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Rising Temperatures, Rising Stakes: The Role of International Policy Negotiations in the Climate Crisis

Sarah M. Davis
Fordham University, sdavis36@fordham.edu

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Sarah Davis

Environmental Policy/Studies Department

Fordham College at Rose Hill

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Introduction:

Awareness of anthropogenic climate change as an issue facing the planet, and action to address it, are relatively recent phenomena. The importance of the atmosphere in maintaining the temperature at the surface of the earth, the role of carbon dioxide's and methane's absorption of solar radiation, and the potential for global temperature increases as a result of industrial activities releasing carbon dioxide were first identified in the early 19th century[1]. However, it was not until the 1970s that the World Meteorological Organization (WMO) began to express serious concern that human activities - notably the emission of carbon dioxide - could lead to warming of the lower atmosphere. Scientific concerns about "global warming" grew during the 1980s, and in 1988 these spilled over into political concerns. That year, the WMO and the United Nations Environment Programme (UNEP) established the International Panel on Climate Change (IPCC)[2] to investigate and report on scientific evidence on anthropogenic climate change and possible international responses. This paper explores the subsequent negotiations around the development of climate change policies and their effects from the historical, from the political, and from the economic perspectives of the stakeholder nations.

The IPCC has been central to the subsequent negotiations around the development of climate change policies. Its first and most fundamental assessment report in 1990 fed into the

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[1] IPCC, 2014: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 2014.

[2] Baumert, Kevin A., Timothy Herzog, and Jonathan Pershing. *Navigating the numbers: Greenhouse gas data and international climate policy*. World Resources Inst, 2005.

drafting of the United Nations Framework Convention on Climate Change (UNFCCC) in 1991[3]. In the absence of specific targets, the UNFCCC fell short of the aspirations of many environmentalists and set a dangerous precedent for future negotiations. However it was an important step in establishing foundational principles to guide subsequent debates over national reductions in greenhouse gas emissions. These culminated in a Conference of Parties (COP) meeting in Kyoto, Japan, in 1997[4]. This was the third Conference of Parties meeting (COP-3) where delegates agreed what is known as the Kyoto Protocol. Under this treaty industrial countries agreed to emission reduction targets by 2008-2012 compared to baseline emissions in 1990. For example, the United States agreed to a 7% reduction, France to an 8% reduction, and Japan to a 6% reduction[5]. Developing nations such as China and India were not bound to emissions targets under the treaty, an omission that the United States and some other countries protested. These arguments were supported by major public debates questioning the scientific basis for climate change predictions - with substantial investments by the oil industry, in particular, in lobbying groups questioning or denying climate change[6].

The successive meetings following the Kyoto Protocol, detailed in this paper, culminated in the Paris Agreement adopted in November of 2015. The agreement calls for zero net anthropogenic greenhouse gas emissions to be reached during the second half of the 21st century and calls for the parties to "pursue efforts to" limit the temperature increase to 1.5 °C. While the world lauded the agreement as a triumph towards keeping global temperatures down, others are

[3] IPCC 2014

[4] Oberthür, Sebastian, and Hermann E. Ott. *The Kyoto Protocol: international climate policy for the 21st century*. Springer Science & Business Media, 1999.

[5] Oberthür et al.

[6] Baumert et al.

critical of the accord as being merely a continuation of the trend of voluntary, non-binding target recommendations and ineffectual procedure language that has dominated international climate policy for the past 20 years.

Chapter 1: Quantifying the Crisis

Climate change is a global problem - all nations are involved in both its causes and consequences. This chapter explores the quantitative data surrounding the causes and effects of climate change. Currently developed nations are the largest emitters of greenhouse gases, but emissions by developing nations are projected to grow considerably in coming decades[7]. The most recent scientific evidence indicates that effects during the twenty-first century may range from a global temperature increase of 1.5°C (2.7F) to 4.8°C (8.6F)[8]. In addition to simply warming the planet, other predicted effects include disruption of weather patterns and possible sudden major climate shifts. The problems associated with the climate crisis are innumerable: rising sea levels due to the melting of the polar ice caps contribute to greater storm damage; warming ocean temperatures are associated with stronger and more frequent storms; additional rainfall, particularly during severe weather events, leads to flooding and other damage; an increase in the incidence and severity of wildfires threatens habitats, homes, and lives; and heat waves contribute to human deaths and other consequences[9].

The key term in any attempt quantifying the climate crisis is *uncertainty*: as famously stated by oceanographer Roger Revelle in his 1957 paper with Hans Suess, "...human beings are

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[7] IPCC 2014

[8] Baumert et al.

[9] Miller, George, and Scott Spoolman. *Living in the environment: principles, connections, and solutions*. Cengage Learning, 2011.

now carrying out a large scale geophysical experiment of the kind that could not have happened in the past." When the quantitative implications of climate change on health are estimated, uncertainties arise from many sources and the issues associated with an increase in surface temperature are many and varied. The global average surface temperature has increased by 0.8°C in the last century and by 0.6°C in the last three decades[10]. Climate modeling has also predicted further global warming by several degrees Celsius by the end of the current century[11] dependent on the rate of greenhouse gas (GHG) emissions. Climate change is anticipated to be an integral health determinant for people in vulnerable areas[12]. Additionally, there are growing concerns that climate change will be responsible for deaths from malnutrition because of diarrhea, drought and agricultural failure, vector-borne infectious diseases, such as malaria[13], and respiratory diseases. From a policy perspective, it is imperative that these uncertainties be presented in unambiguous ways in any study of the future impacts of climate change[14]. Otherwise, rather than being helpful for policymakers, such studies may give misleading projections of the impacts of climate change.

Regardless of the degree of uncertainty, the physical impacts of anthropogenic climate change – both impending and currently manifesting - are very real and very dangerous. This first

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[10] 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, no. 39 (2006)

[11] Solomon, Susan, ed. *Climate change 2007-the physical science basis: Working group I contribution to the fourth assessment report of the IPCC*. Vol. 4. Cambridge University Press, 2007.

[12] Confalonieri, Ulisses, Bettina Menne, Rais Akhtar, Kristie L. Ebi, Maria Hauengue, R. Sari Kovats, Boris Revich, and A. J. Woodward. "Human health." *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (2007).

[13] Tanser, F.C., Sharp, B. and Le Sueur, D., 2003. Potential effect of climate change on malaria transmission in Africa. *The Lancet*, *362*(9398), pp.1792-1798.

[14] Campbell-Lendrum, Diarmid, and Rosalie Woodruff. "Comparative risk assessment of the burden of disease from climate change." *Environmental health perspectives* (2006): 1935-1941.

chapter details the 10 most urgent impacts agreed on by the global scientific community as likely to occur. Unless otherwise noted, each effect assumes a temperature rise of 2 degrees Celsius (3.6 F) by the year 2100 (a value which the IPCC has suggested we are "more likely than not" to exceed) and a sea level rise of 0.5 meters (1.5 feet) by 2100[15]. It should be noted that this is a relatively conservative estimate - other studies predict significantly more sea level rise.

1. The costs of climate change will exceed hundreds of billions of dollars per year.

Forced relocation, extinctions, asset destruction, droughts, and all other negative externalities will cost the global economy a great deal. The Natural Resources Defense Council recently reported that the US Climate Disruption Budget – which deals with costs related to drought, storms, and growing climate disruptions - was nearly $100 billion this past year[16]. According to the Climate Vulnerability Monitor, climate change costs are expected to cost the global economy $700 billion annually by the year 2030[17]. As climate change continues to worsen (and as examined further in Chapter 4) costs will continue to rise. Efforts to mitigate the extent of the damage will not be inexpensive either - for instance, putting the world on a path for sustainable energy production will cost $53 trillion, according to the International Energy Agency's World Energy Investment Outlook[18]. However, it is important to emphasize that these investments are likely to save money in the long-term.

[15] IPCC 2014

[16] O'Sullivan, Terrence M. "Environmental Security is Homeland Security: Climate Disruption as the Ultimate Disaster Risk Multiplier." *Risk, Hazards & Crisis in Public Policy* 6, no. 2 (2015): 183-222.

[17] Kjellstrom, Tord, Bruno Lemke, Matthias Otto, Olivia Hyatt, David Briggs, and Chris Freyberg. "Climate Change and increasing heat impacts on Labor Productivity." (2015).

[18] Smith, M. *Doubling Energy & Resource Productivity by 2030–Transitioning to a Low Carbon Future through Sustainable Energy and Resource Management*. ANU Discussion Paper, 2015.

