Journal of Future Robot Life 2 (2021) 23–41
DOI 10.3233/FRL-200016
IOS Press

Climate change, global population growth, and humanoid robots

James McBride *
Ph.D., J.D., New York University, New York, NY, USA

Abstract. According to the 2015 Paris Agreement, signatories were to limit global warming to 1.5°C above pre-industrial levels by 2050. However, it is more likely that global warming will rise above 1.5°C by 2050 and 2.0°C by 2100. The primary driver of climate change is population growth. 7.7 billion people live on the planet with projections of 11 billion by 2100. Accordingly, developed countries like the US, which disproportionately generate the CO_2 causing climate change, need to reduce population; however, the U.S. government, in particular, is increasingly hostile to the availability of birth control and abortion. It is in this context that the technological world of humanoid robots may make a significant impact upon populations in the developed world. Scholars project the proliferation of humanoid robots as objects of sexual desire. As people increasingly use humanoid robots as sexual partners, particularly in developed countries where individuals can afford expensive sexbots, the birth rate of developed countries will surely fall from the current 1.7 in the US, 1.6 in Europe, and 1.4 in Japan. This article explores the problems with and the possibilities of humanoid sex robots as a prophylactic to human population growth and climate change.

Keywords: Climate change, global warming, global population growth, GHGs, CO_2 emissions, humanoid robots, sex robots, sex dolls, anthropomorphism, Uncanny Valley, Eliza effect

> This is all wrong. I shouldn't be up here. I should be back in school on the other side of the ocean. Yet you all come to us young people for hope.... You have stolen my dreams and my childhood with your empty words. And yet I'm one of the lucky ones. People are suffering. People are dying. Entire ecosystems are collapsing. We are in the beginning of a mass extinction, and all you can talk about is money and fairy tales of eternal economic growth. How dare you!
> Greta Thunberg, U.N. Climate Action Summit, September 23, 2019

Greta Thunberg, the 16-year-old Swedish activist, boldly condemned the world's leaders in September 2019 at the U.N. Climate Change Summit. She highlighted the abject collapse of human agency in the face of the existential threat to the global environment and humanity itself. If, as John Danaher (2019) has suggested, moral agency is the application of the capacity to process information, formulate strategies, and implement action plans, while exhibiting the capacity to learn and grow, then the adult world, on which future generations rely, has failed, and the consequences of that failure are nothing less than dire. For nearly fifty years, governments have endeavored to reduce, mitigate, and stop global environmental damage from the Stockholm Conference in 1972, the Brundtland Report in 1987 and the Rio Declaration in 1992 to the Kyoto Protocol in 1997 and the Paris Agreement in 2015 (Sands and Peel, 2018). However, ever since the Rio Declaration, global efforts to curtail environmental damage and climate change have been linked to a "devil's bargain" between developed and developing nations: that such efforts would be balanced by "sustainable development," *viz.*, Principle 4. Rio Declaration (Dupuy and Viñuales, 2018, p. 91) – an elastic term that all too often provides the leverage for countries to avoid environmental responsibilities.

This article examines a development, which, although not directed specifically at climate change, may have an indirect effect on the outcome of our contemporary environmental crisis. By the end of the

*E-mail: ejm12@nyu.edu.

21st century, robots will be ubiquitous throughout human societies, particularly in developed countries (Frey and Osbourne, 2013). They will replace both white- and blue-collar workers, provide child- and elder-care, and serve as personal assistants in the home. Humanoid robots will provide more than information and labor. Computer engineers are already working on robots that not only physically look human but also resemble humans in terms of emotional and sexual capacities. If human beings embrace humanoid robots as their intimate companions, perhaps even wed them as marriage partners, the consequences would include the decline in the birth rate, particularly in developed countries, which contribute more carbon emissions per capita to global warming than developing nations. This article will discuss the current state of climate change, its links to global population growth, and the development and possible impact of humanoid sex robots on global warming.

1. CONSEQUENCES OF CLIMATE CHANGE

According to the Paris Agreement of 2015, drafted at the United Nations Framework Convention on Climate Change, signatories committed themselves to limiting the rise in global warming to 1.5°C above pre-industrial levels by 2050 and 2.0°C by 2100 (Paris Agreement, Art. 2(1)(a)). Researchers now estimate that although technically feasible, such limitations are unlikely without "early and rapid action on a global level" (Marcucci et al., 2019, p. 249), including the retirement of fossil-based fuel plants. On the contrary, a recent study concluded that it is more likely that "committed emissions" from the present course of infrastructure development will drive global warming above 1.5°C before 2050 and could surpass 2.0°C by 2100 (Tong et al., 2019), particularly in light of the U.S. withdrawal from the Paris Agreement (Marcucci et al., 2019). Indeed, even aggressive measures to curb greenhouse gases (GHGs) may nevertheless result in global warming of 2.0°C by 2050; lax measures could result in increases as high as 2.4°C in 2050 and an astronomical 5.4°C by 2100 (Portner et al., 2019). In January 2020, more than 11,000 scientists from 153 countries stated "clearly and unequivocally that planet Earth is facing a climate emergency" (Ripple et al., 2019, p. 8). At the U.N. Climate Change Summit in 2019 (somewhat ironically called the U.N. Climate Action Summit by the U.N. itself), the U.N. admitted afterwards that "[t]here was also widespread concern that the world is presently way off course to meet the global target, as emissions continue to increase, and global temperatures rise" (UN Climate Action Summit, 2019). As one scholar at the Centre for Environmental Studies at the Graduate Institute of International and Development Studies, Geneva, has concluded,

> [s]ince the beginning of the new millennium, the initial hopes that emerged after that elaboration of the Kyoto Protocol to construct a strong international climate regime with mandatory reduction obligations have faded … The Kyoto Protocol system has been seriously threatened through the defection of Canada, and the Paris Agreement has moved from country-specific reduction goals (Kyoto Protocol) to national voluntary target setting (called Nationally Determined Contributions (NDCs)) (Luterbacher, 2018, p. 2).

NDCs have simply eviscerated any enforcement mechanism to compel nation-states to curtail climate change. Given the present course, global warming will have catastrophic effects on the environment and human populations.

As a species, we face a parade of horribles. Global warming is evidenced by the fact that "nine of the ten deadliest heat waves in human history have happened since 2000" (McKibben, 2019, p. 36). The National Oceanic and Atmospheric Administration reported that January 2020 was hotter than any January in the 141 years of climate records ("January 2020 was Earth's Hottest January on Record," 2020). Temperatures in the Antarctica have shattered previous records, reaching 64.9°F in February

2020 (Specktor, 2020). Such temperatures in the Antarctic, as well as the Arctic and northern latitudes, have adversely affected the fragile cryosphere of the earth, those portions on the surface of or below the land or oceans which are frozen including "snow cover, glaciers, ice sheets, ice shelves, icebergs, sea ice, lake ice, river ice, permafrost, and seasonally frozen ground" (Portner et al., 2019, SPM-2). The Intergovernmental Panel on Climate Change (IPCC) reports with very high confidence "mass loss" from glaciers, ice sheets, snow cover, Arctic sea ice, and permafrost (Portner et al., 2019, SPM-4). Calving of icebergs from the Antarctic ice sheet has increased markedly over the past few years, including A68, roughly twice the size of Rhode Island in 2017 (O'Leary and Luckman, 2017). More recently, Antarctica shed another iceberg the size of Atlanta (Rech, 2020). In light of global heat waves and drought conditions, catastrophic forest fires have taken place in Australia, Indonesia, Siberia, California, Oregon, Washington, and Alberta, Canada, exacerbated by the elevation of temperatures of the global sea surface that otherwise serves as "air conditioning for the planet" (Schauenberg, 2020).

