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ORIGINAL RESEARCH REPORT

Chapter 8. Bending the Curve and Closing the Gap: Climate Justice and Public Health

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Climate change is projected to cause widespread and serious harm to public health and the environment upon which life depends, unraveling many of the health and social gains of the last century. The burden of harm will fall disproportionately on the poorest communities, both in the U.S. and globally, raising urgent issues of "climate justice". In contrast, strategies for climate action, including those of an institutional, and cultural nature, have the potential to improve quality of life for everyone. This chapter examines the social dimensions of building carbon neutral societies, with an emphasis on producing behavioral shifts, among both the most and the least advantaged populations. In support of Bending the Curve solutions 2 and 3, the case studies offered in this chapter rely not only on innovations in technology and policy, but innovations in attitudinal and behavioral change as well, focused on coordinated public communication and education (Solution 2), as well as new platforms for collaborating, where leaders across sectors can convene to tackle concrete problems (Solution 3).

Findings

- Climate change will cause unprecedented harm to human populations, with the greatest burden falling on children, the elderly, those with underlying illnesses, and the poor, particularly poor women.
- Climate Change will disproportionately affect low income countries, especially their coastal cities, and will also disproportionately affect poorer people within wealthier countries.
- Technological and policy solutions to climate change must be combined with policy changes and innovative approaches to changing social attitudes and behavior.
- Technology can work to address climate change only if people in countries that produce most of the greenhouse gases also shift to low-carbon behavior patterns.
- Many of the necessary changes to reduce greenhouse gases will also result in improvements to public health and greater social justice.
- Reducing industrial carbon emissions can bring co-benefits of reduced air pollution, while better public transportation and increased urban density can improve mobility and promote physical activity in communities.
- Using revenue from the sale of carbon credits or from a carbon tax to fund greenhouse gas reduction programs in disadvantaged communities is a way of maximizing climate, health, and social justice benefits.
- Shifts in production away from cattle and an emphasis on production of plant proteins will dramatically reduce methane production from agriculture while reducing deforestation and air and water pollution and increasing the availability of healthier food.
- Climate education and participatory climate action in underserved urban communities contributes to producing healthier, more equitable, climate-friendly cities. Social and multimedia networking can tie local efforts together at larger regional and global scales to create meaningful reductions in greenhouse gases.
- Greater connectivity among civil society organizations, religious organizations, scientists and universities, at local and global scales, can enhance the adoption of new technologies, and develop new capacities for climate action and social innovation.

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Introduction

Today. . . . we have to realize that a true ecological approach always becomes a social approach; it must integrate questions of justice in debates on the environment, so as to hear both the cry of the earth and the cry of the poor.

—Pope Francis, Encyclical Letter

Climate change is projected to cause widespread and serious harm to public health and the environment upon which life depends, unraveling many of the health and social gains of the last century. Unprecedented heat waves, drought, extreme storms, poor air quality, floods and wildfires are all linked to climate change. These conditions pose potentially serious health impacts including heat stress, dehydration, injuries, allergy, exacerbations of asthma and cardiac disease, hunger, social, psychological and economic strife. The health effects of climate change are already occurring, and are predicted to become devastating by mid-century if significant greenhouse gas reductions do not occur. The burden of harm will fall disproportionately on the poorest communities, both in the U.S. and globally, raising urgent issues of "climate justice". In contrast, strategies for climate action, including those of an institutional, and cultural nature, have the potential to improve quality of life for everyone.

Climate change is driven by interacting factors, including: harmful technologies, short-sighted public and economic policy, unsustainable land use patterns, and destructive human behaviors. Climate justice entails giving special attention to correcting patterns of disproportionate responsibilities and harms. The top 1 billion residents of the planet are accountable for the bulk of greenhouse gas emissions. In contrast, the billions of people living in poverty globally are the ones most affected by these emissions. This double disparity represents a "climate gap" between rich and poor, which must be closed if we hope to bend the curve of climate change. Wealthy countries, regions, and industries must bear primary responsibility for mitigating the harms and urgently mobilizing a low-carbon global economy.

This chapter examines the social dimensions of building carbon neutral societies, with an emphasis on producing behavioral shifts, among both the most and the least advantaged populations. In support of Bending the Curve solutions 2 and 3, the case studies offered in this chapter rely not only on innovations in technology and policy, but innovations in attitudinal and behavioral change as well, focused on coordinated public communication and education (Solution 2), as well as new platforms for collaborating, where leaders across sectors can convene to tackle concrete problems (Solution 3). A focus on behavior is both an ethical and a practical matter: all the best technologies and policy in the world, all the best top-down intentions and investment, will not make a dent until people are educated and ready to adopt new technologies, and adapt their practices to new policies.

This chapter also recommends rethinking the way we design our built environment and its relationship to broader ecological environments, and assessing the ethical responsibility for developing low-carbon, green economies in the poorest regions of the world. We highlight actionable strategies already underway in urban, agricultural and rural settings in California and globally, to demonstrate that it is possible to mitigate carbon emissions while maximizing public health and social equity.

Adopting effective strategies, however, requires a widespread and pervasive cultural shift in our attitudes about a lower carbon lifestyle, especially in developed and rapidly developing economies. Some people worry that a low-carbon lifestyle will lead to lower quality of life, but the opposite is true, at least for most people. A high-carbon lifestyle, in addition to consuming a large portion of the earth's resources, is ultimately unhealthy and inequitable. A high-carbon lifestyle is associated with obesity, metabolic syndrome, respiratory disease, and cancer, even among the wealthy. Reducing greenhouse gas emissions will bring significant dividends both for public health and for social justice.

Climate Change and Health

Climate change will exacerbate numerous existing health problems, magnifying challenges within health care systems globally. Increases in atmospheric heat will directly lead to more extreme temperatures, and increases in atmospheric heat energy will bring more extreme weather events such as droughts, severe storms, and floods. Resulting direct and indirect health effects will include a predictable cascade of injuries and illnesses that will affect millions, and disproportionately strike young children, the elderly, the poor, and people with chronic underlying health conditions [1]. The human and economic toll of climate-related morbidity and mortality is expected to be massive. The World Health Organization already estimates that climate change is responsible for more than 250,000 deaths per year globally, and the numbers will rise dramatically in coming decades [2].

Heat waves, the most direct effect of global warming, cause large numbers of deaths and severe illnesses, depending on the intensity and duration of the heat event. Those most likely to die or require emergency hospitalization include the elderly, infants, pregnant women, outdoor workers, outdoor athletes, people with a range of underlying medical conditions, and poor people without air conditioning living in urban areas [3]. Major increases in deaths, hospitalizations, and emergency room visits have been documented to occur during heat waves, with 70,000 deaths reported in the 2003 European heat wave, over 55,000 deaths in Russia in 2010, and thousands of deaths in other heat waves worldwide [4]. In many developing countries, the impact from heat waves is unrecorded because of the expense of clinics for most inhabitants and the fact that there are often no reliable tracking systems to measure increases in illnesses or deaths.