2. Hundreds of millions of people will experience forced displacement by 2050.

According to the Internal Displacement Monitoring Center, "98% of all displacement in 2012 was related to climate- and weather-related events[19]. Antonio Guterres, the UN High Commissioner for Refugees agrees, stating that climate change is likely to become the biggest driver of forced migration and displacement. In 2008, 36 million people were displaced globally by natural disasters - at least 20 million of those people were driven from their homes by disasters related to climate change, like drought and rising sea level. The UN anticipates that countries in the Southern Hemisphere will be most affected by displacement in the future. If this happens, "not only states, but cultures and identities will be drowned," Guterres said at a 2009 conference[20]. The Internal Organization for Migration estimates that 200 million people by 2050 could be forced to leave due to environmental changes. Even more alarming, a 2014 study published in Environmental Research Letters predicted that sea level rise created by a temperature increase of 3 degrees Celsius would force more than 600 million people to find new homes[21].

3. Water scarcity will affect hundreds of millions of additional people by 2100.

According to a recent study, in 2013, over 1.3 billion people lived in water-scarce regions. Researchers estimated that an additional 8% of the world's population would enter a state of

[19] Center, Internal Displacement Monitoring. "Iraq IDP Figures Analysis."*Updated January* 15 (2015): 2015.

[20] Hall, Nina. *Displacement, development, and climate change: international organizations moving beyond their mandates*. Routledge, 2016.

[21] Center, Internal Displacement Monitoring 2015

"new or aggravated water scarcity" due to climate change at the projected 2 degree Celsius temperature increase[22].

4. Thousands of species will lose their native habitats.

While habitat destruction and over-exploitation are the major threats to most species today, many experts agree that climate change will become the greatest cause of declines and extinctions in the near future. A study published last year in the journal *Nature* projected that nearly half of all plants and a third of animals will experience the loss of more than 50% of their current range by the year 2080. As a result, the researchers predicted a "substantial reduction in biodiversity" by the end of the current century[23].

5. 20 million additional children will face starvation by 2050.

A report from the World Food Program expects extreme weather events like droughts, floods, tropical cyclones, and forest fires to wreak extensive damage on farmlands, threatening food security for millions of people[24]. The report estimated that climate-based impacts on crop yields will increase the number of malnourished children by around 10 million in Africa, 11 million in Asia, and 1.4 million in Latin America. By 2050, crop yields in Asia are expected to

[22] Larsen, Stefano, Jeffrey D. Muehlbauer, and Eugenia Marti. "Resource subsidies between stream and terrestrial ecosystems under global change."*Global change biology* (2015).

[23] Warren, R., J. VanDerWal, J. Price, J. A. Welbergen, I. Atkinson, Julián Ramirez-Villegas, T. J. Osborn et al. "Quantifying the benefit of early climate change mitigation in avoiding biodiversity loss." *Nature Climate Change* 3, no. 7 (2013): 678-682.

[24] Downing, Thomas E., ed. *Climate change and world food security*. Vol. 37. Springer Science & Business Media, 2013.

fall by 50% for wheat and 17% for rice compared to 2000 levels. This will threaten billions of people worldwide who rely primarily on agriculture for their livelihoods.

6. Growing droughts will make the driest regions even drier.

Using precipitation data from 28 different scientific models, a 2014 study published in the journal *Nature* projected the frequency of “dry days” around the world and found that Western Indonesia, parts of Central and South America, and the Mediterranean Sea region would accrue up to 30 extra “dry days” per year compared to the 1960 to 1989 average by the end of the century[25]. Droughts could pose a variety of threats, according to the IPCC. In areas of higher drought, water stores will not be replenished and water pollutant concentrations could rise[26].

7. There could be no more reefs after 2050.

Climate change creates unsuitable conditions for the survival of coral reefs. If global and local reef threats continue, all reefs could be at risk of disappearing by 2050, according to the findings of the World Resources Institute[27]. Rising ocean acidity created by higher carbon dioxide levels means fewer carbonate ions, a key ingredient for coral skeleton building. According to the report, ocean carbonate levels have dropped by 25% since preindustrial times. "Corals cannot survive more than a 2 degree global average temperature increase over pre-industrial levels before coral is no longer able to replace itself faster than coral bleaching will destroy it," the report said. Temperatures are expected to rise at least that much by 2100.

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[25] Nature 2014

[26] IPCC 2014

[27] Burke, Lauretta Marie, Jonathan Maidens, M. Spalding, P. Kramer, and E. Green. *Reefs at Risk in the Caribbean*. Washington, DC: World Resources Institute, 2004.

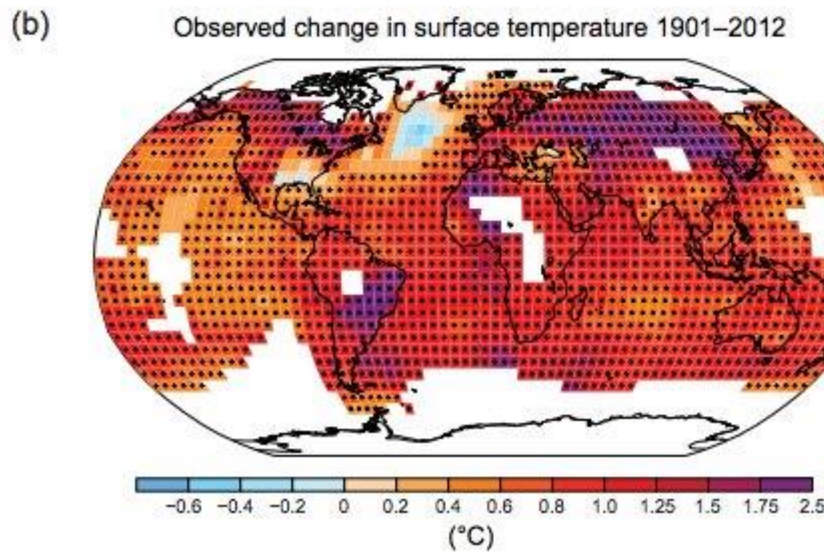

Figure 1: "Observed change in surface temperature".[28]

Losing these reefs will also take a huge toll on tourism and industry. According to the World Resources Institute, coral reefs provide tourism-related income to at least 94 countries[29]. Australia will losses of up to$6 billion and over 63,000 jobs from Great Barrier Reef damage. 70% of the countries and regions most vulnerable to reef damage are small-island states. The nine countries considered most extremely vulnerable to reef degradation, including Haiti and Fiji, are dependent on the reefs and "have limited capacity to adapt to reef loss," the report wrote. Besides being biodiversity hotspots, coral reefs act as a buffer to storms and erosion. 100 countries globally could lose coastal protection along almost 100,000 miles of shoreline.

8. The marine food chain could fall apart.

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[28] World Resources Institute, 2004

[29] World Resources Institute 2004

Unfortunately, corals aren't the only organisms that suffer greatly from ocean acidification. Animals such as sea urchins, mollusks, and some types of plankton are also expected to suffer as the average ocean pH drops. Most of these species are crucial to the marine ecosystem and provide an important food source for larger organisms. Their population loss has the potential to cause a shift in the entire marine food web[30].

9. Coastal cities risk millions of lives and trillions of dollars in assets.

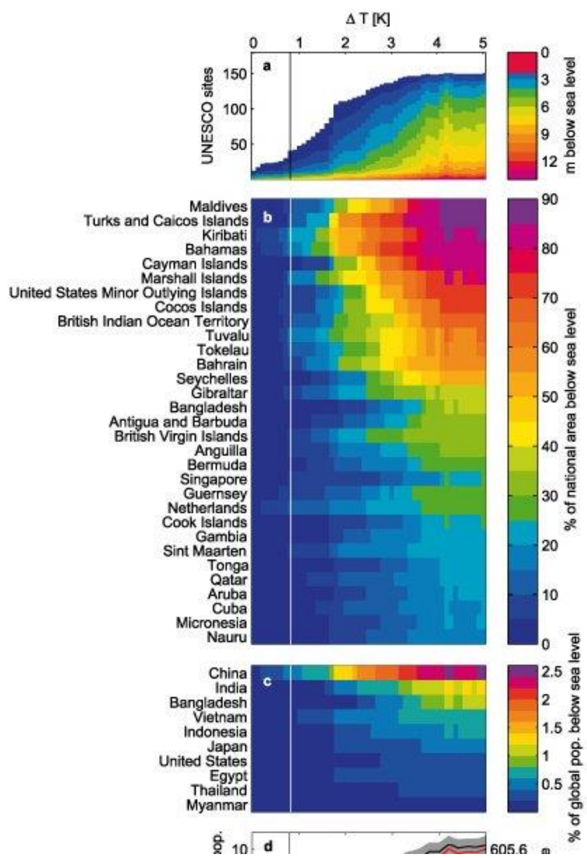

Figure 2 *"Loss of cultural world heritage and currently inhabited places to sea-level rise," Ben Marzeion and Anders Levermann*[31]

[30] IPCC 2014

[31] Marzeion, Ben, and Anders Levermann. "Loss of cultural world heritage and currently inhabited places to sea-level rise." *Environmental Research Letters*9, no. 3 (2014): 034001.

