapse videos of the glaciers retreating were particularly compelling.

Fogarty, David. "Q+A-How Will the Maldives Fight Climate Change?" *Reuters*. Reuters, 18 Feb. 2010. Web. 09 Feb. 2014.

This short Reuters article is presented in a question and answer type format which does a good job of outlining how Maldives, the world's lowest lying country, will deal with climate change. Furthermore the person answering the question is the president of Maldives whose responses do a good job of explaining how dire the situation is while at the same time keeping a hopeful outlook for the future.

Forecasting the Future: Exploring Evidence for Global Climate Change. Arlington, VA: National Science Teachers Association, 1996. Print.

One of the early works referenced. While it is a good resource for climate change especially for teachers who are planning a curriculum for grade school students, it was not in the same league with other works in the reviewed literature. It simply does not deal with global warming in a technical or policy manner; rather it is an introductory guide with many activities. It is however a good place to start, especially if one is interested in how to make global warming relevant to everyday people.

Gore, Albert. *Our Choice: A Plan to Solve the Climate Crisis*. Emmaus, PA: Rodale, 2009. Print.

No study of global warming would feel complete without including something from Al Gore. This book is basically the illustrated print version of his film *An Inconvenient Truth*. It is not short of drama or dire predictions and this is a benefit especially after many hard scientific reads. Most of the information mirrors that of other sources such as the IPCC reports and so the book's main value comes in the uniqueness of being written by someone in the political inner circle. The later sections that dealt with policy are cited in this thesis numerous times.

"Government Information Service." *Health Officials Confirm One Case of Chikungunya Disease on Dominica*. Dominica Republic Information Service. 17 Jan. 2014. Web. 10 Feb. 2014.

One of the main reasons I decided to write about global warming was because it is something that is contemporary. This can be perfectly seen in the case of Chikungunya, a disease that is spreading north together with the tropical mosquitoes that carry it. This article was released in January and it talked about how there was a confirmed case of Chikungunya in Dominica. By May of the same year, Chikungunya has spread throughout the Caribbean and is now threatening to become an epidemic.

Green, Bryan A. "Lessons from the Montreal Protocol: guidance for the next international climate change agreement." *The Free Library* 01 January 2009. 24 September 2013. Web.

A very useful work for this thesis. It basically attempts to condense the lessons learned from the Montreal Protocol and ozone depletion and apply them to climate change. Green acknowledges that the parallels are imperfect as climate change is a problem on a much larger and more complex scale. There is also a good analysis of the Kyoto Protocol, and the Vienna Convention both of which were very useful. The discussion on state sovereignty was also prominently featured in the thesis.

Haeberli, Wilfried and Beniston, Martin. "Climate Change and Its Impacts on Glaciers and Permafrost in the Alps." *Ambio*. Vol. 27, No. 4. Print.

This scholarly article provides a very good overview of the impact climate change is having on the Alpine region of Europe. Its focus is more scientific than political or economic and it outlines the evidence of how climate change has affected the ecosystem of this region of Europe. The authors are very methodical in the way they represent the data and the paper does a good job in preempting counter arguments from climate change critics by sticking to hard science.

Hasan, Anjum. "Why the violence in Assam is not communal." *BBC World News*, 2 September 2012. Web. 05 Feb. 2014.

This BBC article written by a novelist greatly influenced the India specific section of this thesis. It outlined the history of ethnic tensions within modern day India and made a compelling case of how the events on one side of the country influence what happens in other parts that are detached from the seemingly isolated events. For example, violence in Assam against Bangladeshi Muslims fuels protests in the western regions bordering Pakistan and big cities like

Mumbai. It does a good job of reminding the reader of how complex this country of 1.2 billion people really is.

Haley, James. "*Global Warming: Opposing Viewpoints*". San Diego, Calif: Greenhaven Press, 2002. Print.

This short book is part of a series called *Opposing Viewpoints* and is basically a debate written on paper. It was one of the early works consulted for this thesis but its ideas do not feature prominently within it as the purpose of this thesis is not to debate whether global warming is real. Furthermore much of what was written in it is explained better and in more detail by some of the other listed works. Two essays in the book stood out. One was "Global Warming Will Severely Harm Human Health" by Paul Kingsnorth which made a convincing connection between global warming and the spread of malaria and potential epidemics. The other was *Solar Variability Causes Global Warming* by John L. Daly which presented a well worded summary of a second global warming theory.

Hansen, James, Makiko Sato, Reto Ruedy, Ken Lo, David W. Lea, and Martin Medina-Elizade. "Global temperature change." *Proceedings of The National Academy of Sciences* 103. 26 September 26, 2006. Web.

