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Climate Change and its Relationship with Technology

From the 17th century through modern day, the world has plunged head-first into the era of technological development and its companion, capitalism. For the last 300 years we have scaled and progressed continuously in our quest for innovation and power. At every discovery, technology has stood in lock-step with us, acting as our platform upon which we were able to continuously climb the ladder as the most dominant and intelligent species our planet has to offer. But we have done so recklessly. We don't often enough ask ourselves, as a species, if we are behaving in a way that will preserve the conditions in which humanity can continue to exist. Because we haven't been emphasizing this concept, humanity has for decades now treated this world as its eternal supplier of life.

It seems, though, that even mother Earth has her limits. The gloabal temperature is increasing year over year, sea levels are rising, and polar ice has reached record lows (Melillo et al. 4). These concerns are alarming in their own right, but when considered as part of a larger perspective, we can see the vast and expansive nature of climate change's effects. Not only will individual regions experience their own effects, *all* regions will experience the effects of such a disruption to our global climate.

There is, however, technology. The human-ness that got us into this existential precariousness is the same mechanism by which we can avoid a premature demise. In the coming years and decades, humanity will be forced to quickly invest in global operations to mitigate the natural effects of climate change. These endeavors will likely involve extensive research in fields like Artificial Intelligence, quantum mechanics, energy production and distribution, and food production.

To understand the implications of the effects climate change has brought, we must first establish what factors have enabled climate change, and how we understand it now. Fortunately, there are an abundance of scientific data and studies from the last 50 years that demonstrate the truth: the planet is warming, and in recent decades, human activity has been the primary cause. The first thing scientists point to as a massive factor is the continued release of carbon dioxide into the atmosphere. CO_2 levels have been rising since the industrial revolution, but the majority of the growth in CO_2 production in the United States has occurred since the 1970s (Melillo et al. 4). This CO_2 traps heat in our atmosphere, causing what has long been called the “greenhouse effect”. Typically, some heat is dissipated through the atmosphere that reflects off the surface of the earth. However, with such a massive increase in carbon dioxide, we have trapped heat in our atmosphere that should have been allowed to escape. The most prolific cause for extra CO_2 production is the burning of fossil fuels. Burning coal, oil, and gas, as well as continued deforestation has made a surplus of carbon dioxide in the atmosphere that is continuously destabilizing our system. While it might seem that simply warming the earth some is a benign byproduct of technological advancement, evidence shows that only a few degrees of global temperature increase can have destructive consequences. As just an example, longer periods of high temperatures in some regions have led to a lengthening of the drought/wildfire seasons, exposing those regions to more risk of such events, and providing conditions that make wildfires even harder to contain (Melillo et al. 6).

Unfortunately for us, a warming globe doesn’t just lead to more wildfires in places that are already dry. Rising temperatures means less cold temperatures. It causes sea ice to melt, which has its own variety of effects. Melting sea ice causes a general rise in sea levels. It also allows for more moisture to be absorbed into the atmosphere, which means that many regions experience higher than usual rainfall. This abnormality might overwhelm regional systems which are not equipped to handle such an unexpected amount of rain. Runoff systems can fail, resulting in flooding and erosion.

Another way in which climate change is effecting us in unseen ways is beneath the surface of the oceans. Increased amounts of CO_2 in our atmosphere interact with our bodies of water, forming carbonic acid. According to the Third National Climate Assessment:

> Ocean surface waters have become 30% more acidic over the last 250 years as they have absorbed large amounts of carbon dioxide from the atmosphere. This ocean acidification makes water more corrosive, reducing the capacity of marine organisms with shells or skeletons made of calcium carbonate (such as corals, krill, oysters, clams, and crabs) to survive, grow, and reproduce, which in turn will affect the marine food chain. (Melillo et al. 7)

It is important that we realize the big picture of all the evidence scientists have produced: all changes of such scale have impacts that scale as well. Our current global economy hinges upon our ability to function in a highly complex, highly interconnected system. It does not take an imaginative mind to realize that a disruption to something as important as our marine food chain will propagate through systems that depend on it, becoming disruptions to those systems as well. A good example of such a systemic disruption to our global supply chain occurred only recently, when the massive shipping vessel, the Ever Given, was run aground in the Suez Canal. The blockage of the canal lasted only six days, but some estimates suggest the blockage cost global commerce approximately $400 million USD per hour.