Even during a non-heat-wave period, there are documented associations between higher temperatures and a range of morbidity, including respiratory disease, emphysema, heart disease, heart attacks, stroke, diabetes, renal failure, intestinal infections, heat stroke, dehydration, hypertension, and asthma [5]. For every increase of temperature by 10 degrees Fahrenheit, there is a nearly 9 percent increase in preterm births [6]. Research has shown that surprisingly, people living in normally cooler areas are more susceptible to health effects from even modest temperature increases. During the 2006

California heat wave, the greatest increase in emergency room visits occurred in the normally cooler coastal cities [7]. This phenomenon is probably because fewer buildings are air conditioned in these areas, and people are less physiologically adapted to heat. Additional air conditioning is required to counter-balance increased temperatures, thereby generating greenhouse gas emissions and worsening the cycle. But most in the developing world do not have air conditioning, leaving them with fewer options as the planet warms.

Increased heat also has numerous secondary effects. Heat speeds the atmospheric conversion of vehicle tailpipe emissions into ozone smog. Thus the health threat on hot days stems both from heat itself and from increased ozone levels that cause respiratory and cardiac damage [8]. Fires, also associated with heat and drought, emit large quantities of respirable particulate matter in addition to significant carbon release [9]. Particulate matter causes respiratory and vascular inflammation, respiratory and cardiovascular illness, and increased mortality [10]. Even if the fires are remote, winds may move respirable particulate matter into urbanized areas. Fires have been an increasingly significant issue in the U.S. and in many countries, such as Indonesia, in recent years.

Warmer weather conditions with higher concentrations of carbon dioxide in the air also foster the earlier and longer bloom of allergenic weeds such as ragweed [11]. Studies done in greenhouses have shown that instilling air slightly enriched in CO_2 dramatically increases the amount of pollen produced from individual ragweed plants [12]. These findings suggest increasing health challenges associated with nuisance symptoms such as hay fever, as well as more serious conditions such as asthma.

Although it is difficult to pin any single weather event to climate change, the climate models demonstrate that extreme weather fluctuations are increasingly likely to occur as the earth warms [13]. For example, rain is likely to fall in larger amounts when it does occur, leading to increased risk of flooding and erosion. Flooding can cause numerous drownings, injuries, and destruction of homes and property. After floods, mold is a well-known hazard that invades homes and can cause serious respiratory illness in those returning to the area [14]. Erosion causes topsoil loss, a major concern in many poor agricultural regions where crops and livelihoods can be destroyed by a single storm, and re-planting can be hindered by loss of fertile soil. Areas impacted by wildfires are denuded of ground cover and are therefore especially vulnerable to erosion and soil loss. In addition to ecological harm, storm runoff can cause illness and death, for instance when contaminated runoff spills into surface water sources and contaminates drinking water supplies [15].

Extreme rainfall events also increase runoff into lakes and coastal waters, where the nutrients from the soil and warmer waters foster explosions of harmful algal blooms. These blooms can make it dangerous to swim, or consume fish or shellfish from affected waters [16]. They are also devastating to ecosystems and wildlife, including marine mammals, resulting in mass mortality. Pathogenic bacteria can also thrive in warmer waters offshore. Vibrio species, including cholera, thrive in warm contaminated waters and lead to major outbreaks of gastrointestinal disease either through direct contact with water or from consumption of contaminated shellfish. Cholera has been increasing steadily since 2005 worldwide [17]. An outbreak of Vibrio parahemolyticus on a cruise ship in Alaska in 2004 was traced to locally-harvested contaminated oysters. That year was the first year that ocean temperatures did not drop low enough in Alaska to kill the organism. The authors concluded that warming oceans may cause outbreaks of serious gastrointestinal illnesses in coastal areas not previously affected [18].

Ponding of stagnant water, in warm conditions, creates conditions ideal for the lifecycle of numerous pests including the mosquitoes that carry diseases ranging from malaria and yellow fever to Zika, dengue fever and chikungunya [19]. These viral fevers have all been shifting in recent years to more temperate countries where they did not previously occur, including further north in the Americas and into Europe and the United States; the dramatic spread of Zika virus in 2015–2016 through South and Central America, with resulting birth defects and paralytic Guillain-Barre syndrome, grabbed headlines worldwide. Further shifts of vector-borne diseases are predicted with climate change [20]. Diseases not pathogenic to humans can also cause devastation to human populations. Pests can wipe out entire crops when they are inadvertently introduced to a new area through global trade. As temperate climates warm, pests that did not previously survive the winters are able to thrive year-round [21]. New pest pressures increase the use of toxic pesticides, and the risk of crop losses.

Ultimately, coastal areas will be inundated due to sea level rise, while other areas face increasing challenges from drought-associated food and water shortages; many areas will encounter riverine flooding, outbreaks of vector-borne disease, and increased agricultural pest-pressures resulting in crop losses [22]. All of these events can lead to increased conflicts over remaining resources, population displacement, an over-strained health system from both physical and mental illnesses, and social disruption. Experience from such events both in the United States and globally, has shown that the people most likely to suffer and die include the poorest segments of society, the very young, the elderly, and those with preexisting medical conditions [22].

The Carbon Economy and Health

The many health effects of climate change described above are well-recognized by numerous health and medical organizations. Such discussions, however, often do not describe the health effects of our current high-carbon lifestyle. Three principal aspects of the carbon economy contribute significantly to ill health: excessive driving, overconsumption of processed foods and meat, and fossil fuel pollution.

Many developed countries, and segments of developing countries, are experiencing an obesity epidemic.

This is particularly true in the United States. Obesity is a major risk factor for metabolic syndrome, diabetes, and cardiovascular disease. Although obesity is multifactorial, it is largely due to a combination of insufficient physical activity and excessive calorie consumption. Communities where people largely drive cars tend to be associated with higher rates of obesity, whereas walkable, bikeable communities with public transit promote greater physical activity and reduced rates of obesity, metabolic syndrome and related diseases.

Overconsumption of calories is a direct use of global resources, and when those calories come from processed foods or from meat, the carbon intensity is even greater. Climate impacts associated with foods are discussed in more detail below. Over-nutrition is a known public health problem, and diets that include too much meat or processed foods are associated with cancer and heart disease.

In addition to these contributions to obesity and ill health, the use of fossil fuel feedstocks results in an enormous pollution problem globally, with associated direct health effects.

Emissions associated with fossil fuels are linked to health hazards from the extraction phase, through transportation, processing and ultimate combustion. For example, mining of coal or oil-sands or extraction of oil and gas is associated with occupational injuries and illnesses as well as the potential for significant contamination of drinking water resources and air emissions. Transportation of petroleum by rail has caused catastrophic explosions and fires in Quebec, Canada and elsewhere. Refineries are often located in disadvantaged communities, where they pose a threat from explosions, fires, and routine emissions. Ultimately, power plants, industries that use coal, oil, or gas, and motor vehicles all contribute significantly to ambient air pollution and ill health.

