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Utilizing 5G Enhanced IoT Services for Improved Decision-Making in Environmental Resource Management

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Abstract

The possibilities offered by moving to a 5G infrastructure are fairly well known—decreased latency, enhanced connectivity options, and greatly improved speeds. These technological advancements will make multi-player gaming easier, decrease download time for HD media, and allow for exciting possibilities regarding development of driverless cars technologies. The possible applications for 5G technology to enhance business and leisure stretch as far as the imagination. However, this paper is not about the technical aspect of 5G technology and infrastructure, nor is this paper about how 5G opens up new economic possibilities in various markets. Instead, this paper focuses on how 5G dramatically enhances our ability to obtain data (especially in real time) which opens up significant opportunities regarding how we use data to inform and improve decision-making at all levels. I argue that the move to 5G infrastructure and technology facilitates our ability to develop and deploy new Internet of Things-based services (IoT) in critical areas—like the management of scarce environmental resources. This paper explores the possible ways in which 5G infrastructure can facilitate the creation of new IoT services that improve our responses to the two greatest interrelated environmental threats of our lifetime: climate change and water scarcity.

Introduction

Of course, there are multiple ways in which global society may respond to these twin threats. There are political solutions at the local, state, national, regional, and international levels. The track record for implementing widespread water conservation or reducing greenhouse gas emissions declines as the political solution includes larger groups of people. Even at the local and state levels political solutions are inadequate simply because of the global nature of climate change. In short, political solutions are slow moving and are not dramatic enough given prevailing models on temperature rise and water scarcity. Legal solutions also exist in the form of litigation, but they are differently slow than political solutions and in

many countries, plaintiffs seeking to enjoin oil and gas production face major substantive and procedural hurdles that make successful claims unlikely. However, people can change in ways not dictated via court order or legislative statute. This compels us to investigate non-legal and non-political methods of altering human behavior and decision making to address water scarcity and climate change.

The focus of this paper is on data and how we use it or make it accessible to improve decision-making at individual levels in order to improve the allocation of scarce environmental resources. The advent of 5G technology has come at the right moment, because consumers are more concerned with both conserving water and reducing their carbon footprint given the scientific modeling regarding the emerging “new normal” for our planet. The linkage between 5G technology and improved environmental decision-making exists in the opportunity to create robust and dynamic IoT services. 5G infused IoT can provide better data and real time information which allows consumers and individuals to make better decisions about their purchases or actions that better reflect the true costs and consequences of their choices.

The Climate–Water Nexus

Water scarcity and climate change are inherently intertwined. Our changing climate has brought us enhanced drought, reduced snowfall, floods, and a host of other intensified weather events. Rising temperatures increase evaporation thereby demanding higher volumes of water for irrigated agriculture. In short, climate change has stressed our water resource availability. The science is very clear concerning the interrelationship of these two concepts.

Anthropogenic climate change is focused only on certain gases released into the atmosphere: carbon dioxide, methane, nitrous oxide, water vapor, and other man-made gases like chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆).¹ When these gases are emitted into the atmosphere they “allow direct sunlight (relative shortwave energy) to reach the Earth’s surface unimpeded.”² This shortwave energy heats the surface

¹ *What Are Greenhouse Gases?*, NAT’L CTRS. FOR ENVTL. INFO., <https://www.ncdc.noaa.gov/monitoring-references/faq/greenhouse-gases.php> [<https://perma.cc/5BWS-X42M>].

² *Id.*

and “longer-wave (infrared) energy (heat) is reradiated to the atmosphere.”³ The “greenhouse gases” absorb this longer-wave energy and prevent heat from the Earth’s surface from returning to space.⁴ It is contained in the lower atmosphere.⁵

The primary greenhouse gas at issue is carbon dioxide since humans produce so much of it. Once carbon dioxide is dispersed into the air, “it is repartitioned among the atmosphere, the ocean, and the near-surface materials of the land. That portion that remains in the atmosphere causes global warming and other forms of climate disruption, while that portion that enters the ocean causes ocean acidification.”⁶ Another reason to focus on carbon dioxide is that it stays in the atmosphere far longer than other greenhouse gases.⁷ In contrast, methane, which is more potent, has an atmospheric life of only ten to twelve years.⁸ Therefore, given that (1) humans produce a significant amount of carbon dioxide, (2) carbon dioxide is the most prominent greenhouse gas, and (3) it has the longest atmospheric lifespan, it is the focus of nearly all climate change mitigation solutions and strategies.