The marine food chain is not the only food-related implication that climate change brings about. As stated previously, we live in a monolith of intricately connected states, each offering certain exports and expecting certain imports. According to a report by the Climate Change Global Food Security and U.S. Food System, “The actual effects of natural disasters and food-security shocks are mediated by socioeconomic conditions and the effectiveness of disaster response.” (Brown et al. 23). That is to say, a group’s socioeconomic status will inevitably play a key role in the group’s ability to mitigate their experienced effects of climate change. This means that underprivileged groups, an example of which might be an underdeveloped nation-state, will be *more* impacted by climate than states of higher-up socioeconomic standing. It is an important point for even the United States, the wealthiest country in the world, to pay attention to because of how much our economy depends on the products of smaller economies. Furthermore, food supply systems are highly dependent on energy. Maintaining conditions necessary for food to arrive from point A to point B in the global trade demands high investments in energy systems. These systems must constantly keep food at temperature and cannot fail, lest a large portion of product be spoiled.

There are two ways in which humanity will respond to climate change: adaptation and mitigation. In adaptation, we will prepare for and adjust to the problems presented to us. That is, when we adapt to problems, we find some way for humanity to conform to those challenges. In this way, we modify ourselves to remain suited for our environment. In mitigation, we attempt to eliminate or minimize the contributing factors to climate change, thus striving to bring about benevolent change in the future. These two methodologies are complimentary and highly related, and both will need to be continuously analyzed in order to minimize the sustained damage from climate change. At the center of our quest to adapt to and mitigate climate change is the crutch upon which we will make it all happen: technology, and our human knack for innovation.

To attempt to try to illustrate every way in which climate change will drive technology would be an impossible task. The development of technology almost always comes with a certain veil of opacity; where humanity is, in a way, holding its breath hoping our newest developments are for the best. Still, we can certainly guess as to what kind of technology will be needed to mitigate and adapt to our changing planet. We will need to embrace change that is needed in all sectors, starting most blatantly with energy. As now uncountable sources tell us, our reliance on burning fossil fuels can last no longer. This means our attention must turn to less utilized, and less known alternatives. Solar, wind, and nuclear energy alternatives seem to be at the forefront of researchers' minds. These areas of interest cannot be fully researched without finding some way to force funds to be dedicated to that research. So, before all of this, mankind must agree on a "carbon tax".

In order to solidify the notion that humanity must move away from its dependence on fossil fuels, and to begin our quest in reducing the amount of CO_2 we send into our atmosphere, we should immediately put a price on greenhouse gas emissions (Barrett 54). Furthermore, this funding will need to be fundamentally different in a way that can survive the patent system. This is because of the nature of the problem we are attempting to overcome: research that enables humanity to make progress toward this global dilemma cannot be hindered by our urge to privatize and capitalize on our work. If scientists from the UK create a new type of energy production, for example, it would be entirely counter-productive for that technology to have a high price tag, thus excluding its efficacy from under-privileged states. Therefore, yet another component of this endeavour will certainly be the battle to ensure that the progress we do make is distributed as fairly and transparently as possible.

The carbon tax will enable the R&D to begin our global quest, but that is only the beginning. Deciding what kind of areas in which we dedicate that research will be equally as crucial to our communal success. The most immediately obvious attack vector here is studying CO_2-free energy. As previously alluded to, solar, wind, and nuclear energy become the most known solutions to this problem.

Barrett gives an example of wind energy being a viable alternative to fossil fuels in their regional example in the United States: "DeCarolis and Keith (2006, p. 402) find that wind power situated near Chicago, the Windy City, can compete with the alternative of natural gas at a carbon price of $38/t$CO_2$." (Barrett 56). Barrett goes on to talk about other scenarios for Chicago, which involve moving wind energy production further from the city and inevitably raising the carbon tax of such a scenario. Further, we find that discussing this change would have new benefits and detriments: moving the wind energy production away from the city will provide better reliability (as the windmills would be more spread out and thus allow for more consistent generation of energy) but would demand higher transportation costs. Moreover, the transportation of this energy would depend on the current grid implementation. This current methodology involves large power plants situated near metropolitan areas to manage the power demands. However, under this hypothetical wind energy system, there would need to be high voltage direct current rather than the existing alternating current infrastructure. This means the cost of moving to this particular new model would be tied to the cost of converting the infrastructure to support new demands (Barrett 56).

Denmark and Norway provide an interesting example upon which a case for wind energy can be built. Denmark currently creates 17% of its energy using wind production. However, this feat is made possible only by a symbiotic relationship with Norway: when Denmark is producing wind energy, it exports this energy to Norway. However, when the winds are not favorable, Norway utilizes energy stores in its hydroelectric dams, selling surplus energy to Denmark. Together, the two states have found a highly efficient way to manage energy stores. This luxury is a product of convenient energy solutions available to these nations, and is not available to all other countries (Barrett 57). While current wind production models do offer a potential avenue to solving our energy problem, non-existing notions of wind energy still remain a potential solution.