Climate Justice: Rethinking Responsibilities and Harms

Climate change is caused disproportionately by the production and consumption habits of the world's richest populations. The richest 1 billion people on the planet are responsible for about 50% of greenhouse gas emissions; while the poorest 3 billion, without access to affordable fossil fuels, are responsible for about 5% [23]. In contrast, the bottom 3 billion suffer the greatest harms associated with climate change. The vulnerability of the bottom 3 billion has already produced a nomadic underclass of "climate refugees" susceptible to the perils of human trafficking, forced labor, and the degradations of urban poverty in cities and urban slums that are swelling at a rate of 77 million people each year.

Climate Justice demands that we recognize the imbalances between responsibilities and harms, and intervene to correct them. Climate Justice is a subset of Global Justice, which places an ethical imperative on the most advantaged populations to improve conditions of the least advantaged. The vast disparity between rich and poor, dramatized by the gap between developed and undeveloped countries (and gaps within those countries as well) is the most profound injustice of our age. The demands of global justice become particularly acute when the advantage of a few is responsible for producing or aggravating the deprivation of many. The causal linkages are deepened by the unregulated activities of corporations in the developing world – privatizing and extracting natural capital, deforestation, land-clearing, the dumping of waste, and many other stressors on the natural world and social systems.

Climate justice demands additionally that those least responsible for climate change and yet most harmed by it are not subjected to further deprivation in the transition toward low-carbon solutions. Disadvantaged people are typically least capable of assuming the costs of adopting new technologies for mitigating climate change. For example, the use of firewood, dung and crop residue in cooking practices among the bottom 3 billion increases the atmospheric concentration of black-carbon and particulate matter. But the poor are typically unable to bear the costs of integrating cleaner-burning cooking technologies. Such costs should be borne by richer countries, for the good of all.

Solutions to climate change should be designed to further the human rights and dignity of the least advantaged, empowering individuals, promoting community agency and self-reliance, reducing poverty, improving health and overall quality of life [24]. Solutions must pay significant attention to context and local needs rather than a one-size-fits-all package. For both ethical and practical reasons implementation strategies must be participatory, integrating unique local knowledges, and particularly the voices of women who typically bear the brunt of climate change in disadvantaged communities. Climate justice actions also need to be attuned to informal economies, and dynamics that fall outside conventional market frameworks. That said, the reworking of market models, and emergence of hybrid models has been an evolving area of policy and practice [25, 26, 27, 28, 29].

Climate justice demands urgent intervention to reassert our global commitment to human rights and public goods, and to posit a broader conception of self-interest that includes the sustainability of human settlements on our planet. Global decarbonization and equitable, sustainable development require urgent collective action across sectors, mobilizing governments at every scale, the private sector, international institutions, religious organizations, research universities, non-profits and communities both rich and poor.

Climate Justice in the United States and California

Climate change is of great importance within the field of environmental justice because of its overall consequences, and its disparate impact on vulnerable and socially marginalized populations. Vulnerability to climate change is determined by the ability of a community or household to anticipate, cope with, resist, and recover from the direct and indirect impacts of extreme weather events, degraded ecosystems and shifts such as sea level rise, hurricanes and

floods, heat waves, air pollution, and infectious diseases. While climate justice has a global dimension, the "climate gap" refers to the ways in which climate change and climate change mitigation can disproportionately impact certain groups within a society, such as people of color and the poor [30], often groups that are least responsible for greenhouse gas emissions [30, 31, 32].

Low-income urban communities and communities of color in the US and California are especially vulnerable to extreme weather events such as heat waves and higher temperatures because they are often segregated in neighborhoods in inner cities that are more likely to experience "heat-island" effects [33]. Heat-islands occur in urban areas when lighter-colored (higher albedo) materials such as grass, trees, and soil are replaced by darker-colored (lower albedo) materials such as roads, buildings, parking lots, and other surfaces, leading to increased absorption of sunlight. This phenomenon decreases the dissipation of heat, and increases warming [34]. A recent national land cover analysis found persistent racial and ethnic disparities in heat risk-related land cover characteristics of neighborhoods, disparities that persisted even after adjusting for biophysical factors that strongly influence tree growth [35]. Studies indicate that technological adaptation is another critical extrinsic factor in heat-associated health outcomes; lack of access to air conditioning is correlated with risks of heat-related morbidity and mortality among communities of color and low income groups, as well as the urban elderly and disabled in the United States [36]. One study using heat-wave data from Chicago, Detroit, Minneapolis, and Pittsburgh, found that African Americans had a 5.3% higher prevalence of heat-related mortality than Whites and that 64% of this disparity was potentially attributable to disparities in prevalence of central air conditioner technologies [37].

Studies also indicate that communities of color and the poor will likely suffer disproportionately from sea level rise. A California Energy Commission study used a sea level rise scenario based on medium to high greenhouse gas emissions from the Intergovernmental Panel on Climate Change, and estimated that a 1 to 1.4 meter sea level rise would put 220,000–270,000 people at risk of a 100-year flood event in the San Francisco Bay Area, based on the current population. These sea level rise scenarios are also predicted to disproportionately impact communities of color and low income people who live in some of the more low lying vulnerable areas [38].

When extreme weather events lead to flooding, the most disadvantaged populations are also the most likely to die. For example, in Hurricane Katrina, the elderly, the disabled, the poorest segments of the population, and African Americans were least likely to have the means to evacuate the city of New Orleans before the storm. The greatest risk of death, property loss, and displacement fell on the poor and on African American residents of New Orleans, as shown in **Table 1** [39].

Minority groups are also more highly impacted by the fossil fuel industry from the point of production near refineries to the points of emissions near power plants, major roadways, ports, railyards and airports. Indeed, an analysis of the demographic correlates of exposure to particulate matter and nitrogen oxide pollution from California power plants and petroleum refineries found that minorities are more likely than non-Hispanic whites to reside in close proximity to these facilities, even when controlling for household income [42, 43].

Similarly, sprawl, a pattern of low-density development associated with concentrated poverty, racial residential segregation, and fragmented planning across multiple municipalities [44] is causally related to vehicle miles traveled [45]. Nationally, vehicle miles traveled in passenger cars and light trucks are the largest source of transportation-related greenhouse gas emissions, and urban sprawl has contributed to the 35 percent increase in travel miles since 1990 [46]. Communities of color and the poor are more likely to be exposed to traffic related air pollution from major roadways [47, 48]. It is therefore necessary to address inequitable land use development patterns, including the role of discriminatory urban sprawl, to reduce anthropogenic GHG emissions that cause climate change.

