

**The Impacts of Climate Change on the Health of Low-Income Individuals and People of
Color in the U.S.**

Thesis

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Bachelor of Science in Environmental Studies

By

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Abstract

This thesis investigates how climate change disproportionately affects the health of low-income individuals and people of color in the U.S. on account of their various societal disadvantages. Climate change increasingly impacts natural processes and systems, translating into intensified and lengthened heat waves, droughts, sea level rise, and wildfires in the U.S. Additionally, the frequency and severity of vector-borne diseases, floods, and extreme weather events are influenced by climate change. Each of these climatic factors can degrade the physical, biophysical, and mental aspects of human health. Low-income individuals and people of color are particularly at risk for negative health effects, because of elevated exposures to climatic hazards and low resiliency levels. However, policymakers at all levels of the government can institute adaptive measures that bolster the resiliency of these groups in the face of continued climate change-related events. A literature review of relevant journal articles and governmental sources was performed to ascertain the physical and mental health impacts from these climate change-related factors. This analysis resulted in an edifying array of ways that climate change negatively affects human health, although adaptation efforts exist to alleviate them. It is essential for individuals, communities, and policymakers to foster the resiliency of marginalized groups so that human health can be maintained in the face of climate change.

Dedication

I dedicate this thesis to my family, for their unfailing support throughout my collegiate studies, and to Professor Richard Mowrer, for his guidance in refining the proper methods of scholarly writing.

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Introduction

An individual's bank account and skin color fundamentally relate to their resiliency to the health impacts of climate change. Throughout the U.S., climate change alters natural processes, precipitation, and temperature patterns to grievous effect upon residents of the nation. The physical health impacts resulting from climate change can be direct or indirect, such as by sustaining a burn injury from a wildfire or encountering clean drinking water problems after floods. People's mental health can also be affected by climate change as they navigate increasing environmental hazards. Heat waves, defined as temperatures that exceed the seasonal average, wildfires, droughts, flooding, sea level rise, and extreme weather events are increasing in frequency and intensity throughout the U.S. as a consequence of anthropogenic climate change (Bell et al., 2018; Widerynski et al., 2017, p. 2). In addition, climate change alters the distribution of vectors that carry diseases, defined as organisms such as ticks and mosquitoes that can transmit pathogens between hosts (American Public Health Association [APHA] & Centers for Disease Control and Prevention [CDC], 2019; Luber et al., 2014, p. 225). Each of these climatic factors can impair human health, with low-income individuals, defined as people whose household's taxable income does not exceed 150% of the poverty level, and people of color particularly exposed as well as less resilient to the impacts (United States Department of Education, 2021). Yet, adaptation measures can be taken to bolster the resilience of marginalized groups to climate change.

The field of climate change and its impacts on humans has attracted many researchers over the years, although some gaps still exist in the discipline. Research has shown that the seven climatic factors listed above can negatively and disproportionately impact people's physical as well as mental health depending on social vulnerability. Climate change projections estimate

progressively severe impacts as greenhouse gases (GHG) continue to be released into the atmosphere, which has implications for human health. The majority of articles that researched the health impacts of climate change on human populations focused on a single climatic factor, one region of the U.S., or a single group of people, such as elderly individuals. This thesis represents a unique perspective by considering a wide range of climate change-related factors throughout the entire country, and how they impact the health of both low-income individuals and people of color. Through performing a literature review, this thesis explores the ways in which climate change impacts the health of low-income individuals and people of color. In addition, the literature review investigates measures that individuals and policymakers can undertake in order to strengthen the resiliency of these marginalized groups. Peer-reviewed journal articles and governmental documents comprise the majority of the sources reviewed for this thesis. Prior to exploring the health impacts of climate change-related factors and events on marginalized groups, anthropogenic climate change and the foundation of people's social vulnerability must be understood. The next section provides a background to anthropogenic climate change and the preexisting vulnerabilities of individuals in society, while the findings sections are organized by climatic impact.

Background

Anthropogenic Contributions to Climate Change. Humans have interfered with natural processes and balances by emitting GHG into the atmosphere, which drives anthropogenic contributions to climate change. Concentrations of carbon dioxide (CO₂), a GHG, have exponentially risen from a 10,000-year stable level of 280 ± 20 parts per million (ppm), to 410 ppm in 2019 as a result of the industrial revolution (Le Treut et al., 2007, p. 100; United States Environmental Protection Agency [U.S. EPA], 2021b). Similarly, methane, a long-lasting

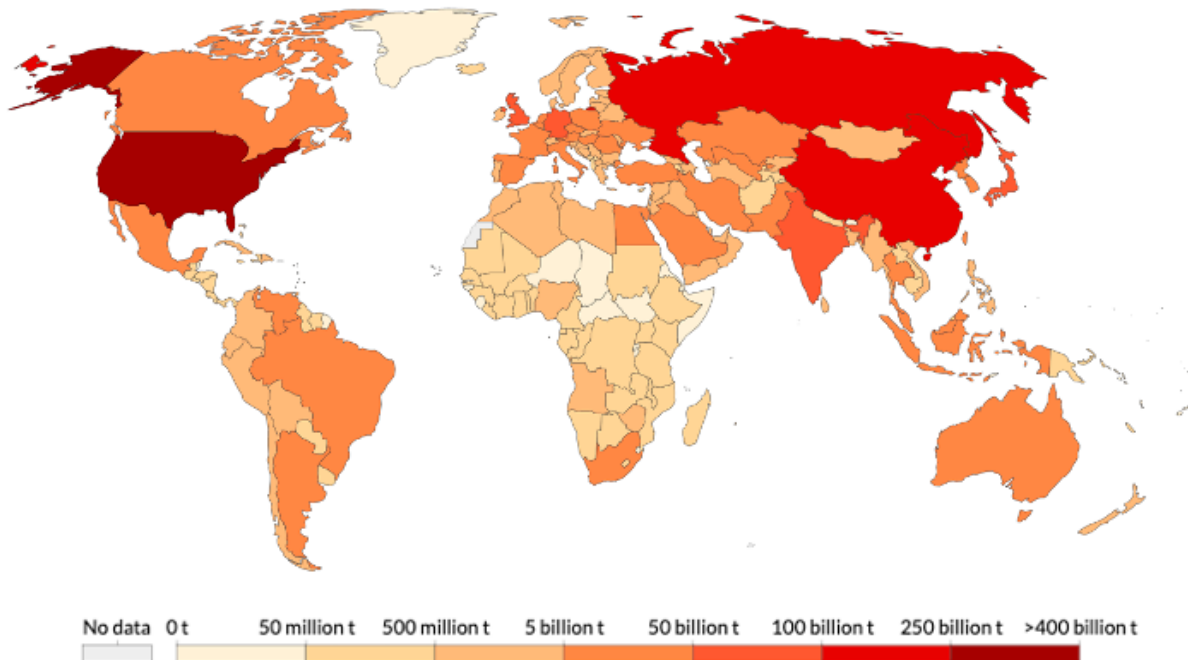
GHG, remained at a relatively stable level between 400-700 parts per billion (ppb) for 500,000 years up until the 19th century, whereupon concentrations have reached over 1,800 ppb in 2019 (Le Treut et al., 2007, p. 100; U.S. EPA, 2021b). Hence, even though atmospheric concentrations of these GHGs were subject to variation prior to the industrial revolution, humans have vastly accelerated natural climatic changes through industrial practices that burned fossil fuels.

Industrialized nations around the world are particularly responsible for anthropogenic climate change, as their modern societies have been founded on burning fossil fuels, releasing GHGs that warm Earth's atmosphere. The U.S. has accounted for 25% of the world's CO₂ emissions since 1750, or 417 billion tons, from burning fossil fuels and cement, as Figure 1 illustrates (Ritchie, 2019). Every nation has a responsibility to reduce their GHG emissions, but particularly the industrialized nations portrayed in Figure 1, who have contributed the most to anthropogenic climate change. In the U.S., the burning of fossil fuels is largely undertaken for the energy sector, constituting 74% of the nation's total GHG emissions in 2019 (United States Energy Information Administration, 2021). While the energy produced allows residents to lead their energy-intensive lives, corporations, industries, and the U.S. government are the entities responsible for the country's usage of fossil fuels in this sector.

Historic and Continued Foundations of Social Vulnerability. People of color and low-income individuals are socially vulnerable to health impacts from climate change in the U.S. due to historical as well as present racial discrimination and a lack of resources. Although the foundations of racism are rooted in history, actions taken in the more recent past have considerably contributed to systemic racism in the U.S. In the 1930s, the Home Owners' Loan Corporation and the Federal Housing Authority supported racial covenants that denied mortgage

Figure 1

Global CO₂ Emissions since 1750 from Combustion of Fossil Fuels and Cement



Note. This map portrays the proportion of CO₂ emitted in tons by each country from burning fossil fuels and cement since 1750, where darker reds represent higher cumulative emissions (Ritchie, 2019).

insurance to people of color in certain areas and practiced redlining, which color-coded the risk of neighborhoods based on racialized classifications in order to determine where the federal government would insure loans (Brown & Barganier, 2018, pp. 173, 175). Consequently, otherwise eligible people of color were denied home loans in low-risk White neighborhoods because mortgage lenders were desirous of federally insuring their loans (Board of Governors of the Federal Reserve, 2017). This historical racist practice systemically disadvantaged people of color and worked to limit their upward economic mobility. Resulting from this historical economic disinvestment of neighborhoods of color, health care providers and infrastructure are currently inequitably distributed in Black communities (Bailey et al., 2019, pp. 222-223). While people of color face continued effects of racist housing policies, low-income individuals also

struggle against societal disadvantages. In 2020, 37.2 million individuals were in poverty in the U.S., with people of color being more likely to experience poverty within their lifetimes than their White counterparts (Healthy People, 2021; Shrider et al., 2021). This illustrates that these factors of marginalization can intersect to worsen underprivileged people's experiences in the U.S. As the Assistant Secretary for Planning and Evaluation (2021) maintains, 30 million U.S. residents did not have healthcare insurance in the beginning of 2020, with people of color and those with low incomes being the most likely to lack this critical resource (pp. 1, 15). Hence, low-income individuals and people of color have been historically marginalized, which translates into modern inequities that can degrade their resiliency to ill-health.

