Chapter 2

How We Got Here: Producing Climate Inequity and Vulnerability to Urban Weather Extremes

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Abstract This collected volume is intentionally future-oriented; it is authored by a team of interdisciplinary scientists and practitioners who collaborate to translate research findings into networked adaptive practices that we hope will protect urban communities against the impacts of extreme weather. While future-oriented, we cannot protect future generations against urban weather extremes without understanding the historical processes through which these existential and ethical crises came about. This chapter describes how economic and political institutions produced the climate crisis in ways that also constitute a humanitarian crisis, inscribing climate inequity into the urban built environment and institutions. It offers reflections on ways in which this history must be wrestled with in the context of equitable and resilient urban futures.

Keywords Urbanization · Extreme weather · Climate inequity · Procedural injustice · Distributional injustice

Using the example of Hurricane María in Puerto Rico and more general trends, this chapter illustrates how particular processes of economic change, ecological change, national and international policy, and power shape experiences with weather extremes. Understanding how crises like Hurricane María are produced involves more than scientific descriptions of global warming and extreme weather in relation to historical averages. It involves more than accounting for outcomes in terms of recovery cost, mortality rates, and climate migration predictions, or even differentiating these across geographies and social groups. It requires establishing how institutions at multiple scales and in multiple linked (social–ecological–technological domains [see Chap. 3]) inscribe inequality. Historically, climate change has its roots in economic change—the industrialization and carbonization of our economic processes, with concomitant development of cities. Owing to ways in which their biophysical landscape was designed, it is cities that are now particularly susceptible

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Z. A. Hamstead et al. (eds.), *Resilient Urban Futures*, The Urban Book Series,
https://doi.org/10.1007/978-3-030-63131-4_2

to heat islands, sea level rise, and extreme weather. But the question of which cities are able to harness resources necessary for recovery and which social groups within cities receive those resources is a matter of politics, power, and exclusionary practices. Examining how the social separateness that forms unequal climate burden is embedded in planning, policy, scientific, and economic practices is crucial for transforming these institutions in ways that protect vulnerable communities from extreme weather.

Vulnerabilities to extreme weather events are driven by interactions between exposure to the hazard (e.g., coastal location of infrastructure) and capacities for coping (e.g., ability to mobilize recovery resources). (For more information about vulnerability to weather extremes, see Chap. 4.) As global trade and other carbon-intensive activities increase exposure to extreme events globally, geographic differences make those exposures uneven, while economic, political, and other forms of social separateness drive differential abilities to cope with the impacts. Vulnerability is often described in terms of distributional injustice—the spatial, temporal, and demographic patterns of environmental burden and benefit. However, less attention is paid to conditions of recognition, respect, and fair and inclusive processes which are preconditions for distributional injustices, or ways in which distributional injustices exacerbate procedural injustices in turn. Procedural injustices committed by the state and other institutions are related to exclusionary practices that assign respect and recognition, (dis)enabling participation in political processes (Schlosberg 2007). Procedural justice can, therefore, be seen as a tool to achieve more equitable material distributions. All these forms of injustice play a role in vulnerability to weather extremes. Here, I use environmental justice theory and historical context to explain climate injustice. First, I describe broad trends in weather extremes and ways in which they are influenced by urbanization. I then describe various roles of power and politics in producing an unequal climate burden.

2.1 Breaking Climatological Records

In early September of 2017, category 5 Hurricane Irma brought wind gusts of 74 miles per hour (mph) [119 km per hour (kph)], storm surge flooding along the north coast, and heavy rainfall in the central and eastern portions of the island of Puerto Rico. Three weeks later, category 4 Hurricane María made landfall, bringing maximum sustained winds of 175 mph (282 kph). Along the northern, eastern, and southeastern coastlines, maximum storm inundation reached 10 feet (ft [3 m]), with heavy rainfall peaking at 37.9 inches (96.3 cm) (Fig. 2.1). Riverine flooding displaced communities along the Guajataca River, and over 2,000 people had to be rescued from rooftops in the municipality of Toa Baja (Ferré-Sadurní 2017) on the northern part of the island. Flooding also caused heavy metal and bacterial contamination of drinking water. Most of Puerto Rico's toxic waste sites—some of which contain coal ash comprised of heavy metals like lead and arsenic—are located along the southeastern coastline, which was heavily inundated (Funes 2017). Since more than a third of the sewerage treatment plants did not function after the hurricane and water service restoration