Race and Ethnicity
· Damaged areas were 45.8 percent African American, undamaged areas, only 26.4 percent. For the city of New Orleans alone, these figures were 75% and 46.2 percent, respectively
· Around the time of Katrina, poor Blacks were much less likely to have access to cars than even poor Whites, 53 versus 17 percent [40].
Poverty
· Damaged areas had 20.9 percent of households living below the federal poverty line, undamaged areas only 15.3 percent. For the city of New Orleans alone, these figures were 29.2 percent and 24.7 percent, respectively
· In the city of New Orleans, before Katrina hit, women had much higher poverty rates than men, with 2004 figures of 25.9 percent and 20 percent [41].
· Damaged areas had 45.7 percent renter-occupied households, undamaged areas, only 30.9 percent.

Table 1: Disproportionate Effects on Poor and Non-White Residents of New Orleans After Hurricane Katrina.

Climate change also exacerbates social inequality by increasing costs for basic necessities such as food [49] and water [50], thereby disproportionately affecting low-income households that already spend the highest percentage of their incomes on such essential goods [30]. Poor people may also lack the ability to implement green solutions, since they are typically preoccupied with the daily tasks of survival, often battling hunger, disease, violence and the deprivation of human rights that tend to cluster in conditions of scarcity. Despite the burdens on the poor and on communities of color, however, studies have shown that such communities are more inclined to support strong government action to reduce greenhouse gas emissions [51].

Equity and the Climate Gap: California Solutions

The interconnections between climate change, health, and justice suggest the importance of incorporating co-benefits into climate mitigation policy to ensure that solutions leverage improvements in community health and livelihoods, while advancing climate justice. Linking social equity, health and sustainability goals in environmental policy has the very real ability to mobilize key constituencies to address climate change more effectively than just a focus on climate change alone. California has made significant efforts to integrate equity into policies and programs to address climate change in order to ensure that disadvantaged populations receive an appropriate distribution of benefits as well as protection from additional harms.

The California Global Warming Solutions Act (AB 32) includes specific language mandating consideration of procedural, geographic, and social equity in the law's implementation. While the law has ambitious goals for reducing greenhouse gases, some of the centerpiece, market-based strategies for doing so, particularly the cap-and-trade and offset programs, have been the subject of controversy, particularly for environmental justice organizations. These groups have pointed out that market-based programs, such as cap and trade, could allow the state's largest emitters of greenhouse gases — power plants, refineries, and cement kilns which are disproportionately located in low income communities of color — to purchase their way to compliance rather than reducing their own emissions. This scenario is problematic from an equity perspective because reductions in carbon emissions can produce significant health co-benefits in the form of cleaner air in the communities that host these large greenhouse gas emitters. Motivated by this equity concern, a group of environmental justice organizations legally challenged the use of such market-based strategies, but ultimately these programs were allowed to proceed. In the wake of the litigation, environmental health and justice advocates succeeded in getting legislation passed to create a Greenhouse Gas Reduction Fund (GGRF), which directs a specified portion of revenues from the auction of greenhouse gas allowances to less advantaged communities. The law specifically requires that at least 25 percent of auction revenue be invested in projects that provide benefits to disadvantaged communities and that a minimum of 10 percent be directly invested in projects within those communities. Ultimately, one of the key goals of the GGRF is to advance mitigation, adaptation, and equity strategies that address the climate gap.

Disadvantaged communities in California have been identified and prioritized for funding using the California Communities Environmental Health Screening Tool [52]. CalEnviroScreen was developed through a public process that included extensive community input. It enables the identification of communities in California that are burdened by a combination of factors, including contact with pollutants, adverse environmental conditions, biological vulnerability due to underlying disease burden, and social vulnerability due to poverty and other community characteristics. The concept of using cumulative impacts in communities to prioritize areas for funding allows some important principles of climate justice to be integrated into climate mitigation decisions.

Hundreds of millions of dollars from California's climate mitigation programs has already been spent to benefit disadvantaged communities and hundreds of millions more are anticipated annually for projects to improve public transit, transit-oriented development, affordable housing, active low-carbon transportation, urban forestry, wetlands and watershed restoration, water-energy efficiency, rebate programs for zero-emission vehicles, weatherization programs for low income communities, recycling and waste minimization, and forest health. In addition to reducing greenhouse gases, these investments bring jobs into disadvantaged communities, create local conditions that promote health, and help redress environmental injustices. This program has the potential to serve as a model for a way to use a market-based greenhouse gas reduction program to generate funds that serve to also address principles of health and climate justice.

Localizing the global: climate mitigation at the urban scale

Cities are now home to more than half the world's population. Covering less than 2% of the earth's surface, the United Nations estimates that cities consume 2/3 of the world's energy and produce 70% of the world's greenhouse gas emissions through industrial and energy production, vehicles, and biomass use [53]. At the same time, cities are highly susceptible to the effects of climate change. Cities everywhere at all latitudes experience the effects of urban heat islands because of the absorptive nature of building and road materials. In California, for example, this heat island effect can raise urban ambient temperature by as much as 4–19 degrees F compared with non-urban landscapes. [54]. In essence, cities today are living the planet of the future. Further, 90% of cities are located in coastal and riparian areas [55], putting most at risk for flooding from sea level rise and storms, raising urgent questions about the present location of key urban infrastructure – airports, power plants, hospitals, water management facilities.

From the perspective of both climate justice and sheer self-interest, cities must be at the forefront of global climate change mitigation, as well as adaptation strategies to reduce the growing vulnerability of urban populations. And some already are. We will discuss several examples in this section emerging from California and Latin America. In most industrialized nations, there is far more climate action at the municipal level than at the national level, with agile, climate-minded mayors and governors who are capitalizing on the emerging power of cities in a globalizing world of distributed flows, and who understand their capacity to coordinate innovative cross-sector collaborations and regional mobilizations to produce rapid change. [56]. It was mayors that Pope Francis first convened when seeking global support for his encyclical letter of May 24, 2015 calling for urgent coordinated global climate action [57].

Urban strategies to reduce carbon emissions tend to focus on infrastructure, planning and public policy to tackle unsustainable patterns of urban sprawl and create dense cities with mixed-use affordable housing and urban green spaces, green "net-zero" buildings and retrofits, expanded rail and public transportation, and intelligent water and waste management practices. Many of these strategies have been discussed at length in earlier chapters, but often they do not enjoy widespread public support. A guiding assumption of this report is that research and analysis of climate mitigation needs to integrate a diversity of approaches. Sustainable urban development depends not only on designing the best physical infrastructure and technologies, but these interventions must be informed by public policy, economics and social behavior. Here, we contextualize the conversation about sustainable urban development in the concrete social reality of cities, with an emphasis on deepening urban inequality across the world, and the wall of prevailing public opinion and behavior patterns that resist climate change ranging from outright denial, motivated by political or market ideologies, to apathetic disregard. Opinion on the urgency for increased public investment in our cities to address deepening inequality seems to follow the same distribution pattern. Ultimately, these two social challenges – urban inequality and the urgent need for public investment in strategies of equitable climate mitigation – are cross-cutting and intertwined.