Bedrock scientific principles hold that the range of habitable climates for human beings is limited and subject to change based on our actions. It is not simply the case that climate change will render an area of the world too hot to live in. The consequences of climate change go far beyond simply warming the planet to an uncomfortable degree. There are consequences to global warming that may be delayed, non-intuitive, or flatly unpredictable—this is the real insidiousness of climate change. What we know for sure will happen as the world warms is already bad, but

³ *Id.*

⁴ *Id.*

⁵ *Id.*

⁶ R.T. Pierrehumbert, *Cumulative Carbon and Just Allocation of the Global Carbon Commons*, 13 CHI. J. INT’L L. 527, 528 (2013).

⁷ The atmospheric life of carbon dioxide is longer than methane, but measuring its exact lifespan is difficult. Indeed, in *Atmospheric Lifetime of Fossil Fuel Carbon Dioxide*, the authors state that “[t]he fate and lifetime of fossil fuel CO₂ released to the atmosphere is not inherently scientifically controversial, but the packaging of this information for public consumption is strewn with such confusion.” David Archer et al., *Atmospheric Lifetime of Fossil Fuel Carbon Dioxide*, 37 ANN. REV. EARTH & PLANETARY SCI. 117, 118 (2009); see also Pierrehumbert, *supra* note 6, at 529-30.

⁸ *Methane*, NAT’L CTRS. FOR ENVTL. INFO., <https://www.ncdc.noaa.gov/monitoring-references/faq/greenhouse-gases.php> [<https://perma.cc/5BWS-X42M>] (click CH4).

what about the consequences that scientists did not see coming? Or those that trigger other indirect consequences? The interrelation between global temperature increase and water resources demonstrates this nicely.

The increase in global temperature already has, and will continue to have, an effect on water resources.⁹ Three primary areas of water resources will be impacted by temperature increase. Surface water evaporation will be enhanced.¹⁰ Snowpack accumulation, location, and timing will be modified.¹¹ And weather patterns will change—resulting in drought intensification.¹² Changes to the availability of water resources—groundwater, surface water, rainfall, and snowpack—shake the foundation of communities because the systems of water resources regulation have been built upon the idea of stationarity. Examining the law’s reliance on this concept is critical.

Stationarity, as used here, refers to “the idea that natural systems fluctuate within an unchanging envelope of variability.”¹³ This means that any variable, like stream flows in a river, has a time-*invariant* function that allows for future planning to be done based on past measurements.¹⁴ Some scientists assert that, in the context of water management, “stationarity is dead” and anthropogenic climate change killed it.¹⁵ It is intuitive to see the problems that can arise when the Farmer’s Almanac is no longer very good at predicting rainfall for a given region. That makes the farmers’ jobs harder and riskier. Which, in turn, places food security and agricultural economies at much greater risk.

A more detailed look at global water resources independent of climate paints a similarly dire picture. In 1997, the United Nations and the Stockholm Environment Institute prepared the Comprehensive Assessment of the Freshwater Resources of

⁹ See C.K. FOLLAND ET AL., CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS 105–20, 130–33 (J.T. Houghton et al. eds., 2001); Kathleen A. Miller, *Grappling with Uncertainty: Water Planning and Policy in a Changing Climate*, 5 ENVTL. & ENERGY L. & POL’Y J. 395, 396 (2010).

¹⁰ C.K. FOLLAND ET AL., *supra* note 9, at 119–20.

¹¹ *Id.* at 92–96.

¹² *Id.* at 97, 105.

¹³ P.C.D. Milly et al., *Stationarity Is Dead: Whither Water Management?*, 319 SCIENCE 573, 573 (2008).