Fig. 2.1 Estimated rainfall totals from Hurricane María in Puerto Rico and the U.S. Virgin Islands with totals from reporting stations. Image credit: NOAA

was slow in many parts of the island, some people depended on waterways mixed with raw sewerage for drinking and bathing.

Damage to critical infrastructure cut off services for months as the death toll mounted and a mass migration to the United States mainland ensued. One month after the hurricane, more than 92% of Puerto Rico’s roads were closed due to massive landslides and downed trees, leaving people struggling to get medical supplies, food, and water. In the storm’s aftermath, Puerto Ricans experienced the largest blackout in U.S. history; 1.5 million residents were without power, which was not fully restored for almost a year. Overall, the Federal Emergency Management Commission (2018) estimates that María caused US \$90 billion in damages, making it the third costliest storm in U.S. history (Table 2.1). In the year following the storm, an estimated 160,000 Puerto Ricans had relocated to the mainland (Hinojosa and Meléndez 2018).

U.S. Caribbean islands like Puerto Rico are sensitive to large-scale weather patterns such as the El Nino-Southern Oscillation and the Atlantic Multidecadal Oscillation, which can lead to weather and climate extremes (Gould et al. 2018). Since 1950, annual average temperatures in Puerto Rico have increased by about 1.5°F, or approximately 0.8 °C. Under a high emissions scenario, temperatures are projected to increase by as much as 9°F (5 °C) and sea level rise is expected to increase 9–11 ft (2.7–3.4 m) by 2100. In the Caribbean, these climatic changes will likely lead to water shortages, as some locations experience longer dry seasons and

Table 2.1 Damage estimates for costliest storms in U.S. history

Hurricane	Year	Cost (billion)
Katrina	2005	\$161
Harvey	2017	\$125
María	2017	\$90
Sandy	2012	\$71
Irma	2017	\$50

Source Federal Emergency Management Commission (FEMA 2018)

shorter, but wetter wet seasons. Ocean warming and acidification will threaten coral reefs. The frequency and intensity of extreme heat events will increase. In addition to large-scale weather patterns, the coastal orientation of human settlements, with critical infrastructure, ecosystems, and economic activity in Caribbean islands make them especially vulnerable to destruction and human health impacts associated with severe storms.

Across the globe, communities are experiencing unstable weather and climate conditions unfavorable for the wellbeing of humans, and the ecological and technological systems on which they rely. Scientists describe extreme weather and climate phenomena in reference to historic averages; they exist on the outer boundaries of meteorological distributions, or the ranges of precipitation, temperature and other weather phenomena that have been observed in the past. Since these distributions are based on a location’s recorded weather history, what is typical in one place may be extreme in another. The Intergovernmental Panel on Climate Change (IPCC) defines *extremes of atmospheric weather and climate variables* as:

The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable (IPCC 2012, p. 557).

As climate change shifts the mean distributions of weather and climate, human adaptation is not keeping pace, causing injury to countless communities across the globe. Extreme weather events—including heat waves, droughts, heavy precipitation events, hurricanes, tropical storms, wildfires, landslides, and mudslides—have all caused irreversible damage in the last decade. The 14th edition of the Climate Risk Index analysis produced by Germanwatch reports that between 1998 and 2017, more than 526,000 deaths and U.S. \$3.47 trillion (in purchasing power parities¹) of damages were directly caused by over 11,500 extreme weather events (Eckstein et al. 2019). Globally, weather-related disasters have more than tripled since the 1960s (World Health Organization 2018). In some parts of the world, it is estimated that human-induced climate change has more than doubled the probability of heat waves and it will not be possible to reverse a large proportion of climate change within

¹Purchasing power parity is based on different countries’ relative prices levels for the same basket of goods, and provides a way to translate countries’ currencies into U.S. Dollars (Dornbusch 1985).

the next 100 to 1,000 years (IPCC 2014). Even if humans were to stop emitting greenhouse gases, warming will continue to undermine human survival.