With the IPCC's "virtually certain" conclusion that the rise of CO_2, absorbed by the oceans, will cause increasing acidification (Portner et al., 2019, SPM-8), the worldwide fishing industry will be adversely affected, resulting in a 30% decline of the global annual catch by 2080–2090 (Portner et al., 2019, SPM-27). Currently, 10–12% of the global population relies on fishing for their livelihood and 4.3 billion depend on fish for 15% of their protein (Grooten and Almond, 2018). On the other hand, 33% of human protein consumption is derived from livestock (Godber and Wall, 2014); however, heat stress caused by drought will certainly harm the production of livestock, not only in the developing world but also in developed countries. Global warming will result in significant per capita water reduction at 1.5°C to 354 million people, whereas at 2.0°C over 420 million will face severe water scarcity (Singh and Kumar, 2019). Vulnerability to food insecurity (VFI) will be especially problematic in developing countries, particularly under a worst-case scenario in which global warming greatly accelerates. As of 2017, 815 million are food insecure, but that figure will rise, even under the most favorable projections of climate change (Richardson et al., 2018). The production of crops is at risk, not only from global drought but also due to the alarming decline in pollinating insects, on which productive farms depend. Water shortages curtail the floral resources necessary for their survival (Phillips et al., 2018), and with a decline in the population of pollinators, such as bees, butterflies, beetles, and wasps, global warming will add significantly to VFI (Marshman et al., 2019). But it is not only pollinators at risk.

The Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) concluded in its May 2019 report that about 1 million animal and plant species face extinction. The rate of biodiversity loss continues to accelerate at a pace "tens to hundreds of times higher than it has averaged over the past 10 million years" (IPBES, 2019, p. 4). The Fifth Assessment Report of the IPCC concluded that the world faces an era of "committed climate change" wherein certain effects of global warming, like the loss of biodiversity and the extinction of species, are now irreversible (United Nations Environment Programme, 2015, pp. 117–118). Ironically, as the planet heats up and the Artic becomes ice-free, perhaps as soon as 2040, the release of cold freshwater from Greenland glaciers will slow the Gulf Stream heading towards Great Britain, Ireland, and the west coast of Europe (Alexander et al., 2020), thereby changing weather patterns and adversely affecting food production (Francis, 2018).

With the degradation of permafrost, the melting of sea ice and land snow at both poles, the massive reduction of glaciers in Antarctica and Greenland, and thermal expansion of the oceans, the consequent sea level rise (SLR) by 2100 will reach anywhere from 2 to 4 feet (Aral and Guan, 2016). 44% of the global population lives within 150 km of the ocean, and eight of the 10 largest cities in the world sit on the coast, including Tokyo, Mumbai, New York City, Shanghai, Lagos, Los Angeles, Kolkata, and Buenos Aires ("Human Settlements on the Coast," 2016; Morton, 2019). Today under

the low GHG emissions scenario, some 190 million people currently live below high tide projections for 2100. Under the high emissions standard, that number rises to 630 million. Currently 1 billion live under 10 meters above sea level; 250 million live below one meter (Kulp and Strauss, 2019). Coral reefs protect many coastal cities and towns from storm surges, but their deterioration through acidification will leave 200 million people vulnerable (Grooten and Almond, 2018). Between 100 and 260 million will suffer from 1 in 100-year catastrophic coastal flooding events by the end of the century (Merkens et al., 2018) Extreme weather will become more frequent with more powerful hurricanes (Pant and Cha, 2019) and typhoons (Bhatia et al., 2018); worldwide SLR will force mass migration of population from island nations and coastlines. Living through what has been called the "Great Acceleration" (Grooten and Almond, 2018, p. 10), combining unprecedented economic development and largely unregulated exploitation of natural resources with a burgeoning global population, the problems related to climate change will have disastrous effects on the world's geo-political order.

Not only will we witness a marked increase in deaths directly associated with adverse weather conditions, SLR, and mass starvation, but the consequent migration of 10s of millions of people from coastal areas and the struggle over limited resources will likely result in regional, if not global, wars between nations and peoples trying to survive in a world increasingly hostile to human habitation (Entwisle et al., 2016; Walker, 2016; Saleem and Ali, 2019). The pace of climate change has taken its toll not only upon the environment but also on climate scientists who assess what seems to be the inexorable march of global warming toward environmental disaster. According to one 2018 study, some 80% of climate scientists and professionals experience burn-out and, in many cases, grief in dealing with what seems to many, at its worst, is the death of the planet (Moser, 2019). The latest UN Report *United in Science (UiS) 2020* suggests that global warming is accelerating rather than remaining stable or declining as envisioned by the 2015 Paris Agreement. The latter asked nations to commit to steps ensuring that global temperature rise would be no more 1.5°C above pre-industrial levels in 2050 and 2.0°C in 2100. However, the *UiS 2020 Report* projected that the forthcoming 2020–2024 period may reach as high as 1.59°C, thereby breaching the targeted limit set for 2050 some twenty-five years early. There seems to be little will on the part of governments and corporations to combat climate change in any coordinated fashion.

Some place their hopes in such green solutions as renewables. However, renewables alone cannot stem the tide of global warming. While an enthusiastic supporter of renewable energy technologies like wind and solar power, Bill Gates, the billionaire founder of the Gates Foundation, acknowledges that wind and solar power innovations alone cannot solve the problem of climate change. It will need a combination of imposed controls through taxes and subsidies, perhaps even universal carbon trading, as well as breakthroughs in the development of nuclear energy and energy storage (Nickelsburg, 2018). Indeed, 2019 is the first year to see the worldwide development of renewable energy sources slow down (IRENA, 2020). The hopes of a younger generation in the promise of renewable energy, particularly in developed countries, are largely misplaced (DeLong et al., 2010). Renewable sources by themselves cannot significantly reduce U.S. carbon emissions (Dong, K., Dong, X., & Dong, C., 2019a).

The late French philosopher Bernard Stiegler suggested that to avoid an apocalyptic conclusion to the dystopic anthropocene, human beings must conceive of their world in a different way. In short, it requires a change of human consciousness to navigate the transition to what Stiegler calls the neganthropocene. Stiegler's work on late modern capitalism, including *The Neganthropocene* (Stiegler, 2018), uses Freud and Lacan to psychoanalyze the metamorphosis of desire into drive which results in the destruction of the ecosystems on which human life depends. Stiegler's work is provocative and intellectually stimulating, but its practicality in calling for fundamental changes to the way human

beings regard nature is highly questionable in the short-term, particularly considering the impending catastrophic consequences of global warming by the 22nd century.

The world has simply lacked the consciousness and the will to carry out an obligatory system of carbon reduction, mandated by the Kyoto Protocol in 1997, and the 2015 Paris Agreement rubric of even *voluntary* NDCs failed to slow global warming, as evidenced by the *UiS 2020 Report*. Although some criticized Greta Thunberg's speech at the United Nations as the exaggerated claims of a naïve, young activist, her words, in light of these dire consequences, seem prescient: "For more than 30 years, the science has been crystal clear. How dare you continue to look away and come here saying that you're doing enough, when the politics and solutions needed are still nowhere in sight" (Thunberg, 2019).

2. GLOBAL POPULATION GROWTH

It may belabor the obvious, but climate change is intimately tied to global population growth. As the IPCC concluded in 2019, "[r]eductions in population growth can reduce overall carbon demand and mitigate climate change" (IPCC, Strengthening and implementing the global response, 2019, § 4.4.3., p. 362). Currently, there are 7.7 billion people on the planet. The United Nations Department of Economic and Social Affairs projects a total population of 8.5 billion in 2030, 9.7 billion by 2050, and nearly 11 billion by 2100 (*World Population Prospects*, 2019). "The size of the human population, in the near-term and distant future, is a key determinant of climate policy: All else equal, a larger population entails more emissions and therefore more mitigation to achieve a given climate target . . . , and it also means more future people will be vulnerable to climate-related impacts" (Scovronick et al., 2017, p. 12338). In 2009, statisticians Paul Murtaugh and Michael Schlax (2009) examined the link between population growth and carbon emissions. Using 2005 carbon emissions in the United States as a baseline (20.18 metric tons per capita) and the U.S. fertility rate of 2.5 children per woman, the researchers simulated the carbon emissions of 10,000 female-only lineages. Given the rising rate of carbon emissions at 1.5 times the 2005 value, each woman would add 2,030 metric tons in her lifetime and, through her line of descendants, 12,730 metric tons for every child she bears (Murtaugh and Schlax, 2009). In other words, population growth has a stunning impact on carbon emissions. Of course, the contribution of population growth to climate change is not uniform across the globe.