The purpose of including this article was to supplement the IPCC reports. The data between the two is largely consistent but this work concentrates the information to a manageable size. Furthermore it predicts future trends more poetically than the technical IPCC reports and doesn't shy away from making bold predictions using very specific numbers. Unsurprisingly, the findings include record temperatures for this geological era, mass extinctions and the other effects mentioned in the vast majority of sources listed here. The primary use of this work for this thesis is to backup IPCC numbers.

Houghton, J T. "*Global Warming: The Complete Briefing*". Cambridge: Cambridge University Press, 1997. Print.

This book was very similar in layout and findings to some other books like *Dire Predictions* and *Our Choice*. However information was not presented in the easiest manner and the book was less reader friendly than similar works cited in this thesis. Its main contribution to this work was providing validation to information cited from other works. The book is also relatively dated, having been published in 1997 and so offers a perspective of when the global warming issue was just beginning to take center stage.

Hulme, Mike. "Abrupt climate change: can society cope?" *Philosophical Transactions of The Royal Society A: Mathematical, Physical and Engineering Sciences* 361 (Sept. 15, 2003): 2001-2021. Web.

One limitation of this article is that it is dealt only with Northern Europe, a region where the IPCC predicts climate change will have only a minimal effect when compared to hotspots like Africa or oceanic islands. It is also one of the more climate-skeptic resources cited for this thesis as it concludes that global warming does not warrant avoidance at all costs. Rather this resource predicts that adaptability strategies are more cost efficient and that they might be enough to prevent potential catastrophes. This resource was not cited in this thesis, but it was referenced in research.

“Illegal immigration into Europe in numbers”. BBC. 4 Oct. 2013. Web. 6 May 2014.

This short BBC article was only cited once in this thesis. It provides some figures on how many illegal immigrants come to Europe and outlines the most common routes taken.

Kaur, Gunisha. "Remembering the Massacre of Sikhs in June of 1984." The Huffington Post. TheHuffingtonPost.com, 03 June 2013. Web. 09 Feb. 2014.

This article in the Huffington Post is only cited once in this thesis, but plays a nonetheless important role in underscoring the volatile nature of race relations in the Indian Subcontinent. It gave a somewhat hard to read account of how 20,000 Sikh civilians were killed in retribution for the assassination of Indira Gandhi.

Kirby, Alex. "*Climate in Peril: A Popular Guide to the Latest Ipcc Reports*". Nairobi [u.a.: United Nations Environment Programme, 2009. Print.

A short resource meant to be a summary of the major IPCC Reports. This work is cited throughout the thesis as it directly takes the data behind the IPCC reports but presents it in such a way that makes it easy to summarize and analyze. In addition illustrations and graphs are aesthetically presented and explain core concepts well. The main strength of this work is that it focused solely on the big picture and the most important data and didn't deviate into distractions.

LeBlanc, Allan. "Is the US About to Accidentally Meet Kyoto Protocol Targets?" *Berkeley Energy & Resource Collaborative.*, 4 Sept. 2012. Web. 10 Feb. 2014.

This easy to read article does a good job of showing how volatile and unpredictable climate change policy really can be. In short, even after America led an effort to come up with the Kyoto protocol the US Congress refused to ratify the treaty. Now a decade later the US is one of the few countries that actually lived up to its would-be obligations to the treaty due to American natural gas displacing coal and oil. This report by LeBlanc is a worthy read and it reminds readers that the climate change debate is more complex than most believe it to be.

Lubell, Mark, Sammy Zahran, and Arnold Vedlitz. "Collective Action and Citizen Responses to Global Warming." *Political Behavior* 29 (Sept., 2007): 391-413. Print.

A work very different from the other sources cited here. It focuses on civil society and ways grassroots movements can materialize in ways to create more than symbolic protest against climate change. A technical read and at times difficult read but it provides ideas not found in the standard global warming books. Most intriguing was the analysis between free riding on the work others do in regards to activism and the scale at which this will be outpaced by individual action.

Lustgarten, Abraham. "Will Global Warming Melt the Permafrost Supporting the China-Tibet Railway?" *Scientific American Global RSS*. Scientific American, 21 July 2009. Web. 12 Feb. 2014.

This is a good article from Scientific American that deals with how the Tibet railroad is threatened due to global warming induced permafrost loss. The author does a good job of reminding readers that the adverse effects of climate change will go well beyond the obvious and one comes away trying to think of what other aspects of society might be threatened by climate change in what are as of now obscure ways. Furthermore Lustgarten's article does a good job in highlighting how humans are one step behind in the battle to cope with climate change.

Marr, David G. *“Vietnam 1945: The Quest for Power”*. Berkeley, CA: University of California, 1995. Print.