Climate-induced extreme events exacerbate existing vulnerabilities in ecosystems, infrastructure, economic systems, and human health. The agricultural sector is particularly vulnerable to climate change-induced drought in lower latitudes (IPCC 2007), threatening national economies and pushing farmers off their land. Extreme weather causes disruptions to infrastructure like water systems, sewer systems, roads, and power plants, already aging and in need of repair (USGCRP 2016). The United Nations High Commissioner for Refugees estimates that 22.5 million people were displaced by climate or weather-related events between 2008 and 2015, equivalent to 62,000 people each day (Yonetani et al. 2015). Weather extremes are occurring with levels of frequency, duration, and intensity for which ecosystems, human health, institutions, and technological infrastructure are ill-adapted.

According to the IPCC (Seneviratne et al. 2012), we can expect substantial warming in temperature extremes throughout the twenty-first century, especially over land areas. Particularly in high latitudes and tropical regions, the proportion of total rainfall from heavy precipitation events will increase and, in some regions, those increases will occur despite total decreases in precipitation. These changes will impact the natural environment in ways that drive droughts, floods, extreme sea level, waves, coastal impacts, cryosphere-related impacts, landslides, and sand and dust storms.

With high concentrations of people and engineered materials in locations which are often coastal, cities are particularly susceptible to extreme weather events and their impacts. Urbanization can describe many human settlement processes and patterns—from urban densification to suburban and exurban sprawling land use patterns. These forms involve altering ecosystems and replacing them with engineered infrastructure, which exacerbates extreme atmospheric events (Hamstead and Coseo 2020). During the mid to late nineteenth century, Europe and the United States underwent a period of industrial urbanization. This economic transformation marked a shift to carbon-intensive activities and land use patterns which not only led to global warming but also created unique vulnerabilities in the sites of that carbon-intensive activity.

2.2 Urbanization and Extreme Weather Events

Long before the industrial period, colonization and subsequent processes of economic change brought major transformations to the ecology and human settlement patterns of Puerto Rico. Before Europeans began to seize control of the island in the late fifteenth century, the Taíno people grew crops such as corn, yucca, yams, and cotton. Mangroves—coastal shrubs and trees that are crucial for shoreline protection and soil stabilization—were prevalent and widely distributed along the coast of the island. During this colonial period, sugar was becoming one of the most valuable European trade commodities. Thus, in Puerto Rico and elsewhere, land was cleared to make

way for sugarcane and slaves were brought to fulfill labor demands. As sugarcane, tobacco, citrus, coffee, bananas, and other new crops were introduced, many native habitats like mangrove forests were destroyed.

When Europeans began to control Puerto Rico, there may have been 12,146 hectares (30,000 acres) of mangroves on the island (Miller and Lugo 2009). By 1975, half had been destroyed due to agriculture and human developments along the coast. By the mid-1980s, up to 75% had been destroyed or highly altered. Endemic mangroves are among the most important plant communities for water filtration and protection against flooding. Mangroves dampen the power of storm waves, as their roots stabilize land that would otherwise be eroded into the sea. They filter nutrients and sediments, along with treating waste that is harmful to human health, and providing aquatic and avian habitat. Altered hydrology, impervious surfaces that do not allow water to be absorbed into the soil, and aging infrastructure all intensify vulnerability to weather extremes in cities. As Puerto Rico's industrial and service-dominated economies have expanded in recent decades, urban areas have rapidly developed in low-lying zones. These zones are more vulnerable to sea-level rise, increasing the need for ecosystems such as mangrove forests to stabilize soil and filter water.