Rather than harvesting energy from intermediate and unpredictable wind currents on the surface of the earth, what if we instead looked to the sky? In particular, wind about 10km above the earth where the jet stream is the strongest and most consistent, provides a tantalizing opportunity for wind energy production. “Flying windmills” could act as a kind of kite, tethered to earth via a cable, sending their energy down to a station on the ground. These kites could generate energy as they gained altitude, and could then change their angle to consume less energy in their period of descent than they produced in their ascent. It is estimated that this solution could provide multiple magnitudes of energy greater than all the energy needed by man, but not without difficult implications. Air space would need to be regulated around these tethers. Furthermore, maintenance to such airborne generators and functionality during storms present interesting complications that would need to be successfully navigated to make this notion a viable one. It is worth noting that such ideas have yet to be demonstrated at scale (Barrett 58).

Now that we have considered some examples of potential wind energy solutions, we can turn our attention to the next energy-rich resource universally available to us: sunlight. Solar energy has long been on humanity’s radar as an option for electrical energy production. “Photovoltaic systems, which convert solar energy to direct current electricity, are already in use, but they operate at low efficiency and are only economic in sun-rich off-grid areas." (Barrett 58). It is clear that an improvement to both photovoltaic systems' efficiency as well as affordability is required for such a solution to be a viable mechanism in overcoming climate change. Barrett discusses a potential avenue in navigating this issue: systems which deal with "concentrated solar power" to maximize their energy production. So called "power towers" have the potential to capture more solar energy than traditional solar panels. These constructions can be comprised of sun-tracking mirrors that beam light in a desired direction to a collection point. Because this concept involves dynamically adjusting the system to incoming light, we increase our production potential. Barrett discusses that such a system could potentially produce all the energy needed by the United States in a concentrated solar power setup that would only need to be 100 square miles (58). However, this option is only afforded to regions of high solar availability: the US south west, north and south Africa, Australia, and parts of China, India, and central Asia. Of course, this energy could be moved to other regions after production, but this would face logistical issues that too would need analysis and deliberate policy implementation to avoid being non-viable.

Another area of interest within solar power is the notion of "space solar power". This idea is similar in premise to flying windmills, in that you could orbit large solar arrays in space, capturing energy and transmitting it via satellites to earth for use. This concept is vast and ambitious, met with equally complex requirements for implementation. For example, a massive amount of funds for R&D would be required, which would need to be balanced via a proportional carbon tax to ensure efficacy in global implementation. Furthermore, the same logistical issues would arise in making sure the produced energy is transported to all necessary recipients, not just the producing entity itself.

Nuclear energy is yet another promising means for minimizing CO_2 emissions. Nuclear energy is a proven technology and has for decades been studied and utilized. However, it comes at significant costs: it is potentially environmentally disastrous, and we still do not have nuclear waste disposal techniques that extend beyond simply storing spent nuclear waste in large, potentially vulnerable deposit locations. Furthermore, nuclear energy costs are tied tightly with capital costs, and therefore are dependent on implementation design, scale, and utilization rates (Barrett 59) which are variable country to country. Because nuclear energy production favors scale, its adoption by smaller economies has been greatly minimized. Therefore in regions of lower grid capacity and smaller energy requirements, smaller nuclear energy production plants are needed. In South Africa, “pebble-bed modular reactors” have been developed that are as small as 100 megawatts. In order for these small-scale plants to be made useful, large-scale economies must accommodate and incorporate their contribution successfully.

As humanity attempts to navigate the perils of the unknown, we’ll need to be very clever about how we present solutions to these problems. It should be abundantly clear, at this point, that no solution is complete without full consideration of the new problems that it presents, and ensuring, through cooperation and deliberation, that these by-product problems do not make the solution at hand useless. For example, a solar power tower cannot be considered as an option without making sure it can function at scale, and in differing conditions. In order to accomplish this with minimal cost overhead and without wasting precious time in research, we might employ the use of artificial intelligence and specially designed simulations, which can help us check unforeseen circumstances in the real world that we may have not anticipated.