The consequences of these societal and economic disadvantages translate into negative health outcomes for low-income individuals and people of color in the U.S. Hayes et al. (2018) affirm that factors such as race, income level, and gender among others, dictates the vulnerability of individuals to the impacts of climate change (p. 2). Low-income communities face higher risks of chronic diseases, mortalities, mental illnesses, and have lower life expectancies than more privileged individuals in the U.S. (Healthy People, 2021). Additionally, the implicit biases of health care providers can cause patients of color to receive lower quality health care and less prescribed pain medication than White patients (National Academies of Sciences, Engineering, and Medicine [NASEM], 2017, p. 109). This clearly illustrates the enduring presence of racism in U.S. institutions, which negatively impacts the health of people of color under normal circumstances. The result of systemic discrimination is that Black infants in the U.S. are more likely to have a low birthweight than their White counterparts, and Black mothers are over two times as likely to experience a stillbirth (CDC, 2020b; NASEM, 2017, p. 101). The already inequitable distribution of these negative health outcomes for low-income individuals and people

of color exacerbates their health impacts resulting from climate change. Furthermore, the health impacts of climate change disproportionately affect low-income individuals and people of color because of their preexisting social vulnerabilities and the regions that climate change will particularly impact.

Findings

Due to societal and economic factors, low-income individuals and people of color are disproportionately vulnerable to the health impacts from climate change in the U.S. Melillo et al. (2014) assert that the impacts of climate change on the U.S. will manifest in the increased frequency, intensity, and duration of heat waves, droughts, wildfires, vector-borne diseases, floods, sea level rise, and extreme weather events (pp. 15-16). The following sections will explore each of these factors in greater detail, including the extent and geographical region of the climatic impacts, the effects on the health of marginalized groups, as well as adaptation measures that can be undertaken to bolster the resiliency of vulnerable communities.

Heat Waves

Effect of Climate Change on Heat Waves. As a result of climate change, global temperatures are rising and the frequency of heat waves is intensifying in the U.S. Across the U.S., average temperatures have increased between 0.2-0.5°C since 1895, and the frequency of heat waves in major cities has tripled from two events annually in the 1960s to six every year in the 2010s (Sarofim et al., 2016, p. 45; U.S. EPA, 2021h, p. 35). This represents a significant and abrupt departure from the normal temperature patterns experienced in the U.S., which has consequences for human health. Hassan et al. (2016) affirm that heat waves are predicted to expand in strength and frequency on account of climate change, thereby worsening air pollution

along with the urban heat island effect. Morello-Frosch et al. (2009) define the urban heat island effect as occurring in urban environments where the dark materials used in constructing buildings, roads, along with other structures, absorbs and concentrates heat within the region (p. 8). This phenomenon causes urban regions to be hotter than other areas that are populated by soils, forests, and other non-industrial substances, which indicates that heat waves will especially impact urban environments. Heat waves particularly affect the health of residents of western Washington and Oregon, since heat events have been historically rare in this region and thus people's resiliency has not been built up over time, which is evidenced by a lack of air conditioners (Bumbaco et al., 2013). Yet, Gutierrez & LePrevost (2016) identify the Southeast of the U.S. as being the most vulnerable to climate change-related heat waves. However, Kumar (2018) labels the individuals who reside in urban areas as under the greatest threat from heat waves, specifically people with low-incomes and people of color. While these authors clearly take different approaches to defining the vulnerability of populations to heat waves, it must be recalled that marginalized communities throughout the U.S. will be especially impacted by rising temperatures and heat waves as a consequence of their preexisting social vulnerabilities.

Impacts of Heat Waves on Human Health. Climate change-related heat waves substantially impact the health of humans, although low-income individuals and people of color are the most vulnerable by reason of social and economic factors. Heat waves are the primary cause of weather-related mortality in the U.S., as high temperatures are associated with several reproductive problems in humans, including preterm or stillbirths (Ebi & Hess, 2020). As climate change continues to alter temperature patterns, the reproductive health of low-income communities and communities of color, which is already inferior to their privileged counterparts due to discriminatory factors in healthcare services and society, will decline even further. More

generally, the health problems associated with heat waves include heat exhaustion, heat cramps, heatstroke, hyperthermia, heat syncope, and death (Berko et al., 2014; Sarofim et al., 2016, p. 46). Between 2006-2010, heat-related mortality rates were 2.5 times greater for people of color compared with White people in the U.S., and disproportionately high rates of death were also observed for low-income counties (Berko et al., 2014). This signifies that the foundational inequities present in low-income populations and communities of color enhances their vulnerability to environmental harms, such as extreme heat. Sarofim et al. (2016) maintain that heat-related mortality rates are difficult to assess because of inconsistent diagnoses on death certificates (p. 45). Intensified and lengthened heat waves increase stress on people's cardiovascular systems, which supports thermoregulation, the process of releasing heat from humans through sweat (Anderson & Bell, 2011). Additionally, it is predicted that rising temperatures will release volatile compounds that have contaminated water sources, such as polychlorinated biphenyl, which can affect the health of humans through inhalation or ingestion (Gutierrez & LePrevost, 2016).

People of color and low-income individuals are especially vulnerable to these impacts, because they lack the resources to cope with these climate change-related illnesses. Individuals with low-incomes have higher rates of extreme heat-related death, as they frequently lack health insurance and thus cannot obtain adequate healthcare services (U.S. EPA, 2021h, p. 33). From a national focus and localized scope of the Los Angeles-Long Beach Metropolitan Area, Seebaß (2017) and Morello-Frosch et al. (2009, p. 12) respectively concluded that people of color and those with low-incomes often cannot afford to take adaptive measures against heat exposure such as installing air conditioning units. It is therefore evident that income levels contribute to people's degree of resiliency to heat stress in the U.S. Furthermore, low-income individuals are

exposed to more heat than their privileged counterparts, since they live in less expensive neighborhoods that often lack environmental amenities such as trees (Seebaß, 2017). Echoing Seebaß's article, Morello-Frosch et al. (2009) found that low-income people and people of color residing in four urban regions in California had less tree cover and more concrete heat-trapping materials than their privileged counterparts (p. 8). Hence, the societal and economic marginalization of these groups influences the neighborhoods in which they reside, thereby causing disadvantaged populations to experience the worst environmental impacts. Morello-Frosch et al. (2009) assert that low-income populations and communities of color frequently reside within the inner part of cities, which exacerbates their health risks to heat waves because of the urban heat island effect (p. 8). The historic and prevailing practices that discriminate against marginalized groups, such as redlining, have clearly placed these suppressed communities in undesirable portions of urban regions, which will only increase in environmental threats due to climate change. In 108 of the 175 major U.S. cities under investigation by Hsu et al. (2021), neighborhoods that were redlined in the 1930s experienced higher summer surface temperatures than other residential regions. This illustrates the profound legacy of historic racial discrimination upon the modern-day distribution of environmental harms. On the whole, it is evident that many physical health impacts result from climate-change related heat waves in the U.S.

Yet, several mental health impacts can also result from heat waves. During periods of high temperatures, suicide rates amidst mentally ill patients escalates and the health of schizophrenic patients deteriorates because their prescribed medication interferes with their ability to thermoregulate (Luber et al., 2014, p. 228). This has negative implications for homeless individuals struggling with mental health, as well as other marginalized groups such as low-

income individuals or people of color, who may encounter difficulties in accessing appropriate medical care. Additionally, with over 80% of the U.S. population residing in urban regions, the mental health impacts associated with heat waves, including aggressive behavior, violence, and suicide among others will increasingly affect U.S. residents (Dodgen et al., 2016, p. 222). This is especially important when one considers that people of color comprised only 21.7% of the U.S. populations residing in rural areas as compared with 42.7% of the residents in urban regions in 2018 (United States Department of Agriculture, 2020). Consequently, heat waves negatively and disproportionately impact both the physical and mental health of marginalized groups in the U.S., which indicates the urgent necessity for policymakers to install adaptation measures and build the resiliency of these groups.

Increasing Marginalized Groups' Resiliency to Heat Waves. Multiple strategies have been proposed for individuals and policymakers to reduce the negative effects of heat waves on populations in the U.S. Policymakers can lessen the intensity of heat waves by reforesting areas and minimizing the number of felled trees (Hassan et al., 2016). This represents both an adaptive measure, since trees provide shade that can cool areas, and a mitigation measure, because reforesting efforts aid in reducing the amount of carbon dioxide in the atmosphere. In California, Alameda County has targeted adaptation measures at low-income individuals and people of color currently residing in environmentally degraded areas in an effort to reduce their disproportionate vulnerability to climate change (Cooney, 2011). These measures included establishing cooling centers, planting trees, or installing green and cool roofs to support marginalized communities' resiliency to heat waves (City of Alameda, 2019, pp. 87, 139). While occurring on a small scale, these efforts can work to address the historic and systemic marginalization of these groups in society. To lessen the impact of rising temperatures on the urban heat island effect, cities can

invest in light-colored urban infrastructure such as roads and houses, along with green roofs which can cool the surrounding region (Hassan et al., 2016). New York City has embraced this initiative by planting trees, changing pavements to minimize heat absorption, and improving ventilation systems in apartment complexes within socially vulnerable neighborhoods (Kumar, 2018). This represents another example of city-level efforts that aim to reduce the negative health impacts of climate change on marginalized individuals. Yet Hsu et al. (2021) assert that while greening low-income communities and neighborhoods of color lowers temperatures in the summertime, this strategy also raises housing and property costs, which can displace socially vulnerable populations. Defined as green gentrification, the process of replacing dilapidated lots in historically disinvested areas with new green spaces often leads to low-income individuals and people of color being forced to relocate to more environmentally degraded and overcrowded neighborhoods as affluent White people displace these populations (Maantay & Maroko, 2018). Although greening initiatives attempt to further climate change adaptability and health equity in marginalized communities, they may result in green gentrification unless low-income residents and people of color are able to participate in planning urban greening projects (Jelks et al., 2021). Therefore, while Hassan et al. and Kumar each propose greening neighborhoods to alleviate the influence of heat waves, inadvertent consequences can follow that negate targeted efforts to improve the health of marginalized groups.