During Hurricane María, major flooding occurred in coastal urban areas like the capital of San Juan (FEMA 2018), which is covered in sealed soil with little capacity to absorb stormwater. Most of San Juan's critical infrastructure, electric power plants, businesses, and hotels are located in the coastal zone of the San Juan Metropolitan Area (PRCCC 2013). As San Juan's aging sanitary and stormwater infrastructure were clogged with fallen debris and inundated by heavy rainfall, residents of low-lying La Perla and other neighborhoods waded through contaminated water to remove debris and transport people with medical emergencies to hospitals (Mazzeio and Martinez 2017).

2.2.1 Urban Industrialization

Urban industrialization is a process through which greenhouse gas emissions changed the climate at a global scale, but which also created unique material and social vulnerabilities in the very sites of that production. The Industrial Revolution—which began in England between 1760 and 1840, and spread throughout Europe and then North American during the early nineteenth century—marked the shift to fossil fuel-based energy. Coal fueled expansion of the steam engine and transportation, as well as the dominance of the factory system of production over home labor and agriculture. This shift from home labor and agriculture to factory production centralized laborers in cities. Prior to the industrial revolution in England, a series of economic shocks and the practice of enclosure had pushed tenant farmers off their land and driven households into economic decline. Poor relief was provided to supplement wages, based on the price of bread and the size of the family. As the demand for urban labor grew, these relief programs became controversial, and the state was blamed

for creating indigency by interfering in self-regulating labor markets (Block and Somers 2003). Thus, the Poor Law Amendments—which required the indigent to receive “assistance” in urban workhouses—were passed in 1834. Within 20 years, the population of cities had doubled and urban communities underwent major physical transformations as the need for housing, sanitary water and sewer, transportation, and other infrastructure became concentrated alongside these industrial activities.

2.2.2 *Urban Climatology*

Historical processes of urbanization—including urban density and expansion—have not only warmed the globe through greenhouse gas-emitting activities but have also warmed the local climate and changed local weather patterns through land use changes. Cities replace agricultural and rural landscapes with mineral-based materials that seal soil and warm the environment (Stone 2012). Sealed soil leads to more stormwater run-off and reduces the land’s natural ability to cool itself. Engineered materials also alter the albedo or reflectivity of the land surface; cities absorb 80–85% of incoming solar radiation, making them hotter than non-urban locations (Taha 1997). In addition, industrial and transportation activities produce waste heat emissions. Where human-engineered materials predominate, heat waves, precipitation events, droughts, and wildfires are more intense since heat provides fuel for storms and dries the air mass. The increasing concentration of people in cities where these materials predominate makes cities particularly risky places to live in the context of climate change.

2.3 Breaking Political Will

Although extreme weather events (such as heavy precipitation or high temperature) are environmental phenomena, these phenomena and associated human vulnerabilities are altered and exacerbated by social processes that are political, economic, and exclusionary in nature. Industrial, transportation, and residential land use-driven greenhouse gas emissions—which make extreme events more likely and exacerbate their impacts—are the result of political action and inaction. Political agendas entail favoritism for certain types of economic activity and power over others, and use rhetoric ranging from economic liberty to stigmatization of the communities which threaten and are oppressed in order to maintain that power. Altering the climate is an economic and political endeavor, as is curbing climate change and adapting to climate-exacerbated extreme weather events.

At a global scale, inter-jurisdictional relationships of trade and governance play important roles in climate (in)action. Scientific, economic, and political narratives obscure the political economy drivers of climate change and its relation to class, race, and other means of oppression. Particularly for places like Puerto Rico, colonial

histories and political status that convey rights to particular types of claims and not others play important roles in recovering from and building resilience to extreme weather events.