Large-scale simulations of all types have long been employed by research and development branches in developed nations. Weather models help us predict day-to-day weather. Climate models have been used to study climate data from years past, allowing for projections to be drawn to help us examine potential climate outcomes in the future. The same kind of simulations could be utilized in all areas of climate mitigation/adaptation research. For example, if we are designing geo-oribital solar arrays as a potential solution, researchers might make use of spacial-orbital models to determine all sorts of factors involved in that solution: how high in altitude such satellites must be positioned, how few can be used to still maximize solar exposure and thus eliminate “dead times”, etc. It follows that research will also be needed to improve our ability to model any desirable event, and it goes without saying that improving the correctness and accuracy of such models will be absolutely necessary.

In a post from the Columbia Climate School "State of the Planet" blog, Renee Cho discusses some ways in which artificial intelligence is already playing a crucial role in climate change:

> In India, AI has helped farmers get 30 percent higher groundnut yields per hectare by providing information on preparing the land, applying fertilizer and choosing sowing dates. In Norway, AI helped create a flexible and autonomous electric grid, integrating more renewable energy.

Cho goes on to mention a project of the name Protection Assistant for Wildlife Security (PAWS) from the University of Southern California. The project's goal is to fight poaching by using machine learning to study data about previous poaching events, in order to attempt to predict future incidents. If nothing else, these examples inform us of the undeniable importance of modern technology in producing solutions to our growing problems. Artificial intelligence's usefulness, because of its boundless number of applications, is therefore essentially only limited by our imagination of its application, and the problem that we are attempting to overcome. It should be considered, therefore, a crucial component of our global mission.

In terms of using AI to benefit us in applications like energy, Cho also provides several excellent examples. Wind companies have used AI to study the windmills themselves. Sensors on the equipment feed real-time data to algorithms that compute changes needed to maximize energy production constantly. In short, the sensors detect environmental variables that can predict how the turbines need to spin in light of the incoming wind and its pertinent conditions. Google made use of AI to conserve energy consumption. Cho discusses that Google's ML algorithms studied when and where users would likely participate in power-consumptive activities, like streaming video. Then, their AI could make automatic adjustments to Google's servers' cooling systems, which ultimately reduced some of Google's energy consumption by 40%.

As yet another example of AI making humanity better at dealing with climate change, Cho discusses changes in agriculture. As our world has grown more connected, the Internet of Things (IoT) has exploded. In fact, there are more IoT devices in the world today than there are people (Maayan, 2020). These IoT devices come in various forms, but almost all revolve around a central idea: making arbitrary data available to consuming applications constantly reachable via the internet. These IoT devices come into play as absolutely crucial in many modern AI applications. Our previous example of sensors attached to windmills is demonstrative of this: IoT sensors feed real-time data to consuming AI applications for real-time adjustments and decisions to maximize energy production. In agriculture, sensors can be placed in fields to measure a huge number of crop metrics: soil moisture, pH levels, nutrient levels, etc. This data can be used to help AI determine when crops need changes in management, whether it be adding more water or increasing nitrogen levels. Again, the usefulness of such technologies is essentially hindered only by our imagination of its applications.

In every way that humanity begins its necessary endeavour to tackling the affects we've had on our planet, we will be forced to make smarter and more informed decisions. We will also be forced to expand our horizons and investigate how we can make preexisting technologies better, as well as look at entirely novel ideas and solutions. During this time, humanity will need to constantly battle some crucial hindrances: the solutions we produce must be universally available, they must work to improve our human experience as a whole, and they must be carefully evaluated at every step, to ensure that they won't produce unwanted and counter-productive results. Doing so will require humanity to cooperate at scale we have never accomplished before. In the name of our own preservation, we will need to circumvent the tendencies of capitalism to privatize research, and to benefit only the largest capital contributors. Without these considerations, our quest may very well fail.

Finally, humanity must be willing to come to terms with a concept we have not yet mastered: the ability to reign in unfettered production waste, and perhaps to even begin to ask ourselves when enough is enough. If we do solve the abundance of issues presented by climate change, we might very well find ourselves in identical shoes a short time later. Perhaps we begin to make heavy use of nuclear powered energy, but don't find a long-term solution to storing nuclear waste, and 200 years in the future we might find ourselves needing to fly our waste to space, or some other resource-intensive requirement that we could have otherwise avoided. It is necessary for humanity to recognize that the use of technology in overcoming our problems is not without drawback. Oftentimes, technology has allowed us to prolong problems, to the point where the drawbacks seem buried in the incredibly distant future. It is time for us to abandon this ideology, and adopt a mindset of constant introspection and self-doubt, for it is by this contentious progression that we will be able to differentiate between technologies that enable a better world forever, and technologies that simply mask or obfuscate an underlying issue in our consumptive existence.

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