¹⁴ *Id.*

¹⁵ *Id.*

the World (CFWA).¹⁶ Ninety-seven percent of the world's total water supply is found in oceans and seas—salt water.¹⁷ Of the remaining two and a half percent constituting global freshwater supply, roughly two-thirds exist in glaciers and in the snow covered polar areas.¹⁸ The remaining one-third of freshwater resources is found in rivers, lakes, and groundwater aquifers.¹⁹ By far, groundwater makes up the largest volume of available freshwater.²⁰

Uitto suggests that, based on CFWA estimates, “by 2025 close to 5.5 billion people...will live in areas where the availability of good quality water will pose serious limitations to food production, economic development and social progress.”²¹ Famiglietti states that “two billion people rely on groundwater as their primary water source.”²² Critically, he also states that “half or more” of the water used to irrigate crops to produce food for the world comes from underground sources.²³ Famiglietti concludes that the global groundwater crisis is underappreciated.²⁴ Mainstream media's coverage of this emerging crisis has increased recently, with major newspapers, documentary films, and other media have focused on groundwater scarcity in areas such as California, Texas, India, Morocco, and Peru.

The concern over the growing groundwater crisis is bolstered by the impact of climate change on the availability of freshwater resources and challenges to agricultural production. Groundwater is more than just a direct resource for extraction and use. In regions with available surface water—from lakes or rivers—during times of drought those sources may not be available. Groundwater serves as

¹⁶ Comprehensive assessment of the freshwater resources of the world, Stockholm Environment Institute (SEI), 1997 (at: <https://www.ircwash.org/resources/comprehensive-assessment-freshwater-resources-world>).

¹⁷ *Id.*

¹⁸ *Id.*

¹⁹ *Id.*

²⁰ Jac Van der Gun, *Groundwater and global change: Trends, opportunities and challenges*, United Nations Educational, Scientific and Cultural Organization 7, 2012 (at: <http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/Groundwater%20and%20Global%20Change.pdf>)

²¹ Juha Uitto, *Global Freshwater Resources, World Forests, Markets and Policies* pp 47-58, 2001.

²² J.S. Famiglietti, *The Global Groundwater Crisis*, *Nature Climate Change* volume 4, pages 945-948 (2014).

²³ *Id.*

²⁴ *Id.*

an important buffer for avoiding the devastation that drought may have upon an agricultural region. As global temperature increases, surface water resources will be stressed due to evaporation and the increased intensity, frequency, and duration of droughts—all of which are well known consequences of global climate change. This results in greater reliance upon groundwater resources to rescue communities from drought and dwindling surface water.

In 2001, the United Nation held a “World Day for Water” where speakers estimated that freshwater demands outpaced supply by fifteen to twenty percent and that within twenty-five years, two-thirds of the world’s population would experience significant water shortages.²⁵ UNESCO, in 2011, estimated that freshwater withdrawals from across the globe tripled over the past fifty years.²⁶

In the context of climate change, the nexus for the existence of a reliable water supply, food security, reliable weather patterns, and human health is Earth’s habitable climate. In prior work, I described certain watercourses and aquifers as a type of CPR. I have written about certain types of CPRs that warrant special attention, called vital commons.²⁷ The Earth’s habitable climate is a vital commons. A vital commons is one in which:

- 1) the benefits of the CPR are internalized by nearly all members of a given massive population;
- 2) the costs of the CPR’s depletion are externalized among nearly all members of that same massive population;
- 3) augmentation or depletion of the CPR by one party affects the ability to use the CPR by another party within the same massive population;
- 4) the CPR itself is necessary for sustenance; and
- 5) damage or depletion of the CPR is non-remediable or extremely difficult to correct.²⁸

The habitable climate as well as common groundwater aquifers and major surface water rivers like the Nile or Mississippi River meet the above definition. Garrett Hardin’s iconic work, *The Tragedy of the Commons*, provides a helpful and

²⁵ Kenneth N. Brooks et al, *Hydrology and Management of Watersheds* 15 (2012).

²⁶ *Id.*

²⁷ See Pearl, *supra* note **Error! Bookmark not defined.**, at 1024.

²⁸ *Id.* at 1022, 1041.

clear illustration.²⁹ Imagine a common pasture used by a number of ranchers.³⁰ Each person lets her cattle graze on the pasture.³¹ When a rancher adds a cow, she internalizes the benefit of that addition because she is able to sell the cow and claim the profit.³² This simultaneously imposes a cost on the pasture by reducing the grass available for consumption.³³ She certainly bears some of that cost but so do all other ranchers in equal share.³⁴ The cost she imposes by adding the cow is externalized to the community.³⁵ Hardin claims that the economically rational action—adding cows—necessarily means ruin for the common pasture.³⁶ The most frequently cited solution to the tragedy of the commons is the privatization of the land into separate parcels. Therefore, one rancher may add only that number of cattle which may be sustained by the pasture, thereby avoiding the exhaustion of the resource. Of course, other less mindful ranchers may continue to add cattle to extract as much revenue from the resource prior to exhaustion. The alternative solutions for managing this resource are governmental regulation or relying upon the operation of grassroots communal social norms that curtail individual behavior.