Climate justice and the urban poor

Cities are epicenters of global financial power and influence, flowing with the rapid movement of people, products, information, ideas and fashion, but they are also teeming with social inequality. In the developing world, rapid urbanization in recent decades has produced dramatic "asymmetrical" growth patterns as the poorest populations have amassed by the millions in precarious informal settlements, often peri-urban, and frequently along rivers and lagoons, uniquely exposing them to the effects of climate change – floods, drought, food and water shortages, and disease [58]. The explosion of slums at the periphery of cities across the planet is a humanitarian crisis of gargantuan proportion that cities in the developing world today are proving unprepared to confront [59].

The urban poor are often further marginalized by mitigation solutions themselves. In recent years, urban growth has been primarily supply-side, stewarded by developers who concentrate their investments in zones of greatest profitability; while zones of greatest need go neglected. In developed cities, even urban resilience projects with climate-friendly mandates have been transformed by private developers into mega-scale urban infill opportunities that gentrify neighborhoods with "themed" and gated environments, anchored by generic cultural and commercial franchises, ubiquitous enclaves of consumption that appeal to a cosmopolitan millennial class, and drive diverse, disadvantaged demographics from urban neighborhoods [60]. Climate justice suggests that strategies to produce resilient, sustainable and walkable cities guard against inequitable demographic displacements that homogenize and destroy the social fabric and micro-economies of urban neighborhoods.

Equitable climate mitigation requires that a city's global and local climate agendas converge, that participation in global decarbonization efforts improves quality of life for the urban poor at home. For example, when a city regulates emissions and relies more heavily on renewable energy sources, the planet benefits, and the impact on local public health is immediate, particularly in disadvantaged areas of the city that are often closer in proximity to carbon-producing industrial and freeway infrastructure.

Changing cities, norms first: bringing climate change home

When Antanas Mockus became mayor of Bogota, Colombia during its most challenging period of urban violence in the late 90s and early 2000s, he declared that urban transformation begins not with infrastructural intervention but with pedagogical strategies designed to transform social behavior. He became legendary for the distinctive ways he intervened into the behavioral dysfunction of Bogota, dramatically reducing violence and lawlessness, reducing water consumption while improving quality of life for the poor, reconnecting citizens with their government and with each other, and ultimately paving the way for Mayor Enrique Penalosa's renowned TransMilenio BRT system, and the Cyclovia bicycle paths, which revolutionized public transportation in Latin America [61].

Mockus emerged from a tradition of participatory urbanization, stewarded by climate-forward mayors committed to urban pedagogy and public participation to ignite a sense of collective agency and dignity among the poor, and ultimately produce greener, more equitable cities. From the Worker's Party mayors who stewarded participatory budgeting in Porto Alegre, to Jaime Lerner who pioneered bus rapid transit and dozens of green interventions in Curitiba, to the "social urbanism" of Sergio Fajardo that transformed Medellin, Colombia from the most violent city on the planet to a global model of urban transformation, this tradition still thrives in cities across the

continent, from La Paz to Quito to Mexico City, and carries important lessons for successful climate action in cities across the world today [62, 63, 64, 65].

Urban climate mitigation strategies must be situated in a social context of norms and habits, which are frequently contradictory to climate-friendly agendas. Climate action plans typically focus on the reduction of GHG emissions through top down intervention. But they need supporting strategies of civic engagement and public education to challenge prevailing opinion and behavior patterns and activate bottom-up participatory climate action. Research shows that respondents are more receptive to climate-friendly public policy when they better understand the specific local impact of global climate change [66, 67, 68]. Proximity matters. In a study commissioned by the Union of Concerned Scientists, subtitled "Start with Impacts / End with Action", for example, there were two essential findings. The first relates to the proximity of negative climate impact, and the second to the proximity of actionable solutions. Making the negative effects of climate change tangible and present for people, rather than something far-off like melting icecaps and polar bears, makes receptivity and corresponding behavior more likely. Focus-group research shows that understanding precisely how sea-level rise will affect one's city, or one's neighborhood, makes it likelier that an individual, even an individual self-described as politically "conservative", will be receptive to the concept of global climate change generally and supportive of climate-friendly public policy. Second, the focus group research found that people are more receptive to global climate change when solutions are connected to concrete opportunities for local action.

Participatory Climate Action in Underserved US Neighborhoods: The UCSD-EarthLab Community Station

Focus group research is reinforced by the success of neighborhood-scale participatory climate action projects across the world, documented by organizations like Climate Action Network International and the Climate Justice Alliance. In disadvantaged neighborhoods plagued by poverty, violence, failing schools and failing infrastructure, climate can seem remote from the acute challenges of everyday life. Disadvantaged urban populations are likelier to become engaged in climate action, and are likelier to change consumption and production habits, when they understand the linkages between climate and poverty in their neighborhoods; and when local opportunities for participatory action with neighborhood-scale impact (e.g., interventions that increase localized food and water security) are made available to them.

UC San Diego, through its Community Stations Initiative, has developed a new approach to participatory climate action in underserved neighborhoods, partnering with community-based environmental non-profits throughout the San Diego-Tijuana region on climate education and participatory climate action at neighborhood scale. An example is the EarthLab Community Station, a special partnership with Groundwork San Diego, based in Encanto, a low-income community of color situated along the city's most polluted waterway. Encanto is emblematic of many inner-city neighborhoods in the US, whose physical and social fabric has been disrupted by the imposition of freeway infrastructure, pre-emptive water management systems, utility easements and discriminatory land use policies.

UC San Diego and Groundwork, in collaboration with the San Diego Unified School District and industry partners, convened to create the UCSD-Earthlab Community Station, a field-based research and teaching hub that promotes STEM success for at-risk youth and participatory, project-based environmental education and climate action at neighborhood scale. EarthLab is an outdoor civic classroom of 4 acres, replete with community gardens, solar houses, water harvesting facilities, an energy "nano-grid", and other environmental sustainability infrastructures, designed in collaboration with UC San Diego researchers and students as learning tools for the six public schools in walking distance of the site. Hundreds of low income youth and their families circulate through EarthLab each year, learning about climate justice and climate action in very concrete ways.

The university also gains from climate action partnerships with community-based agencies like Groundwork, providing an unprecedented climate action laboratory *in situ*. For example, UC San Diego is a global leader in energy storage research, and home to one of the world's most advanced microgrids, which generates about 92 percent of campus energy needs, at a savings of more than $8 million a year. EarthLab Community Station presents a unique opportunity to develop energy solutions for Encanto, advancing the university's research mission while providing a huge climate mitigation asset for a local urban neighborhood and its residents. Recognizing the potential of this unique cross-sector collaboration to serve as a model for climate action in disadvantaged communities across the state, the California Energy Commission in 2016 granted the UCSD EarthLab Community Station a planning grant of 1.5M to design advanced energy solutions for the community of Encanto. A significant portion of the planning grant will be focused on neighborhood-scale environmental education and attitudinal / behavioral shift.