While the adaptation measures listed above require extensive urban planning and time in which to implement reforestation, greening, or light-colored infrastructure, other efforts such as cooling centers are less time intensive. Cities can establish cooling centers where the people most vulnerable to the health impacts of heat exposure, such as low-income individuals, can gain respite from elevated temperatures (Widerynski et al., 2017, p. 3). However, this adaptation

measure is not wholly effective in protecting humans from heat waves, because some people may not have access to transportation and thus cannot make use of them (Widerynski et al., 2017, p. 17). This indicates that even if cooling centers are intended to protect the health and safety of marginalized groups, their foundational inequities can preclude the effectiveness of this strategy. For instance, Morello-Frosch et al. (2009) uphold that people of color in the Los Angeles-Long Beach Metropolitan Area lack access to vehicles in higher proportions than White people (p. 12). Moreover, air conditioning units are powered by electricity, and in 2019, 62% of U.S. electricity was obtained from GHG-emitting sources (U.S. EPA, 2021e; Widerynski et al., 2017, p. 18). Hence, initiatives that seek to install air conditioning units in underserved communities can bolster their resiliency to the impacts of heat waves on human health, especially if they coincide with renewable energy projects to avoid degrading the environment for future generations. Rather than focusing on offering resources for socially vulnerable people once a climatic threat such as heat waves are already occurring, Kumar (2018) suggests that the factors marginalizing individuals, such as low-income, must be directly addressed in order to combat the disproportionate health impacts caused by climate change. Overall, decision-makers must implement adaptation measures tailored to each individual community, to alleviate the health impacts from heat waves on socially vulnerable communities.

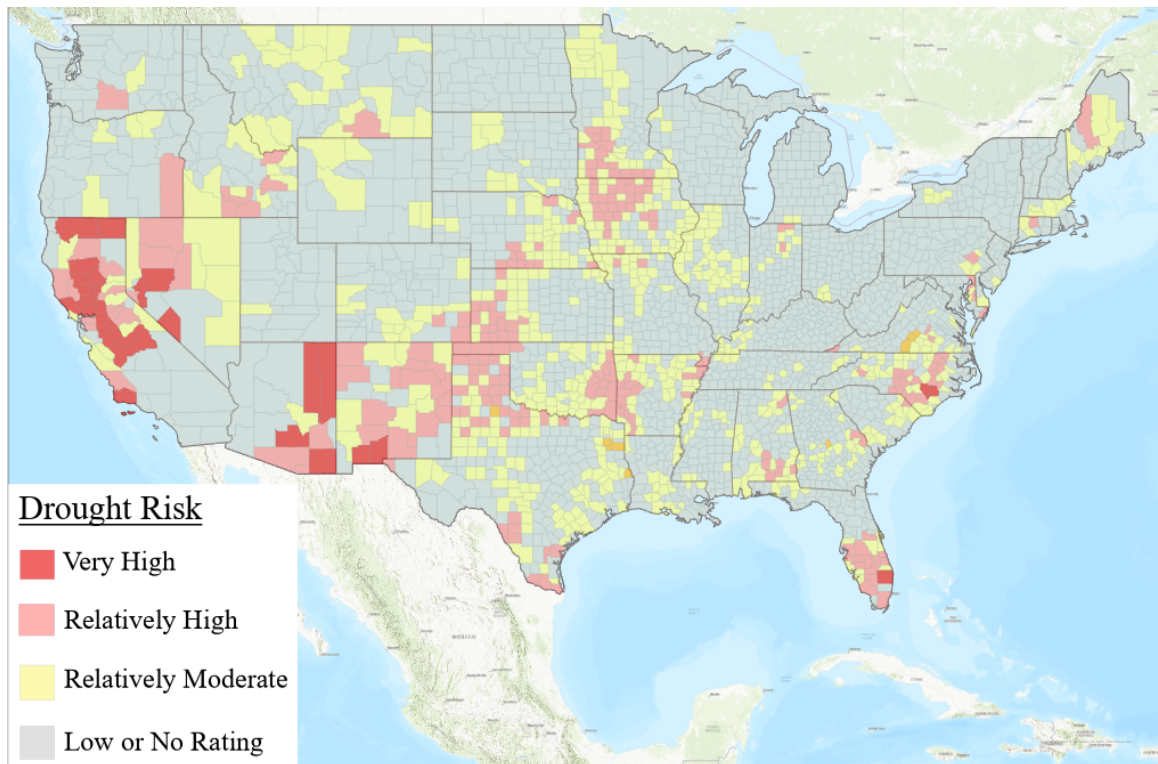
Droughts

Influence of Climate Change on U.S. Droughts. Climate change-related droughts will progressively impact communities in the U.S., as they struggle against water shortages and the associated health impacts from these events. As Bell et al. (2018) uphold, the severity and frequency of droughts has increased in recent years on account of rising temperatures as well as alterations in precipitation patterns, which particularly affects the southwestern and western

regions of the U.S., as is evidenced in Figure 2. With the ongoing emission of greenhouse gases, the Earth's climate will continue to change to the detriment of regions that already experience water stress. California experienced an acute drought between 2011 and 2017 due to low levels of precipitation, extreme heat that diminished the ability of vegetation from holding water, and warmer winters that lessened the amount of water retained by the state's snowpack (Constible et al., 2019, pp. 5-6). Hence, Constible et al. (2019) furthers Bell et al.'s (2018) argument by providing a specific example of a California drought that occurred because of changing climatic

Figure 2

U.S. Counties Drought Risk



Note. Modified from the Federal Emergency Management Agency ([FEMA], n.d.), this map illustrates the drought risk for U.S. counties, where darker reds represent heightened drought risk.

patterns. Additionally, droughts often create favorable conditions for other climatic impacts, or occur alongside them, which can exacerbate the effects on human health. Extreme heat events, water shortages, dust storms, wildfires, flooding events, and harmful water as well as air quality are associated with droughts in the U.S. (Bell et al., 2016, p. 108). Overall, climate change will influence the occurrence as well as severity of droughts in the U.S., which has several implications for human health, particularly for low-income communities and populations of color.

Impacts of Droughts on Marginalized Groups' Health. Droughts can acutely impact human health, with low-income individuals and people of color disproportionately experiencing the effects of droughts on their physical and mental wellbeing. The water quality along the U.S. coasts is specifically endangered by droughts because saltwater can seep into and contaminate groundwater supplies (Bell et al., 2016, p. 108). This can exacerbate water shortages in communities, which negatively impacts low-income individuals and people of color since they are the least resilient to these stresses. Aside from the water stress occasioned by coastal water quality, communities can also experience water scarcity from inland water supply and quality issues. In California, residents living in the San Joaquin Valley faced deficient and increasingly expensive water supplies as well as decreased water quality from 2014-2016; most of the residents were Hispanic, and two-thirds were low-income (Constible et al., 2019, p. 6). Aside from creating water shortages, droughts can also increase the prevalence of vector-borne diseases in the U.S. During times of drought, the occurrence of the West Nile virus escalates because the virus hosts and vectors, namely birds and mosquitoes respectively, are in closer proximity to each other as they strive to access scarce water sources (Bell et al., 2016, p. 108). As a result, socially vulnerable communities must navigate the health impacts directly resulting from water

shortages, in addition to an increased rate of vector-borne diseases within their communities, which can be challenging to adapt to since these groups often lack necessary healthcare resources. Moreover, droughts can lead to dust storms as well as wildfires, contributing to high concentrations of airborne particulate matter, which exacerbates cardiovascular conditions including the risk of heart disease, and creates respiratory illnesses (Bell et al., 2018). On the whole, the health of socially vulnerable groups such as low-income individuals and people of color is put at risk by climate change-related droughts, indicating that policymakers should work to reduce their disproportionate exposure as well as vulnerability to this climatic factor.

Adaptation Measures and Individual Resiliency Against Droughts. There are several adaptation measures that policymakers can institute to alleviate the impacts of droughts on marginalized communities. Phoenix, Arizona already faces significant water stress, as it relies on the Colorado River to serve its residents along with the populations of six other surrounding states (Sullivan & Tarlock, 2019). Yet, the city has not crafted adequate water conservation goals or taken into account the impacts of climate change upon its water supply (Sullivan & Tarlock, 2019). This illustrates that the first step local governments should take in implementing drought adaptation plans is acknowledging the impacts of climate change upon the resources that humans depend upon for survival. One of the major solutions that Sullivan & Tarlock (2019) identify, is for Phoenix and other cities to reduce urban sprawl so that less water and energy is required to sustain the lives of its residents. However, while this strategy may help future generations reduce their water usage, policymakers must address the current health impacts that climate change-related droughts are producing in marginalized communities in adaptation measures. According to the State Water Resources Control Board (2020), California's Safe and Affordable Funding for Equity and Resilience program supports the right of every Californian to attain affordable and

clean drinking water by funding projects that minimize environmental contaminants in drinking water supplies while specifically focusing on aiding low-income individuals as well as disadvantaged populations (pp. 6-8). Local governments and communities can prepare for droughts by increasing water storage systems, developing drought contingency plans that anticipate alternate water supplies, and encouraging the agricultural sector to use drip irrigation systems (U.S. EPA, 2021a). These initiatives can bolster the resilience of communities to droughts, especially when combined with individual reductions in water usage. In California, the city of San José encouraged residents to limit their water consumption and succeeded in reducing city-wide intake by 28% during a drought period (Bazo et al., 2020, p. 2). While this strategy does result in conserving water and thereby reducing water stress on the whole city, a total reliance on individual-level water conservation action will not support the health and wellbeing of the most vulnerable individuals in society. Thus, cities should develop more adaptation plans that specifically address this concern, and offer clean drinking water in marginalized communities to prevent their deficiency in water intake.