This research paper was used to cite population numbers in Vietnam and to reference how many people died due to weather induced famines. The wider focus of this paper is not climate change related. However, this scholarly article will be useful to those who have an interest in this part of the world and who want to better understand the evolution of Vietnam in the year following the Japanese withdrawal. It helps the reader better understand how the French Indochina War and the later American involvement in Vietnam came about.

McFadden, David. “Recently Arrived Chikungunya Virus Gains Foothold In Caribbean” *The Huffington Post*. 2 May 2014. Web. 6 May 2014.

This Huffington Post article was only cited once in this thesis, and was the last and most recent source to be included. It deals with the Chikungunya virus, a tropical disease that has spread north into the Caribbean. It was used as a follow up to an article cited back in January of 2014 from the Dominican Information Service, and gave what was in effect real time coverage of this outbreak.

Mann, Michael E. *“The Hockey Stick and the Climate Wars: Dispatches from the Front Lines”*. New York: Columbia University Press, 2012. Print.

This book focuses on the political side of the climate debate. As this thesis takes global warming as a given, this book's contribution was minimal. If anything it showed how messy politics can be but this too is perhaps a given. The main benefit of this book was that it brought more of the arguments against climate change into the mix which is perhaps something that is missing in this thesis (by design). Even so Mann's book was refreshing to go through as it was not necessarily a book of hard science. Mann's other book *Dire Predictions* was also used for this thesis.

Mann, Michael E, and Lee R. Kump. “*Dire Predictions: Understanding Global Warming*”. New York: DK, 2008. Print.

Both the thesis and this work take the IPCC reports as the main and most reliable source for information. Mann and Kump have basically rewritten the IPCC reports for the masses and have done so in a very effective and aesthetic way. The book also stands out from the literature used for this thesis as it focuses on the results and the ‘what’ rather than the why or how’s of climate change.

Michaels, Patrick J. “*Shattered Consensus: The True State of Global Warming*”. Lanham: Rowman & Littlefield, 2005. Print.

This thesis does not explore the debate of whether global warming is real or fake; it takes for granted the fact that it is. So this book, by a global warming skeptic, does not greatly feature into the thesis. However, it was referenced to gain another perspective of the debate. The book is made up of essays which make surprisingly good arguments on why climate change is not real, or at least not in the way it is being presented. However, after having consulted a large number of other global warming books, it can be said that this book misses the general point of the global warming policy; surviving the next two hundred years and the droughts, floods, and storms that will result from global warming.

Reay, David S. "Costing climate change." *Philosophical Transactions of The Royal Society B: Biological Sciences* 360 (Dec. 15, 2002): 2947-2961. Web.

This was a well written article on the economics of climate change policies. Sources vary widely on what the direct cost to global GDP proposed climate change policy might have. This article is well cited and its author, David Reay, is a well respected climate scientist and so figures expressed in this source are also quoted in the thesis. The findings are that the economic costs of climate change policies are not the substantial burden many make them out to be even before calculating the negative economic costs of degraded ecosystems and peak oil. This is a

worthwhile and down to earth read for politicians who oppose climate change reform on economic grounds.

Rogers, Simon. "Immigration to Europe: how many foreign citizens live in each country?". *The Guardian*. 7 Sept. 2010. Web. 6 May 2014.

This article from *The Guardian* provides a detailed chart that shows how many of Europe's citizens are foreign born. Its data was cited in the European immigration section of this thesis.

Tagliabue, John. "GLETSCH JOURNAL; Frozen in Memories, but Melting Before Their Eyes." *The New York Times*. *The New York Times*, 24 Oct. 2006. Web. 10 Feb. 2014.

This is a good *New York Times* article that deals with the human impact of climate change in the Swiss Alps. For this thesis, it complemented nicely with Haeberli and Beniston's assessments of the damage climate change is causing to the Alpine ecosystem. Tagliabue provides an account of how ordinary Swiss people living in the Alps are having their lives

affected by climate change and provides stories that give a human meaning to the science. Readers are left with a sense of urgency upon finishing the article.

United States. Department of Energy. Office of Policy, Planning, and Program Evaluation. "*Climate Change impacts on the United States*". Cambridge University Press, 2000. Print.

The report looks at each region of the United States separately and analyzes the effects climate change has already had on the local economies and ecosystems. Especially useful were the sector sections in the end of the book which gave a great overview of the relationships between the key systems such as water, agriculture, forests, and public health and their connection to climate change. Also beneficial were prediction charts that predicted how each region would cope with global warming.

United States. Department of Energy. Office of Policy, Planning, and Program Evaluation. *The Climate Change Action Plan*. Washington, DC: The Office, 1993. Print.