"A child born in, say, North America, will have a heavier footprint than will her age-mate born in sub-Saharan Africa" (Ezeh, 2016, p. 189). CO_2 emissions per capita in developed countries far exceed that of the developing world. Today, the United States per capita generation of CO_2 in metric tons is 15.5, more than double that of the PRC at 7.5 metric tons (CO_2 emissions (metric tons per capita) – United States, 2019). It is high consumption rates, rather than simple population growth alone, that triggers global warming (Dong, K., Jiang, Sun, & Dong, X., 2019b); Stephenson et al., 2010). Consequently, although "[p]opulation is the major denominator of this model" (Stephenson, et al., 2010, p. 155), population *and* high income are "the critical driving forces in increasing carbon emissions" (Hashmi and Alam, 2019, p. 1108). "In the first ten days of each year, the average British citizen put out as many greenhouse emissions as the average person in a less developed country does in one year. The United States (US), with 4% of the global population, produces over 20% of the world's greenhouse emissions" (Potts & Graves, 2013, pp. 9–10). Although the highest income stratum constitutes only 16% of the global population, it contributes 39% of production-based CO_2 emissions and 46% of consumption-based CO_2 emissions. More specifically, the United States and Europe comprise 15% of the global population, yet contribute 33% of production-based CO_2 emissions and 37% of consumption-based CO_2 emissions (Ritchie and Roser, 2018). "In other words, climate change is

driven more by consumer behaviour than simply by population number" (Stephenson et al., 2010, p. 151).

It is therefore somewhat alarming that, whereas fertility rates have been falling in developing countries (*World Population Prospects*, 2019) and population growth has somewhat slowed in the United States each year since 2015 (Johnson [U.S. Census Bureau], 2019), the total fertility rate in developed European countries is rising. "In recent years, fertility has declined in nearly all regions of the world. Even in Africa, where fertility levels are the highest of any region, total fertility has fallen from 5.1 births per woman in 2000–2005 to 4.7 in 2010–2015. Europe has been an exception to this trend in recent years, with total fertility increasing from 1.4 births per woman in 2000–2005 to 1.6 in 2010–2015" (UNDESA, 2017). The world may face the sobering thought that while global population growth may slow, the populations of some of the highest producing GHG countries may rise, thereby mitigating any benefit from family planning programs in developing countries (Campbell et al., 2014).

As demographers Leiwen Jiang and Karen Hardee have argued, "the contribution of 'population' to climate change has been underestimated" (Jiang and Hardee, 2011, p. 295). John Bongaarts and Brian O'Neill of the Population Council have observed that, due to the influence of the U.S. government and its policies on family planning, the IPCC is "largely silent about the potential for population policy to reduce risks from global warming" (Bongaarts and O'Neill, 2018, p. 650). If governments wanted to make a serious effort at reducing global CO_2 emissions, developed countries like the United States would support programs to accelerate the decline in their own populations as well as support efforts to decrease population growth in developing countries. Yet the U.S. government actively seeks to undermine the availability of birth control, both domestically and internationally. Half the pregnancies in the United States are unintended ("Unintended Pregnancy," Reproductive Health, Centers for Disease Control and Prevention, 2019). "Averting unintended pregnancies ... happens to be the most cost-effective way of reducing the carbon footprint of the US and other industrialized nations" (Potts & Graves, 2013, pp. 9–10). Moreover, the U.S. government is increasingly hostile to the availability of birth control and abortion services abroad, and has, under the Trump Administration, pursued a policy which not only denies climate change but also blocks family planning services to developing countries, either through its foreign aid program or its influence over international aid agencies.

The so-called Mexico City policy, established by the Reagan Administration in 1984, barred funding by the American government for any NGO that provided abortion counseling or referrals or promoted the decriminalization of abortion. The Obama Administration withdrew the Mexico City Policy on January 23, 2009, but the Trump Administration reinstated it on January 23, 2017 (Flowers, 2019; Trump, 2017). "The U.S. does not endorse population 'stabilization' or 'control.' The 'ideal' family size should be determined by the desires of couples, not governments. The U.S. strongly opposes coercive population programs" ("Population," US Dept. of State, Bureau of Population, Refugees, and Migration, n.d.). In short, the United States is doing nothing about the primary driver of global warming: population growth. Influenced by the conservative Christian agenda, both Evangelical and Catholic, the United States pressures international governmental agencies, like those acting under the aegis of the United Nations, as well as NGOs to drop programs that would offend these American constituencies. As a result, "[a] critical evaluation of attainable solutions to the synergistic effects of population growth and climate change is notably absent from the literature" (Bergstrom et al., 2013, p. 148).

2.1. Climate change and the fortuitous development of humanoid sex robots

Despite the decline in global carbon emissions during the COVID-19 pandemic, reducing GHG production by some 17% (LeQuéré et al., 2020), it is undoubtedly only a temporary respite in the inex-

orable rise in global warming. It seems as if humanity is incapable of assuming the responsibility to effect a comprehensive global reduction of climate change and avoid the inevitable parade of horribles which follow. If there is a solution to global warming, it lies outside the realm of human moral agency. One possible contribution likely will come from the unintended consequences of human activity. It is in this context that the technological world of humanoid robots may make a valuable impact upon populations in those developed countries which disproportionately generate the CO_2-caused climate change. Scholars project the proliferation of humanoid robots as caregivers and nannies in the next few decades, and predict that as early as mid-century, human beings will begin to marry their robotic companions. The so-called sex doll industry is rapidly developing various models of humanoid robots for human sexual pleasure, and while men far exceed the number of women who would engage in sexual activity with a robot, the number of human men and women who view humanoid robots as objects of sexual desire is growing. As human beings increasingly use humanoid robots as sexual partners, particularly in developed countries where individuals can afford expensive sexbots, the birth rate of developed countries, whose per capita generation of CO_2 is largely responsible for global warming, will surely fall downwards of the current 1.7 in the United States, 1.6 in Europe, and 1.4 in Japan.

Of course, the objection might be made that sexbot manufacturing plants may generate more carbon emissions than that saved by the declining birth rate. However, progress has been made in this regard in the robotics sector. In 2019, ABB Japan, the leading producer of industrial robots in the world, announced the opening of a carbon-neutral plant (Market Line Company Profile: ABB Ltd., 2020), i.e., a manufacturing complex which uses only renewable energy and is net-zero in terms of water, waste, and energy. One of the largest manufacturers of industrial robots, Midea Group, first established in Germany and now owned by a Chinese conglomerate, has embraced the philosophy of "clean production" and "continuously adopts comprehensive prevention-based environmental strategies in its production processes, products and services to minimize the risks for mankind and the environment" (Midea Group, 2019, p. 53). Softbank Group Corp., whose subsidiary Softbank Robotics manufactures one of the most widely-recognized personal robots Pepper, is a founding member of the Japan Climate Initiative and is dedicated to realizing a carbon emissions-free world (Softbank Group Annual Report, 2019, p. 044). These examples suggest that robotics manufacturers, particularly in Japan, where environmental concerns are dispositive in the development of new products, will strive to make the production of sexbots carbon-neutral in the 21st century.

The controversy regarding human sexual relations with robotic companions has been a part of public discussion since at least David Levy's 2007 book, *Love + Sex with Robots*. Levy wrote that by the 2050s, humanoid robots "will not be exactly like us, but close" and that marriage with such robots will be legal in some countries (203). Despite Levy's prediction, it is difficult to imagine the appearance of machines designed to appear not only as humans but as sexually functioning synthetic humans. The idea of a sex robot often immediately yields an association with sex dolls, and in that regard people are not mistaken. The sex doll industry is actively developing models of sexually capable humanoid robots. As Noel Sharkey of Responsible Robotics, an opponent of the development of sex robots, has noted, these models include Harmony (Abyss Creations), Android Love Doll (Android Love Dolls), Roxxxy Gold and Rocky Gold (TrueCompanion), and Suzie Software and Harry Harddrive (Sex Bot Company), costing between $5,000 (Android Love Doll) to $15,000 (Harmony) (Sharkey et al., 2017, p. 4). "They look like sex dolls but are equipped with sensors, actors and artificial intelligence. They are able to display conversation, emotions and preprogrammed personalities. And they can perform partially autonomous behavior such as simulating sexual movement, getting into various sexual positions, and expressing orgasm" (Döring and Pöschl, 2018, p. e53).