The UC San Diego Community Stations present a compelling model of what a successful, cross-sector neighborhood-scale climate action partnership in an underserved community can look like. Obviously particular configurations will vary from context to context, but university-community partnerships for climate action are highly replicable and scalable since research universities everywhere can cultivate long-term partnerships with environmental non-profits in local underserved neighborhoods, and develop collaborative research and teaching on climate action. And when this happens, university, community and planet all benefit.

Agriculture, Food Justice and Climate Change Mitigation

Industrial smoke stacks; power plants; exhaust from cars, trucks, ships, trains and airplanes typically get listed first when someone is asked to identify human-generated sources of greenhouse gases (GHGs). Other less obvious

sources include land use (e.g., how we grow food, build cities) and land cover (e.g., impermeable concrete paving, crops, pasture or forests). The 2014 U.S. Global Change Research Program's Third National Climate Assessment includes chapters with key messages about land use and land cover, agriculture, forests, cities and infrastructure. The sector referred to as Agriculture, Forestry and Other Land Use (AFOLU) emits approximately one quarter of anthropogenic GHG emissions. Choices about land-use and land cover often have major impacts on the degree to which human communities are vulnerable to climate change. Better land-use and land management choices can help reduce atmospheric greenhouse gas levels. This point is abundantly clear in the case of the Amazon, where dramatic declines in deforestation have averted megatons of carbon emissions thanks to a convergence of new institutional arrangements, regulations, political will, land use monitoring, social pacts and social change and supply chain monitoring [69].

The Third National Climate Assessment also stresses the point that energy, water and land use patterns interact. Thus we need more integrative approaches to mitigating climate change. We need to do a better job, for instance, jointly considering risks, vulnerabilities, and opportunities where energy, water, and land use systems intersect [70]. The National Science Foundation (NSF) has devised a compelling approach to this challenge by identifying what it calls the water security, food security, and energy security trilemma. The NSF is supporting much needed research "to understand, model, design, and manage the interconnected food-energy-water system, which incorporates natural, social and human built components" (NSF).

Climate change and the next green revolution

The Intergovernmental Panel on Climate Change (IPCC) warns that the world's food supply is in jeopardy. This is not the first time such concern has been expressed. The "Green Revolution" from the 1960s to 1990s averted what some had worried would be widespread famine in less developed countries, especially in Asia. Unfortunately, food security concerns have (re)emerged over the past two decades as the growth rate of crop yields worldwide has slowed down significantly [71]. Michael Oppenheimer, a Princeton University climate scientist, points out that yields in some areas have stopped growing entirely. Moreover, Oppenheimer says: "My personal view is that the breakdown of food systems is the biggest threat of climate change" (cited in [72]).

What are the appropriate means for bringing about a new green revolution? This is a subject of considerable debate. Broadly speaking, there are two competing visions. One vision embraces modern genetic engineering of plants and seedstocks. The other sees reliance on genetic engineering—including Genetically Modified Organisms (GMOs)—as problematic. The latter view expresses concern that genetically modified seeds are an expensive input into a fossil fuel intensive food production system that depends too much on synthetic fertilizers which, when applied to agricultural fields emit potent greenhouse gasses. Hans Herren, a World Food Prize laureate, represents this view arguing that "We need a farming system that is much more mindful of landscape and ecological resources. We need to change the paradigm of the green revolution. Heavy-input agriculture has no future—we need something different." (cited in [73]).

Part of the problem, regardless of whether or not one supports genetic engineering, lies in the emergence of large-scale monocrop agriculture as a form of industrialized factory farming. Monocropping is efficient in some respects (i.e., it enables specialization in equipment and crop production) but it tends to reduce biodiversity. Loss of biodiversity increases the risk of widespread impacts across large fields of genetically similar crops when said crops are challenged by disease, pests or shifting temperature, soil or water conditions. Climate change is expected to hit modern agriculture hard, and in ways that disproportionately increase food insecurity placing the greatest burden on the urban poor [74]. The rising interest in "urban" agriculture can be understood, in part, as a countervailing response to the faltering of modern agriculture and its vulnerabilities [75, 76, 77].

Urban Agriculture: Climate friendly Food Forests and Food Justice

Interest in Urban Agriculture (UA) as a way to address food disparities is on the rise in the USA and around the world. A team of seven University of California (UC) researchers recently published the results of a needs assessment examining the status of UA throughout California. They cite the following definition of UA: "Urban and peri-UA refers to the production, distribution and marketing of food and other products within the cores of metropolitan areas (comprising community and school gardens; backyard and rooftop horticulture; and innovative food-production methods that maximize production in a small area) and at their edges (including farms supplying urban farmers markets, community supported agriculture and family farms located in metropolitan green belts)" [78]. Food Justice has emerged as a critical framework underpinning progressive approaches to UA, including interconnected efforts "to ensure that the benefits and risks of where, what, and how food is grown, produced, transported, distributed, accessed and eaten are shared fairly" [79].

The installation of community gardens and Food Forests in places where people live in poverty and lack access to fresh fruits and vegetables (i.e., food deserts) creates opportunities to foster food justice by driving socio-ecological change that is civically engaged and climate friendly. An urban Food Forest—which is really an agroforest is a land management system that replicates a woodland or forest ecosystem using edible plants, trees, shrubs, annuals and perennials. Fruit and nut trees provide the forest canopy layer; lower growing trees and shrubs create an understory layer; and combinations of berry-producing shrubs, herbs and edible perennials and annuals make up the shrub and herbaceous layers. Other companions or beneficial plants, along with soil amendments, provide nitrogen and mulch, hold water in the soil, attract pollinators, and prevent erosion. By recreating the

functions of a forest ecosystem, a Food Forest improves air, water, and soil as it creates habitat, harvestable food, and greenspace in the densest urban areas or campus environments. Trees, plants and soil stabilize nitrogen, reduce soil erosion and stormwater runoff, sequester carbon, and remove harmful pollutants. As urban green spaces, Food Forests reduce urban heat island effects and give residents a visual and physical respite from the impacts of urban living. Amended and re-planted soils produce a healthy soil microbiome, which supports more nutrient-dense foods and sequesters carbon. Pollinators, beneficial insects, and birds also find habitat in a Food Forest. And by providing food yields without more intensive garden maintenance practices, Food Forests provide an important compliment to other urban gardening palettes.

The localization of food production reduces "food miles" (i.e., the distance food travels from farm to table) potentially lowering the carbon footprint of certain foodstuffs. A study completed by researchers at the University of California, San Diego found this to be the case with organic oranges grown locally in San Diego when compared with oranges imported from Florida [80]. The energy and water consumption needed to produce food can be reduced when urban agriculturalists avoid petrochemical based fertilizers, build soil with organic wastes (compost), use recycled wastewater, and harvest rainwater and urban runoff. Climate benefits can also be realized by reducing food wastage. The concept of wastage incudes (1) food **lost** for human consumption as a result of supply chain inefficiencies (e.g., failure to harvest crops in time, damage to the food during processing or transport), plus (2) food waste (e.g., edible items that get discarded for a variety of reasons—such as imperfections in appearance, spoilage, and people putting too much food on their plate).