Assuming a sea-level rise of .5 meters by 2070, with an extra .5 to 1.5 meters to account for storms, a 2008 study ranked the most exposed cities in the world[32]. The analysis found enormous potential losses in cities around the world. Calcutta, India in particular may be the most exposed, with 14 million people and $2 trillion in assets at risk. Miami also may face staggering losses, with 4.8 million people and $3.5 trillion at risk.

10. Entire small island nations could be destroyed.

Low-lying tropical islands are particularly vulnerable to sea-level rise. "It has been suggested that the very existence of some atoll nations is threatened by rising sea levels associated with global warming," the IPCC has said[33]. Additionally, the IPCC estimated that out of the 10 nations ranked with the highest mitigation cost as compared to their GDP, eight were island nations. Sea-level rise leads to erosion, stronger storm surge, and flooding, which place these small islands and coastal regions at risk for even more damage. Climate change will also wound fisheries, agriculture, and tourism in these regions. Baron Waqa, chair of the Alliance of Small Island States and president of Nauru, presented an address at the 2014 UN Climate Summit in which he stated, “no one better understands the grave risks posed by climate change than SIDS [Small Island Developing States]. Climate change and sea level rise are already threatening our viability and even our existence as sovereign nations."34

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[32] Nicholls, Robert J., Susan Hanson, Celine Herweijer, Nicola Patmore, Stéphane Hallegatte, Jan Corfee-Morlot, Jean Château, and Robert Muir-Wood. "Ranking port cities with high exposure and vulnerability to climate extremes." (2008).

[33] IPCC 2014

[34] Ashe, John W., Robert Lierop, and Anilla Cherian. "The role of the alliance of small island states (AOSIS) in the negotiation of the United Nations framework convention on climate change (UNFCCC)." In *Natural Resources Forum*, vol. 23, no. 3, pp. 209-220. Blackwell Publishing Ltd, 1999.

Climate change has already started to cause a wide range of physical effects— with serious implications for all of the Earth's inhabitants, including investors and businesses. While weather variability and extremes have always existed, the science shows that extreme weather events are becoming more frequent and intense, that incremental climatic changes are already underway, and that the impacts of climate change are expected to grow more severe over the coming years and decades, assuming the IPCC's expected 2 degree Celsius temperature increase. The following chapter will explore the history of the discovery of anthropogenic climate change and the precedent for policy set by previous international environmental agreements.

Chapter 2: **Setting the Precedent: Climate History and the Montreal Protocol**

This chapter will explore the historical precedent set by landmark international environmental treaties considered to have occurred before the political onset of the climate crisis, primarily the Montreal Protocol. The Montreal Protocol's success is based on the combination of incentives to act multilaterally, a strong leadership-role of the US as the main polluter, its infinite time-frame, the benefits from international ozone layer protection for each country, enforcement by trade restrictions, deterring from free-riding by endogenous minimum participation requirements, but most notably the self-interest of the US to act domestically regardless of an international agreement[35][36].

Studying the historical aspect of human interaction with Earth's ecosystems is vital to understanding the influence of nature on human culture on society. Without an in-depth

[35] Penner, Joyce E. *Aviation and the global atmosphere: a special report of IPCC Working Groups I and III in collaboration with the Scientific Assessment Panel to the Montreal Protocol on Substances that Deplete the Ozone Layer*. Cambridge University Press, 1999.

[36] Miller

understanding of environmental history, it would be impossible to address complex problems, like climate change or ozone depletion, and to help find solutions for them. Awareness of anthropogenic climate change as an issue facing the planet, and action to address it, are relatively recent phenomena. In the mid-1950s, there were few scientists who were concerned that humans were adding excessive carbon dioxide gas (CO2) to the atmosphere by the burning of fossil fuels - hypotheses that atmospheric carbon could change the climate had been abandoned decades earlier by nearly everyone[37]. The foremost particularly simple but strong argument was that the added gas would not linger in the air and that most of the CO2 on the surface of the planet was not locked in the atmosphere but instead dissolved in the huge volume of water in the oceans[38]. By this theory, it would seem obvious that no matter how much additional anthropogenic carbon we might pour into the atmosphere, nearly all of it would wind up safely buried in the depths of the ocean.

The theory was disproved, albeit indirectly, by researcher Hans Suess who developed a method of measuring carbon isotopes in the annual rings of old trees collected from various regions[39]. Initially, Suess had little idea how his carbon research would have practical use for climate studies - he and his colleagues were simply interested in learning more about how carbon cycled through the atmosphere and using that knowledge to make the carbon-14 dating technique more reliable. In 1955 Suess detected a "contamination" of recent wood by stable carbon - this carbon had to come from the burning of fossil fuels. Carbon-14 is continuously renewed in the atmosphere as rays from the sun hit nitrogen atoms and convert them to the isotope, but in

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[37] Penner, 1999
[38] Lamb, Hubert H. *Climate, history and the modern world*. Routledge, 2002.
[39] Revelle, Roger, and Hans E. Suess. "Carbon dioxide exchange between atmosphere and ocean and the question of an increase of atmospheric CO2 during the past decades." *Tellus* 9, no. 1 (1957): 18-27.

ancient coal and oil, the radioactive carbon-14 has all decayed away. Although Suess's measurements were very preliminary, his report pointed to a new research opportunity - just as he had discovered how to quantify the CO2 that was absorbed by old trees, he might now measure how it was absorbed by the oceans[40].

Very little was known about how carbon factored into oceanic chemistry - ignorance was just as great regarding the “turning over” of ocean waters, which refers to the mixing of the volume of benthic water with water towards the surface of the ocean - this was a particularly politically-charged scientific problem, since Japan was very concerned with the rate of turnover for nuclear fallout absorbed by the ocean. Oceanographers in 1955 admitted that "nobody knows whether it takes a hundred years or ten thousand" for this process to complete. One researcher at the Scripps Institute of Oceanography, Roger Revelle, was particularly interested in this scientific puzzle - and especially why oceans didn't absorb *all* CO2. Ongoing nuclear tests in the Pacific created massive amounts of radioactive carbon isotopes. Carbon isotopes as large as carbon-22 and as small as carbon-8 were created - many of these had a half-life of milliseconds or less. However, carbon-11 has a half-life a little over 20 minutes - a much better time frame for conducting experiments. While Revelle didn't use the C-11 created by nuclear explosions, carbon-11 did give him the idea to create CO2 using carbon-11 and see how it reacted when exposed to ocean water. The substance was radioactive enough to be very easily traceable, but would not decay immediately. Here, the mechanism for tracing carbon throughout it cycle in the biosphere was fundamentally created[41].

[40] Revelle and Suess, 1957

[41] Revelle and Suess, 1957

What he found was densely complicated[42] - ocean water is not just sodium chloride, but is a complex combination of thousands of chemicals, sediments, and living organisms. That being known, there are then seemingly countless numbers of reactions that CO2 can make with the different components of seawater. To give a brief synopsis of Revelle's findings, it had been suspected that the oceans had what became referred to as a "buffering mechanism". What Revelle discovered was that in many cases, CO2 combined with chemicals in the seawater and created volatile compounds that quickly evaporated back into the air. Once these molecules were back in the atmosphere, the carbon would encounter free oxygen, or be dissociated by ultraviolet light, and create CO2. When he raised CO2 concentrations slightly, to 350 ppm (parts per million) or 400 ppm in the atmospheric samples over the tanks of seawater, molecules containing the radioactive carbon-11 were returned back to the air in significant amounts, while significantly less carbon-11 remained in the seawater. In 1955 and 1956 he determined that when CO2 in the atmosphere was increased, about half of what the oceans absorbed would be evaporated out from these volatile organic compounds within a year - a significant amount more than the zero that had been initially theorized.

Perhaps the most contextually relevant part of the paper he co-authored with Suess occurs in the final section - Revelle wrote in a few sentences at the end that assuming that CO2 emissions stayed at 1957 levels, CO2 would rise in the atmosphere about 40% (to 440 ppm) over the next few centuries and stabilize. He then made a very pointed (and from today's climate science perspective, a very prophesizing) statement - before he sent off the paper he had written

[42] Lamb, 2002

with Suess for publication, he added a remark that the accumulation of gas "may become significant during future decades if industrial fuel combustion continues to rise exponentially."[43] However, Revelle's work was also incomplete. While he succeeded in identifying some of the main chemical pathways by which CO2 dissolved in the oceans returns to the atmosphere in volatile compounds, many other oceanographers and chemists have been working since to identify other pathways and have that thousands of them exist[44]. Individually, most are negligible - but together they create a significant fraction of carbon dioxide atmospheric return. The gains to climate science from this paper were certainly enormous, but much was also to be gained politically and socially in terms of a newfound awareness of a global warming problem - Revelle and Suess might not have set out to change the face of the environmentalist movement, but that’s exactly what they did. Contextually, when this paper was published in 1957, American cities were engulfed in a smog of pollution left by the crude-burning internal combustion engines and poorly refined gasoline that powered cars and trucks and from the uncontrolled emissions from power plants and factories. There was a serious - and very valid - concern about the health consequences of this excessive pollution. As a result, a strong environmental movement was beginning to demand action. Coupled with this newly published data from Revelle and Suess, climate fears that had previously been considered unfounded began to take on scientific substance[45].