Great strides have been made in developing the human-like appearance of these robots. Hanson Robotics has developed prototypes of robot heads which not only replicate the structure of the human

head, but also have used biometric principles to program a FACE (Facial Automaton for Creating Emotions) which mimics human facial expressions using 32 micro motors (Lazzeri et al., 2018). Although humanoid robots may appear human from a distance and even use facial movements to express human-like emotion, most human beings would find touch to be a dead give-away. After all, humanoid robots at best would be made of hard silicone that betrays their artificial nature. However, recently researchers have made breakthroughs on the development of a substance that simulates supple human flesh, including the capacity to generate heat (He et al., 2019). Likewise, Columbia Engineering has developed "self-contained electrically driven soft actuators with high strain density" (Miriyev, Stack, and Lipson, 2017, p. 1; He et al., 2019), in effect, synthetic muscle tissue (Shah, 2017). Concurrent with these developments in artificial human flesh and human facial expression, Japanese engineers are currently working on a project to construct a "pain nervous system" in which sensors in an artificial skin would transmit impulses that could be transformed into expressions of discomfort and pain in the robot's face (Sanders, 2020, p. 10).

Not surprisingly, sex robots are overwhelmingly gendered female. They are depicted as stereotypical female sexual objects, large breasts, long hair, narrow waist, and broad hips capable of pleasing the sexual fantasies of heterosexual men. In this respect, current development tracks the commercial interests of sex doll manufacturers. The association of sex robots with sex dolls raises some important considerations. The use of sex dolls in lieu of human partners reflects a type of fetishism, in which an individual compulsively depends on nonliving objects (for example, articles of clothing or shoes) or a body part (most often other than genital) to become sexually aroused or achieve sexual climax. Practiced overwhelmingly by men, fetishism is classified as a paraphilia, but is not necessarily a fetishistic disorder (DSM-5 302.81), unless the penchant for fetishism interferes with daily life, causes unmanageable stress, or leads to harm of oneself or another. For example, a sex doll user might suffer from a fetishistic disorder if the practice leads to abuse of women or isolation from society, including family members. Psychosis is not normally affiliated with ownership of sex dolls (Knafo, 2015). Studies of the effects of sex dolls on their owners are rare, but in one of the few such studies available, researchers concluded that over half of the subjects not only engaged in fantasized sexual activity but also regarded their relationship with the sex doll as a form of companionship (Langcaster-James and Bentley, 2018). These anthropologists argue that instead of a sex doll, these ersatz partners ought to be called "Allodolls," used for the purpose of creating a "necessary or desired social relationship" (Langcaster-James and Bentley, 2018, p. 15). As two German researchers noted in their study of doll-owners, they frequently prefer the term "love doll" to "sex doll" since the former reflects a more meaningful relationship (Döring and Pöschl, 2018, p. e53).

Currently, there are no legal impediments to the manufacture and distribution of sex dolls in the United States (Maras and Shapiro, 2017), other than in the state of Alabama where they fall under a broader proscription of sex toys.[1] However, some feminist scholars are alarmed that certain practices in the sex doll industry may be replicated in the manufacture of sex robots. Two researchers argue that sex robots might augment the problem of pedophilia in society for a number of reasons. The use of child-like sex dolls or sex robots might falsely suggest that children would be safe from pedophiles, who use dolls or robots as a surrogate. Pedophiliac desires might actually be strengthened by the proliferation of such dolls and robots. Such use would distort their perceptions of the reactions of children to

[1] Alabama Statute: Code of Alabama – Title 13A: Criminal Code – Section 13A-12-200.2 – Distribution, possession with intent to distribute, production, etc., of obscene material prohibited; penalties; distribution of fines … "(3) It shall be unlawful for any person to knowingly produce, or offer or agree to produce, any obscene material or any device designed or marketed as useful primarily for the stimulation of human genital organs for any thing of pecuniary value. Material not otherwise obscene may be obscene under this section if the distribution of the material, the offer to do so, or the possession with the intent to do so is a commercial exploitation of erotica solely for the sake of prurient appeal."

pedophiliac aggression. Sex dolls and sex robots may encourage pedophiles to act out their desires on real children. Moreover, the availability of child-like sex dolls and robots might impress upon their imagination that it is acceptable to use children for sexual gratification. Sex dolls and sex robots could also be used to practice grooming and training young children to engage in sexual relations. Above all, child-like sex dolls and sex robots would teach pedophiles that sex is largely about "one-sided" relationships without any emotional ties (Maras and Shapiro, 2017, p. 17). These arguments suggest that the problems caused by the link between pedophilia and sex dolls could spread in society through its replication in the manufacture and distribution of sex robots.

A long line of United States Supreme Court cases, running from Griswold v. Connecticut, 381 U.S. 479 (1965) (striking down a Connecticut statute barring contraception and establishing a Constitutional "penumbra" of privacy) to Lawrence v. Texas, 539 U.S. 558 (2003) (invalidating a Texas law that prohibited private consensual homosexual relations in the home) and Obergefell v. Hodges, 576 U.S. 644 (2015) (affirming a fundamental right to marry for same-sex couples) all may be cited to claim that sexual activity in the home is protected by the Constitution, and therefore nothing could be done to contain pedophilic consequences of the manufacture and distribution of sex dolls and sex robots. Although arguments about the social dangers of pedophilia are well-taken, the Constitutional protection of sexual intimacy does not necessarily bar the regulation of the sex doll and sex robot industries. For example, sex dolls themselves are not a form of sexual intimacy but rather property that could be regulated under the U.S. Constitution's Commerce Clause (Article I, Section 8, Clause 3), in much the same as child pornography (Simmons, 2016). Indeed, a bill was introduced in the U.S. House of Representatives in 2017, the CREEPER ("Curbing Realistic Exploitative Electronic Pedophilic Robots") Act, that would have prevented the distribution or importing of such child sex dolls in the U.S. Although it passed the House (H.R. 4655), the bill failed in the U.S. Senate. Nothing would prevent the adoption of such a statute, other than the lack of political will. Since the government could bar the manufacture and distribution of child-like sex robots, the arguments based on pedophilia carry little weight. However, other arguments claim that the use of sex robots would not be mentally healthy.

"Humans naturally anthropomorphize" (Dacey, 2017, p. 1152). There is a popular fear that this human tendency, which plays a significant role in how users of sex robots regard their companions, may be hijacked by deep-seated neuroses. Some mental health professionals fear that sex robots could lead to obsessive behaviors, comparable to online addictions (Morsünbül, 2018). One study of HRI (Human–Robot Interaction) recognizes the penchant of human beings to anthropomorphize robots (Kaplan, Sanders, and Hancock, 2019). Human beings commonly anthropomorphize "cute" robots, from Lovot to Robi and Paro to Buddy; these robots largely have the appearance of stuffed animals and elicit expressions of affection by human adults as well as children. However, that study concluded that agreeableness, intellect, and extroversion were the strongest predictors of anthropomorphism; neuroticism played a "secondary role" (Kaplan, Sanders, and Hancock, 2019, p. 7). Other researchers have found that HRI is typically characterized by the application of social rules by human beings to different media. As an instance of media equation theory, "[t]he presence of a few fundamental social cues, like interactivity, language, and filling a traditionally human role, is sufficient to elicit automatic and unconscious social reactions" (Horstmann et al., 2018, p. 2). Anthropomorphic perceptions of robots are therefore not an indicator of neuroses, but rather of normality. The more a robot displays indicia of autonomous behavior, the more people treat a robot "as if it is alive" (Horstmann et al., 2018, p. 11).