Urban-Rural Planning: A Bioregional Approach

Urban and peri-urban agriculture are important localized solutions to the problem of global climate change. But in order to fully realize the potential of place-based solutions, urban, peri-urban, and rural areas need to be conceptualized together. Rather than imagining cities, suburbs, and rural areas separately, a bioregional approach defines regions around existing biological and environmental features such as watershed areas. A bioregion's boundary is not fixed. It takes into account factors including climate, topography, flora, fauna, soil, and water together with the territory's sociocultural characteristics, economy, and human settlement patterns. Thayer, a widely noted bioregional scholar, argues that "the bioregion is emerging as the most logical locus and scale for a sustainable, regenerative community to take root and to take place" [81].

Bioregional theory demands a shift in how we imagine the places we live in and how we develop land, communities and industry. Moving to a bioregional approach requires both a spatial and conceptual shift. As early bioregional theorists Berg and Dasmann describe, "the term refers both to geographical terrain and a terrain of consciousness – to a place and the ideas that have developed about how to live in that place" [82]. In a bioregional approach, urban dwellers are pushed to imagine the space they live in to include resources we usually think of as rural land issues. Rural and peri-urban areas are more than peripheries to a city; they are integral components of land-human-energy-water-space-ecosystem-infrastructure systems that encompass urban and non-urban land use areas together. As the Carnegie UK Trust describes in its 2009 Manifesto for Rural Communities, "In an increasingly fragile world, rural areas should be recognized as resource rich; places where assets are stewarded for the nation as a whole. After decades where rural areas have just been seen as hinterlands to large urban areas and city regions, this imperative places rural communities at the heart of policymaking for the nation as a whole."

The most basic tenet of bioregional theory is that we human beings are social animals; if we are to survive as a species we need healthy relationships and secure, "rooted" attachments with one another and with the land, waters, habitat, plants and animals upon which we depend. Rootedness is defined here as having secure attachments to one's life place and the people associated with sustaining it [83]. A bioregional approach is a promising route toward building environmentally sustainable and socially just futures. As Thayer describes, "a mutually sustainable future for humans, other life-forms, and earthly systems can best be achieved by means of a spatial framework in which people live as rooted, active, participating members of a reasonably scaled, naturally bounded, ecologically defined territory, or life-place"[81]. When human beings are rooted, they feel deeply connected to place, to natural systems, and to communities. In the bioregional framework we describe here, rootedness becomes a core goal for social, racial and environmental justice [84, 85].

Rural Agricultural Production: Livestock and Climate Change

According to the United Nations Food and Agriculture Organization, the raising of livestock for human consumption contributes about 18 percent of global greenhouse gas emissions [86]. Livestock differs in its contribution to climate change, with the approximately 1.3 billion cattle globally responsible for about 40% of the total livestock GHG emissions [87]. This makes a cow a much more important contributor to climate change than a car.

Although livestock accounts for less than ten percent of global carbon dioxide emissions, this sector contributes disproportionately to emissions of two potent short-lived climate pollutants: nitrous oxide (N_2O) and methane, significantly elevating the total emissions from livestock. Animals, especially ruminants such as cattle, sheep, and goats, produce large amounts of methane through their digestive process; N_2O is emitted from manure as well as from synthetic fertilizers used to grow crops for animal feed. The production of crops for livestock feed and the use of land for grazing jointly accounts for about 70 percent of agricultural land, and 30 percent of the land surface of the entire planet [86]. Deforestation of tropical forests is significantly driven by the conversion of

forest land to pastures, and the elimination of the carbon sequestration and environmental services formerly provided by the tropical forests. Global demand for meat is projected to nearly double by 2050, significantly exacerbating the current problems. Further, some 48 million hectares of South American tropical lands have been deforested and converted to industrial soy/corn production to feed animals.

In addition to greenhouse gas emissions, livestock production results in significant depletion and degradation of other environmental resources, including depletion of freshwater resources, erosion, sedimentation, and eutrophication of surface water and offshore environments. Overall, cattle account for 1/3 of the global water footprint of total agricultural production [87]. In certain areas, such as in the Midwestern U.S. and California, there is depletion of groundwater aquifers due in significant part to livestock production [88]. In the U.S. where animal feedlots predominate, there is documentation of significant water and air pollution in low-income minority communities near feedlots, and associations with stress-related cardiovascular health effects [89, 90, 91], as well as the local spread of antibiotic-resistant organisms due to the heavy use of antibiotics in such facilities [92, 93].

Over-consumption of red meat has been shown to cause a wide array of adverse health effects, including increased risk of total mortality, and mortality from cardiovascular disease and cancer [94]. Specific associations have been documented between excess red meat consumption and colorectal cancer, diabetes, hypertension, and cardiovascular disease. Red meat consumption during adolescence has also been associated with a 43 percent increased risk of premenopausal breast cancer in women [95]. As developing countries move through a nutritional transition from traditional diets toward greater consumption of meat, there have been corresponding shifts in disease patterns, with an increase in cardiovascular and renal disease, as well as shifts in cancer incidence [96]. Therefore reduced consumption of red meat could bring significant health benefits to populations in the U.S. and in some rapidly industrializing societies.

Addressing the GHG emissions from livestock production should be a high priority because it could reduce short-lived climate pollutants and therefore slow warming in the near-term. Unfortunately, livestock production is currently projected to increase substantially by 2050, mainly in countries of low or middle income. The current global average meat consumption is 100 grams per person per day, with about a ten-fold variation between high-consuming and low-consuming populations. While current predictions show a global rise in meat consumption alongside population growth and a globally growing middle class, stabilizing or decreasing meat consumption could be a way to lower GHG emissions while continuing to raise animals for dairy and meat. 90 grams per day has been proposed as a target, shared more evenly across countries, with not more than 50 grams per day from red meat from cattle and other ruminants [97]. Efforts such as the "Meatless Mondays" movement, which is currently on at least seven campuses within the University of California system, can both educate people about the climate impacts of meat, and directly reduce consumption through emphasizing healthy vegetarian alternatives at institutional cafeterias.