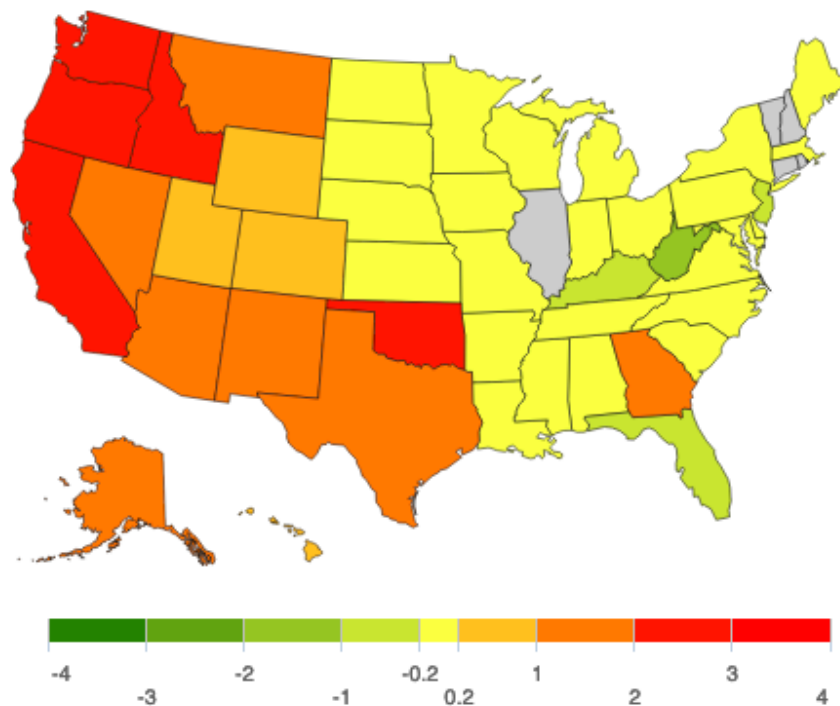
Wildfires

Influence of Climate Change on Wildfires. While climate change increases the risk of wildfires in the U.S., other climatic factors such as droughts and extreme heat events, which are both influenced by climate change, further contribute to favorable wildfire conditions. In the western U.S., Constible et al. (2019) links climate change-related extreme high temperatures and droughts with producing advantageous conditions for wildfires, which inflates the frequency as well as severity of these events (p. 2). Masri et al. (2021) maintain that aside from the dry vegetation exacerbated by climate change in California, periods of heavy rainfall encourage thick vegetative growth, which fuels wildfires in the state. Hence, with more vegetation growing in

these regions and drying out due to extreme heat events, droughts, and rising temperatures, the threat of wildfires will significantly intensify in the coming years for specifically the western regions of the country, as is seen in Figure 3. In the U.S., approximately 6.4 million acres of land have annually burned in wildfires from 2000-2010, and they are only expected to increase in size and frequency in the coming years (Brown et al., 2013, p. 320; Luber et al., 2014, p. 223). As climate change continues to influence natural systems, wildfires will progressively figure as an annual climatic impact, which will significantly threaten the health of humans living in fire-prone regions.

Figure 3

Changes in Annual Acreage Burned by State Between 1984-2001 and 2002-2018



Note. This portrays the change in annual acreage burned between two multi-year ranges, where darker colors represent greater numbers of acreage burned (U.S. EPA, 2021d).

Impacts of Wildfires on Physical Human Health. There are a multitude of direct impacts from wildfires that affect the health of humans in the U.S. Contrary to other climate change-related impacts on human health, some studies found that wildfires do not disproportionately affect the health of marginalized communities. Davies et al. (2018) assert that the attraction of wildfire insurance, emergency aid, and environmental amenities, encourage high-income individuals to reside in regions at risk to wildfires in the U.S. However, low-income groups are generally less resilient to wildfires than their wealthier counterparts (Davies et al., 2018). The higher income populations living in fire-prone areas are still better equipped to access resources that help them adapt to and prepare for this threat in comparison to the people of color and low-income individuals who reside in regions with high risk of wildfires. Low-income communities in California are still vulnerable to wildfires because they lack the economic resources to rebuild after a fire, pay for insurance, or harden their residences against wildfires by removing fuels (Davies et al., 2018). These factors contribute to the larger threat of wildfires upon the health of marginalized groups, because they cannot prepare for or cope with the effects of these events to the extent of their more privileged counterparts. White Americans, who are largely not socially vulnerable, comprise 76% of the 29 million residents that live in census tracts with a moderate to high risk for intense wildfires (Davies et al., 2018). Unlike Davies et al.'s national perspective, the study conducted by Masri et al. (2021) exclusively focuses on California wildfires, averring that rural regions with lower income communities experienced the greatest burned area from wildfires. Not only did these two studies differ in their scope, but they also measured different aspects of wildfires, namely the risk and the area burned. Analyzing these two approaches results with the perspective that some marginalized groups might be more at risk from higher intensity wildfires than other groups, yet there are also indirect health impacts

from wildfires that we must consider, such as smoke inhalation. Impacts from direct contact with wildfires include burn injuries and death, although populations farther away from fires can still be affected by the vast quantities of smoke that are produced (Brown et al., 2013, p. 317). During large wildfire events, healthcare and public health infrastructures are often overburdened because of widespread evacuations, the necessity of opening shelters, and treating patients for injuries from being in direct contact with the fire or from smoke inhalation (Bell et al., 2016, p. 111). It is therefore apparent that wildfires have many negative direct impacts on human health, and those communities that are already confronted with social vulnerabilities will face the largest challenges in being resilient to them.

Aside from the direct physical impacts of wildfires on human health, many indirect physical impacts also affect the health of marginalized communities in the U.S. As Bell et al. (2018) assert, air pollutants are emitted by wildfires that can worsen respiratory illnesses in populations as much as 1,000 miles away from the event for several weeks. Furthermore, Luber et al. (2014) identifies particulate matter, nitrogen oxides, carbon monoxide, and volatile organic compounds that are found in smoke from wildfires as negatively impacting air quality in surrounding communities (p. 223). Thus, even if low-income populations are not as commonly situated in high fire-prone regions of the U.S., they can still be impacted by wildfires that occur from a large distance. During the Camp Fire in 2018, communities in northern California suffered ‘unhealthy’ and ‘very unhealthy’ air quality levels due to smoke for 11 days, with the greatest affects being suffered by the most vulnerable individuals, such as homeless people who struggled to escape smoke exposure (Bazo et al., 2020, p. 17; Constible et al., 2019, p. 2). These low-income communities are severely underprivileged in comparison to their higher income counterparts, because they cannot evade smoke inhalation by staying inside; meanwhile low-

income people who have homes might not be able afford air purifying devices, the electricity that sustains them, or tightly sealed homes. Exposure to wildfire smoke is associated with increased medicinal dispensations for conditions such as bronchitis, chest pain, asthma, and chronic obstructive pulmonary disease, while hospitalizations associated with cardiovascular and respiratory conditions rose in frequency (Luber et al., 2014, p. 223). Marginalized individuals employed in outdoor occupations experience greater exposures to smoke and may lack the monetary resources to purchase medicine or afford healthcare services for these health problems. Bell et al. (2016) found that emergency room visits increased by 50% during high concentrations of fine particulate matter as compared with conditions removed from wildfires (p. 110). This illustrates that smoke from wildfires presents an acute impact on the health of marginalized groups in the U.S., although there are other indirect effects from wildfires that harm human health.

The health of low-income individuals and people of color is also impacted by factors that occur either indirectly or in the aftermath of wildfires. Low-income individuals may encounter difficulties in evacuating during a wildfire because of fuel costs or a lack of access to a vehicle (Davies et al., 2018). Their low-income status also places this socially vulnerable group at higher risk for burn injuries from wildfires, since they are more likely to be in direct contact with fire. In the times following wildfires, alterations in runoff and soil erosion contribute to flooding events and contaminate water sources downstream (Bell et al., 2016, p. 111). Additionally, post-wildfire rainstorms can elevate the rate of mudslides, which causes severe injuries in individuals (Brown et al., 2013, p. 317). Since the majority of residents in high fire risk regions are White and in possession of higher-incomes, the threat of mudslides might not disproportionately impact marginalized groups. However, the compounding societal and economic factors that marginalize

them can act to make these populations less resilient to mudslides. Moreover, Bell et al. (2016) state that wildfire smoke can degrade visibility for drivers, increasing the probability of injuries and death from vehicular accidents (p. 110). In consequence, even in the aftermath of wildfire events, marginalized communities may still experience lingering impacts from them, which indicates the need to strengthen the adaptive capacity and resiliency of these groups.