A description of the Clinton policy on climate change. It is composed of 43 actions that range from reduced pesticide use to the creation of a contest to create efficient electric motors. The main value of this useful booklet was that it was an actual global warming policy. It is well

detailed providing cost estimates and timetables. Additionally it states that a dual goal is to grow the economy and this is reflected in the policies. This report has many good ideas and it is an important part of the literature consulted for this thesis.

United States. Department of State. "*U.S. Climate Action Report, 2002: Third National Communication of the United States of America Under the United Nations Framework Convention on Climate Change*". Washington, D.C: U.S. Dept. of State, 2002. Print.

When this thesis was begun, it was an implied goal to write about something along the lines of what this report is about. However, upon finding this resource the goal of the thesis was refocused as the Climate Action Report does everything the thesis was originally intended to do. It is extensive, detailed, and well cited but at the same time not overly technical. Had it not been for the IPCC reports, this work would have been the bedrock of the literature reviewed for this thesis. Especially noteworthy is the appendix section which goes through numerous climate change mitigation programs. Nearly the best comprehensive report on climate change, especially in terms of focusing on the policy side.

Visser, Nick. "Super Typhoon Haiyan Could Be One Of The Strongest Storms In World History." *The Huffington Post*. TheHuffingtonPost.com, 07 Nov. 2013. Web. 12 Feb. 2014.

This Huffington Post report on Typhoon Haiyan was very rich in data and numbers which were used in the Asia portion of this thesis. The author does a good job in putting this typhoon

into historical perspective. Furthermore the ties to climate change are discussed in depth and interviews with prominent scientists are featured, creating a very useful article.

White, Rosalind V. "Earth's biggest 'Whodunnit': Unravelling the clues in the case of the end-Permian mass extinction." *Philosophical Transactions of The Royal Society A: Mathematical, Physical and Engineering Sciences* 360 (Dec. 15, 2002): 2963-2985. Web.

A good work. First off, it was scientific and yet very readable and it has a feeling of a popular book. Moreover it very effectively explained the theories behind what caused life's greatest catastrophe; the Permian Triassic extinction when the majority of life disappeared from the Planet. Its direct value to this thesis is in the parallels between what was happening then with what is happening now. This source argues that the P-T extinction was caused by global warming, ineffective carbon sinks, and methane hydrate release. This of course has direct implications with the current debate.

"World of Change: Arctic Sea Ice: Feature Articles." *World of Change: Arctic Sea Ice: Feature Articles*. NASA Earth Observatory, n.d. Web. 12 Feb. 2014.

The official NASA Earth Observatory website is a great resource for anyone wanting to find information about the general state of planet Earth. Some of the features included are false color map databases that show forest concentrations, ultra violet radiation levels, and rainfall distribution. For this thesis, the maps showing the shrinking of Arctic sea ice were referred to and cited. This is a fascinating website to explore for those who desire to see the 'big picture' of things.

Yee, Amy. "In Bangladesh, More Shelter From the Storms." *New York Times*, 24 June 2013. Web. 05 Feb. 2014.

While there is no shortage of sources that point out the problems Bangladesh faces in terms of climate change, this short New York Times article deals with some positive developments taken in Bangladesh to ready the country for climate change. In particular it dealt with the cyclone warning system developed in the 1970s and discussed the importance of storm shelters in Bangladesh.

York, Richard. "Kyoto Protocol Participation: A Demographic Explanation." *Population Research and Policy Review* 24 (2005): 513-526. Web.

This is an interesting article on the correlation between a country's population growth and its participation in the Kyoto Protocol. The conclusion that population growth means decreased probability of implementing climate policies was not very surprising since growth rates are highest in developing countries and these countries are also the ones who need cheap and available energy. The implications this has on the ratification of future climate policies was gloomy as the author predicted negative population growth was a prerequisite for substantial climate policy adoption. As a central part of this thesis is that climate policy will change with the weather, I respectfully take a view different from the one presented in this article.

Additional Sources Cited in Supplementary Materials

Dow, Kirstin, and Thomas E. Downing. *The Atlas of Climate Change: Mapping the World's Greatest Challenge*. Berkeley: University of California, 2006. Print. p. 31.

Fetter, Steve. "How Long Will the World's Uranium Supplies Last?" *Scientific American Global RSS*. Scientific American, 26 Jan. 2009. Web. 11 Feb. 2014.

Freeman, Katherine H., and J. M. Hayes. "Fractionation of Carbon Isotopes by Phytoplankton and Estimates of Ancient CO levels." *Global Biogeochemical Cycles* 6.2 (1992): 185. Print.

