

CLI BACKGROUND PAPER NO. 1B (Executive Summary)

Health Consequences of Climate Change: Present and Future, Direct and Indirect

by Maureen F. McCue, M.D.*

To date, discourse about climate change has been dominated by environmentalists, scientists, economists, business leaders and policy makers challenging one another's perceptions of what is or isn't occurring, what is or isn't significant or important, and who or what is responsible. Such debates focus primarily on the risks or benefits of changes that will come or need to be made in economic activity or individual lifestyles and behaviors. The voice and perspectives of public health and medicine have been missing. As evidence mounts from disparate sectors of scientific and caring communities, climate change is increasingly understood to be a complex global phenomenon that interfaces with social structures, human rights, and public health through a bewildering array of mechanisms—only some of which can be precisely described or foreseen. One has only to reflect on the recent weather related disasters from Hurricanes Rita and Katrina in the U.S., or the cyclones Sidr in Bangladesh and Nargis in Burma, where reporters noted, "the ponds are full of dead bodies, the wells have saline water,"¹ to begin to appreciate the range and depth of health challenges faced well beyond the initial horrific loss of life in these and other unfortunate regions.

Health Outcomes: A Matter of Perspective and Analytical Framework

Health impacts of climate change cannot be readily explained in a linear one to one relationship. Predicting and appreciating potential health implications of the many complex phenomena associated with climate change involves realizing that health itself is the sum outcome of a complex array of interacting factors. In the Western world we tend to focus on manipulating individual behaviors, genetics and access to quality health care as the factors most important to determining our health and well being. While these are clearly important, existing health disparities all over the world are much more readily explained by examining the interactions of the health determinants well beyond the individual, or, extant economic, physical, environmental and social factors. When health is understood within this larger context it is easier to appreciate how climate changes will add to and exacerbate the many health stresses already faced by much of the global population—and at the same time confuse the attribution of observed health effects to climate change. For many, climate change is a threat added to a long list of serious health risks already faced.

Overview Anticipated Climate Change Health Outcomes

Some of the clearest additional dangers to health-related anticipated climate changes include those associated with extreme heat, extreme weather events like flooding, drought and fire, movement of disease vectors, and loss of biodiversity. As recently as the Kyoto negotiations in 2003, the World Health Organization (WHO) asserted that "[g]lobal warming killed 150,000 people in 2000." WHO scientists went on to note that for that same year, a further 5.5

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¹ Amy Kazmin, "Health disaster feared in Burma," Boston Globe Online, May 12, 2008, http://www.boston.com/news/world/asia/articles/2008/05/12/health_disaster_feared_in_burma/ (last visited June 8, 2008).

million healthy years of life were lost worldwide due to debilitating diseases caused by climate change. They then asserted, “we see an approximate doubling in deaths and in the burden in healthy life years lost” by 2030 if current trends are not reversed.² However, given the rapidly increasing numbers of climate related disasters unfolding around the world in most recent years these may turn out to be very conservative estimates based on an overly narrow analytical framework.

Heat-Related Disease

Heat can cause death directly by inducing heat stroke, or heat exhaustion for the elderly and those with chronic conditions including those such as diabetes, high blood pressure and heart disease—vulnerable populations that are all on the rise around the world. Others, including those on medications that depress the central nervous system or affect the ability to sweat, those with asthma, obesity, or heart problems, as well as infants and small children, the homeless, alcoholics and chronically mentally ill, and those who labor out doors, are all especially vulnerable to the deadly effects of extreme heat.³ Although wealthy industrialized nations mitigate the impacts of heat waves through air conditioning, effective disaster response plans with cooling centers, and health services for effective care of dehydration, heat stroke and any underlying conditions including associated heart attacks, these costly mitigating measures are unavailable for many, even within the U.S. Often poverty, lack of air conditioning, limited mobility, limited health literacy and understanding of heat associated risks, and reduced access to adequate health care reduce the effectiveness of such public health measures.

Increasingly over crowded, poorly planned, and under resourced cities around the world exacerbate increased heat effects by acting as “heat islands,” wherein buildings and asphalt absorb more heat than do trees and plants. This additional urban heat keeps temperatures high around the clock, unlike more rural areas that cool down at night. It is predicted that more than 60% of the world’s population will live in urban areas by 2025, up from 45% in 1995, with almost all of this growth occurring in developing countries in Africa and Asia. This increase in urbanization combined with increased temperatures, makes an already bad situation just that much worse.