The possibilities for human–robot sexual intimacy, however, have been questioned by what is widely-recognized as the Uncanny Valley effect. Originally published in 1970 in the journal *Energy* as *Bukimi No Tani*, translated as the "Uncanny Valley," the essay published by the pioneering Japanese roboticist Masahiro Mori noted that when a prosthetic hand looks and acts like a human hand, "we lose

our sense of affinity and the hand becomes uncanny" (Mori, 2012 [1970]). The Uncanny Valley principle suggests that, although humans might feel comfortable with robots and relate to them anthropomorphically, the closer the robot resembles a human, the more likely we have a visceral negative reaction, registered in the ventromedial prefrontal cortex (Rosenthal von der Putten et al., 2019). The Uncanny Valley effect therefore would act as an impediment to the development of robots with sexual attributes, which humans might otherwise regard with affection as their companions (McClelland, 2017). Although the Uncanny Valley effect does impact the level of sexual arousal in human beings responding to sex robots, it does so in unexpected ways. In one study, researchers found that stereotypic behaviors, (i.e., female robots displaying "feelings" and warmth, and male robots displaying agency and competency) elicited Uncanny Valley reactions in human subjects (Otterbacher and Talias, 2017). Their research suggests that commercially successful designs for sex robots may be diametrically opposed to sexist stereotypes, typified in the sex doll industry. Consequently, the fears expressed by some critics of sex robots, e.g., that people may become more likely to view their human partners simply as stereotypical sex objects (McArthur, 2018), may be without basis. The long-accepted theory of the Uncanny Valley has been recently challenged by a different formulation: Robot Accommodation Process Theory (RAPT). "RAPT predicts that exposure to robots over time will reduce aspects of uncanniness, even in humanlike robots that are recognized as artificial life. The Uncanny Valley theory illustrates the idea of repulsion felt by people encountering some classes of humanlike robots, while RAPT acknowledges this uncanniness, but regards it as a temporary condition, open to change at individual and cultural levels" (Carpenter, 2018, pp. 280–281). Consequently, "repeated exposure to robots" as well as their "emotional expression" (McClelland, 2017, p. 257) may in fact mitigate the Uncanny Valley effect.

Although sex robots may play a role in gratifying human libidinal desires, the question remains whether human beings could formulate an emotional bond with their synthetic partners. Nothing seems more off-putting than the disjointed rhythm of computerized voices. While Alexa, Siri, Cortana, and other personal assistants can convey information, they don't express the feeling of intimacy so necessary to human personal interconnection. "A machinic voice makes the listener to wonder what makes it speak and how much actual autonomy and individuality might be found behind the words uttered" (Mannisto-Funk and Sihvonen, 2018, p. 57). However, there may be a solution to this problem. In the 1960s, Joseph Weizbaum, a faculty member at MIT, developed a simple computer program to engage human subjects in conversation. Astutely, he modeled the program on psychotherapeutic exchanges. Whenever it failed to identify the proper response to its human interlocutor, the program would fall back on a standard strategy employed by thousands of Rogerian-style psychotherapists each day in America, encouraging its human counterpart with phrases such as "Please go on" or "Tell me more" (Hall, 2019). Although Weizbaum himself later became alarmed at the disintegration of boundaries between human and artificial intelligence and warned about its dangers, he designed a program which, he soon realized, allowed human beings to have meaningful conversations with computers on an emotional level (Hall, 2019). This so-called "Eliza effect" suggests that it would be possible to create a humanoid robot that could provide more than mere information or carry out more than assigned tasks, but would simulate commiseration with human beings about their psychological states, their passions, their anger, their disappointments.

One group of researchers decided to put the "Eliza effect" to the test. In the experiment, the researchers had a subject, an individual seeking psychotherapy, interact with a live Cognitive-Behavioral psychotherapist as well as the "Eliza" computer program, and then distributed the transcript to 138 practicing therapists to evaluate the sessions.

> One of the most interesting and revealing results was that the participants who evaluated the transcripts from the two therapists ("Eliza" software and human therapist) seemed to view them both as human therapists. At no point did any of them mention that the interaction with therapist 1 (the "Eliza" program) displayed unusual features or that it was a strange, unnatural therapist-patient interaction. This result is consistent to the main body of research pointing to the "Eliza effect" . . . , a psychological phenomenon that describes the anthropomorphic tendency of people to attribute human-like characteristics to embodied computer agents (Cristea et al., 2013, p. 296).

If professionals cannot tell the difference between the simulated emotional reaction of a computer program from the genuine emotional response of a human being, perhaps the companionship of a humanoid robot could produce the illusion of authenticity sufficient to satisfy its owner. In a different experiment, researchers found that when human-like robots, which had shared stories about its "personal" experiences with human interlocutors, expressed objection to being turned off by participants in the study, human beings were far less likely to do so (Horstmann et al., 2018). Of course, the illusion of autonomy might be dispelled by the staccato rhythm of a computerized voice. Yet, Google has discovered that by interjecting "um's" and stutters into the speech of an AI "Duplex" program, the human listener could not tell the difference between a human or computerized interlocutor (Hall, 2019). Accordingly, if a humanoid robot were programmed with both Google's parsing of human language and the Eliza effect, human beings may find humanoid sex robots as not only satisfying sexual partners but also as supportive emotional companions.

2.2. Climate change and human reproduction

Researchers have now long recognized the link between human reproduction and climate change. Fewer births mean less CO_2 emissions. Scholars have been particularly focused on the availability of family planning and its impact on future carbon admissions. In his widely cited cost-benefit analysis for British Optimum Population Trust, Thomas Wire showed that reduction of unintended pregnancies carried to term by 72% between 2010 and 2050 would decrease global CO_2 emissions by 34 Gtonnes (Wire, 2009, p. 20). The reduction will be equivalent roughly to the entire amount of global CO_2 emissions for 2020. ("Forecast of carbon dioxide emissions worldwide from 2018 to 2050," 2019b). Currently, the U.S. produces 15% of global CO_2 emissions ("Each Country's Share of CO_2 Emissions," 2020), and according to World Bank statistics, the United States has the highest per capita production of CO_2 emissions at 15.5 metric tonnes (CO_2 emissions (metric tons per capita), 2019). Eliminating an unwanted birth in the U.S., however, does more than reduce total CO_2 output by 15.5 metric tonnes annually. Because the removal of one individual also eliminates that person's descent line, the disappearance of an unwanted pregnancy carried to term reduces CO_2 emissions in developed countries by 58.6 metric tonnes annually (Wynes and Nicholas, 2017). The elimination of those who would otherwise be born has a disproportionate effect on CO_2 emissions. In other words, just 100,000 fewer births each year in the U.S. would result in an annual reduction of 5.86 million metric tonnes. (100,000 represents only 2.6% of 3.79 million births in the United States in 2018 ("Births in the U.S.-Statistics and Facts," 2019a).) This decrease in CO_2 emissions is equivalent to the elimination of one mid-sized coal-powered plant in the United States every year, e.g., the Daniel Generating Station producing 5.29Mt of CO_2 annually (Evans and Pierce, 2020).

3. CONCLUSION

Although the world has witnessed a temporary respite from climate change due to the coronavirus pandemic, global warming will continue its inexorable rise, particularly with the end of the world health crisis (Foster et al., 2020). The growth of renewable energy resources alone is insufficient to stem the tide of climate change. According to climate scientists, the major driver of global warming is human population growth, particularly in the developed world, where high levels of consumption exert extraordinary burdens on energy for the production of food, as well as for urban development and a Western-inspired consumer culture (Bridgeman, 2017). Politicians and business leaders in developed and developing countries have not exhibited the moral courage necessary to curb CO_2 emissions, and a new generation, led by individuals like Greta Thunberg, seethe with frustration because their elders seemingly have neither the desire not the will to halt their advance.

It is in this context that the development, manufacture, distribution, and promotion of humanoid sex robots may play a role to diminish the pace of population growth in developed countries. Widespread introduction of humanoid sex robots into everyday life would certainly have a prophylactic effect on population growth in societies that are the major culprits in global warming. Some might question whether human beings are ready for the advent of humanoid sex robots. However, Neil Sharkey, a vocal opponent of humanoid sex robots, reported a 100-person American study in which 2/3's of men and 1/3 of women would engage in sexual activities with a sex robot (Sharkey et al., 2017). Another U.S. study, conducted by the internet sex toy retailer EdenFantasys.com, reported that 40% of respondents would engage in sexual behavior with a robotic companion and that 1 in 6 Americans would actually prefer sexual relations with a robot over sexual intimacy with a human (Renner, 2018). YouGov's most recent survey indicated that there is an upward trend in the general public's acceptance of robot sex, noting an overall rise among American adults from 16% to 22% between 2017 and 2020. The rise in approval occurred among all age groups, but perhaps most significantly among those 18–34, jumping by 12% to approximately 32% of this population (Nguyen, 2020). These figures suggest that Levy's prediction of marriage of human beings to humanoid robots, capable of sexual and emotional intimacy, may not be as radical as it seemed in 2007, although it may raise significant religious and legal questions in the human community (Ryznar, 2019; McBride, 2015).