Fridleifsson, Ingvar B. "Status of Geothermal Energy amongst the World's Energy Sources." *Geothermics* 32.4-6 (2003): 379-88. Print.

Heaton, Emily A., Frank G. Dohleman, and Stephen P. Long. "Meeting US Biofuel Goals with Less Land: The Potential of Miscanthus." *Global Change Biology* 14.9 (2008): 2000-014. Print.

Held, Isaac M., and Brian J. Soden. "Water Vapor Feedback And Global Warming¹." *Annual Review of Energy and the Environment* 25.1 (2000): 441-75. Print.

"Methane Emissions." *EPA*. Environmental Protection Agency, 9 Sept. 2013. Web. 12 Feb. 2014.

Ratner, Albert. "CFD Modeling of Co-Firing Wood Chips with Coal for UI Power Plant Boiler 10." *University of Iowa*. 8 August, 2011. Print.

"Quiz: What You Don't Know About Wood Energy." *National Geographic*. National Geographic, n.d. Web. 12 Feb. 2014.

Scientific Glossary

The Greenhouse Effect

Greenhouse gasses are what help keep planet Earth's surface warm and consistent. Without them life would not thrive if it would exist at all. Up to 70% of the greenhouse effect on the planet is a result of water vapor and clouds, although this varies by topography and altitude. As the planet warms, more water vapor will enter the atmosphere which has the potential to cause more warming and hence create a dangerous positive feedback loop.⁴⁴ Carbon dioxide by comparison is responsible for roughly 15% with the remainder being divided up between Methane and Ozone. However, not all greenhouse gasses are equal.

One molecule of methane contributes 12 times as much to the greenhouse effect when compared to a molecule of CO₂. Sulfur hexafluoride can potentially be 32,600 times as powerful as CO₂. However, since there is vastly more CO₂ in the atmosphere than other trace gasses most of the attention regarding climate change has rightfully gone to carbon dioxide.

During the last 500 million year CO₂ levels have varied greatly from about 7,000 parts per million (ppm) to under 100 ppm. During the Jurassic era when dinosaurs and forests covered the planet CO₂ levels were over 1000 ppm and life thrived.⁴⁵ Today CO₂ levels are near a

⁴⁴ Held, Isaac M., and Brian J. Soden. "Water Vapor Feedback And Global Warming1." *Annual Review of Energy and the Environment* 25.1 (2000): 441-75. Print.

⁴⁵ Freeman, Katherine H., and J. M. Hayes. "Fractionation of Carbon Isotopes by Phytoplankton and Estimates of Ancient CO levels." *Global Biogeochemical Cycles* 6.2 (1992): 185. Print.

historical low at under 400 ppm. It follows that the planet's average temperature is also low when compared to the vast span of Earth's history. The planet is in fact experiencing an Ice Age which began 2.5 million years ago and continues into today. However, now Earth is in an interglacial period when the ice sheets retreat. There have been five such interglacial during this ice age with the current one having begun 11,000 years ago and as was previously mentioned, the climate has been stable by an unprecedented amount since then. Human induced climate change now threatens to break this stability.

And those changes are indeed occurring. Since the start of the industrial revolution, atmospheric carbon dioxide has increased by 33% from 280 ppm to the current 375 ppm.⁴⁶ This has been a direct cause of the burning of carbon fuels such as wood, coal, oil and natural gas. Much of this has gone into the oceans and forests. For plants and green algae this change has been great as CO₂ is an essential ingredient for photosynthesis. All changes have winners and losers but for most of the ocean higher acidity levels are not a good thing (perhaps jellyfish and algae being exceptions).

From these facts one could make two valid arguments. One is that CO₂ is not bad for life or for the atmosphere. This is true since life has thrived precisely because plants had a vast amount of CO₂ in the atmosphere to take advantage of. Second, one could say that reentering the ice age is not in the best interest of most of the life on Earth today and actions should be taken to avert glaciers advancing to Chicago and New York as they had done 12,000 years ago. This is a

⁴⁶ Dow, Kirstin, and Thomas E. Downing. *The Atlas of Climate Change: Mapping the World's Greatest Challenge*. Berkeley: University of California, 2006. Print. p. 31.

bit more problematic. Glaciations is something that would take place in a span of the next 500 human generations. Barring calamities such as volcanoes and asteroids, climactic changes on Earth usually happen very slowly and therefore give life enough time to evolve to cope with the changes. However the immediate problem at hand is not an impending ice age, but rather dramatic changes in climate and weather patterns that will take place during the next two human generations.