Prior to the U.S. invasion of Puerto Rico during the 1898 Spanish-American War, the island had just won autonomy from Spain, enabling it to elect voting delegates to the Spanish Parliament and its own legislature. The American military invaded with promises to help secure Puerto Rico's liberty, motivating many Puerto Ricans to fight against the Spanish during this invasion. That promise of liberty was not upheld. Once the Treaty of Paris was signed, the United States instituted a system of colonial rule over Puerto Rico, and made issues of citizenship ambiguous (Erman 2018). Under the Foraker Act of 1900, the governor of Puerto Rico and all other major offices were appointed by the U.S. President, and local laws were subject to veto by U.S. Congress (Miller and Lugo 2009). Puerto Rico was prohibited from negotiating trade treaties with foreign nations and the peso was retired at 60 cents to the dollar, causing a 40% rise in the cost of living and a fall in the price of land, enabling U.S. sugar corporations to purchase vast areas for sugar production.

Until President Woodrow Wilson signed the Jones-Shafroth Act in 1917 so that Puerto Ricans could enlist and be drafted to WWI, the people of Puerto Rico had limited legal rights. Jones-Shafroth granted Puerto Ricans Congressional citizenship but not Constitutional citizenship, though the Act was eventually amended in 1947 to allow governors to be popularly elected. Additionally, the island would become its own Commonwealth and develop its own Constitution in 1952. However, this Commonwealth status came with neither full independence nor full U.S. citizenship rights. Today, Puerto Ricans still do not elect voting representation to Congress or vote in presidential elections unless they reside in one of the 50 states.

Following Hurricane María, U.S. President Trump characterized Puerto Ricans as lazy and threatened to reduce recovery efforts, claiming on Twitter that “they want everything done for them.” Stigmatization, misrecognition, and other status injuries form important means through which distributional and procedural inequities are institutionalized. Without representation in Congress or the ability to vote in general elections, Puerto Rican residents and their leaders have little political leverage to rapidly direct critical emergency resources. Indeed, recovery resources for Puerto Rico were insufficient and withheld for long periods. Here, we see a form of procedural inequity reinforced through status injury and translating into a material withholding, or distributional inequity. By comparison, recovery benefits to victims of Hurricane Harvey—which struck Houston, Texas only weeks earlier than Hurricane María struck Puerto Rico—were more generous and quickly deployed. A Politico Investigation outlined these discrepancies:

Within six days of Hurricane Harvey, U.S. Northern Command had deployed 73 helicopters over Houston, which are critical for saving victims and delivering emergency supplies. It took at least three weeks after María before it had more than 70 helicopters flying above Puerto Rico.

Nine days after the respective hurricanes, FEMA had approved \$141.8 million in individual assistance to Harvey victims, versus just \$6.2 million for María victims.

During the first nine days after Harvey, FEMA provided 5.1 million meals, 4.5 million liters of water and over 20,000 tarps to Houston; but in the same period, it delivered just 1.6 million meals, 2.8 million liters of water and roughly 5,000 tarps to Puerto Rico.

Nine days after Harvey, the federal government had 30,000 personnel in the Houston region, compared with 10,000 at the same point after María.

It took just 10 days for FEMA to approve permanent disaster work for Texas, compared with 43 days for Puerto Rico.

Seventy-eight days after each hurricane, FEMA had approved 39% of federal applications for relief from victims of Harvey, versus 28% for María (Vinik 2018).

Comparing measures of federal spending, federal resources distributed, and direct and indirect storm-mortality estimates, Willison et al. (2019) found that although Hurricane María caused more damage in Puerto Rico than did Hurricane Irma in Florida or Harvey in Texas, fewer resources were dedicated to the post-storm recovery in Puerto Rico.

2.3.1 Liberal Trade Narrative

During the 1980s, scientific consensus was beginning to form an understanding that climate change is anthropogenically-driven. Klein (2014) argues that the timing of this consensus-forming unfortunately coincided with the adoption of major trade deals that made climate action subordinate to the liberal trade agenda. In the early 1990s when global leaders were negotiating how to reduce greenhouse gas emissions through the United Nations Framework Convention on Climate Change (UNFCCC), the World Trade Organization (WTO) adopted a set of policies that undermined the UNFCCC. Free trade agreements governed by the WTO limit national economic sovereignty, and in some cases have stymied communities' abilities to locally invest in green energy technology. Rhetoric against these programs—which involve subsidies and local industry requirements—claim they distort the free market; yet, fossil fuel companies receive up to US \$1 trillion in annual subsidies (Bast et al. 2012), limiting the extent to which green energy technology can freely compete. Political economy narratives such as those associated with liberal trade have been particularly effective at obstructing collective climate action that would curb carbon-producing activities.