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[43] Revelle and Suess, 1957

[44] Lamb, 2002

[45] Moser, Susanne C. "Communicating climate change: history, challenges, process and future directions." *Wiley Interdisciplinary Reviews: Climate Change* 1, no. 1 (2010): 31-53.

Coupled with this newfound knowledge of anthropogenic climate change is the precedent set by international negotiations whose purpose was to address global environmental problems. Although nations were eager to engage in dialogue about the potential solutions to the new "global warming" problem, their error came in following the primary example of the 1987 global agreement which addressed the depletion of the ozone layer. The remainder of this chapter (and Chapter 3) discusses the pitfalls of basing climate policy on the Montreal Protocol's example. Setting the precedent for future international policy negotiation, and the Montreal Protocol is considered the most effective environmental treaty ever implemented[46]. While no single factor led to its success, there was an unprecedented level of cooperation and commitment shown by the international community during its negotiation. Inhabiting an Earth without the Montreal Protocol would, essentially, be impossible: two-thirds of the ozone layer would have been destroyed by 2065, and the UV index (a measure of the strength of the sun's ultraviolet radiation) would have tripled with tropical biomes experiencing a particularly large increase in UV rays reaching Earth's surface[47]. While the Montreal Protocol was undoubtedly a success for the international environmental community, it set a very dangerous precedent for future climate negotiations (particularly the Kyoto Protocol). Simply stated, the two vastly different ecological problems (though both dealing fundamentally with atmospheric conditions) were treated too similarly in the political and economic arena. Stakeholders assumed that what worked in Montreal would work in Kyoto - an enormous misstep that has led to years of political discord.

[46] Penner, 1999

[47] Murdoch, James C., and Todd Sandler. "The voluntary provision of a pure public good: The case of reduced CFC emissions and the Montreal Protocol." *Journal of Public Economics* 63, no. 3 (1997): 331-349.

The Montreal Protocol broke new ground in its negotiation and in its construction. It was ratified or accepted by all 197 UN member states, a world first for any treaty and highlighting the strong global commitment to this treaty[48]. Most importantly, it is doing its job well - the ozone layer is expected to return to 1980 levels between 2045 and 2060 as long as all countries continue to meet their obligations and phase out the last ozone-depleting substances in the next few years[49]. Frankly, no other international agreement demands so much from so many parties. However, the cuts in emissions that its signatories promised have actually been fully implemented. More surprisingly, it has been expanded - there are few countries with working governments that have not signed on. Not least, the agreement covers more substances and has grown to demand not just the 50% emissions cut originally agreed upon, but a comprehensive emissions ban[50]. Despite the fact that it demands so much from so many stakeholder parties, the Montreal Protocol succeeded where the Kyoto Protocol failed due in part to its ability to reverse the incentives to free ride. Only a handful of other treaties have altered the rules of the game and worked in such a self-enforcing way.

Politically and economically, the treaty was able to offer big gains to the biggest player: the United States, both the world's largest producer and consumer of chlorofluorocarbons (CFCs). If the US alone had cut its output of CFCs, the treaty would have done well - the gains in terms of lives saved would have been worth more than a trillion dollars - 65 times the costs[51].

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[48] Penner, 1999

[49] Murdoch, 1997

[50] Chipperfield, M. P., S. S. Dhomse, W. Feng, R. L. McKenzie, G. J. M. Velders, and J. A. Pyle. "Quantifying the ozone and ultraviolet benefits already achieved by the Montreal Protocol." *Nature communications* 6 (2015).

[51] Longhofer, Wesley. "From Precaution to Profit: Contemporary Challenges to Environmental Protection in the Montreal Protocol By Brian J. Gareau. Yale University Press. 2013. 384 pages.*Social Forces* 94, no. 1 (2015)

However, America had even more to gain from signing on to a treaty - three times as much, according to an Environmental Protection Agency analysis completed at the time. Huge gains came largely from eradicating the health risk that ozone depletion entails - the EPA calculated that implementing the Montreal Protocol would prevent 245 million cancers, including more than 5 million cancer deaths, by 2165[52].

One extremely serendipitous aspect of the Montreal Protocol was that the costs of implementing CFC cuts were relatively low - an undeniably fortuitous aspect of the treaty that owes to the coincidence of negotiations with the expiration of CFC patents and substitutes for most uses of CFCs becoming widely - and affordably - available. These particularly situational political and economic differences– the ability and incentive for parties to immediately adopt low-cost alternatives to emission-causing substances – is the main reason why climate-change negotiations the Kyoto Protocol have failed where treaties like the Montreal Protocol succeeded. Some economists argue that climate crisis is less “profitable” to stakeholder nations than the ozone crisis. In the case of the climate crisis, the balance of benefits and costs is much less favorable than it was in the case of ozone depletion. Some adaptation to climate change is likely to reduce the damage, as farmers develop new techniques and biotechnology engineers develop new varieties of crop. In addition, agriculture in some countries (such as Canada and Russia, both giant producers of fossil fuels may benefit from climate change, even if farmers in other lands do worse (while no region benefits from ozone depletion). In monetary terms, the benefits from avoiding climate change are likely to be lower than those from protecting the ozone layer.

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[52] Titus, James G., ed. *Effects of Changes in Stratospheric Ozone and Global Climate: Sea level rise*. Vol. 4. US Environmental Protection Agency, 1986.

But the costs of adjustment appear to be much higher: the economies of most rich countries are built around the automobile and around electrical power generated with fossil fuels. No easy substitutes exist to replace fossil fuels in power stations and vehicles. According to the EPA, the estimated the payoff to the United States from the Montreal Protocol, even from unilateral measures to tackle ozone depletion, is 65 times the costs[53]. The best estimates regarding climate change reckon that the benefits of measures to reduce global emissions by just over 5% by 2015 would only be 3 times the costs. To achieve the targets implied in the Kyoto Protocol, the United States (easily the world's biggest source of GHG's) would have to cut its output by 30-35 percent in 2008-12, from the business-as-usual level[54]. It is no surprise, then, that President Bush rejected the treaty. Even if Al Gore had been president, the Senate would have been unlikely to ratify such a costly pledge. The following chapter will explore the politics of Kyoto Protocol, and all the following attempted global agreements, more in-depth.

Chapter 3: **Political Players on an International Stage**

The 1997 Kyoto Protocol had a number of weaknesses that defined the key political stakeholders in climate policy. These include an early expiration date, the withdrawal of US participation, and the path-dependent agreement to only account for the emissions of countries considered as industrialized countries in the early 1990s[55]. Since then, the international negotiation position of the key emerging economies have remained within the traditional win-

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[53] Longhofer, 2015

[54] Moser 2010

[55] Bodansky, Daniel, Sophie Chou, and Christie Jorge-Tresolini. *International climate efforts beyond 2012: A survey of approaches*. Washington, DC: Pew Center on Global Climate Change, 2004.

lose mindset of sharing burdens; the costs associated with mitigation efforts and reduced economic growth are high, although the long-term prospects from climate mitigation outweigh the short-term investments. However, the same governments who, as this chapter will examine, continuously refuse to accept a legally binding international deal that removes the differentiation of industrialized and developing countries (without any emission reduction commitments under the Kyoto Protocol) are embracing green growth strategies in the name of poverty alleviation and economic development[56]. These include Brazil, South Africa, China, and India. This chapter will explore in-depth stakeholder participation and influence at UN negotiations including and since Kyoto.

The Kyoto Protocol arose from the United Nations' Earth Summit held in Brazil in 1992. Identifying an urgent need to cut greenhouse gas emissions, the organization proposed a treaty that would help stabilize emissions " at a level that would prevent dangerous anthropogenic interference with the climate system." It was assembled from of a complicated process of scientific assessment and international negotiations. At the time that the agreement was signed, the world hailed it as one of the greatest achievements in international relations - not only was it able to address the scientific concerns of the IPCC, it did so in a way that accounted for the "common but differentiated responsibilities" of countries. Specifically, Kyoto's had two main goals: reduce greenhouse gas emissions by a least 5% of the 1990 levels in Annex I countries, and encourage transfer of green technologies among all signatory nations. The Kyoto Protocol

[56] Kasa, Sjur, Anne T. Gullberg, and Gørild Heggelund. "The Group of 77 in the international climate negotiations: recent developments and future directions." *International Environmental Agreements: Politics, Law and Economics* 8, no. 2 (2008): 113-127.

therefore adopted a combination of greenhouse gas reduction obligations for Annex I countries and 3 flexibility emissions-trading mechanisms: join implementation (JI), emissions trading, and the Clean Development Mechanism (CDM).