However, the global habitable commons is non-privatizable. As Professor Sarah Krakoff has said, “[t]he atmosphere is a global commons; no matter where in the world you are, your emissions contribute to its increasing insulating properties.”³⁷ She states that the habitable commons “cannot be compartmentalized.”³⁸ She goes on,

For example, the fact that the United States has the highest historical greenhouse gas emissions does not mean that our atmosphere is “thicker” and that we will suffer from global warming proportionately more than other countries. The spatial dispersion also means that

²⁹ See generally Garrett Hardin, *The Tragedy of the Commons*, 162 *SCIENCE* 1243 (1968).

³⁰ *Id.* at 1244.

³¹ *Id.*

³² *Id.*

³³ *Id.*

³⁴ *Id.*

³⁵ *Id.*

³⁶ *Id.*

³⁷ Sarah Krakoff, *American Indians, Climate Change, and Ethics for a Warming World*, 85 *DENV. U. L. REV.* 865, 866 (2008).

³⁸ *Id.*

reductions in one part of the globe can be rendered meaningless by increases in another part of the globe. If the total parts per million of CO₂ continue to rise overall, it does not matter where the parts come from. This spatial dispersion feature of global warming means that disparate effects from climate change cannot be redressed by targeting the emitters closest to the affected area.³⁹

In the context of Hardin's ordinary pasture, overuse and exhaustion would force the population to, perhaps, move elsewhere. In contrast, overuse of the vital commons does not simply result in the rancher moving to the city and working at a factory or selling insurance. Exhaustion of the habitable climate and water resources are vital commons and they are the Climate Crisis. There is nowhere else—save for Mars or the Moon—for us to go.

Public Perception of Climate Change

The increase in the public's concern over climate change and water scarcity. For example, even in the United States (where public concern over climate change has lagged behind other nations), for the first time in history, a majority of U.S. citizens are concerned about climate change affecting them in their lifetimes. The increase in public concern has translated to some attempted legislative action. Recently, representatives in the United States Congress have proposed a "Green New Deal" that seeks to spur and guide the transition to a green economy and dramatically reduce the United States' reliance on fossil fuels for electricity generation. However, the Executive Branch of the United States refuses to meaningfully regulate carbon emissions while demonstrating no concern at all with water shortages.

As numerous reports from the Intergovernmental Panel on Climate Change (IPCC) have stated, the consequences of increased global temperature are occurring more rapidly, thereby heightening the urgency to mitigate carbon emissions. Of course, these consequences absolutely enhance societal stress from increased water scarcity. The transition to a lighter carbon lifestyle is lagging—

³⁹ *Id.* (citation omitted).

especially in the United States. However, given the public's recent increase in concern, this is a prime opportunity to give consumers the tools needed to make different lifestyle and market choices that result in both water conservation and a lower carbon footprint.

The focus of this paper is on impacting voluntary consumer choices. The traditional framing for developing and implementing widespread responses to climate change is through top-down hierarchical legal and regulatory structures. Climate change can more easily be addressed via a statute that bans internal combustion vehicles, coal plants, or other high carbon industries. But, the United States, and many other heavily carbon-leveraged industrialized nations do not have the political willpower to make such bold change. Even incremental change is difficult via a top-down politics driven solution. Even more concerning is the utter failure of the "Green New Deal" in the United States Congress which was a bill that expressed policy positions—but contained no changes to actual regulations or laws.⁴⁰ With the failure of political solutions readily apparent, widespread change has to come from the ground up.