2.3.2 Rational Choice Narrative

Economic narratives of climate change as a market failure or market externality are equally problematic, as they position climate change as a phenomenon that can be dealt with via market correction rather than as a result and necessary outcome of the growth-based global economy (Daly 1996). Rational choice economic theory assumes that people make decisions by choosing among possible alternatives an option that maximizes their utility based on preferences and budget constraints. Under

this ideology, behavior and decisions are themselves evidence of people's preferred choice. Rather than placing responsibility on collective action of societies (e.g., on governments) and society, sustainability is cast as a matter of individual choice to be achieved via market-based approaches that incentivize pollution reduction and shift consumption patterns in favor of green products. This rational choice-based sustainability narrative obscures the far more impactful role of institutions and systems in producing climate change (and influencing individual choices (Simon 1986)). For instance, if the majority of transportation dollars are spent on optimizing the number of automobiles that can travel along our highway system, what actual role does personal choice afford in making more sustainable mobility decisions?

Similar to liberal trade narratives—which obscure the role of government in providing subsidies to support fossil fuel industries—the rational choice narrative has associated liberty and freedom of choice values with automobile-based transportation in order to obscure the role of government subsidy. Peter Norton (2015) argues that the automobile industry and U.S. government used a “Love Affair Thesis” to convince the Americans that they prefer automobile-based transportation in spite of its safety risks. In the United States, 43–74% of the cost of the highway system has been directly subsidized by government rather than supported through gas taxes (Dutzik et al. 2015). Yet, the personal automobile is cast as a “private” form of transportation in which individual-level rational choice plays the dominant role in behavioral decisions compared with mass, or “public” transit which the government coerces people to pay for and use. Thus, political economy narratives such as those associated with rational choice theory (like those associated with liberal trade) are effective at stymying collective action to change carbon-producing behaviors such as those in the transportation sector.

2.3.3 *Global Climate Narrative*

While scientific narratives may be designed to encourage particular types of climate action in a global arena, they effectively obscure more granular distributional dimensions of climate change and extreme event impacts in ways that reinforce power relations. In 2016, parties to the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement agreed to limit global temperature rise to below 2 °C, or about 3.6°F. However, given that a global temperature rise of 2 °C will entail major rises in sea level, longer droughts and more intense heat waves among other effects (not to mention that communities across the globe have already experienced irreversible impacts from climate change), this threshold is more political than scientific. Shaw (2015) argues that “2-degrees” is a symbol which “validates stories that are designed to mask the conflicts between interests of the ruling class and those of society as a whole” (p. 10). Global averages obscure the uneven geographies of responsibility—who is benefiting and who is bearing the burden of climate change. Although scientific narratives focus on estimates of average historic and projected warming, the globe is not warming evenly and people (at the national, sub-national,

or even neighborhood level) do not have equal capacities to cope with warming experienced in their communities. Over the past half century, it is estimated that climate change has increased between-country inequality by 25%, associated with economic output declines in hotter poorer countries, and economic growth in cooler, wealthier countries (Diffenbaugh and Burke 2019). Places like Puerto Rico are much more vulnerable to climate change, not only due to their coastal location but also because they lack political leverage and political autonomy to harness resources that would enable climate change-related mitigation, adaptation, and response. Although greenhouse gases accumulate in the atmosphere globally, not all parts of the globe experience this accumulation in the same way.

2.4 Urban Climate Extremes Exacerbate Existing Inequities

Social separateness embedded in many institutional forms is exacerbated by climate change. In the case of Puerto Rico's sovereign political status, we saw that distributional inequities are reinforced through procedural inequities and misrecognition. But distributional inequities also exist between different communities within territorial boundaries and cities. These are codified in exclusionary practices of misrecognition and unfair participation that determine, for instance, who has access to protective housing and financial resources, or even whose fatalities are counted among the climate-induced.