JI sought to encourage technology transfer by allowing Annex I countries to commence an emissions - reduction project in another Annex I country in exchange for emissions permits. The emission trading scheme would allow an Annex I country to sell any unused permits to another Annex I country. The idea, commonly known as “cap and trade”, is that by creating a market for emissions, nations will have the incentive to find ways to reduce emissions so that they can sell any excess permits and create a profit; countries that are unable to meet their reductions obligations will be able to buy permits from more “efficient” countries.

Last, the CDM sought to extend emissions reductions even further to non-Annex I countries by allowing an Annex I country to earn credit by creating an emissions reduction project in a non-Annex I country. The logic was to encourage Annex I countries to exploit cheap opportunities to reduce emissions in poor countries, as well as promote technology transfer. By not requiring developing countries to commit to emissions reductions, but encouraging cooperation between Annex I and non-Annex I countries, Kyoto’s architects believed the Agreement would divide reduction burdens efficiently, but also based on wealth. These economic mechanisms will be examined in more detail in Chapter 4.

Despite this 3-pronged approach (structured similarly to the Montreal Protocol), the Kyoto Protocol failed miserably to reduce greenhouse gas emissions worldwide. Most criticism of the Protocol has addressed its deficient structure, such as the agreement’s inability to implement the emissions trading scheme. Some blame the failure on the exemption of developing countries from reductions requirements, or the United States' refusal to ratify the agreement (the US's leadership in the Montreal Protocol accounts for much of its success).

However, it is clear that these deficits are symptoms of a larger problem - at a fundamental level, Kyoto's failure is a problem of collective action. Explored further in the following chapter on climate economics, the problem of climbing C02 levels is our Earth's greatest example of the "tragedy of the commons". Simply stated, given the diffuse nature of common goods (such as the atmosphere), an individual stakeholder's benefit of the provision of a common good is negative from a national perspective. Essentially, any state reducing pollution emissions is paying the whole of the costs of those emission reductions in the short term, while only receiving a fraction of the benefits as the positive externalities cross borders and are only realized in the longer term.

Countries that have failed to reduce emissions have stated their decision to defect was due to the negative effects this would have on short term growth objectives. The greater importance states appear to place on short term growth over longer term emissions reductions suggests that states have low discount rates regarding the environment, meaning that they value gains accrued in the present more than the future. This find corresponds with work done by Duncan Brack.3

Second, although states may want to see global pollution emissions reduced, the incentive to free ride (i.e. not incur the short term costs of cooperation) is high given the large number of participants in the agreement. The larger the group size the less likely a cheater will be reprimanded as the effects of cheating will be spread among the larger group. The fact that the individual net benefit of participation is negative, and the incentive for free riding is high, has made attempts at coordinating pollution emissions reductions difficult.

Given this, while future protocols may include emissions trading schemes, or binding commitments for developing countries, they are unlikely to be successful as they will still not address the fundamental problem of collective action. Since Kyoto, there have been numerous attempts at reaching global consensus on the climate policy front. The remainder of this chapter details the timeline of attempted agreements since the UNFCCC's establishment:

Earth Summit, 1992: At the so-called Earth Summit (also known as the UN Conference on Environment and Development) in Rio De Janiero, Brazil, the UN Framework Convention on Climate Change (UNFCCC) was adopted and opened for signatures[57]. 154 signatories to the UNFCCC agreed to stabilize "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system." The US was the fourth nation overall and the first industrialized nation to ratify the UNFCCC. Because it sets no mandatory limits on GHG emissions, the treaty is not legally binding - instead, the treaty provides for future negotiations to set emissions limits[58]. The first principal revision is the Kyoto Protocol.

COP 1, 1995: The first Conference of the Parties (COP 1) to the UNFCCC was held in Berlin, Germany. Parties agreed that the original mechanisms drafted in the UNFCCC were inadequate and agreed to what would was called the Berlin Mandate, which allows parties to make specific commitments. Under the Berlin Mandate, non-Annex 1 countries are exempted from additional obligations[59].

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[57] Secretariat, Climate Change. "United Nations Framework Convention on Climate Change." *UNEP/IUC. Geneva* (1992).

[58] French, Hilary F., Erik Hagerman, and Megan Ryan. *After the Earth Summit: the future of environmental governance*. Vol. 107. Washington, DC: Worldwatch Institute, 1992.

[59] Boyd, Emily, Esteve Corbera, and Manuel Estrada. "UNFCCC negotiations (pre-Kyoto to COP-9): what the process says about the politics of CDM-sinks." *International Environmental Agreements: Politics, Law and Economics* 8, no. 2 (2008): 95-112.

COP 2, 1996: COP 2 was held in Geneva, Switzerland. Attending parties supported the results of the IPCC's second ever assessment report. The nations noted, but did not adopt, the Geneva Ministerial Declaration, which in part called on parties to accelerate negotiations on a legally binding protocol[60].

COP 3, 1997: COP 3 was held in Kyoto, Japan. The Kyoto Protocol was adopted on December 11th with more than 150 signatory nations. As previously discussed, the Protocol included legally binding emissions targets for developed country Parties for the six major GHGs. The Protocol offered additional means of meeting targets by way of three market-based mechanisms: emissions trading, the Clean Development Mechanism (CDM), and Joint Implementation (JI). Under the Protocol, industrialized countries' actual emissions have to be monitored and precise records have to be kept of the trades carried out.

COP 4, 1998: COP 4 was held in Buenos Aires, Argentina – attending parties adopted what was called the Buenos Aires Plan of Action, which allowed a two-year period to develop mechanisms for implementing the Kyoto Protocol. The COP also decided it would be necessary to review the financial mechanism of the agreement every four years[61].

COP 5, 1999: COP 5 was held in Bonn, Germany. Parties continued negotiation efforts with a focus on "the adoption of the guidelines for the preparation of national communications by

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[60] Jagers, Sverker C., and Johannes Stripple. "Climate Govenance beyond the State." *Global governance* 9 (2003): 385.

[61] Parry, Martin, Nigel Arnell, Mike Hulme, Robert Nicholls, and Matthew Livermore. "Adapting to the inevitable." *Nature* 395, no. 6704 (1998): 741-741.

[developed] countries, capacity building, transfer of technology and flexible mechanisms", but no formal treaty or agreement was reached according to the UNFCCC[62].

COP 6, 2000: The first part of COP 6 was held in The Hague, Netherlands. Negotiations faltered, and parties agreed to meet again. The second portion of COP 6 was again held in Bonn, Germany – this time, a consensus was reached on what was called the Bonn Agreements. All nations except the United States agreed on the mechanisms for implementation of the Kyoto Protocol. The US declined to join and was involved in observational capacity only[63].

COP 7, 2000: COP 7 was held in Marrakesh, Morocco. The official details regarding the implementation of the Kyoto Protocol were adopted and referred to as the Marrakesh Accords. Additionally, the meeting established the Special Climate Change Fund (SCCF), whose reported purpose was to "finance projects relating to: adaptation; technology transfer and capacity building; energy transport, industry, agriculture, forestry and waste management; and economic diversification." A Least Developed Countries Fund was also established in order to "support a work program to assist Least Developed Country Parties (LDCs) carry out, inter alia [among other things], the preparation and implementation of national adaptation programs".

COP 8, 2002: COP 8 was held in Delhi, India. Present parties adopted the Delhi Ministerial Declaration that primarily called for developed countries to transfer technology to developing countries[64].

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[62] Fletcher, Susan R. "Global climate change: the Kyoto Protocol." Congressional Research Service, Library of Congress, 2001.

[63] Jagers et al., 2003

[64] Jagers et al. 2003

COP 9, 2003: COP 9 was held in Milan, Italy. The negotiations produced new emissions reporting guidelines based on IPCC recommendations. The Special Climate Change Fund (SCCF) and the Least Developed Countries Fund (LDCF) were further developed[65].

COP 10, 2004: COP 10 was held in Buenos Aires, Argentina. Parties focused primarily on discussing adaptation options, and reportedly "addressed and adopted numerous decisions and conclusions on issues relating to development and transfer of technologies; land use, land use change and forestry; the UNFCCC's financial mechanism; [developed countries'] national communications; capacity building; adaptation and response measures; and UNFCCC Article 6 (education, training and public awareness) examining the issues of adaptation and mitigation, the needs of least developed countries (LDCs), and future strategies to address climate change," according to the UNFCCC report[66].

COP 11/CMP 1, 2005: COP 11/CMP 1 were held in Montreal, Canada. This conference served a dual function, since it was the first meeting to take place after the Kyoto Protocol took force. In addition to the annual meeting between the parties (COP), discussions were supplemented by the first annual Meeting of the Parties to the Kyoto Protocol (CMP). Nations that had ratified the UNFCCC, but not accepted the Kyoto Protocol (including the US) took an observational status at the latter conference. Present parties addressed issues such as "capacity building, development and transfer of technologies, the adverse effects of climate change on developing and least

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[65] O'riordan, Timothy. *Politics of climate change: a European perspective*. Psychology Press, 1996.