Access to potable water, sanitation facilities, or well preserved perishable food sources are exacerbated by high heat. Dehydration from excess heat and co-existent water- and/or food-borne diarrhea is particularly deadly in the developing world.⁴ Already in 2003, WHO estimated climate change was to blame for 2.4 percent of cases of diarrhea because heat exacerbates any bacterial contamination of food—over and above any impacts experienced as a result of any other storm events. In December 2003, the UK Guardian reported findings that Salmonella rises steeply in hot months: a 12% increase in salmonella food poisoning is reported to health authorities for every 1°C rise in temperature, starting as low as 5°C.⁵

² Comments taken from WORLD HEALTH ORGANIZATION, CLIMATE CHANGE AND HUMAN HEALTH—RISKS AND RESPONSES (Dec. 2003), launched in Milan during the Kyoto discussions. This source is widely quoted and reviewed by multiple reporters and web sites. For more details and associated links, see <http://www.who.int/mediacentre/news/releases/2003/pr91/en/> and <http://www.who.int/globalchange/en/>.

³ Christina Koppe, *et al.*, “Heat Waves: Risks and Responses,” *World Health Organization Health and Global Environmental Change Series* (No. 2), <http://www.euro.who.int/document/e82629.pdf> (last visited Mar. 8, 2008).

⁴ See Ulisses Confalonieri, *et al.*, “Human Health,” U.N. Env’t Programme & World Meteorological Org., Intergovernmental Panel on Climate [IPCC], *IPCC Fourth Assessment, Climate Change 2007: A Report of the Intergovernmental Panel on Climate Change, Summary for Policy Makers, Contribution of Working Group II* (M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & Ce.E. Hanson eds., 2007), at 391-431 [hereinafter “IPCC Fourth Assessment Summary”]. See also Sudha Ramachandran, “India’s Rite of Summer: Death from the Heat,” *Asia Times*, available at http://www.atimes.com/atimes/South_Asia/HE24Df01.html (last visited Mar. 8, 2008).

⁵ Paul Brown, “Global Warming Kills 150,000 A Year: Disease and Malnutrition the Biggest Threats, UN Organisations Warn at Talks on Kyoto,” *UK Guardian*, Dec. 12, 2003, available at <http://www.guardian.co.uk/environment/2003/dec/12/climatechange.climatechangeenvironment> (last visited Mar. 2, 2008).

Finally, long, warm, growing seasons and high CO₂ levels together accelerate the production of plant based allergens like poison ivy, as well as molds and air borne allergens and smog. These latter two, especially when also combined with high humidity, adversely affect respiratory and cardiac function in many vulnerable individuals, young and old. Rates of asthma in children everywhere are soaring due to a multiplicity of air pollution co-factors. Climate change induced heat waves and their associated phenomena are unfortunately more exacerbating factors for active children who spend much of their time outdoors.

Flooding, Drought, Fire

Flooding, like that which has recently struck much of the U.S. Midwest, and elsewhere around the globe in association with extreme weather events, brings about injuries, death, and emotional distress immediately in its wake, especially where disaster planning and early warning systems are inadequate. However, for weeks and months after the acute events, there is an increased incidence of skin and respiratory disease secondary to the deposition of molds in the affected environments. Difficult to measure or predict are the long term consequences from exposure to a variety of toxic substances that inevitably find their way into flood waters and associated deposits along their route. Finally, floods are an additional source of altered disease vectors and pest species, and, this combination of factors ultimately adversely impacts agricultural productivity.

At the opposite end of the spectrum of climate related hydrologic cycle changes are the areas where droughts and fires present an increasing threat to the built environment and to those who live and labor in their vicinity. Areas of long standing drought not only loose agricultural productivity but are also the source of wind driven particulate matter. This is exacerbated by fires like those now being experienced year round on the U.S. west coast. Dry areas and fires both release large quantities of particulate matter which are associated with respiratory and heart disease stress for populations residing within many miles depending on prevailing wind patterns—this is over and above the cardio-respiratory stresses being experienced due to the heat alone.