Calle Norzagaray in Old San Juan overlooks the Atlantic Ocean. An elevated route used by tourists to visit the historic Castillo de San Cristóbal also forms a boundary with the low-lying historic shantytown neighborhood of La Perla. Along this panorama of economic and climate injustice is a mural which refutes the U.S. government's official Hurricane María death count (Fig. 2.2).

There are multiple ways to calculate death rates due to extreme weather. Conventionally, the practice is to use death certificate reporting. Known as *directly related disaster death*, this accounts for people who die during the peak of the storm from physical impacts like structural collapse. According to the Centers for Disease Control and Prevention, *indirectly related disaster death* should also be reported. This type of fatality could be due to unsafe or unhealthy conditions during pre-event preparations or post-event cleanup (US DHHS 2017). However, even this approach does not account for indirect deaths due to longer term loss of water, emergency services, and delays or interruptions in health care due to power outages. Kishore et al. (2018) conducted a stratified survey-based study of 3,299 households from January 17 to February 24, 2018 to compare death rates during that period to the same period in the prior year. Using a measure of "excess mortality," the researchers estimated 4,645 deaths likely due to Hurricane María, far higher than the official U.S. government count of 64. The mural on Calle Norzagaray draws attention to this discrepancy and the broader misrecognition of the very nature of hurricane-related

Fig. 2.2 “Recordemos nuestros Muertos (Remember our dead) 4,645” mural overlooking La Perla, Old San Juan, Puerto Rico. Image credit: the author

vulnerability. Extreme weather-related deaths are not mere acts of nature. Recognizing that lack of critical infrastructure and services are to blame for thousands of deaths would implicate people and institutions, especially those with power.

Whereas conventions used for causal attribution only allow classification of deaths attributable to immediate physical impact, excess mortality captures the fragility of our infrastructure and service provisioning in the face of extreme events, particularly in ways that impact low-income communities of color who may not be able to afford energy generators or flights to safe communities (e.g., the U.S. mainland). Moreover, spatial segregation along racial and class lines often places low-income people of color in communities most exposed to environmental burdens, including extreme weather events.

Inequity is produced at the intra-urban scale through institutions that govern access to jobs, housing, transportation, and land use. Early industrialization formed cities, but those cities were reconfigured during industrial relocation processes that occurred during the middle of the last century, along with suburbanization processes which segregated poor communities of color in inner cities that lacked job opportunities. These reconfigurations reshaped both the biophysical and social contexts of cities in ways that would ultimately—due to a coupling of land use and social segregation—concentrate poor communities of color in hot microclimates and locations that are

disproportionately exposed to environmental burdens such as air pollution, toxic waste, and flooding (Bullard 2000).

Throughout the twentieth century in the United States, an enormous wealth gap grew between black and white households. In 1935, the Home Owners Loan Corporation (HOLC) was established to insure home mortgages following the banking crisis of the 1930s that had resulted in many foreclosures. Favoring suburban development for white households, this insurance was unavailable to racial and ethnic minorities, immigrants and for homes situated in urban communities. It was the HOLC's policy to ensure that "incompatible racial groups should not be permitted to live in the same communities" (Federal Housing Administration 1936). This policy was codified through residential security "redlining" maps, which delineated boundaries around communities in which it was considered "safe" or "unsafe" to offer insurance. As cartographic guide to a host of local land use tactics, residential security maps created a spatial logic by which officials, developers, and real estate agents would: (a) create suburban all-white neighborhoods, (b) rigidize existing segregation patterns, and (c) segregate formerly integrated neighborhoods. As white neighborhoods were rezoned as single-family only, black neighborhoods were rezoned commercial or industrial (or granted variances for such uses) (Rothstein 2017). Under the auspices of economic protection, uses like polluting industries could only exist in black neighborhoods. Recent research finds that surface temperatures in redlined communities are 2.6 °C (4.7°F) hotter relative to non-redlined neighboring communities (Hoffman et al. 2020). In addition to inscribing environmental burden like heat in the built environment, redlining also created unequal access to wealth. Since home ownership became affordable for white families, it formed a primary means through which middle class families generate wealth and pass on wealth to their children in the form of higher education and other investments. In addition, residential property tax forms an important means through which communities collectively invest in local infrastructure. Household and neighborhood-level resources can be crucial for resilience to heat or flooding, as access to quality weatherized housing, energy for air conditioning, and flood insurance is largely a matter of income and wealth. Communities already facing high food, energy, and housing burdens have greater sensitivities to extreme weather events.