Data indicates that the time is right for this type of grassroots change. The Yale Program on Climate Communications is a clearinghouse for data on United States' citizens' attitudes, beliefs, perceptions, and policies related to climate change. When it comes to climate change attitudes, the YPCC has categorized Americans into six different categories: Dismissive, Doubtful, Disengaged, Cautious, Concerned, and Alarmed.⁴¹ Americans categorized as "Dismissive" do not at all believe that climate change is occurring and strongly oppose any legislative action related to addressing climate change.⁴² In contrast, "Alarmed" Americans are extremely concerned and are supportive of radical legislative responses to climate change.⁴³ YPCC now has five years of data on American attitudes. In 2013, Americans attitudes were categorized in the following ways: Dismissive: 14%, Doubtful, 14%, Disengaged: 4%, Cautious: 23%, Concerned, 29%, and Alarmed:

⁴⁰ <https://www.npr.org/2019/03/26/705897344/green-new-deal-vote-sets-up-climate-change-as-key-2020-issue>

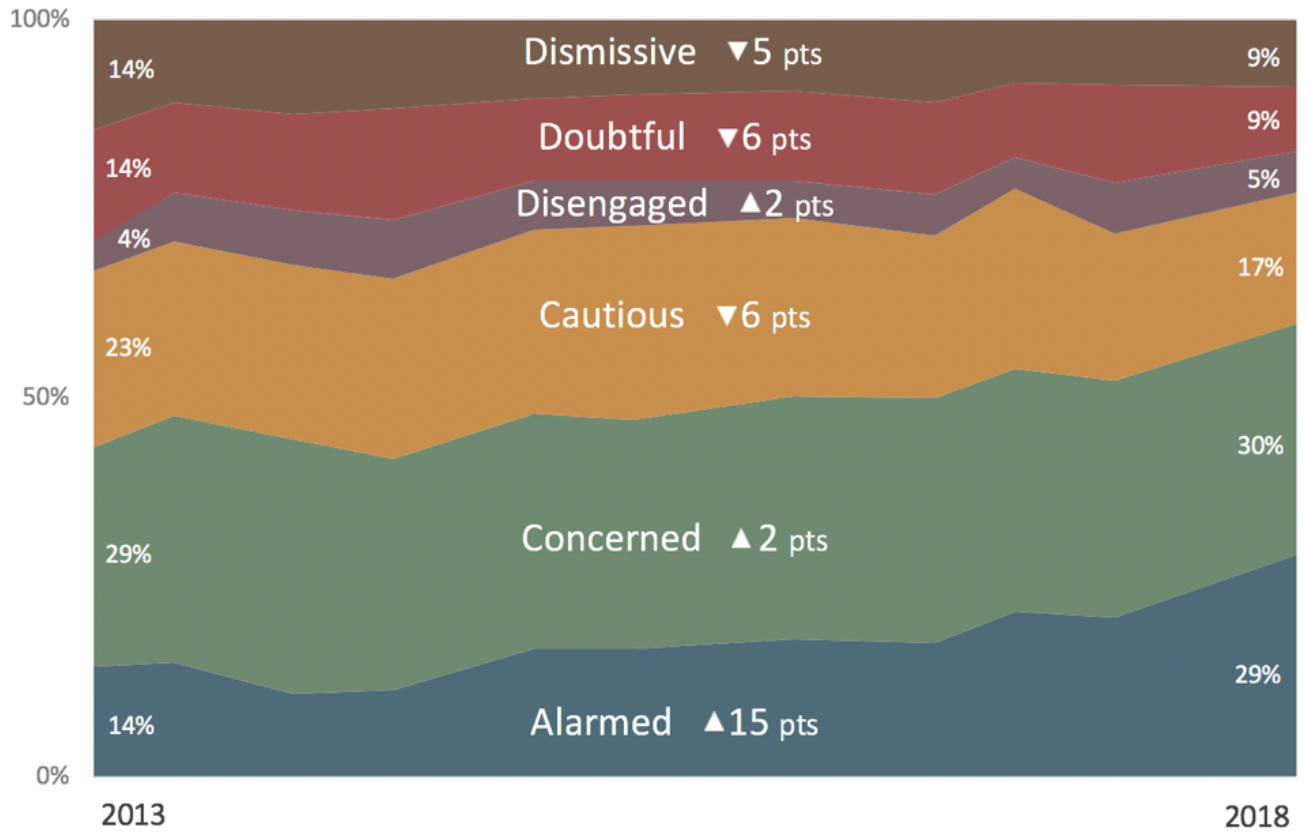
⁴¹ <https://climatecommunication.yale.edu/visualizations-data/six-americas/>