[66] Ott, Hermann E. *It takes two to tango: climate policy at COP 10 in Buenos Aires and beyond*. Wuppertal Institut für Klima, Umwelt, Energie GmbH, 2005.

developed countries, and several financial and budget-related issues, including guidelines to the Global Environment Facility (GEF).[67]"

COP 12/CMP 2, 2006: COP 12/CMP 2 were held in Nairobi, Kenya. The present nations discussed financial mechanisms and further decisions were made about the Special Climate Change Fund[68].

COP 13/CMP 3, 2007: COP 13/CMP 3 were held in Bali. COP parties agreed to what they referred to as the Bali Action Plan in order to negotiate GHG mitigation actions after the Kyoto Protocol was set to expire in 2012. However, unlike the Kyoto Protocol, the Bali Action Plan did not require binding GHG targets for developing countries[69].

COP 14/CMP 4, 2008: COP 14/CMP 4 were held in Poznan, Poland. Participatory parties began preliminary negotiations on the financing mechanism to help less developed countries adapt to the effects of climate change. Negotiations continued about what would succeed the Kyoto Protocol, however no consensus was reached[70].

Pre-COP 15, 2009: Participating governments met in Bonn, Germany, to begin discussions on draft negotiations that would form the basis of an agreement at the upcoming COP 15 meeting in Copenhagen.

COP 15, 2009: COP 15 was held in Copenhagen, Denmark. The present nations failed to agree on binding commitments after the Kyoto Protocol commitment period was set to end in 2012.

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[67] Golombek, Rolf, Catherine Hagem, and Michael Hoel. "Efficient incomplete international climate agreements." *Resource and Energy Economics* 17, no. 1 (2008): 25-46.

[68] Harstad, Bård. "The dynamics of climate agreements." *Journal of the European Economic Association* (2015).

[69] Golumbeck et al., 2008

[70] Harstad, 2015

During the final hours of the summit, leaders from the United States, Brazil, China, Indonesia, India and South Africa agreed to what would be called the Copenhagen Accord which recognized the need to limit the global temperature rise to 2°C based on the science of climate change. While no legally binding commitments were required by the deal, countries were asked to pledge voluntary GHG reduction targets. $100 billion was pledged in climate aid to developing countries[71].

Post-COP 15, 2010: The United States and over 130 nations agreed to the Copenhagen Accord that was previously discussed at COP 15 in December of 2009[72].

COP 16, 2010: COP 16 was held in Cancun, Mexico. Present parties officially adopted major tenets of the Copenhagen Accord including limiting temperature rises to 2°C, protecting vulnerable forests, and establishing a framework for a Green Climate Fund, which was intended to deliver funds to developing countries for mitigation and adaptation actions[73].

COP 17, 2011: COP 17 was held in Durban, South Africa. Parties agreed to the Durban Platform for Enhanced Action - framework to establish a new international emissions reduction protocol. The details of the protocol were to be finalized by 2015 and it slated to come into force in 2020. The European Union also agreed to extend their Kyoto Protocol targets, which were set to expire at the end of 2012, into a second commitment period from 2013-2017. Russia, Japan and Canada did not commit to new targets[74].

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[71] Dimitrov, Radoslav S. "Inside UN climate change negotiations: The Copenhagen conference." *Review of policy research* 27, no. 6 (2010): 795-821.

[72] Dimitrov, 2010

[73] Harstad, 2015

[74] Rajamani, Lavanya. "The Durban platform for enhanced action and the future of the climate regime." *International and Comparative Law Quarterly* 61, no. 02 (2012): 501-518.

COP 18, 2012: COP 18 was held in Doha, Qatar. Parties agreed to extend the expiring Kyoto Protocol, creating a second commitment phase that would begin on January 1, 2013 and end December 31, 2020. This is considered as a bridge to the Durban Platform for Enhanced Action. Parties failed to set a pathway to provide $100 billion per year by 2020 for developing countries to finance climate change adaptation, as agreed upon at COP 15 in Copenhagen. The concept of "loss and damage" was introduced as developed countries pledged to help developing countries and small island nations pay for the losses and damages from climate change that they are already experiencing[75].

COP 19, 2013: COP 19 was held in Warsaw, Poland. Parties continued discussion on the aid that developed countries would pay to help emissions cuts by developing countries – however, they resisted calls to set targets for the rest of the decade. The draft resolution of the conference only mentioned setting "increasing levels" of aid. The Warsaw Mechanism was proposed, which would provide expertise, and possibly aid, to developing nations to cope with loss and damage[76].

COP 20, 2014: COP 20 was held in Lima, Peru. In adopting the Lima Call for Climate Action, where parties agreed on loose arrangements for bringing forward their "intended nationally determined contributions" to the Paris agreement[77].

COP 21, 2015: COP was held in Paris, France. A legally binding treaty to reduce greenhouse gas (GHG) emissions has officially been finalized (which will come into effect in 2020).

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[75] Rajamani, 2012

[76] Schäfer, Laura, and Sönke Kreft. "Loss and Damage: Roadmap to Relevance for the Warsaw International Mechanism." *Germanwatch (March 2014), at* 5 (2014).

[77] Rajamani, Lavanya. "Lima Call to Climate Action." *Progress Through Modest Victories and Tentative Agreements, in: Economic and Political Weekly* 50, no. 1 (2015): 14-17.

Although the most recent agreement has been hailed as a success, differences of opinion by participating nations on responsibility of GHG emissions between developing and developed countries led to a flexible ruling on the wording and a "plan to discuss further". A non-binding agreement was reached among countries to set up a system tackling the "loss and damage" issue, although details of how to set up the mechanism were not discussed. Little progress was made on developed countries committing to the agreed upon plan of providing $100 billion per year by 2020 to developing countries[78]. Although world leaders are lauding the meeting in Paris as a revolutionary agreement to mitigate climate change, it is clear when observing the timeline of redundant unsuccessful negotiations that it may likely be just another in the long line of agreements.

Chapter 4: **Climate Economics: Costly Challenges or Opportunities for Investment?**

The primary approach by most economists to the climate crisis has been to frame the analysis of global climate change in the context of cost-benefit analysis. While this type of analysis is particularly useful for universalizing the financial value of complex scientific problems, some have criticized this approach as an attempt to put a valuation on issues with social, political, and ecological implications that go far beyond dollar value[79]. In a cost-benefit analysis of climate change, the benefits refer to the damages potentially averted through action to prevent climate change; the costs are the economic costs of shifting away from fossil fuel dependence, as well as other economic implications of greenhouse gas reduction. Cost/benefit studies have estimated both costs and benefits in the range of several percent of GDP to both

[78] Bodansky, Daniel. "The Paris Climate Change Agreement: A New Hope?."*American Journal of International Law* 110 (2016).

[79] Stern, Nicholas Herbert. *Stern Review: The economics of climate change*. Vol. 30. London: HM treasury, 2006.

developed and developing nations[80]. In addition, some effects such as species loss and effects on human life and health are difficult to measure in monetary terms. In addition to national economies, ultra-large fossil fuel corporations and those dependent on them make significant influences in international business practices[81]. The chapter will examine economists' efforts to capture the impacts of global climate change through cost-benefit analysis, and then return this information to the debate over how to construct and implement international climate policies.

Global climate change presents a threat to the condition of humans and non-human citizens through varying impacts on ecosystems, capital productivity, biodiversity, and human health. The economics of climate change addresses these issues by offering both theoretical and empirical findings relevant to the design of policies to adapt, avoid, or mitigate climate change. These extensive economic analyses have yielded new estimates of benefits, improved tools for policymaking under the threat of uncertainty, a better understanding of costs in the presence of numerous market distortions or imperfections, and new mechanisms for allowing flexibility in policy responses. Such contributions have greatly influenced the formulation and execution of a range of climate change policies at the international level – although few have been successfully implemented.

Since the appearance of William Nordhaus's "How Fast Should we Graze the Global Commons?" (1982), climate change economics has focused primarily on diagnosing the economic foundations of climate change and offering both positive and normative analyses of

[80] Pulver, Simone. *Power in the public sphere: The battles between oil companies and environmental groups in the UN climate change negotiations, 1991-2003*. University of California, Berkeley, 2004.

[81] Peters, Glen P., and Edgar G. Hertwich. "CO2 embodied in international trade with implications for global climate policy." *Environmental Science & Technology* 42, no. 5 (2008)

policies to approach the problem[82]. While overlapping with different areas of environmental economics, climate change economics is uniquely focused due to unique features of the climate problem, which include the length of the time scale, the global scope of the problem, the extent of uncertainties, and the unequal distribution of policy benefits and costs across both time and space[83].

As noted, the projected consequences of climate change include greater average temperatures, increased frequency of extreme temperature events, sea level rise, and changes to precipitation patterns[84]. These biophysical changes affect human welfare - while the distinction is not perfect, most economists divide the (primarily negative) human welfare impacts into two main categories: *market* and *non-market* damages.