Scholars of racial capitalism have argued that racism and capitalism are intrinsically linked, since capitalist wealth production is not possible without the production of social separateness that can be used as a tool to exploit labor (Melamed 2015; Pulido 2017). Social separateness is embedded in processes of wealth accumulation and economic development that determine land use patterns, and it produces residential locations, the hazards to which people living in those residential locations are exposed, and spaces that enhance or minimize collective life. Moreover, extreme weather exacerbates forms of separateness which are ingrained in unfair institutions of housing, transportation systems, and economy that often predate an extreme event. In Gulf region states of the United States affected by Hurricane Katrina, women and women of color were most likely to lack access to health insurance, experience disproportionately high rates of poverty, and engage in low-wage work despite high

work participation rates (Jones-DeWeever and Hartman 2006). These forms of exclusion that were in place prior to the storm made relocation and recovery exceptionally arduous after the storm. Understanding how historical processes of industrial extraction, as well as housing, transportation, and other land use policies and practices have formed spatial configurations across cities is crucial for recognizing and mitigating contemporary forms of exclusion and the production of vulnerability to weather extremes.

2.5 Conclusion

Our climate and humanitarian crisis has been produced by an economic system that devalues labor and natural resources, and which is supported by housing, transportation, and land use institutions that reinforce vulnerability of oppressed groups through exclusionary practices. At the same time, barriers to addressing these crises are cast as a problem of individual-level choice that could be rectified by market-based approaches. The Human Rights Council of the United Nations has used the term “climate apartheid” to describe the impacts of an overreliance on the private sector for climate disaster protection (United Nations Human Rights Council 2019). Addressing these crises must involve transparency about who is benefiting, who is burdened, and how we institutionally produce this inequality. Scientific narratives that generalize climate change signals and impacts based on averages without also describing distributional exposures and disproportionate impacts exacerbate this inequality. Examining how social separateness that forms unequal climate burden is embedded in planning, policy, economic, and scientific practices is crucial for transforming those institutions to design adaptation strategies that protect vulnerable communities from extreme weather.

Creating resilient urban futures will involve forecasting, projecting, and visioning, using all the technical and creative tools at our disposal. However, we cannot truly understand the nature of the problems we are trying to solve for the sake of future generations unless we understand how problems were produced in the past. This is because climate change and vulnerabilities to weather extremes have been institutionalized in structures that are designed to replicate themselves. Resilient futures practice is a multi-sectoral activity, as we see that vulnerability is embedded not only in systems of ecology and health, but also economy and housing. Each of these and many more sectors has played a role in producing oppression and each must reckon with that history in developing strategies for transforming social separateness into social cohesion. Environmental justice theory offers conceptual tools for unpacking ways in which misrecognition, distributional injustice, procedural injustice, and other forms of social separateness exist in such institutions. In order to create positive and transformative future narratives that will show us the way forward, we must first construct narratives that help us understand where we are and how we got here. Thus, urban futures work situated in history and informed by environmental justice theory is an essential first step toward climate equity and resilience.

Acknowledgements This work was supported by the Urban Resilience to Extreme Weather-Related Events Sustainability Research Network (URExSRN; NSF grant no. SES 1444755). The author is grateful to Joyce Coffee, Philip Gilbertson, Elizabeth Cook, and to Tico Taussig for their thoughtful comments.

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