⁴² <https://climatecommunication.yale.edu/publications/americans-are-increasingly-alarmed-about-global-warming/>

⁴³ *Id.*

14%.⁴⁴ Five years later, the breakdowns were as follows: Dismissive: 9%, Doubtful: 9%, Disengaged: 5%, Cautious: 30%, Concerned: 30%, and Alarmed 29%.⁴⁵

Global Warming's Six Americas: 5yr Trend



Data from 11 national surveys (n=13,103) from Dec. 2013 to Dec. 2018. Difference scores are calculated before rounding (example: 30.3% - 28.7% = 1.6% which, after rounding, would appear in the figure as 30% - 29% = 2%).



YALE PROGRAM ON
Climate Change
Communication



GEORGE MASON UNIVERSITY
CENTER for CLIMATE CHANGE
COMMUNICATION

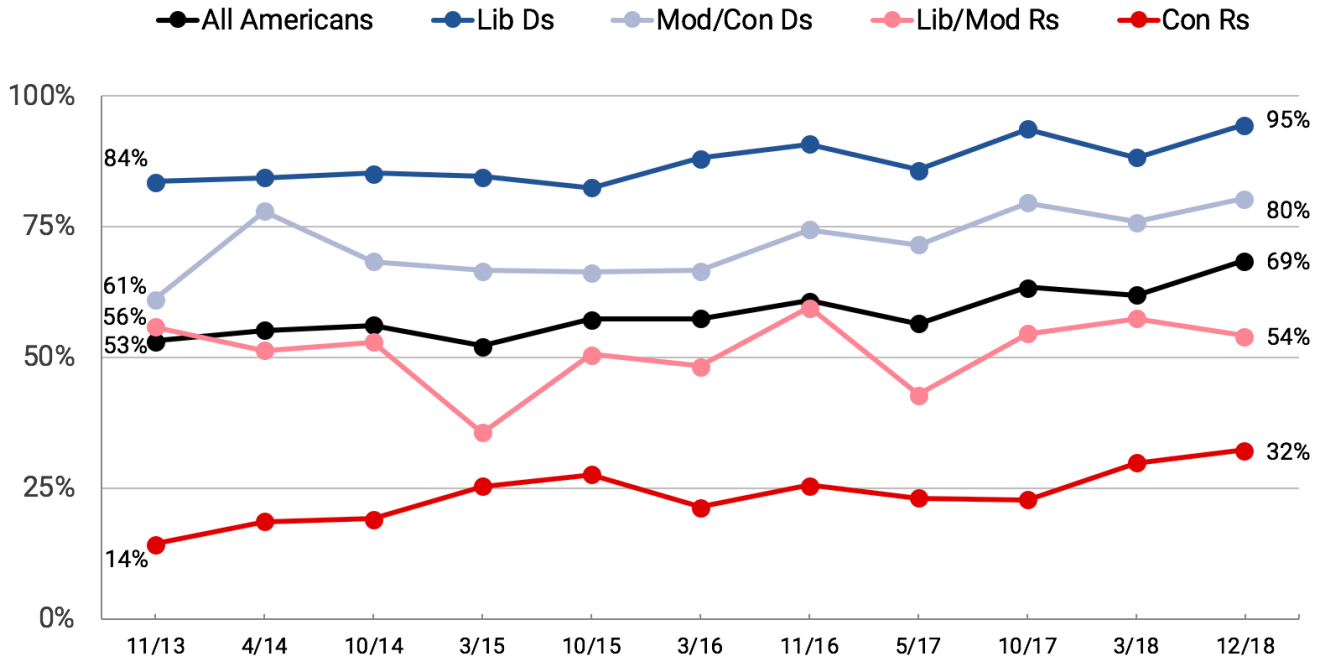
In addition, in 2013, 53% of Americans said that they were “somewhat worried” or “very worried” about climate change. In 2018, that percentage jumped to nearly 70%.⁴⁶

⁴⁴ *Id.*

⁴⁵ *Id.*

⁴⁶ <https://climatecommunication.yale.edu/publications/a-growing-majority-of-americans-think-global-warming-is-happening-and-are-worried/>

5yr Trend in Proportion of Americans That are Worried about Global Warming - % who say "Very" or "Somewhat" worried -



How worried are you about global warming?
 Nov. 2013 to Dec. 2018. Base: 13,103 American adults.
 Values for political parties include only registered Voters (n=11,262).