However carbon dioxide is not the only greenhouse gas. Methane (CH₄) is responsible for 17% of the planet's warming since the Industrial Revolution began not counting water vapor.⁴⁷ One molecule of methane produces twenty times as much global warming as a molecule of CO₂.⁴⁸ According to the IPCC, the amount of atmospheric methane produced naturally is not outstripped by methane coming from anthropomorphic sources with the two main sources of anthropomorphic methane being cattle herds and byproducts of energy production. Even though methane is twenty times more potent of a greenhouse gas than CO₂, it only makes up a very small portion of the atmosphere and so contributes less to overall global warming than CO₂.

The Super Grid

⁴⁷ Dow, Kirstin, and Thomas E. Downing. *The Atlas of Climate Change: Mapping the World's Greatest Challenge*. Berkeley: University of California, 2006. Print. p. 31.

⁴⁸ "Methane Emissions." *EPA*. Environmental Protection Agency, 9 Sept. 2013. Web. 12 Feb. 2014.

There are few aspects to the climate change problem that are more common sense than the creation of a super grid. Other names for such a project include the smart grid or the Electranet (an internet for electrons). In the case of the smart grid, all of the aspects are already in place. The technology has already been developed and is available, the cost savings would be enormous, many jobs would be created and carbon emissions would be dramatically reduced and eventually eliminated.⁴⁹ The one piece that is missing is the policy aspect of it all. Before solutions to this are proposed, it is necessary to define what a smart grid is.

There are three main elements to it. First, today electricity is made and consumed instantaneously and if one outweighs the other then bad things can happen. As a result a lot of energy is being produced on standby to be ready when needed. This is not only wasteful but if not done correctly one way or the other can lead to blackouts. The fundamental part of a smart grid is to solve this problem through information technology. All aspects of the energy supply chain would automatically communicate with each other and determine where and when energy is needed. This is what occurs now as well but on localized scales. In the future with a smart grid in place, if Los Angeles experiences a heat wave while it is a nice day in Denver then the energy exchange would happen on a national scale. However, even if a smart grid is in place the energy still needs to come from a renewable source in order for climate change to be combated. And it is here that the economics become a bit more problematic at least on the surface.

⁴⁹ Gore, Albert. *Our Choice: A Plan to Solve the Climate Crisis*. Emmaus, PA: Rodale, 2009. Print.

Solar Energy

Grid parity is the moment when sustainable energy sources such as wind and solar become the same cost as traditional fuels. Solar energy for electricity is as of now almost an afterthought in the picture of energy production on this planet. In 2012, solar power accounted for 0.05% of global energy production. As staggeringly small as this is, all the indicators are pointing towards an impending explosion in the use of solar. Its ascent as an industry in the next few decades is likely only to be matched with the growth in computing and DNA technology. Three factors will be behind this. First, once the panels are made the fuel will be free forever. This is a significant advantage over fossil fuels and uranium since sunlight costs nothing. Second, the rate of technological advancement of photovoltaic panels is increasing while prices are dropping. Billionaire entrepreneur Elon Musk equated solar panels with drywall saying that drywall is even more complex to make and distribute than PV panels. Finally with fossil fuels becoming more expensive solar power is achieving grid parity in more and more places. A perfect storm of economics, politics, and technology are coming together to create boom times for solar power.

Thomas Edison once told Henry Ford and Harvey Firestone, “I’d put my money on the sun and solar energy. What a source of power! I hope we don’t have to wait until oil and coal run out before we tackle that”.⁵⁰ It is certainly a good time to be an investor looking to get in at the bottom of an industry. But should governments really risk tax payer money by investing in solar.

⁵⁰ Gore, Albert. *Our Choice: A Plan to Solve the Climate Crisis*. Emmaus, PA: Rodale, 2009. Print. p. 57 + 58.

After all the Obama administration does not have a great track record with this sector. But the reason Solyndra failed was precisely because solar is such an explosive industry. An American company was not able to compete with subsidized Chinese companies that produce PV panels for low costs which they sell to the world.

There are other aspects of solar energy as well. A majority of solar power now produced is actually from solar thermal energy where the sun is used to heat liquids that spin turbines to make electricity. There are solar thermal plants in the US that have been creating clean energy for decades now and ambitious projects are underway in Spain and Australia. There are even far flung ideas of using satellites and mirrors in space to focus solar energy. There are drawbacks to solar power the main one being that a supplementary energy source is required for nighttime and cloudy days. So even if dramatic steps are made to move toward solar, other energy sectors will be required to keep the equation balanced, particularly advancements in energy storage capacity so that solar power can be used at night. The solution to the energy crisis in the 21st Century at least will include not just one element but rather a whole collection of developments and advancements each of which will be a move in the right direction. Therefore existing technologies, such as nuclear, will have their part to play as well.