Market damages are the impacts to human health that arise from fluctuations in prices or quantities of marketed goods[85]. Typically, these changes are reflected by changes in productivity. Economists use climate-dependent production functions to project these changes: by specifying wheat production, for example, as a function of climate variables such as temperature and precipitation, they can model any output in wheat production as a dependent variable and assign

[82] Nordhaus, William. "How fast should we graze the global commons?." *The American Economic Review* 72, no. 2 (1982): 242-246.

[83] Stern, 2006

[84] Burke, M., M. Craxton, C. D. Kolstad, C. Onda, H. Allcott, E. Baker, L. Barrage et al. "Opportunities for advances in climate change economics."*Science* 352, no. 6283 (2016): 292-293.

[85] Peters and Hertwich, 2008

a price point[86]. This approach has been applied to industries other than agriculture, including energy services, forestry, , coastal flooding from sea level rise[87], and water utilities.

Non-market damages include the direct loss of utility as a result of a less hospitable climate, as well as costs attributable to lost ecosystem services or lost biodiversity[88]. For these damages, revealed-preference methods face ongoing challenges because non-market impacts may not directly reveal changes in price or quantity. The loss of biodiversity, for example, does not have any obvious, numerical connection with price fluctuation or observable demands. Partially because of the difficulties of revealed-preference approaches in this context, researchers often employ stated preference (interview) techniques - most often the contingent valuation method - to assess an individual's willingness to pay to avoid non-market damages[89]. Again, uncertainties that surround both the costs and the benefits from mitigated climate change are vast. Increasingly sophisticated economic models have attempted to deal exclusively with these huge uncertainties regarding costs and benefits[90].

Pragmatically, there have been a number of proposed "solution" mechanisms to encourage the reduction of GHG use and promote investments in sustainable technologies. In the search for regulatory solutions which would mitigate the effects of GHG's, emissions trading has become the most favored policy instrument, as previously discussed in the shortcomings of the

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86 Reddy, P. Parvatha. "Impacts of climate change on agriculture." In *Climate resilient agriculture for ensuring food security*, pp. 43-90. Springer India, 2015.

87 Mansur, Erin T., Robert O. Mendelsohn, and Wendy Morrison. "A discrete-continuous choice model of climate change impacts on energy." (2005).

88 Peters and Hertwich, 2008

89 Burke et al., 2016

90 Stern, 2006

Kyoto Protocol in Chapter 2. To briefly recap, Kyoto sought to establish a market-based mechanism to allow developed countries with binding emissions targets to reduce greenhouse gases such as carbon dioxide, methane, carbon tetrafluoride, trifluoromethane, and nitrous oxide. Under the cap-and-trade system, industries would be allocated allowances limiting them to a certain amount of greenhouse gas emissions each year. Most trading schemes use one ton carbon-dioxide units for sale, or convert non-CO2 gases into CO2-equivalent units for the purposes of trading[91].

Conceptually, the buying and purchasing of allowances provide incentives to make emissions reductions more economical. Some facilities could find it cheaper to reduce their emissions and then sell their surplus allowances as credits, while others may find it cheaper to buy credits to offset their emissions rather than make direct reductions. Greenhouse gas emission credits can be purchased or sold from a carbon market as well as through projects and emissions credits certified by the UN. Cap-and-trade systems have been used before to reduce emissions. The cap-and-trade system instituted under the 1990 Clean Air Act in the United States is credited with achieving significant reductions in acid-rain-causing sulfur-dioxide emissions by power plants[92.] More than actual emissions units can be traded and sold under an UNFCCC (as last created in the Kyoto Protocol) emissions trading scheme. The other units which may be transferred under the scheme, each equal to one ton of CO2, may be in the form of: a removal unit (RMU) on the basis of land use, land-use change and forestry (LULUCF) activities such as reforestation, an emission reduction unit (ERU) generated by a joint implementation project, or

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[91] Nordhaus, William D. "The architecture of climate economics: Designing a global agreement on global warming." *Bulletin of the Atomic Scientists* 67, no. 1 (2011): 9-18.

[92] Belden, Roy S. "Clean Air Act." American Bar Association, 2001.

a certified emission reduction (CER) generated from a clean development mechanism project activity[93]. Transfers and acquisitions of these units are tracked and recorded through the registry systems under the UNFCCC. An international transaction log ensures secure transfer of emission reduction units between countries.

In order to address the concern that participatory nations could "oversell" units, and subsequently be unable to meet their own emissions targets, each country is required to maintain a reserve of ERUs, CERs, AAUs and/or RMUs in its national registry. This reserve, known as the "commitment period reserve", should not drop below 90 per cent of the nation's assigned amount or 100% of five times its most recently reviewed inventory, whichever is lowest[94]. Additionally, emissions trading schemes may be established as climate policy instruments at the national level and the regional level. Under such schemes, governments set emissions obligations to be reached by the participating entities. The European Union emissions trading scheme is the largest in operation[95].

Climate change economics has produced new methods for evaluating environmental benefits, for determining costs in the presence of various market distortions or imperfections, for making policy choices under uncertainty, and for allowing flexibility in policy responses. Although major uncertainties remain, it has helped generate important guidelines for policy choice that remain valid under a wide range of potential empirical conditions. It also has helped

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[93] Atkinson, Scott, and Tom Tietenberg. "Market failure in incentive-based regulation: the case of emissions trading." *Journal of Environmental Economics and management* 21, no. 1 (1991): 17-31.

[94] Atkinson et al., 1991

[95] Grubb, Michael, and Karsten Neuhoff. "Allocation and competitiveness in the EU emissions trading scheme: policy overview." *Climate Policy* 6, no. 1 (2006): 7-30.

focus empirical work by making clear where better information about key parameters would be most valuable. Clearly, many theoretical and empirical questions remain unanswered. From 2003 until 2030, the world is poised to invest an estimated $16 trillion in energy infrastructure, with annual carbon dioxide emissions estimated to rise by 60 percent[96]. How well economists answer important remaining questions about climate change could have a profound impact on the nature and consequences of that investment.

Chapter 5: Conclusions: Crafting a Practical Policy Agreement

Fundamentally, international climate governance with its focus on economic costs, negative consequences, and sacrifice is ill-equipped to address the climate crisis. However, a positive framing of the opportunities that come from combining climate mitigation and economic prosperity can increase countries' ambition to participate in global policy. Progressive national and local action including carbon-neutral cities, regions and countries, the integration of climate considerations into all policy areas such as energy, transport, agriculture and industry, policies reflecting the social costs of carbon emissions, and investment in low carbon technologies can facilitate the transition to a sustainable economic development path that addresses climate change effectively[97]. This can bring the global community on a more cohesive path that may also allow for a more ambitious global climate agreement in the next decade.

There is a broad consensus that a successful climate agreement must be cost effective, environmentally effective, be institutionally feasible (in high agreement) and incorporate

[96] Nordhaus, 2011

[97] Aldy, Joseph, and Robert Stavins. "Architectures for agreement." (2007).

distributional considerations and equity[98]. There is a great deal of speculation and research regarding potential structures for and the substance of future international agreements - as has always been the case in IPCC reports and UNFCCC meetings, because climate change is a globally common problem, any approach that does not successfully include a larger share of global emissions will be either more costly or less environmentally effective[99]. Any proposed outlines for future agreements, which the remainder of this chapter will detail, must include the following: a discussion of goals, specific intended actions, tangible timetables, institutional arrangements and participation, and reporting and compliance provisions[100]. Additionally, such an agreement must address market incentives, non-participation, and non-compliance penalties[101].

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98 Dellink, Rob, Michael Finus, and Niels Olieman. "The stability likelihood of an international climate agreement." *Environmental and Resource Economics* 39, no. 4 (2008): 357-377.

99 Aldy and Stavins 2007

100 Dellink et al., 2008

101 Nordhaus, William. "Climate clubs: overcoming free-riding in international climate policy." *The American Economic Review* 105, no. 4 (2015): 1339-1370.

Goals:

The outright specification of clear goals is a vital element of any climate agreement. Goals provide both provide a common vision about the near-term direction and are able to offer longer-term certainty, which is necessary for economic incentives for businesses. Setting goals provides an incentive to stimulate action, helps structure institutions and commitments, and aids in establishing criteria against which supervising committees may measure the success in implementing measures[102].

Options for the structure of international agreements can incorporate goals for the short, medium and long term. One opportunity is to set a goal for long-term GHG concentrations or a temperature stabilization goal. This might be based on physical impacts to be avoided or conceptually on the basis of the monetary and non-monetary damages to be avoided[103]. An alternative to agreeing on specific CO2 concentration or temperature levels is an agreement on specific long-term actions such as a technology-based research and development and diffusion target – for example, a goal to eliminate carbon emissions from the energy sector by 2060[104]. An advantage of this kind of goal is that it has the potential to be linked to specific actions. Another potentiality would be to adopt what is referred to as a "hedging strategy" – this is defined as setting a clear shorter-term goal on global emissions from which it is still possible to reach a

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[102] Dellink et al., 2007

[103] Ford, J. D., L. Berrang-Ford, R. Biesbroek, M. Araos, S. E. Austin, and A. Lesnikowski. "Adaptation tracking for a post-2015 climate agreement."*Nature Climate Change* 5, no. 11 (2015): 967-969.