American concern over climate change has not translated into policies, regulations, or laws that address climate change. Of course, the election of Donald Trump in 2016 demonstrates a negative correlation between American concern over climate change and electoral outcomes. He has cemented his presidential legacy by declaring the United States' exit from the historic Paris Climate Agreement and overturning a host of carbon emissions reducing regulations and policies from the Obama Administration Era.

Even though the increase in American attitudes about climate change have not obtained political responses, it is possible that these attitudes may demonstrate a commitment to mindfulness and individualized action concerning their own consumer choices, demands for low-carbon products, or reducing water consumption.

Consumer Principles and Actions

There are several methods to hasten the shift to a more conservation-focused lifestyle. Most scholarship focuses only on top-down legal-regulatory options that direct behavioral change, *i.e.* the imposition of laws and regulations to economically promote, or punish, certain behavior. However, I argue that given the groundswell of popular concern—especially among young people—political solutions need not be the driver of social change. I argue that the advent of 5G technology creates opportunities for the development of new IoT based services which allow consumers to make decisions that effectuate their desire to address water scarcity and reduce their own carbon emissions.

The goal is to spur the widespread adoption of a low-carbon and water conservation lifestyle for communities and individuals. This can be done via law, but political solutions will take too long to develop and implement. Social norms can develop much faster, especially in this circumstance where significant numbers of consumers are already thinking about the same issues in common. For those individuals, which includes a majority of Americans concerned about climate change, they likely understand that reducing carbon emissions and conserving water is the objective. But, they may lack an understanding about how exactly to do that and, perhaps more importantly, whether the steps they have taken towards those goals are actually effective.

In order to live a carbon-light and water conservation-based lifestyle, consumers need better access to data. Beyond that, they need the data to be helpful in their own decision-making processes and consumer choices. For example, a critical component of an individual's decision-making with regard to carbon emissions is having a baseline carbon footprint that details the individual's contribution of carbon dioxide to the atmosphere. Right now, an individual has to estimate through one of several dozen online calculators their approximated carbon footprint. The same goes for a water footprint. Three problems are clear: first, the time it takes to calculate your carbon or water footprint (and assess the reliability of the particular online calculator) is not insubstantial, second, the number obtained is merely a yearly estimate rather than a particularized real-time assessment, and finally, an individual has little idea how their own individual choices may affect their

carbon footprint. In other words, the present footprint model is static and approximated, whereas a more effective model must be dynamic and specific.

However, one fundamental debate underlies the possible good news that more Americans believe climate change is a real concern: “whether beliefs predict behavior is an ongoing, multi- decade debate in psychology.”⁴⁷ Hall, Lewis, and Ellsworth published a longitudinal study entitled, “Believing in climate change, but not behaving sustainably: Evidence from a one-year longitudinal study,” that attempts to provide some data on this question. They grouped participants into three categories based on their beliefs regarding climate change: skeptical, cautiously worried, and highly concerned.⁴⁸ The most interesting component of their study for purposes of this paper examined “the consequences of cluster membership for self-reported pro-environmental behaviors and support for government policies to address climate change.”⁴⁹ They asked participants how often they engaged in four types of “pro-environmental behavior... (recycling, using public transportation, purchasing environmentally friendly consumer products, and using reusable shopping bags).”⁵⁰

For three of the pro-environmental behaviors (utilizing public transportation, usage eco-friendly products, and using shopping bags) the “Skeptical” participants reported significantly greater behavior frequency than the other two groups (“Highly Concerned” and “Cautiously Worried”).⁵¹ The study also examined participants support for governmental policies to address climate change.⁵² The opposite correlation emerged. The Highly Concerned participants expressed the greatest support for governmental intervention whereas the Skeptical group expressed the least support.⁵³ While this study may aid in explaining the political failure to address climate change, it presents non-intuitive data for environmentally concerned individuals to live their principles.

⁴⁷ Hall, et al., “Believing in climate change, but not behaving sustainably: Evidence from a one-year longitudinal study,” *Journal of Environmental Psychology* 56 (2018) 55-62 (<https://doi.org/10.1016/j.jenvp.2018.03.001>).