Critics might also argue that the presence of sexbots in the homes of developed countries like the United States would have a *de minimus* effect on the production of CO_2 emissions and therefore negligible impact on climate change. However, as Alisha Graves, executive director of the OASIS Initiative, noted, "There's no single solution for climate change, no magic bullet that can stabilize and eventually reduce the concentration of gasses in the atmosphere. But separating sex from childbearing represents an underappreciated opportunity to forestall climate disaster" (2016, p. 186). Although her comment was made in the context of family planning, the same reasoning could also apply to the introduction of humanoid sex robots into the cultures of developed countries. While the use of sexbots may lead to a decrease in population growth, the magnitude of the climate change problem bars any definitive resolution of global warming through such a development. Nevertheless, as indicated above, even the annual reduction by 100,000 of population growth in developed countries would have a small but tangible effect on global CO_2 emissions. The rise of humanoid sex robots may serve as a contributing factor to addressing this existential threat to humanity. Ironically, that factor's contribution to solving the climate change crisis is based on human desire rather than human moral agency.

REFERENCES

Alexander, M.A., Sang-Ik, S., Scott, J.D., Curchitser, E. & Stock, C. (2020). The response of the northwest Atlantic Ocean to climate change. *Journal of Climate*, *33*(2), 405–428. doi:10.1175/JCLI-D-19-0117.1.

Aral, M.M. & Guan, J. (2016). Global sea surface temperature and sea level rise estimation with optimal historical time lag data. *Water*, *8*(11), 519–534. doi:10.3390/w8110519.

Bergstrom, R., Caddell, R.A., Chynoweth, M.W., Ellsworth, L.M., Henley-Shepard, S., Iwashita, D.K., Lepczyk, C.A. & Miller, K. (2013). A review of solutions and challenges to addressing human population growth and global climate change. *The International Journal of Climate Change: Impacts and Responses*, *4*(3), 147–172.

Bhatia, K., Vecchi, G., Murakami, H., Underwood, S. & Kossin, J. (2018). Projected response of tropical cyclone intensity and intensification in a global climate model. *Journal of Climate*, *31*(20), 8281–8303. doi:10.1175/JCLI-D-17-0898.1.

Bongaarts, J. & O'Neill, B.C. (2018). Global warming policy: Is population left out in the cold? *Science*, *361*(6403), 650–652. doi:10.1126/science.aat8680.

Bridgeman, B. (2017). Population growth underlies most other environmental problems: Comment on Clayton et al. (2016). *American Psychologist*, *72*(4), 386–387.

Campbell, M.M., Casterline, J., Castillo, F., Graves, A., Hall, T.L., May, J.F., Pearlman, D., Potts, M., Speidel, J.J., Walsh, J., Wehner, M.F. & Zulu, E.M. (2014). Population and climate change: Who will the grand convergence leave behind? *The Lancet*, *2*(5), e253–e254. doi:10.1016/S2214-109X(14)70021-X.

Carpenter, J. (2018). Deus sex machina: Loving robot sex workers and the allure of an insincere kiss. In J. Danaher and N. McArthur (Eds.), *Robot Sex: Social and Ethical Implications* (pp. 261–287). MIT Press.

Centers for Disease Control and Prevention (2019). Unintended pregnancy. *Reproductive Health*. Available at: www.cdc.gov/reproductivehealth/contraception/unintendedpregnancy/index.htm.

Cristea, I.A., Sucală, M. & David, D. (2013). Can you tell the difference? Comparing face-to-face versus computer-based interventions. The "Eliza effect" in psychotherapy. *Journal of Cognitive and Behavioral Psychotherapies*, *13*(2), 291–298.

Dacey, M. (2017). Anthropomorphism as cognitive bias. *Philosophy of Science*, *84*(5), 1152–1164. doi:10.1086/694039.

Danaher, J. (2019). The rise of the robots and the crisis of moral patiency. *AI & Society*, *34*(1), 129–136. doi:10.1007/s00146-017-0773-9.

DeLong, J.P., Burger, O. & Hamilton, M.J. (2010). Current demographics suggest future energy supplies will be inadequate to slow human population growth. *Plos One*, *5*(10), e13206. doi:10.1371/journal.pone.0013206.

Dong, K., Dong, X. & Dong, C. (2019a). Determinants of the global and regional CO_2 emissions: What causes what and where? *Applied Economics*, *51*(46), 5031–5044. doi:10.1080/00036846.2019.1606410.

Dong, K., Jiang, H., Sun, R. & Dong, X. (2019b). Driving forces and mitigation potential of global CO_2 emissions from 1980 through 2030: Evidence from countries with different income levels. *Science of the Total Environment*, *649*, 335–343. doi:10.1016/j.scitotenv.2018.08.326.

Döring, N. & Pöschl, S. (2018). Sex toys, sex doll, sex robots: Our under-researched bed-fellows. *Sexologies*, *27*(3), e51–e55. doi:10.1016/j.sexol.2018.05.003.

Dupuy, P.M. & Viñuales, J.E. (2018). *International Environmental Law* (2nd ed.). Cambridge University Press.

Entwisle, B., Williams, N.E., Verdery, A.M., Rindfuss, R.R., Walsh, S.J., Malanson, G.P., Mucha, P.J., Frizzelle, B.G., McDaniel, P.M., Yao, X., Heumann, B.W., Prasartkul, P., Sawangdee, Y. & Jampaklay, A. (2016). Climate shocks and migration: An agent-based modeling approach. *Population and Environment*, *38*(1), 47–71. doi:10.1007/s11111-016-0254-y.

Evans, S. & Pierce, R. (2020). Mapped: The world's coal power plants. *Carbon Brief*. Available at: https://www.carbonbrief.org/mapped-worlds-coal-power-plants.

Ezeh, A. (2016). Population's part in mitigating climate change. *Bulletin of the Atomic Scientists*, *72*(3), 189–191. doi:10.1080/00963402.2016.1170403.

Flowers, P. (2019). "Voodoo demographics": The right-to-life movement confronts the population establishment. In P. Flowers (Ed.), *The Right-to-Life Movement, the Reagan Administration, and the Politics of Abortion* (pp. 89–111). Palgrave. doi:10.1007/978-3-030-01707-1_5.

Foster, P., Forster, H., Evans, M.J., Gidden, M.J., Jones, C.D., Keller, C.A., Lamboll, R.D., LeQuéré, C., Rogelj, J., Rosen, D., Schleussner, C.-F., Richardson, T.B., Smith, C.J. & Turnock, S.T. (2020). Current and future global climate impacts resulting from COVID-19. *Nature: Climate Change*. doi:10.1038/s41558-020-0883-0.

Francis, J.A. (2018). Meltdown. *Scientific American*, *318*(4), 48–53. doi:10.1038/scientificamerican0418-48.

Frey, C.B. & Osbourne, M. (2013). The future of employment. Oxford Martin Programme on Technology and Employment, University of Oxford. Available at: https://www.oxfordmartin.ox.ac.uk/downloads/academic/future-of-employment.pdf.

Godber, O.F. & Wall, R. (2014). Livestock and food security: Vulnerability to population growth and climate change. *Global Change Biology*, *20*(10), 3092–3102. doi:10.1111/gcb.12589.

Graves, A. (2016). Population's part in mitigating climate change: A US response. *Bulletin of the Atomic Scientists*, *72*(3), 186–188. doi:10.1080/00963402.2016.1170400.

Grooten, M. & Almond, R. (Eds.) (2018). *Living Planet Report 2018. Aiming Higher*. World Wildlife Fund International.

Hall, D. (2019). The Eliza effect. *99percentinvisible*. Available at: 99percentinvisible.org/episode/the–eliza-effect/.

Hashmi, R. & Alam, K. (2019). Dynamic relationship among environmental regulation, innovation, CO_2 emissions, population, and economic growth in OECD countries: A panel investigation. *Journal of Cleaner Production*, *231*, 1100–1109. doi:10.1016/j.jclepro.2019.05.325.

He, Q., Wang, Z., Wang, Y., Minori, A., Tolley, M.T. & Cai, S. (2019). Electrically controlled liquid crystal elastomer-based soft tubular actuator with multimodal actuation. *Science Advances*, *5*(10). doi:10.1126/sciadv.aax5746.

Horstmann, A.C., Bock, N., Linhuber, E., Szczuka, J.M., Straßmann, C. & Krämer, N.C. (2018). Do a robot's social skills and its objection discourage interactants from switching the robot off? *PLoS ONE*, *13*(8), 1–25. doi:10.1371/journal.pone.0201581.