[104] Aldy and Stavins, 2007

range of desirable long-term goals[105]. Once the short-term goal is reached, decisions on next steps can be made in light of new knowledge and decreased levels of uncertainty.

Participation and Specific Actions:

There are varying degrees of participation of states in an international climate agreement. Additionally, the actions to be taken by participating countries can be differentiated both in terms of the timeline (when such action is undertaken), and who specifically takes the action and what it entails. States choosing to participate in the same 'tier' would have the same (or similar) types of commitments – additionally, decisions on how to allocate states to tiers should be based on formalized quantitative or qualitative criteria.

A successful climate agreement can either have static (non-changing) participation or can evolve over time. In the case of an evolving agreement, states can move from one tier of commitments to another, based on the passing of quantitative thresholds for specific considerations (or combinations of parameters) that have been previously outlined in the agreement. Such parameters might include GDP per capita, emissions, cumulative emissions, and relative contribution to temperature increase (or other measures of international development, such as the so-called Human Development Index [HDI])[106].

Some experts argue that a successful international agreement only needs to include the major emitters to be considered effective. This is primarily based on the data that indicates that

[105] Aldy and Stevens, 2007

[106] Nordhaus, 2015

the largest 15 countries make up 80% of global GHG emissions[107]. Others claim that those with historical responsibility must be the first to act[108]. A third view holds that the critical factor in a global solution is technological development, and therefore agreements must specifically target development in Annex I countries (which could offset some or all emissions in non-Annex I nations[109]. Still others suggest that a climate agreement should not deal exclusively with mitigation, but must also encompasses adaptation - and that a far larger array of countries is vulnerable to climate change and therefore must be included in any agreement. Specifically, it is clear that developed countries as an entire group need to reduce their emissions significantly by 2020 (10–40% below 1990 levels) and to still lower levels by 2050 (40–95% below 1990 levels) for low to medium stabilization levels (450–550ppm CO2)[110]. Under most of the agreement outlines that have been previously considered for such stabilization levels, developing-country emissions also need to diverge below their projected baseline emissions within the next few decades.

Commitments:

The most frequently evaluated type of commitment is the binding, absolute emission reduction cap as included in the Kyoto Protocol for Annex I countries. The general agreement has always been that the efficacy such a commitment comes from its ability to provide certainty about future emission levels of the participating countries (assuming caps are met)[111] – however,

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[107] IPCC, 2014

[108] Dellink et al., 2008

[109] Hannam, Phillip M., Zhenliang Liao, Steven J. Davis, and Michael Oppenheimer. "Developing country finance in a post-2020 global climate agreement." *Nature Climate Change* 5, no. 11 (2015): 983-987.

[110] IPCC, 2014

[111] Nordhaus, 2015

many experts propose that caps be reached using a variation of flexible approaches which can incorporate multiple GHGs (as opposed to just CO2), span different industrial sectors, as well as incorporate multiple countries through emission trading and/or project-based mechanisms[112].

While the precedent has always existed that absolute caps ought to be applied to all countries in the future, many experts have raised concerns that the inflexibility of such an approach may restrict economic growth unfavorably[113]. While no consensus approach has emerged, there are multiple alternatives available to address this issue, including evolving "dynamic" targets based on changing obligations, and limits on prices (capping the costs of compliance at a given level – which while limiting costs, would also lead to exceeding the environmental target)[114]. These options aim to maintain the advantages of international emissions trading while providing more opportunity for flexibility in compliance.

Market Mechanisms and Incentives:

International market-based approaches can offer a cost-effective means of addressing climate change if they incorporate a broad coverage of countries and sectors[115]. So far, only a few domestic emissions-trading systems are in place, the European Union Emissions Trading Scheme being by far the largest effort to establish such a process, with over 11,500 plants allocated and authorized to buy and sell allowances[116].

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[112] Hannam et al., 2015

[113] Hannam et al., 2015

[114] Nordhaus, 2015

[115] Peters, Glen P., Robbie M. Andrew, Susan Solomon, and Pierre Friedlingstein. "Measuring a fair and ambitious climate agreement using cumulative emissions." *Environmental Research Letters* 10, no. 10 (2015): 105004.

[116] Grubb et al., 2006

Total global costs under an agreement are highly dependent on the baseline scenario, marginal abatement cost estimates, the assumed concentration stabilization level and the degree of participation (how and when allowances are allocated)[117]. If, for example some major emitting regions do not participate in the reductions immediately, the global costs of the participating regions will be higher if the goal is maintained (see also Chapter 3). Regional abatement costs are dependent on the allocation of emission allowances to regions, particularly the timing. However, the assumed stabilization level and baseline scenario are more important in determining regional costs[118].

Despite the Clean Development Mechanism, total financial flows for technology transfer have thus far been limited. Governments, multilateral organizations and private firms have carbon funds valued at nearly $6 billion for the purpose of carbon-reduction projects (to be developed mainly through the CDM)[119]. A key element of a successful climate change agreement will be its ability to encourage the development and transfer of technology. Without this, it will be difficult to achieve emission reductions on a significant scale. Transfer of technology to developing countries depends mainly on investments - creating enabling conditions for investments and technology uptake and international technology agreements are therefore of high importance. One possible mechanism for technology transfer is to create innovative ways of mobilizing sustainable investments to cover the incremental cost of mitigating and adapting to

[117] Stavins, Robert N. "20 Linkage of regional, national, and sub-national policies in a future international climate agreement." *Towards a Workable and Effective Climate Regime* (2015): 283.

[118] Stavins, 2015

[119] Peters et al., 2015

climate change. International technology agreements could strengthen such a knowledge-based infrastructure[120].

Coordinated policies and measures could be an alternative to or complement internationally agreed targets for emission reductions. A number of policies have been discussed in the literature that would achieve this goal, including taxes (such as carbon or energy taxes)[121], trade coordination/liberalization, and sectoral policies and policies that modify foreign direct investment. Under one proposal, all participating nations – industrialized and developing alike – would tax their domestic carbon usage at a common rate, thereby achieving cost-effectiveness[122].

A number of studies have also suggested that a sectoral economic approach has the ability to provide an appropriate framework for a successful agreement. Under such a system, specific targets could be set starting with sectors or industries that are particularly important, politically easier to address, globally homogeneous or relatively insulated from competition with other sectors[123]. Sectoral agreement may provide an additional degree of policy flexibility and make comparing efforts within a sector between countries easier, but may be less cost-effective, since trading within a single sector will be inherently more costly than trading across all sectors[124].

With geological mayhem scheduled to take place over the next several thousand years, the decisions that we are making (read: not making) in the present take on a new light. Clearly

[120] Hannam et al., 2015

[121] Nordhaus, 2015

[122] Nordhaus, 2015

[123] Stavins, 2015

[124] Peters et al., 2015

we need to expand the time scale with which we assess the full implications of the climate crisis beyond the current century. Once humans turn up the planetary thermostat by 2°C, there will be no turning back.

Ultimately, the planet is the definitive "global commons". It belongs to neither a particular individual nor a particular nation. Yet, the political and economic institutions of our society like the UNFCCC are fixated on providing for the present and unable to account for the consequences of our actions on the future. In a crisis of modernity that could also be re-interpreted as one of ethics and values, how should we reframe our choices and actions in the present, in light of tomorrow? In 2014, Pope Francis issued an encyclical, Laudato Si ("Care for our Common Home") which addresses the ecological crisis facing the Earth. By situating the document in scientific, historical, and societal context, Francis makes it clear from the document's onset that the encyclical is addressed to not only members of the Church but should be a vehicle to "enter into dialogue" with all people who are "united by the same concern". At its core, Laudato Si emphasizes that what actually matters as regards global policy in all forms is not so much taking principled stances, but rather developing rational aids to decision-making, so that the various actors can agree on what should be done and develop the concrete policy measures which need to be implemented. Petty disagreements between nations, businesses, anthropocentrists and non-anthropocentrists, humanists and ecocentrists, "shallow" and "deep ecologists", etc., are infinitely damaging in that they divide environmental ethicists and stifle efforts for concerted and effective action. Indeed, the environmental crisis is so serious that we must, as Francis urges, create a fresh approach to human virtue. Adding a hopeful conclusion to such a gloomy realization, Pope Francis writes that "human beings, while capable of the worst, are also capable of rising above themselves, choosing again what is good, and making a new start[125]." Let's hope, for all the Earth's sake, that he is correct.

[125] Francesco, Papa. "Lettera Enciclica Laudato si'." *Libreria Editrice Vaticana* (2015)

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