⁴⁸ *Id.*

⁴⁹ *Id.*

⁵⁰ *Id.*

⁵¹ *Id.*

⁵² *Id.*

⁵³ *Id.*

There may be a number of explanations for this, some of which the authors suggest as areas for future study. However, the conclusion of the study is not all bad news. If the objective is to get as many people as possible to invest in low-carbon and water-conserving lifestyles, then it is good news that certain beliefs are not necessary conditions for behavioral change. Furthermore, it is feasible for individuals to simultaneously believe that urgency is necessary in addressing climate change while also believing that federal policies are not appropriate.

The study helps us understand two things: first, perhaps those highly concerned people need to more closely understand the direct relationship between their behavior and its contribution to climate change, and second, perhaps those skeptical individuals would engage in more conservation-based behaviors if they are divorced from governmental policies. Both of these ideas can be addressed via consumer choices better informed via the data and relationships created via 5G-infused IoT services. Indeed, in a study funded by Ikea, one of the primary barriers to an individual choosing to act more sustainably was “not knowing how to act or what action to take.”⁵⁴ Moreover, participants identified “clear information on what to do” as an important component of how to ease the transition to more sustainable consumer choices.⁵⁵

5G-Enhanced IoT and Mitigating Environmental Threats

Ultimately, this paper is focused on enhancing the availability of data, improving decision making, resulting in better management of water and carbon dioxide through the usage of 5G enhanced IoT services. IoT services can likely solve these problems because of the increased technical capacity of 5G. Decreased latency, increased transfer speeds, and the ease of deploying the technology within specific areas make the possibility of real-time, particularized, and dynamic carbon and water footprints possible. Such a real-time number of a household’s carbon and water footprint takes out the complexity of calculation while increasing the accuracy of the data. Moreover, it replaces mere estimations of carbon load and water usage with actual numbers that allow the individual to easily understand their choices’ impact on water usage and carbon emissions. Most importantly, the water and

⁵⁴ [https://www.ikea.com/ms/en_US/pdf/reports-downloads/IKEA%20Climate%20Action%20Report%2020180906%20\(002\).pdf](https://www.ikea.com/ms/en_US/pdf/reports-downloads/IKEA%20Climate%20Action%20Report%2020180906%20(002).pdf)

⁵⁵ Id.

carbon footprint numbers could shift in real time based on choices made by the individual. This has a critical psychological effect on an individual by forcing them to confront the connection between their actions and the consequences. It also addresses the gap for those consumers who lack a clear understanding of how to change their behavior. This is entirely what IoT seeks to do—allow us to live smarter and more efficient lives because we can make better decisions.

When consumers are given more and better information, they make better decisions. This may be especially true in those circumstances when decisions are made in connection to the things valued by the individual—like reducing carbon reliance and water conservation. With the increased concern over water scarcity and climate change, this information will allow consumers to act consistent with their principles. Some products at market already take advantage of providing consumers with better information about their choices and how it impacts their environmental choices. The most ready example is the proliferation of “smart” thermostats. Nest, and other companies, have developed thermostats that monitor a homeowner’s usage, habits, presence, and other behaviors to create a schedule that minimizes heating/cooling during a 24-hour period. This attempts to address consumer choices by removing the consumer’s choice from the equation altogether. It’s wholly possible to purchase a smart device and have it calibrate the temperature of the home on its own without any consumer intervention. The thermostat also can provide historical and current data on energy usage and does so via a convenient application on a smartphone.

The limitations of smart thermostats are clear. First, obviously, it only accounts for electrical usage due to heating and air conditioning. Second, the feedback given to the homeowner is relatively superficial, and it does not provide a real-time update as to the carbon load when setting the temperature to a particular degree. These are all shortcomings that can be fixed through 5G connected devices that have the capability to provide real-time data on the carbon consequences of setting the interior temperature high or lower. Therefore, there are two aspects to the incorporation of 5G technology into de-carbonizing consumer choice: (1) data gathering from carbon emissions creating products and (2) applications that aggregate and assess the impact of consumer choices on their immediate carbon footprint. The capability of IoT services to take advantage of 5G technology and

provide real-time, accurate, and dynamic information about our conduct allows for individuals to make better decisions based on better data resulting in better management of environmental resources.