Intergovernmental Panel on Climate Change (IPCC) (2019). Strengthening and implementing the global response. In *IPCC Special Report on Global Warming of 1.5°C Approved by Governments* (chap. 4). Available at: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter4_Low_Res.pdf.

Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019). Nature's dangerous decline 'unprecedented' species extinction rates accelerating. Available at: www.dropbox.com/sh/yd8l2v0u4jqptp3/AAACtf6ctsoUQ9hlPQxLpVsKa?dl=0&preview=20190504+IPBES7+Media+Release+Global+Assessment+Final+Errata2+ENG.pdf.

International Renewable Energy Agency (IRENA) (2020). Insights on renewables. Available at: https://www.irena.org/#:~:text=Insights%20on%20Renewables,is%20seen%20to%20slow%20down.&text=Consequently%2C%20the%20share%20of%20renewables,2018%20to%2034.7%25%20in%202019.

Jiang, L. & Hardee, K. (2011). How do recent population trends matter to climate change? *Population Research Policy Review*, *30*(2), 287–312. doi:10.1007/s11113-010-9189-7.

Johnson, S.L. (2019). New estimates show U.S. population growth continues to slow. *United States Census Bureau*, U.S. Government. Available at: www.census.gov/library/stories/2019/12/new-estimates-show-us-population-growth-continues-to-slow.html.

Kaplan, A.D., Sanders, T. & Hancock, P.A. (2019). The relationship between extroversion and the tendency to anthropomorphize robots: A Bayesian analysis. *Frontiers in Robotics and AI*, 5. doi:10.3389/frobt.2018.00135.

Knafo, D. (2015). Guys and doll: Relational life in the technological era. *Psychoanalytic Dialogues*, *25*(4), 481–502. doi:10.1080/10481885.2015.1055174.

Kulp, S.A. & Strauss, B.H. (2019). New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding. *Nature Communications*, *10*(1), 1–12. Available at: https://www.nature.com/articles/s41467-019-12808-z. doi:10.1038/s41467-018-07882-8.

Langcaster-James, M. & Bentley, G.R. (2018). Beyond the sex doll: Post-human companionship and the rise of the 'allodoll'. *Robotics*, *7*(4), 1–20.

Lazzeri, N., Mazzei, D., Cominelli, L., Cisternino, A. & De Rossi, D.E. (2018). Designing the mind of a social robot. *Applied Sciences*, *8*(2), 302. doi:10.3390/app8020302.

LeQuéré, C., Jones, M.W., Smith, A.J.P., De-Gol, A.J., Willis, D.R., Jackson, R.B., Abernethy, S., Andrew, R.M., Peters, G.P., Shan, Y., Canadell, J.G., Friedlingstein, P. & Creutzig, F. (2020). Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement. *Nature Climate Change*, *10*(7), 647–653. doi:10.1038/s41558-020-0797-x.

Levy, D. (2007). *Love + Sex with Robots: The Evolution of Human–Robot Relationships*. Harper.

Luterbacher, U. (2018). Introduction. In U. Urs Luterbacher and D.F. Sprinz (Eds.), *Global Climate Policy: Actors, Concepts, and Enduring Challenges* (pp. 1–12). MIT Press. doi:10.7551/mitpress/10264.001.0001.

Mannisto-Funk, T. & Sihvonen, T. (2018). Voices from the uncanny valley: How robots and artificial intelligencers talk back to us. *Digital Culture and Society*, *4*(1), 45–64. doi:10.14361/dcs-2018-0105.

Maras, M.H. & Shapiro, L.R. (2017). Child sex dolls and robots: More than just an uncanny valley. *Journal of Internet Law*, *21*(6), 3–21.

Marcucci, A., Panos, E., Kypreos, S. & Fragkos, P. (2019). Probabilistic assessment of realizing the 1.5°C climate target. *Applied Energy*, *239*(C), 239–251. doi:10.1016/j.apenergy.2019.01.190.

Market Line Company Profile: ABB Ltd. (2020). Available at: http://eds.a.ebscohost.com.proxy.library.nyu.edu/eds/detail/detail?vid=2&sid=bc7e823b-848c-4f8d-9e49-8cf7e04a5036%40sdc-v-sessmgr02&bdata=JnNpdGU9ZWRzLWxpdmU%3d#AN=142210552&db=bth.

Marshman, J., Blay-Palmer, A. & Landman, K. (2019). Anthropocene crisis: Climate change, pollinators, and food security. *Environments*, *6*(2), 22. doi:10.3390/environments6020022.

McArthur, N. (2018). The case for sexbots. In J. Danaher and N. McArthur (Eds.), *Robot Sex: Social and Ethical Implications* (pp. 33–45). MIT Press.

McBride, J. (2015). The advent of postmodern technoreligiosity. *Journal of Evolution & Technology*, *25*(2), 25–38. Available at: https://jetpress.org/v25.2/mcbride.htm.

McClelland, R.T. (2017). Confronting emerging new technology: The case of the sexbots. *The Journal of Mind and Behavior*, *38*(3/4), 247–270.

McKibben, B. (2019). The size of the board. *Natural History*, *127*(5), 34–39.

Merkens, J.L., Lincke, D., Hinkel, J., Brown, S. & Vafeidis, A.T. (2018). Regionalisation of population growth projections in coastal exposure analysis. *Climatic Change*, *151*(3/4), 413–426. doi:10.1007/s10584-018-2334-8.

Midea Group (2019). 2018 corporate social responsibility report. Foshan City, Guangdong Province, China.

Miriyev, A., Stack, K. & Lipson, H. (2017). Soft material for soft actuators. *Nature Communications*, *8*, 1. doi:10.1038/s41467-017-00685-3.

Mori, M. (2012 [1970]). The uncanny valley: The original essay by Masahiro Mori. *IEEE Spectrum*, 1–6. Available at: spectrum.ieee.org/automaton/robotics/humanoids/the-uncanny-valley.

Morsünbül, Ü. (2018). Attachment and sex with robots: An assessment from mental health perspective. *Current Approaches in Psychiatry*, *10*(4), 417–429. doi:10.18863/pgy.363669.

Morton, M.C. (2019). How the 5 riskiest U.S. cities for coastal flooding are preparing for rising tides. *Science News*, *196*(3), 1–3. Available at: www.sciencenews.org/article/top-five-us-coastal-cities-risk-flooding-rising-sea-levels.

Moser, S.C. (2019). The adaptive mind: Psychosocial support for professionals working on the frontlines of climate change. In *American Geophysical Union, Fall Meeting 2019*. Available at: https://ui.adsabs.harvard.edu/abs/2019AGUFM.U13B..06M/abstract.

Murtaugh, P.A. & Schlax, M.G. (2009). Reproduction and the carbon legacies of individuals. *Global Environmental Change*, *19*(1), 14–20. doi:10.1016/j.gloenvcha.2008.10.007.

National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce (2020). January 2020 was earth's hottest January on record. Available at: www.noaa.gov/news/january-2020-was-earth-s-hottest-january-on-record.

Nguyen, H. (2020). In 2020, both men and women are more likely to consider having sex with a robot. *YouGov*, YouGov PLC. Available at: today.yougov.com/topics/science/articles-reports/2020/03/19/2020-both-men-and-women-are-more-likely-consider-h.

Nickelsburg, M. (2018). Bill Gates: Why renewable energy is not enough to solve climate change. *Geekwire*. Available at: https://www.geekwire.com/2018/bill-gates-renewable-energy-not-enough-solve-climate-change/.

O'Leary, M. & Luckman, A. (2017). Larsen C calves trillion ton iceberg. *Project MIDAS*. Available at: www.projectmidas.org › blog › calving.

Otterbacher, J. & Talias, M. (2017). S/he's too warm/agentic! Influence of gender on uncanny reactions to robots. In *HRI'17: Proceedings of the 2017 ACM/IEEE International Conference on Human–Robot Interaction* (pp. 214–223). doi:10.1145/2909824.3020220.

Pant, S. & Cha, E.J. (2019). Potential changes in hurricane risk profile across the United States coastal regions under climate change scenarios. *Structural Safety*, *80*, 56–65. doi:10.1016/j.strusafe.2019.05.003.