Fostering Adaptation to Wildfires in Marginalized Groups. Taking into account the disproportionate vulnerability of marginalized groups to the health impacts from wildfires, policymakers should build up their resiliency through programs and strategies that specifically target improving their health outcomes. In 2014, when eastern Washington experienced a large wildfire, evacuation warnings sent out by authorities failed to be translated into Spanish for the community of Hispanic residents in the region (Davies et al., 2018). This represents a substantial gap in emergency planning, since emergency warnings should be translated in languages befitting all of the residents of each community so that every population is given the same amount of time to prepare evacuation plans. Similarly to Sullivan and Tarlock's proposed strategy for reducing the impacts of droughts on U.S. residents, Bazo et al. (2020) suggest promoting denser cities rather than allowing human populations to continue extending into the wildland-urban interface, so as to protect communities from wildfires (p. 17). Yet, while this approach is well suited to future urban planning initiatives, it does not address the communities that are currently at risk from wildfires, or those most vulnerable to its associated health impacts. Local governments should manage wildfire risk through proactive measures that foster fire resistant vegetation types and reduces the chance of ignition (Bazo et al., 2020, p. 17). If these proposals are implemented in low-income communities and communities of color, their disproportionate vulnerability to the health impacts from wildfires could be alleviated, since they

often lack the resources to harden their homes or create defensible spaces. Local governments can provide masks and air purifiers with high-efficiency particulate air filters to marginalized individuals during wildfires in order to reduce people's exposure to hazardous air quality (King County, 2021). These efforts can alleviate the negative health impacts associated with smoke inhalation that disproportionately impacts the resiliency of marginalized groups to wildfires due to their heightened exposure and preexisting social vulnerabilities. Additionally, cities can offer aid to low-income individuals and people of color in reaching a clean air shelter or preparing a clean room that is sealed from outside air to reduce smoke inhalation (U.S. EPA, 2021g). Although wildfires present a sizable threat to the health of low-income individuals and people of color in the U.S., the insidious spread of vector-borne diseases resulting from climate change represents a significant hazard to socially vulnerable communities.

Vector-Borne Diseases

Impacts of Climate Change-Related Vector-Borne Diseases in the U.S. Vector-borne diseases are gaining in reach and frequency, as climate change alters the Earth's natural systems. The warming climate is expected to alter the ranges of tropical diseases including cholera, leprosy, dengue, and malaria among others (Cooney, 2011). Rising temperatures are also associated with the expansion of tropical cyanobacterial species towards the poles, which can cause symptoms such as fevers, vomiting, and headaches in humans (CDC, 2021; Trtanj et al., 2016, p. 165). As many marginalized individuals lack healthcare insurance, reliable transportation, and monetary resources, they face challenges in coping with these illnesses. With climate change warming the Earth, the West Nile virus can be transmitted from vectors to hosts even through the winter months, and can disperse into new regions (Brown et al., 2013, pp. 326-327). This poses a threat to the health of U.S. residents, as the low resiliency of people of color

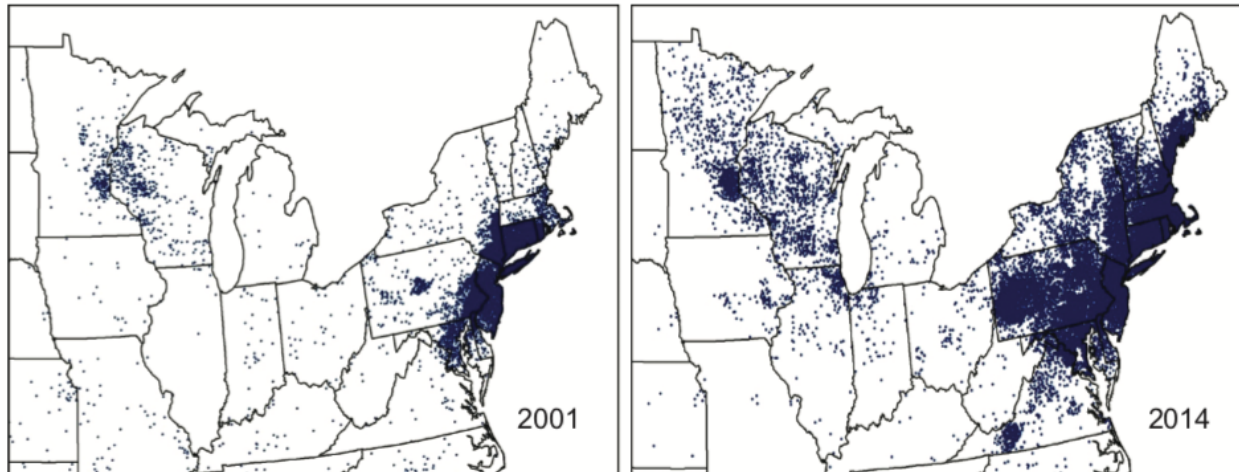
and low-income individuals is compounded by the impact that ill-health can have on their economic, social, and political wellbeing. Currently, preventative vaccines and the medication to treat West Nile virus lag behind the disease, which indicates an urgent need to reduce transmission rates from vectors to humans (APHA & CDC, 2019). Thus, individuals and policymakers must work to reduce the spread of these climate change-related diseases in order to protect human populations.

Mosquitoes often serve as vectors for diseases, and their distributions are predicted to change under shifting precipitation and temperature patterns (Brown et al., 2013, p. 322). The species of mosquito *Aedes aegypti*, which is of greatest concern for vector-borne diseases in the U.S., has globally increased by 8.2% over the last 24 years on account of rising temperatures (Ebi & Hess, 2020). Aside from a rising trend in the distribution and size of mosquito populations in the U.S., ticks are also of large concern as a vector for Lyme disease. In the Northeast of the U.S. where Lyme disease is already most prevalent, climate change is projected to alter precipitation patterns, temperature, and humidity, which will enlarge the geographic region in which ticks can thrive (APHA & CDC, 2019). Increases in tick populations will directly translate into high rates of Lyme disease, since ticks serve as the vectors for the bacterium *Borrelia burgdorferi* that is responsible for the disease, as is seen in Figure 4 (APHA & CDC, 2019; Beard et al., 2016, p. 132). Although both privileged and socially vulnerable communities live within the Northeast of the U.S., each individuals' risk of contracting Lyme disease is influenced by their specific exposure to this vector. Additionally, more privileged individuals with regard to income and race are better equipped to adapt to contracting Lyme disease since they can access the appropriate health care resources. Overall, the resiliency and

adaptability of low-income individuals and people of color to Lyme disease is worse than their privileged counterparts.

Figure 4

Reported Cases of Lyme disease in 2001 vs. 2014



Note. This illustrates the increase in reported cases of Lyme disease from 2001 to 2014 in the Upper Midwest and Northeast of the U.S. (Beard et al., 2016, p. 133).

Influence of Vector-Borne Diseases on Marginalized Groups' Health. Unlike some other factors influenced by climate change, the threat of diseases expanding in range and prevalence cannot be avoided by moving away from rural areas or coastlines, yet the impacts will be inequitably experienced by people of color and low-income populations owing to their preexisting social disadvantages. In the U.S., over 50,000 cases of vector-borne diseases were reported in 2013 alone (Beard et al., 2016, p. 131). Lyme disease has symptoms ranging from headaches, fever, lethargy, and a skin rash when treated, but the disease can attack the heart, nervous system, and infect joints in humans if untreated (Beard et al., 2016, p. 132). This is particularly relevant for low-income people and people of color since they are not as able to afford treatment as their privileged counterparts. Ebi & Hess (2020) assert that the ability of

individuals to protect themselves against diseases and limit their exposures to vectors such as mosquitos is tied to privileged statuses of race and income levels. For instance, while 6.7% of White individuals were employed in outdoor occupations including farming, fishing, forestry, construction, and extraction, 17.1% of people of color and of Hispanic or Latino ethnicity were employed in these areas in 2020 (United States Bureau of Labor Statistics, n.d.). Hence, people of color are more likely to be employed in outdoor occupations, which exposes them to more vectors such as mosquitoes and ticks than their White counterparts. Overall, marginalized groups' increased exposure to vectors and low adaptive capacity due to historic and enduring marginalization in society, makes them particularly vulnerable to climate change-related diseases, which indicates the need for adaptation efforts to be taken.

Adaptation Efforts Against Vector-Borne Diseases. At a local and regional level, policymakers can improve the health of low-income populations and people of color by instituting measures that prevent the continued spread of vector-borne diseases in the U.S. on account of climate change. Several preventative actions can be taken on an individual level to minimize the possibility of contracting a vector-borne disease, such as using insect repellent and wearing long shirts, pants, along with hats (APHA & CDC, 2019). Additionally, removing standing water reduces mosquito populations because their larvae require this environment for survival (CDC, 2020a). However, communities cannot solely rely upon these strategies to reduce the impact of vector-borne diseases in human populations, since underlying social disadvantages work to make some individuals less resilient than others. Beard et al. (2016) maintain that the health impacts from vector-borne diseases can be reduced through community level adaptation measures that work to limit exposures to the disease carrying vectors (p. 142). Focusing this strategy specifically in marginalized populations within a community could minimize their

vulnerability to climate change-related vector-borne diseases. Moreover, the APHA & CDC (2019) encourage all levels of the government to implement mosquito control programs and research where insect outbreaks may occur in the future, so as to best protect public health from vector-borne diseases. Overall, measures can be taken against the spread of vector-borne diseases in the U.S. on an individual and governmental level to limit the transmission of diseases from vectors to socially vulnerable humans. In addition to vector-borne diseases, climate change impacts the health of marginalized groups as a result of flooding events.

Floods

Climate Change and Floods in the U.S. In the U.S., flooding will increasingly impact communities as climate change persists in altering natural processes and weather events. Every state in the U.S. has experienced a flood within the past five years, with the frequency and intensity of flooding events in the Northeast and South-Central regions of the country projected to escalate in the future (Cigler, 2017). Additionally, the U.S. EPA (2021c) asserts that the heightened frequency of extreme precipitation events in the U.S. will increase flood risk. Inland flooding events killed over 600 individuals in the U.S. between 1980 and 2020 (U.S. EPA, 2021h, p. 68). As this illustrates, flooding will considerably impact the health of U.S. residents, most particularly affecting those who are already socially vulnerable due to their race or income level.