Nuclear Energy

Not long after the dust settled on the Trinity test site in New Mexico following the detonation of the world's first atomic weapon did scientific attention turn to the possibility of generating electricity with this new found power. The possibilities and the potential were immense. Nuclear power seemed to be too good to be true. It was in essence an almost unlimited

source of energy that produced no greenhouse gas emissions. So the question is why has nuclear energy not become the dominant source of the world's energy. If it had been then climate change would not be the problem it is today.

Some say that it is because public support of nuclear energy has suffered after disasters such as Chernobyl and Fukushima, which is certainly true. No one really wants to live downwind from a nuclear power plant even if there is only a very small change of something going wrong. Second, there is the issue of nuclear waste storage, which has a lifespan of 10,000 years or more. Not only does a suitable place need to be found, but mechanisms need to be put in place to transport some of the most dangerous materials known to man from facility to storage area.

However, both of these issues are not really that problematic. One can envision an offshore island that would house hundreds of nuclear reactors based underground. Waste could be safely locked away underground while any meltdowns could be averted by just flooding the faulty reactor with sea water. Furthermore as everything happens underground even if a catastrophe did occur it would not spread. Vast quantities of power could be then carried by transmission lines to power the economies of Europe and North America. This would remedy both the concern about safety and the problem of waste.

Even if the whole history of nuclear energy is taken into account there have been far fewer deaths as a result from nuclear accidents than there have been over pursuing other energy sources; one can think of coal mining accidents or wars over oil not to mention lung diseases due to air pollution. However even this island strategy would not address the real issue that has, and

probably always will, hamper the growth of nuclear power; concerns behind nuclear weapons proliferation.

Building a weapon and a reactor are not the same thing. However there is sufficient overlap for certain nations to feel weary about others developing nuclear technology, let alone non-state actors. As a result all aspects of nuclear technology are highly regulated and restricted. As nuclear power is not a part of the free market economy there are enormous prices related to it and competition is almost nonexistent.⁵¹

It is not science or engineering that makes nuclear power problematic. The science is well known and efficient enough so that certain government projects such as aircraft carriers, submarines and even the Mars rover run on self generated nuclear power. The peril of nuclear energy is self inflicted by government regulations and the red tape that goes along with them. If a nation such as Israel openly threatens war with Iran because of their nuclear energy program then the future of nuclear energy as an alternative to fossil fuels is not bright. In theory nuclear energy works. In practice it can work as well. However there is still that divide between reason and reality that is so prevalent in many other aspects of the climate change crisis.

Biofuels

No discussion about alternative fuels would be complete without referencing biofuels. Of the 14% of the world's energy that comes from renewable sources, 10% is from traditional

⁵¹ Gore, Albert. *Our Choice: A Plan to Solve the Climate Crisis*. Emmaus, PA: Rodale, 2009. Print. p. 156.

biomass.⁵² A lot of this is the traditional burning of wood and agricultural byproducts. However, increasingly energy crops grown for the sole purpose of being used as biofuel are taking a larger share of the renewable energy sector. Growing crops for fuel seems like a win-win. It is a renewable process that is carbon neutral and therefore does not contribute to climate change. However there are two big issues. First, setting aside farmland for fuel crops creates direct competition with food production and as a result food prices rise. Burning corn in a furnace for power is a tough sell to make to people when malnutrition and food insecurities are present.

Second, in many cases the production of biofuels has been very harmful for the environment and even climate change. Pristine forests in Indonesia have been cleared to produce palm trees that are destined to become fuel. Practices such as this produce far more greenhouse gas emissions than even the conventional burning of fossil fuels. Worse still, they are labeled as green enterprises and gain money from global warming funds. Finally transportation schemes and farming practices that are used in the production of biofuels create great amounts of greenhouse gas emissions. Growing a forest of poplar trees and transporting them to an energy production facility requires enormous amounts of resources including water and fuel.

However when done right biofuels can be part of the solution. While creating energy from corn is wasteful in several ways, using a grass such as miscanthus makes perfect sense.⁵³ It grows in soils that are not ideal for food production, it is easily harvested and grows almost four

⁵² Fridleifsson, Ingvar B. "Status of Geothermal Energy amongst the World's Energy Sources." *Geothermics* 32.4-6 (2003): 379-88. Print

⁵³ Heaton, Emily A., Frank G. Dohleman, and Stephen P. Long. "Meeting US Biofuel Goals with Less Land: The Potential of Miscanthus." *Global Change Biology* 14.9 (2008): 2000-014. Print.

meters in one growing season. It is also a perennial meaning that replanting it is not required. And most significantly, it carries three times the amount of energy as corn. It grows best in the tropics and Brazil, the world's model for biofuels, is planting it together with sugarcane which is the staple of their energy economy.