Current U.S. policies push meat producers to realize increasing economies of scale, with narrow margins in meat production that must be exploited through producing large volumes in consolidated production facilities. Direct subsidies to livestock production, such as in the U.S. for the production of animal feed crops, contribute to the harmful pattern and should be revised or eliminated. Indirect subsidies for the livestock industry, such as exemptions from air quality and water quality laws and regulations, should also be eliminated. Technologies for methane reduction or capture may have potential to reduce GHG emissions from livestock under certain conditions, but there have been economic and logistical barriers to their use, and they tend to promote concentration of livestock (e.g., large confined feeding operations), which has other adverse environmental impacts. In concert with the urban agricultural models and bioregional approach articulated in this chapter, localized smaller-scale solutions need to be considered as a possible path for the future of meat and dairy production. With robust policy changes and experimental models, the meat industry might be able to realize efficient, safe, affordable protein production through dispersed local production sites for dairy and meat production.

The University of California Global Food Initiative (UC GFI)

The University of California Global Food Initiative (UC GFI) is exploring how we might best sustainably and nutritiously feed a world population expected to reach eight billion by 2025. UC President Janet Napolitano, together with UC's 10 chancellors, launched the UC Global Food Initiative in July 2014. Building on existing efforts and creating new collaborations among UC's 10 campuses, Lawrence Berkeley National Laboratory, and UC's Division of Agriculture and Natural Resources, the initiative draws on UC's leadership in the fields of agriculture, medicine, nutrition, climate science, public policy, social science, biological science, humanities, arts and law, among others.

A UC GFI research project underway at UC San Diego is examining urban agriculture, green infrastructure and food disparities in the San Diego-Tijuana transborder city-region (along the U.S.-Mexico border). The researchers are critically analyzing and evaluating urban agriculture (including community gardens, urban farms, food forests, aquaculture, and animal husbandry) in low-income and underserved neighborhoods to gauge urban agriculture's potential to reduce food disparities, increase food security and enable climate change mitigation through the greening of infrastructure. The latter challenge (climate change mitigation) ties the UC GFI to the UC Carbon Neutrality Initiative.

Conclusion

The challenge of reducing planetary greenhouse gases is deeply intertwined with numerous other global and social challenges: conserving planetary resources and biodiversity, protecting the purity of our air, land and water, ensuring an adequate and safe food supply, protecting public health, and creating the social and ecological conditions to enhance equity both globally and locally. Fortunately there are many tools to help address these many challenges.

In the urban environment, there are examples – in California, Latin America, and around the world – of projects that educate and activate low-income communities, including low-income youth, to address local and planetary challenges. Many communities already have good ideas that can be mobilized. Many such projects also include urban greening and urban agriculture, which tie multiple solutions together to increase sustainability. Health-focused efforts include urban forestry efforts to reduce the urban heat island effect and conserve energy, active transportation efforts to encourage bicycling and walking, and efforts to reduce the over-consumption of meat in more affluent societies. In California, unique funding streams have become available thanks to the auction revenues from the greenhouse gas reduction program. This funding is being used in creative ways to focus support on climate mitigation projects to benefit disadvantaged communities and to also achieve co-benefits for pollution reduction, health and climate resilience.

Recommendations

1. **Focus GHG Reductions on Industrial Sources.** Designate High Priority Zones for GHG reductions in areas where health co-benefits are likely to be large, such as in communities impacted by major industrial sources or power plants. This kind of targeting can make mitigation more efficient in the short-term by enhancing public health benefits, particularly in communities that need them the most.
2. **Target Carbon Mitigation Funding to Projects in Disadvantaged Communities.** Prioritize climate equity in the distribution of funds raised from market-based GHG reduction strategies by targeting investments to low income communities where they can leverage mitigation, adaptation, health, and social co-benefits. Projects that should be supported in such communities include low-income weatherization, solarization, affordable energy-efficient housing, public transit, active transportation (eg. Bicycle lanes), urban forestry, water conservation, waste reduction, and forest conservation, among others.
3. **Track Market Mechanisms and Mitigation Measures to Ensure Against Backsliding.** Carefully track the performance of market-based GHG reduction programs and other mitigation measures to assure that there are no incidental increases in co-pollutant emissions in disadvantaged communities, and to assure that such communities receive benefits from these programs and are not displaced or marginalized.
4. **Educate for Climate Action in Disadvantaged Communities.** Cultivate cross-sector partnerships in climate-vulnerable, underserved urban neighborhoods between research universities, community-based agencies, local school districts and industry partners, to produce *SEEDs – Community Stations for Environmental Education and Development* – research and teaching hubs that promote STEM success for at-risk youth and local economic development through civic engagement, project-based environmental education and neighborhood-scale climate action to reduce GHGs (capitalizing on university expertise in urban forestry, urban agriculture, energy storage, energy monitoring, water conservation, incentivizing photovoltaic retrofits, etc.) Replicate SEED partnerships throughout the University of California system and beyond; and network such projects via social media to ensure a broad impact.
5. **Reduce Meat Consumption among Higher Income Populations.** Promote strategies to reduce the consumption of beef, a major source of the short-lived climate pollutants methane and nitrous oxide, by encouraging institutions and individuals to embrace "Meatless Mondays", and removing public financial support for the meat industry such as subsidies for production of feed crops, use of public lands for grazing, and regulatory exemptions from waste treatment. Reduced beef consumption will also greatly promote health, reduce forest destruction in the developing world, and lead to local improvements in water and air quality.
6. **Enhance Urban Treescapes and Food Forests.** A civically engaged urban forestry program (including fruit and nut tree cultivation in urban food forests) can play a vital role in meeting municipal and regional efforts to deal with climate change. Many cities are creating urban treescape asset maps and developing urban forest management plans for multiple reasons (e.g., sequester carbon, reduce urban heat island impacts, increase local food production, green space, water conservation). It is important to document/evaluate/support this work from climate change mitigation, adaptation and resilience standpoints, and also to include in the calculus of benefits the other environmental services that are generated as well such as biodiversity enhancement, black carbon absorption, interactions with the hydrological system.
7. **Build Green Infrastructure for Stormwater Management.** Climate change models suggest that an increase in the number of extreme weather events will likely bring more torrential downpours and flooding to many parts of California and nearby Mexico. Green infrastructure includes rain gardens,

bioswales, permeable pavements, rain water harvesting, and other naturally designed features created to conserve or enhance land, wetlands, and ecosystems. Green infrastructure that reduces flooding while making more efficient use of water saves money and energy in ways that reduce a city's carbon footprint and vulnerability.

8. **Adopt a bioregional framework for urban-rural planning.** A bioregional approach imagines the city as within and part of the environment, and couples the urban and rural in how we plan regionally. Rather than separate urban and rural planning, bioregions become the spatial and conceptual arena for planning in all realms, including food, water, transportation and energy infrastructures. In a bioregional framework "rootedness," defined as a feeling of affection and healthy attachment to place and community, becomes a core goal for social, racial and environmental justice.
9. **Emphasize rootedness and place-based solutions for public health and climate justice.** Human beings are social animals, and require rooted attachments to other people, land, and natural systems in order to maximize overall health and well-being. A place-based approach, emphasizing the need for human beings to be rooted within communities and ecologies, is a route for improving climate justice and public health outcomes.

Competing Interests

The authors have no competing interests to declare.

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