Flooding Impacts on the Health of Marginalized Groups. The health risks associated with flooding events will intensify in the coming years as climate change drives more frequent and severe floods, which will particularly impact low-income individuals along with people of color in the U.S. The direct impacts of flooding on human health include sustaining trauma from

objects in floodwaters, falling debris, electrocution, motor vehicle accidents or even death from drowning in floodwaters, which has claimed the lives of over 2,500 individuals in the U.S. between 1963 and 2012 (Bell et al., 2016, p. 106). When these flood-related impacts transpire within low-income communities and communities of color, their disadvantages in society translate into low resiliency as they attempt to cope with negative health outcomes. People who are exposed to floodwaters and contaminated drinking water sources can also contract gastrointestinal illnesses along with respiratory and wound infections (Bell et al., 2016, p. 107). Flooding events can introduce or increase the presence of pathogens in waters such as the *Leptospira* bacteria that causes kidney damage, liver failure, respiratory problems, and death when untreated (CDC, 2019; Trtanj et al., 2016, p. 164). As low-income people struggle with affording healthcare services, including a reliable access to necessary medication, these flood-induced health challenges are of notable concern for these socially vulnerable groups. Trtanj et al. (2016) aver that people of color and low-income individuals are disproportionately exposed to contaminated water owing to their unequal access to clean drinking water, unreliable sewer infrastructures, along with a variety of other social, economic, as well as political inequities (p. 170). Therefore, these marginalized communities are simultaneously more exposed to the health impacts resulting from climate change-related flooding events, while also being the least resilient to the ramifications on their health. Echoing Trtanj et al.'s point, the U.S. EPA (2021h) asserts that due to monetary constraints, low-income communities often reside in housing units within coastal zones that are at risk for flooding events; yet they are less resilient to these events because they lack the resources to shield their homes or recover from damages incurred by floods (p. 56). Moreover, extreme events such as floods can damage essential infrastructure that impedes individuals from receiving timely healthcare (Bell et al., 2018). This can strain already

overburdened marginalized individuals, especially if they lack access to transportation and thus struggle to attain healthcare services. Since the health impacts from flooding are disproportionately shouldered by low-income people and people of color in the U.S. on account of their social vulnerability, policymakers must install adaptation measures that address the inequitable experience of environmental harms.

Cultivating Resiliency in Marginalized Groups Against Flooding. While numerous health impacts result from flooding events in the U.S., adversely affecting the most vulnerable communities, such as low-income individuals and people of color, policymakers must build the resiliency of these groups as well as create adaptation measures that offer support to socially vulnerable individuals. On an individual level, residents at risk of flooding can waterproof their basements, sandbag their homes, or elevate critical utilities such as water heaters, furnaces, and electric panels (Cigler, 2017). Yet, these individual-level efforts depend upon the resources available to each person, which places marginalized groups at a disadvantage in flood preparedness. Hence, communities along with cities must prepare adaptation measures that specifically address the increased vulnerability and exposure of marginalized groups to climate change-related harm. Cigler (2017) asserts that only 4% of federal disaster funds are utilized to prepare communities against extreme events. Yet, based on the extensive health threats from floods on humans, the focus of policymakers should more specifically turn to fostering the resiliency of the most socially vulnerable populations. As part of green infrastructure, parks and wetlands reduce 99% of stormwater run-off volume, which decreases the amount of flooding that occurs in the U.S. (Cigler, 2017). This signifies that policymakers should invest in green infrastructure efforts within low-income communities and neighborhoods of color in the U.S. Furthermore, installing rain barrels and rooftop gardens aids in filtering stormwater and reducing

the amount of flooding that affects built environments (Cigler, 2017). Accordingly, cities could aid the most socially vulnerable populations by awarding monetary funds to residents so that they can afford to take these adaptive actions. Inland flooding events impact different regions of the U.S. than coastal flooding events caused by sea level rise. Nonetheless, they can both trigger negative health outcomes in humans, necessitating the attention of policymakers to strengthen the resilience of vulnerable populations. While floods present a significant threat to the health of marginalized groups in the U.S., other factors such as sea level rise can influence the severity of these events while also presenting a challenge to necessary infrastructure on its own.

Sea Level Rise

Climate Change-Related Sea Level Rise in the U.S. In the U.S., sea level rise is predicted to markedly increase under climate change in the upcoming years, negatively impacting the social and economic realities of coastal communities. Climate change-driven sea level rise worsens the destruction caused by hurricanes on human settlements and contributes to nuisance flooding in coastal regions (Bell et al., 2018; Cigler, 2017). On a global scale, the sea level has risen by over 20 centimeters within the last century, which is most visible on the Atlantic coast of the U.S. (Bell et al., 2018). In 2010, 123.3 million people resided in coastal regions of the U.S., but it is projected that by 2100, only 13.1 million people will remain on land that has a sea level rise of 1.8 meters (Robinson et al., 2020). This indicates that many people will be migrating away from the coasts on account of the impracticality of dealing with sea level rise, however marginalized communities may have difficulties in moving away from these vulnerable areas, due in part to financial constraints.

Impacts of Sea Level Rise on the Health of Marginalized Groups. Sea level rise disproportionately impacts low-income individuals and people of color in the U.S., because of historic as well as current inequalities. As compared with other racial groups, Native Americans are 48% more likely to reside in regions that will experience the most severe inundation from sea level rise in the U.S. (U.S. EPA, 2021h, p. 6). This illustrates the influence of historic racism in increasing the number of environmental harms that befall people of color. Communities of color are particularly vulnerable to sea level rise along the Eastern shore of the Chesapeake Bay, due to the regions' low-lying topography, extensive coastline, and their specific exposure to this hazard (Paolisso et al., 2012). Delaware is projected to experience an average of 33 centimeters of sea level rise within the next century, impacting many residents of the state including the 1,600 predominantly low-income individuals and people of color in the Southbridge neighborhood (Perez & Egan, 2016). While Perez & Egan identified the disparate exposure of a marginalized community in Delaware, the Miami-Dade County communicated the inequitable roots of their populations' vulnerability to the impacts of sea level rise. People of color within the Miami-Dade County in Florida have unequal access to resources such as financing and representation, while low-income residents cannot afford flood insurance or home repairs after storms, which makes these groups disproportionately vulnerable to sea level rise (Miami-Dade County, 2021). The health of low-income individuals and residents of color is thus inequitably affected by climate change-related sea level rise by reason of their preexisting social vulnerabilities. The U.S. EPA (2021h) maintains that when decision-makers are forced to weigh the costs of adaptation efforts against the benefits of protecting residences exposed to sea level rise, socially vulnerable communities are frequently excluded from protection since they live in regions with cheaper market values (p. 56). Thus, these marginalized communities enjoy less

protection from the impacts of sea level rise because of society's historical and continued devaluation of their worth, which contributes to their sustained marginalization within the U.S.

Supporting Marginalized Groups in Adapting to Sea Level Rise. In order to properly protect the health of people of color and low-income individuals from sea level rise, policymakers must target adaptation strategies with equity in mind. The U.S. EPA (2021a) states that cities can assemble barriers such as dikes, seawalls, and levees to protect communities against flooding. Yet, after conducting community-based participatory research in the two Maryland communities of color under study, Paolisso et al. (2012) identified a lack of resources, information, and linkages to adaptation programs as constraining the resilience of these communities to sea level rise. As such, it is not enough to build structures that prevent sea level rise from impacting coastal communities, since socially vulnerable populations must be directly given information and resources that aid their resiliency to this climatic factor. Additionally, hardening shorelines by installing levees, seawalls, or rock revetments can result in aesthetic damage and the erosion of the beach front, which merely delays the inevitable inward reach of sea level rise (Griggs & Reguero, 2021). Moreover, the decisions about where to place these adaptive measures are largely impacted by the economic considerations of the community in question, as the U.S. EPA (2021h) article asserted, which could lead to socially vulnerable communities being further marginalized. Policymakers must bolster the resilience of socially vulnerable communities against the impacts of sea level rise so as to prevent disproportionate health outcomes.