However, of all of the practical approaches to climate change biofuels have one drastic and easily implementable solution to offer; co-firing woodchips with coal. In other words, if woodchips left over from other industrial processes were burned together in boilers with coal, the United States would see a 20% reduction in carbon dioxide emissions from its coal fired power plants overnight.⁵⁴ The supply of woodchips is there, the cost savings are there and yet this has not happened because no one has taken charge. Even climate experts spend little time discussing this common sense option here in the US. Co-firing should be immediately implemented as a law in the United States and elsewhere.

While woodchips have a smaller energy capacity than coal, woodchips are rich in oxygen and their addition improves combustion efficiency and reduces the requirements on the air supply system.⁵⁵ While this has been solidly demonstrated in studies, there are remarkably few materials out there that discuss the widespread adoption of firing woodchips with coal. There are three possibilities for why this is. First, environmentalists don't like this approach as it does nothing to move away from fossil fuels as an energy source and only marginally reduces

⁵⁴ Gore, Albert. *Our Choice: A Plan to Solve the Climate Crisis*. Emmaus, PA: Rodale, 2009. Print. p. 130

⁵⁵ Ratner, Albert. "CFD Modeling of Co-Firing Wood Chips with Coal for UI Power Plant Boiler 10." *University of Iowa*. 8 August, 2011. Print.

emissions. Furthermore it creates the danger of clearing forests to have a ready supply of woodchips on hand. Second, coal producers don't like the approach either as widespread adoption would instantly create a 20% decrease in the demand for coal.

Perhaps the reason it has not gained more attention is precisely because of its simplicity. It is one thing for President Obama to stand in front of a crowd and boast about carbon capture and storage and clean coal technology and quite another for him to say, sets place some woodchips in the furnaces to cut the amount of coal needed by 20%. Finally it does not really save money for the energy companies as acquiring wood chips and transporting them to coal plants would outweigh the benefits of requiring less coal.

Geothermal Energy

Another alternative to fossil fuels that could play a huge role in the shift to renewable sources is geothermal energy. This form is unique as power is ultimately derived from the Earth itself rather than the sun as is the case with fossil fuels, wind, biofuels, hydroelectricity and of course solar power. In many ways geothermal energy is in the same place oil was a hundred years ago. Back then using oil for energy only made sense where it was readily available at the surface, such as Azerbaijan. Digging for oil appeared to be too cumbersome and complicated especially since firewood was readily available almost everywhere.

In the same manner, people look at geothermal today as a novelty that only makes sense in places such as Iceland and Hawaii where geysers and volcanoes bring heat to the surface. However, if one drills a few kilometers into the earth at almost any location they have

access to an almost unlimited source of heat which can be used to boil water that would be pumped down. This would turn the water into steam which would spin the turbine that would generate electricity. The energy source is immense. According to the UN, geothermal energy resources are 280,000 times as numerous as all the energy needed by humanity in a given year.⁵⁶ However, as of now, the costs are high as well. This changes dramatically when the externalities of climate change are attached to fossil fuels, but since this mechanism is lacking coal and oil are more profitable. There are other aspects to geothermal such as home temperature control systems that are gaining in popularity. And while in theory a comprehensive move to geothermal would solve the climate crisis, the political and economic landscape make this approach extremely difficult to pull off. Solar makes more sense, but geothermal might still be a big piece of the puzzle.

Other Energy Sources

Finally, one source of alternative energy stands out above all the others because of its long history and widespread adoption. 7% of the world's electricity today is generated by hydroelectric dams. Dams are environmentally controversial as they drastically alter the ecosystem and disrupt wildlife. At the same time, taming rivers has saved millions of human lives and allowed for virtually 100% emission free sources of unlimited free energy. There are still significant undeveloped sources of hydro power in the world.

⁵⁶ Gore, Albert. *Our Choice: A Plan to Solve the Climate Crisis*. Emmaus, PA: Rodale, 2009. Print. p. 95.

However, opposition from environmental groups as well as from oil and gas companies is unlikely to make hydroelectric power more widespread which is in a way a shame. There are also other more exotic sources of using water to make energy including using waves and tides, but solar and wind seem to have more momentum when it comes to research and development and will therefore outpace these other possibilities in the near term at least. One thing that is certain though is that things change and ideas that once seemed ludicrous have in time been able to come into their own. There are currently plans that would involve mirrors in space that would focus energy onto a PV satellite that would then beam microwaves down to earth to produce a source of energy. A less controversial approach involves having mirrors reflect sunlight onto major cities and industrial areas at night to save energy.