Paris Agreement (2015). United Nations framework convention on climate change. Available at: unfccc.int/sites/default/files/english_paris_agreement.pdf.

Phillips, B.B., Shaw, R.F., Holland, M.J., Osborne, J.L., Fry, E.L., Bardgett, R.D. & Bullock, J.M. (2018). Drought reduces floral resources for pollinators. *Global Change Biology*, *24*(7), 3226–3235. doi:10.1111/gcb.14130.

Portner, H.O., Roberts, D.C., Masson-Delmotte, V., Zhai, P., Tignor, M., Poloczanska, E., Mintenbeck, K., Nicolai, M., Okem, A., Petzold, J., Rama, B. & Weyer, N. (Eds.) (2019). *The Ocean and Cryosphere in a Changing Climate: Summary for Policymakers. Intergovernmental Panel on Climate Change*. Available at: https://report.ipcc.ch/srocc/pdf/SROCC_FinalDraft_FullReport.pdf.

Potts, M. & Graves, A. (2013). Big issues deserve bold responses: Population and climate change in the Sahel. *African Journal of Reproductive Health*, *17*(3), 9–14.

Rech, D. (2020). An iceberg nearly the size of Atlanta just broke off a glacier in Antarctica. CNN. Available at: cnn.com, www.cnn.com/2020/02/12/world/iceberg-breaks-off-antarctica-glacier-scn-intl/index.html.

Renner, B. (2018). Sign of the times: 1 in 6 Americans prefer sex with robot over human. *StudyFinds*. Available at: StudyFinds.org, www.studyfinds.org/40-percent-americans-sex-with-robot/.

Richardson, K.J., Lewis, K.H., Kent, C., Wiltshire, A.J., Hanlon, H.M. & Krishnamurthy, P.K. (2018). Food security outcomes under a changing climate: Impacts of mitigation and adaptation on vulnerability to food insecurity. *Climatic Change*, *147*(1/2), 327–341. doi:10.1007/s10584-018-2137-y.

Ripple, W.J., Wolf, C., Newsome, T., Barnard, P. & Moomaw, W. (2019). World scientists' warning of a climate emergency. *BioScience*, *70*(1), 8–12. doi:10.1093/biosci/biz088.

Ritchie, H. & Roser, M. (2018). CO_2 and greenhouse gas emissions. *Our World in Data*, World Bank. Available at: ourworldindata.org/co2-and-other-greenhouse-gas-emissions#co2-embedded-in-trade.

Rosenthal von der Pütten, A.M., Maderwald, S., Brand, M., Krämer, N.C. & Grabenhorst, F. (2019). Neural mechanisms for accepting and rejecting artificial social partners in the uncanny valley. *Journal of Neuroscience*, *39*(33), 6555–6570. doi:10.1523/JNEUROSCI.2956-18.2019.

Ryznar, M. (2019). Robot love. *Seton Hall Law Review*, *49*(2), 353–374.

Saleem, S.B. & Ali, Y. (2019). Effect of lifestyle changes and consumption patterns on environmental impact: A comparison study of Pakistan and China. *Chinese Journal of Population Resources and Environment*, *17*(2), 113–122. doi:10.1080/10042857.2019.1574454.

Sanders, L. (2020). Linking sense of touch to facial movement inches robots toward 'feeling' pain. *Science News*, *197*(5), 10.

Sands, P. & Peel, J. (2018). *Principles of International Environmental Law* (4th ed.). Cambridge U Press.

Schauenberg, T. (2020). Wildfires: Climate change and deforestation increase the global risk. *Deutsche Welt*. Available at: www.dw.com/en/wildfires-climate-change-and-deforestation-increase-the-global-risk/a-51928388.

Scovronick, N., Budolfson, M.B., Dennig, F., Fleurbaey, M., Siebert, A., Socolow, R.H., Spears, D. & Wagner, F. (2017). Impact of population growth and population ethics on climate change mitigation policy. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(46), 12338–12343. doi:10.1073/pnas.1618308114.

Shah, S. (2017). Synthetic muscle breakthrough could lead to 'lifelike' robots. *engadget*. Available at: www.engadget.com/2017/09/21/synthetic-muscle-soft-robot-breakthrough/.

Sharkey, N., Wynsberghe, A., Robbins, S. & Hancock, E. (2017). *Our Sexual Future with Robots*. Foundation for Responsible Robotics. Available at: responsible-robotics-myxf6pn3xr.netdna-ssl.com/wp-content/uploads/2017/11/FRR-Consultation-Report-Our-Sexual-Future-with-robots-1-1.pdf.

Simmons, T.E. (2016). Sexbots; an obloquy. *Wisconsin Law Review*, *2016*, 45–53.

Singh, R. & Kumar, R. (2019). Climate versus demographic controls on water availability across India at 1.5°C, 2.0°C and 3.0°C global warming levels. *Global and Planetary Change*, *177*, 1–9. doi:10.1016/j.gloplacha.2019.03.006.

Softbank Group Annual Report (2019). Available at: https://group.softbank/system/files/pdf/ir/financials/annual_reports/annual-report_fy2019_01_en.pdf.

Specktor, B. (2020). Antarctica just saw its all-time hottest day ever. *LiveScience*. Available at: www.livescience.com/antarctica-record-high-temperature.html.

Statista (2019a). Births in the U.S.-statistics and facts. Available at: https://www.statista.com/topics/4452/births-in-the-us/#:~:text=In%202018%2C%20there%20were%20around,and%20the%20use%20of%20contraception.

Statista (2019b). Forecast of carbon dioxide emissions worldwide from 2018 to 2050. Available at: https://www.statista.com/statistics/263980/forecast-of-global-carbon-dioxide-emissions/.

Stephenson, J., Newman, K. & Mayhew, S. (2010). Population dynamics and climate change: What are the links? *Journal of Public Health*, *32*(2), 150–156. doi:10.1093/pubmed/fdq038.

Stiegler, B. (2018). *The Neganthropocene*. Open Humanities Press.

Thunberg, G. (2019). Transcript: Greta Thunberg's speech at the U.N. climate action summit. Available at: https://www.npr.org/2019/09/23/763452863/transcript-greta-thunbergs-speech-at-the-u-n-climate-action-summit.

Tong, D., Hong, C., Qin, Y., Davis, S.J., Zhang, Q., Zheng, Y., Caldeira, K. & Shearer, C. (2019). Committed emissions from existing energy infrastructure jeopardize 1.5°C climate target. *Nature*, *572*(7769), 373–377. doi:10.1038/s41586-019-1364-3.

Trump, D.J. (2017). The Mexico City policy. *Federal Register*, 82, Report no. 15, FR Doc. 2017-01843.

U.S. Department of State, Bureau of Population, Refugees, and Migration, U.S. Department of State (n.d.). Population. Available at: www.state.gov/other-policy-issues/population/.

Union of Concerned Scientists (2020). Each country's share of CO_2 emissions. Available at: https://www.ucsusa.org/resources/each-countrys-share-co2-emissions.

United Nations (2016). Human settlements on the coast. *UN Atlas of the Oceans*. Available at: http://www.oceansatlas.org/subtopic/en/c/114/.

United Nations (2019). UN climate action summit 2019. *Climate Action*. Available at: www.un.org/en/climatechange/un-climate-summit-2019.shtml.

United Nations Environment Programme (2015). *Climate Change 2014. Mitigation of Climate Change. Summary for Policymakers and Technical Summary*. Cambridge University.

United Nations, Department of Economic and Social Affairs (UNDESA) (2017). World population prospects 2017. Available at: https://www.un.org/development/desa/publications/world-population-prospects-the-2017-revision.html.

Walker, R.J. (2016). Population growth and global security. *American Journal of Economics & Sociology*, *75*(4), 980–1004. doi:10.1111/ajes.12161.

Wire, T. (2009). Fewer emitters, lower emissions, less cost: Reducing future carbon emissions by investing in family planning, a cost/benefit analysis. Published doctoral dissertation, London School of Economics. Available at: http://mindermensen.be/docs/reducing_emissions.pdf.

World Bank (2019). CO_2 emissions (metric tons per capita) – United States. Available at: https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?locations=US.

Wynes, S. & Nicholas, K.A. (2017). The climate mitigation gap: Education and government recommendations miss the most effective individual actions. *Environmental Research Letters*, *12*(7), 074024. doi:10.1088/1748-9326/aa7541.