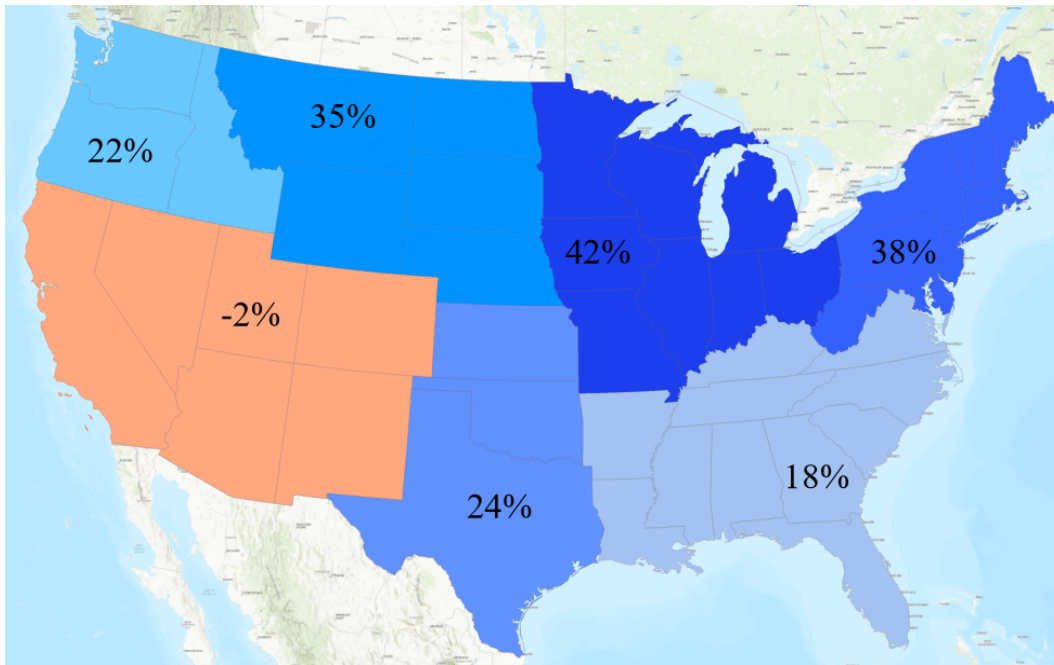
Extreme Weather Events

Influence of Climate Change on Extreme Weather Events. In the U.S., extreme weather events are projected to increase in intensity and frequency as a consequence of climate change. Bell et al. (2018) assert that the frequency, intensity, and length of hurricanes in the Atlantic has escalated since the 1980s. This has implications for the health of marginalized groups, as they may strain to attain the necessary resources to cope with hurricanes. The impacts of climate change on sea level rise magnifies the storm surges along with freshwater flooding that result from hurricanes and injure residents (Bell et al., 2018). In addition, climate change is predicted to warm ocean waters and enhance the amount of moisture in the air, which contribute to the formation of severe thunderstorms predominantly in the eastern U.S., classified as abnormally large hail or wind speeds exceeding 93 kph (National Aeronautics and Space Administration, 2013). The increasing frequency and intensity of these climatic events indicate a concurrent rise in the number of health impacts resulting from them, which is of particular concern for marginalized groups already struggling to cope with environmental hazards. Climate change elevates the atmosphere's ability to retain water vapor, which inflates the number of extreme precipitation events, shown in Figure 5, defined as days when precipitation levels are within the top 1% of the total days with precipitation (U.S. EPA, 2021c; United States Global Change Research Program, n.d.). It is therefore clear that climate change-related extreme weather events will progressively impact the U.S., although vulnerability and adaptive capacity differ between populations.

Impacts of Extreme Weather Events on Essential Infrastructure. Critical infrastructure is often damaged during climate change-related extreme weather events. Extreme weather events can cause power outages that lead to elevated usage of kerosene, propane,

Figure 5

Change in Total Annual Precipitation in Top 1% of Events Between 1901-2016



Note. Reproduced from the U.S. Global Change Research Program (n.d.), this map illustrates the percent change in total annual precipitation falling in the heaviest 1% of events within the last century, where darker colors correspond with greater changes.

charcoal, and gasoline-powered devices to cook food or generate heat, which causes carbon monoxide poisoning from the inhalation of toxic fumes (Bell et al., 2016, p. 105). By impacting the power grid, extreme weather events lead to cascading failures in critical infrastructure that people rely upon for survival. As Trtanj et al. (2016) maintain, wastewater, clean drinking water, and stormwater infrastructure will sustain direct damage or overloading of their capacity due to extreme weather events (p. 158). Moreover, the drinking water systems in the U.S. are currently failing or will face the necessity of being replaced within 30 years, which implies that the health impacts from extreme precipitation events could be heightened by simultaneous difficulties with drinking water infrastructure (Trtanj et al., 2016, p. 164). Thus, aside from the direct impacts of

extreme weather events on marginalized groups, they are also vulnerable to challenges associated with accessing essential resources. Resulting from extreme weather events, chemicals, pathogens, and contaminants that exist in water could infiltrate the drinking water that supports U.S. residents (Trtanj et al., 2016, p. 158). Furthermore, the adverse impacts of extreme weather events on transportation systems as well as health care infrastructure can result in negative health outcomes for the targeted communities for years to come (Bell et al., 2016, p. 105; Ebi & Hess, 2020). Overall, extreme weather events can leave long-lasting impacts on necessary infrastructure in the U.S., which influences the ability of individuals to obtain safe drinking water, food, and healthcare services.

Impacts of Extreme Weather Events on the Health of Marginalized Groups. Low-income people and people of color number among the most vulnerable communities to extreme weather events in the U.S. on account of their multiple and compounding societal inequities. Extreme weather events and storms can cause illnesses, injuries, and death, while also exacerbating existing physical as well as mental health conditions (Ebi & Hess, 2020). Of particular concern are people of color and low-income individuals, as they already struggle against societal discrimination and monetary barriers. For instance, low-income individuals often lack necessary financial resources to prepare against or recover from a storm (Bell et al., 2016, p. 104). Therefore, these marginalized groups face challenges in avoiding the storms and coping with the health impacts resulting from them. In the U.S., 2,170 individuals have died from hazards directly associated with hurricanes between 1963 and 2012, which has disproportionately affected low-income populations and communities of color (Bell et al. 2018). For instance, the levee breakdown during Hurricane Katrina disproportionately affected low-income individuals and people of color, as evidenced by 46% of the damaged areas in New

Orleans being occupied by Black communities and 84% of the missing people being Black as well (Bell et al., 2018; Davies et al., 2018). More specifically, Cuomo (2011) states that structural inequalities grounded in racism and economic discrimination aided in determining which communities were the most impacted by Hurricane Katrina. Consequently, it is clear that individuals' societal and economic statuses influence the extent of the impacts incurred from extreme weather events, because historic and continued valuation systems place White individuals with higher incomes over other groups. Following winter storms and extreme precipitation events such as thunderstorms, individuals can be injured when cleaning up debris, while those with preexisting pulmonary or cardiovascular illnesses can suffer setbacks or even death (Bell et al., 2016, p. 111). Low-income people and people of color in the U.S. are particularly vulnerable to these impacts, since they are the least equipped to pay for clean-up services and are not as resilient to the stress of extreme weather event aftermaths in comparison to more privileged individuals. Since low-income individuals frequently reside in high density, derelict, or substandard housing conditions, they are more at risk for negative health impacts owing to extreme weather events (Bell et al., 2016, p. 104). As a result, marginalized groups are more exposed and less resilient to the direct impacts from extreme weather events due to societal inequity.

Additionally, extreme weather events can also contribute to indirect negative health outcomes in marginalized groups. Trtanj et al. (2016) state that the presence of waterborne diseases in drinking water systems are associated with extreme precipitation events (p. 163). While the direct effects of extreme weather events are substantial, the impacts to drinking water systems can have long-lasting impacts on human health, which is concerning for marginalized groups who cannot always afford medical attention or home water filtration devices. Bell et al.

(2016) assert that wind and precipitation during thunderstorms can elevate the possibility of vehicular accidents, because of hazardous road conditions, fallen trees, and diminished roadway visibility (p. 111). In addition, 1993-2003 witnessed over 4,000 human injuries from airborne debris and falling trees during thunderstorm events (Bell et al., 2016, p. 111). Yet, while the exposure of low-income individuals and people of color to these chance events may be equivalent to their privileged counterparts, their resiliency to these impacts is depressed on account of discriminatory societal as well as economic factors. Frostbite as well as hypothermia result from wintertime storms, which is a substantial threat to low-income individuals who frequently cannot afford residential heating, adequate winter clothing, and reside in substandard housing units that lack proper insulation (Bell et al., 2016, p. 111). As is evident, marginalized groups are more vulnerable to the health impacts from severe storms because they are the least equipped to afford necessary resources and cope with negative health outcomes.

Building Resiliency in Marginalized Groups to Extreme Weather Events.

Policymakers can alleviate the disproportionate impacts of climate change-related extreme weather events on marginalized individuals by instituting adaptive measures within vulnerable communities. Bell et al. (2016) assert that individuals' adaptive capacity to extreme events can be achieved through disaster relief, evacuation aid, and warning systems applied within all levels of government (p. 104). However, low-income people and people of color would likely require more assistance than their privileged counterparts; thus these resources must be distributed in an equitable fashion to U.S. residents. The federal government can save lives by sending dangerous event alerts via cell phones, television channels, and radio stations through the Integrated Public Alert & Warning System (FEMA, 2021). While it is essential for these warnings to be equitably distributed throughout society and translated into relevant languages, they still leave the ability

of individuals to remove themselves from danger zones up to each person, which introduces factors of inequality for socially vulnerable groups. Health insurance further plays a large role in the resilience of individuals to extreme weather events, which illustrates the vulnerabilities of low-income communities to intensified storms (Bell et al., 2016, p. 104). Overall, Bell et al. (2016) suggest that the health of Americans can be safeguarded by bolstering vital infrastructure systems that provide food, water, health care, electricity, and sanitation to vulnerable populations (pp. 104-105). Providing these essential resources to marginalized populations within the affected communities could improve their health statuses during and after extreme weather events. In summary, adaptation measures must be taken at the community and city-level to foster the resiliency of the individuals most vulnerable and underequipped in resources.

Eco-Anxiety due to Extreme Climatic Events

Influence of Climate Change Upon the Mental Health of Marginalized Groups.

Aside from the physical health impacts of climate change-related extreme weather events on people of color and low-income individuals, these climatic events can cause eco-anxiety along with severe mental health problems in populations. Clayton et al. (2017) define eco-anxiety as anxiety or fear about climate change and environmental doom (pp. 27, 68). Climate change-related events have both direct and indirect effects on the mental health of populations, such as trauma from experiencing hurricanes, wildfires, and floods first-hand, or disruptions in daily life occasioned by climate displacement (Hayes et al., 2018). Since marginalized communities are disproportionately vulnerable to these events, and less able to migrate away from climatic hazards because of a lack of resources, their mental health will be severely impacted by these factors. Up to 35% of the individuals affected by Hurricane Katrina suffered mental health problems in the aftermath of the event (Hayes et al., 2018). Dodgen et al. (2016) maintain that

the rate of suicidal thoughts increased by 3.6% among residents over a year and a half after Hurricane Katrina transpired (p. 221). The low-income populations and communities of color in the region are particularly vulnerable to these mental health impacts because they experience the worst direct effects of the storm, they may not be able to afford appropriate counseling services or medication, and their social support systems are damaged. Prior to the onset of extreme climatic events, peoples' anxiety levels can be elevated due to the stress incurred by receiving weather warnings (Hayes et al., 2018). Extreme weather events, which are rising in frequency and severity, can cause anxiety, depression, survivor guilt, substance abuse, and post-traumatic stress disorder (PTSD) among others (Hayes et al., 2018). Moreover, Dodgen et al. (2016) affirm that individuals may rely upon alcohol in order to cope with the mental stress of extreme weather events (p. 221). Ultimately, this behavior does not improve the mental health of the affected individuals, and may degenerate into alcoholism, which can result in a wide array of negative outcomes. Extreme events such as tornadoes, droughts, and wildfires are linked with mental health issues and PTSD, as individuals endeavor to cope with the death of family members, rebuilding homes, and evacuations (Bell et al., 2018; Bell et al., 2016, p. 111). Thus, the social support networks that marginalized groups would normally rely upon during or after extreme climatic events, and which could improve their mental wellbeing, are damaged.

Furthermore, eco-anxiety can affect low-income individuals and people of color even when they do not encounter direct climatic impacts. The dissemination of information relating to climate change in the media impacts individuals' mental health as they become more aware of their risks (Dodgen et al., 2016, p. 220). With a higher rate of extreme climatic events projected in the U.S. as a result of climate change, more individuals will be directly impacted by the stress and trauma that they occasion, thereby burdening mental healthcare resources (Dodgen et al.,

2016, pp. 220-221). As low-income individuals and people of color face these mental health challenges, they will struggle against societal as well as economic disadvantages that degrade the quality or accessibility of their healthcare services. Low-income people and people of color will be particularly affected by climate change-related factors, as these stressors will compound those already present in their lives, such as financial and employment concerns among others (Dodgen et al., 2016, p. 223). Dodgen et al. (2016) assert that low-income individuals are the most vulnerable to the mental health impacts of extreme weather-related events, because their mobility, overall health, access to health care services, and financial ability to purchase necessary items to adapt to climate change is severely impaired (p. 225). Hence, these marginalized groups will not be able to evade the worst mental health impacts resulting from extreme weather events, because their preexisting social vulnerability exposes them to more risk. While experiencing eco-anxiety can feel debilitating and isolating, decision makers within communities can take action to fortify the mental wellbeing of marginalized groups amidst increasing climate change-related impacts.

Counteracting Eco-Anxiety. In the face of negative impacts from climate change-related extreme events, it is important for policymakers and the healthcare system to ease eco-anxiety and support the mental wellbeing of marginalized groups. Cunsolo et al. (2020) recommend providing training to mental health professionals and offering individual as well as group therapy sessions to alleviate the strain of eco-anxiety. Unlike Cunsolo et al.'s work, which explicitly focuses on eco-anxiety, Summers & Vivian (2018) do not specifically address this issue in their article; still, they both agree that people can spend time in green spaces to reduce stress and improve their mental wellbeing. Policymakers can address this by arranging for marginalized groups to have access to green spaces, while ensuring adequate mental health

services are available to serve low-income communities and populations of color in order to promote self-care and the strengthening of social ties through group therapy sessions. Dodgen et al. (2016) state that peoples' mental health is beneficially influenced when they involve themselves in adaptation measures for climate change-related factors (p. 223). Decision-makers should actively encourage people of color and low-income individuals to participate in their community's climate resiliency activities, so that their specific concerns and input may be incorporated, while also reducing their eco-anxiety. In summary, eco-anxiety and the mental health problems associated with extreme weather events take a significant toll on mental wellbeing, particularly of marginalized groups since they are more vulnerable to the negative effects of climate change, which necessitates climate resiliency efforts that address these issues.

Discussion and Conclusion

Human health is markedly influenced by climatic factors in the U.S., and will worsen with climate change. The effects range in severity from death to less acute impacts including injuries, illness, and the exacerbation of preexisting medical conditions. Sudden onset and intense events including heat waves, wildfires, floods, or extreme weather events can result in death, and all seven of the climatic factors discussed in this thesis may also result in negative health impacts for humans. However, the exposure of individuals and their resiliency to the health impacts from these climatic factors are not equally distributed throughout populations of the U.S.

In particular, marginalized groups are disproportionately vulnerable to the impacts of climate change in the U.S. Low-income people already struggle to subsist due to a lack of monetary resources and issues that result from this, such as inadequate transportation, healthcare insurance, and poor housing conditions. People of color face historic and continued

discrimination, which influences where they live, the quality of healthcare they receive, and their ability to adapt to climate change. Moreover, these two marginalized statuses can intersect within communities, compounding the societal and environmental dis-amenities that they experience on a daily basis. The exposure of these marginalized groups to climatic hazards, combined with their diminished resiliency, works to make them disproportionately vulnerable to the physical and mental health impacts from the manifestations of climate change outlined in this thesis.

At the community-, city-, and state-levels, adaptation efforts can be taken to bolster the resiliency of low-income populations and people of color to the health impacts of climate change. Although some scholars recommend greening initiatives to reduce the negative effects of heat waves, other perspectives, such as that espoused by Hsu et al. (2021), maintain that urban greening measures can result in the displacement of marginalized groups. Reducing urban sprawl and human population expansion into the wildland-urban interface are proposed for minimizing the health impacts of droughts and wildfires, respectively. Yet, these each represent future urban planning goals rather than current strategies for easing the negative health impacts of these factors on marginalized groups. Individual-level strategies are also suggested by policymakers, specifically for reducing the health impacts from floods and vector-borne diseases upon humans. However, the individual responses of marginalized groups may be impeded by their societal as well as economic disadvantages, which indicates the need for communities to offer adaptation support to underprivileged groups. As Kumar (2018) asserts, a perspective in health equity must extend beyond efforts that respond to the disproportionate health threats experienced by marginalized groups, by addressing the root causes of marginalization that make some groups especially vulnerable to climate change. Thus, the foundations of the marginalization that low-

income individuals and people of color experience in the U.S., including historic redlining, systemic racism, and low-income, must be addressed to prevent continued inequalities.

The implications of these findings are relevant for the fields of public health, environmental and social justice, city planning, as well as urban housing policies. As climate change persists in impacting natural processes and events, public health practitioners must take note of the effects on humans so as to appropriately address these threats. In addition, the finding that marginalized communities disproportionately bear the negative consequences of climate change in the U.S. implies an important nexus between the fields of social and environmental justice. The origins of people's disadvantaged status in society must be addressed in order to resolve their disproportionate experience of climate change and other environmental hazards. Contemporary city planning and developing trends show a rapid increase in new housing units within regions at risk of wildfires, sea level rise, and floods throughout the U.S. (Marandi & Main, 2021). The planning of U.S. cities should take climate change into account and build new developments in low-risk areas to incentivize these safer regions. City planners should also improve the organization of urban regions to prevent the sustained substandard positioning of low-income individuals and people of color in areas that experience the worst impacts from climate change. Additionally, in view of the multiple social and historical vulnerabilities endured by these marginalized groups, urban housing policies must target initiatives to low-income individuals and people of color so that they may adequately adapt to the physical and mental threats posed by climate change.

This thesis excluded several marginalized groups and was limited in scope with regard to how climate change impacts communities. Through analyzing seven of the largest climate change-related impacts in the U.S., this thesis was limited in considering only the health impacts

on low-income populations and people of color. In addition, the term ‘people of color’ can be further divided into specific ethnic and racial groups in the U.S., since the health impacts from climate change may affect Indigenous communities differently than Mexican immigrants, for example. Furthermore, many other groups are made socially vulnerable to the health impacts of climate change because of their sex, gender, sexuality, age, disability, nationality, citizenship status, education level, and ethnicity among others. Additionally, this thesis did not explore the influence of climate change on the mobility or migration status of marginalized groups in the U.S. In many instances, low-income populations and communities of color will disproportionately experience displacement as a result of climatic hazards, such as extreme weather events, wildfires, and floods, because of their current residency in high-risk areas (Cash et al., 2020, pp. 15-16, 19). Yet, the social vulnerabilities of low-income individuals and people of color may present obstacles to migrating away from the hazards introduced by climate change, since social, political, and economic factors can influence their ability to be mobile.

Aside from the seven climatic factors discussed in this work, earlier snowmelts, melting permafrost, and ocean acidification number among the other events linked with climate change (Melillo et al., 2014, p. 11). These climatic impacts can affect the livelihoods as well as physical and mental health of marginalized groups. Hence, future research should investigate the compounding factors that can work to marginalize individuals in society, thereby diminishing their resilience to climatic changes. The full spectrum of climatic impacts should be explored in relation to the social vulnerability of specific groups in society. In addition, future research should study the relationship between social vulnerability and individuals’ ability to migrate away from climatic hazards.

Although the negative health impacts from climate change-related events are currently disproportionately experienced by marginalized groups in the U.S., hope for the future exists in the form of climate adaptation plans that can alleviate these inequities. The federal government has committed its economy to attain net zero GHG emissions by 2050 through investing in green infrastructure and employment opportunities (The White House, 2021). Additionally, federal programs such as FEMA aid in warning American residents of natural disasters, while the U.S. EPA's (2021f) Environmental Justice Small Grants Program assists communities with developing climate change adaptation strategies. Aside from federal-level action in this sphere, states, cities, and communities can support the resilience and adaptability of low-income individuals and people of color to climate change. The Center for Climate and Energy Solutions (2021) asserts that 34 U.S. states have created climate action plans to mitigate and adapt to climatic changes. Complementing these large-scale actions, cities and communities can prepare emergency plans against heat events, floods, and extreme weather events, while also strengthening critical infrastructure to maximize the accessibility of health care and other necessary resources (U.S. EPA, 2015, pp. 1-3). As noted above in the Findings section, action must be taken at multiple levels to adequately address the negative health impacts of climate change upon marginalized groups. Policymakers in communities and throughout every level of government in the U.S. must balance adaptation as well as mitigation efforts in order to effectively reduce the negative impacts of climate change now and in the future. While more action must be taken against climate change and its negative health impacts, the nation is moving in the right direction for improving the resilience and adaptability of communities to climate change.

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