Decreased global food production, leading to inadequate nutrition is a serious global public health challenge—it both kills and debilitates. Wasting, stunting, cognitive impairment, and increased exposure to and decreased resistance to infectious organisms are the results of chronic malnutrition. The growing global population, climate change associated reduced agricultural productivity, and rising food prices will together exacerbate the already high rate of less than five mortality, maternal mortality and infant mortality and morbidity in the poorest regions of the globe. Such areas are already being decimated by infectious diseases which thrive in the malnourished population. For these populations, hunger/malnutrition is the single most important underlying factor in mortality risks.

UNICEF recently noted, malnutrition will add to the burden of children in areas facing high levels of malaria and pneumonia and where child mortality is already high. "Throughout the Greater Horn [of Africa], malnutrition is compounding the risks to survival that children routinely face, including pneumonia, diarrhoeal diseases and other infections. Recent years have seen an increase in acute watery diarrhoea and cholera in many of these countries affecting tens of thousands of children." The authors note, in Kenya for example, an estimated 1.2 million people are in need of emergency food assistance and many of those are children. Pastoralist populations in the arid and semi-arid north are particularly affected, but food insecurity is growing among other populations as well.

Changing Vector Patterns

Melting ice caps and altered hydrologic cycles bring other adverse health effects and infectious disease risks secondary to the break up or alteration of delicate interspecies networks. Shifting moisture levels means loss or movement of species and diseases. Global warming induced changes in hydrologic cycles will increase the range and intensity of

transmission of numerous vector-, tick-, and rodent-borne diseases, and food and water associated diarrheal illnesses. Heavy rains produce new breeding sites for insects especially mosquitoes; responsible for many serious diseases, drive rodents from burrows, and contaminate clean water systems. For example, the six feet of rain that fell in three days in Central America during Hurricane Mitch caused an upsurge of all three: insect, rodent and water-borne diseases.⁶ The movement of pest species has also been associated with the introduction of new diseases or the resurgence of formerly controlled diseases. Deadly diseases like Malaria, dengue fever, and cholera are all on the increase globally. Recent and expanding outbreaks of West Nile, Hanta and Nipah viruses and Lyme disease are examples of how altered interspecies networks adversely affect human populations.⁷ Given that humans have not yet ever lived in an environment with a marked reduction in biodiversity, the exact health implications are impossible to predict. However, in the many cases studied to date, whenever a species is eliminated, a system of corresponding checks and balances becomes unstable and the result is usually more negative than positive or neutral.

Limitations of Health Outcome Predictions: Impaired Vision

As all these examples demonstrate, there is no one-to-one correlation for any given manifestation of climate change with predictable mortality or morbidity outcomes. Factors like the increasing global human population, environmental degradation including water scarcity, resource depletion and changing patterns of biodiversity, poverty, powerlessness, and the movement or displacement of people to marginal land areas, are themselves all complex and difficult to quantify much less predict their separate or interacting health impacts. Likewise, the severity and distribution of health impacts of any one of the predicted disasters-in-waiting depends on the configuration of local geography and geology layered onto pre-existing non-climatic factors like education, social position and demographics, wealth and resource distribution, physical, social, and public health infrastructures.

For any of the disasters or health challenges described, one victim too often overlooked is the public health system itself. Surveillance, monitoring, prevention, and appropriate interventions are all resource and time consuming endeavors. They require costly laboratory facilities, trained personnel, public and professional educational programs, and publicity campaigns. Every disaster experienced puts stress on systems already stretched to breaking. Too many health care systems are unable to respond to current needs, much less the excess capacity and resiliency required to anticipate and respond adequately to the next threat looming. Each disaster makes weak systems that much weaker when faced with the next challenge.

Billions around the world still live and survive on less than \$2/day. In contrast, the industrialized world, which includes less than 20% of the global population, consumes 80% of the resources, produces a similar level of waste, and has generated over 60% of the green house gases added to the atmosphere since the industrial revolution,⁸ is far less vulnerable to the morbidity and mortality potential of climate driven events. The U.S. and China are the world leaders in the production of greenhouse gases from cars, power generation, and factories, however, the regions most at risk

⁶ See Paul Epstein, *Climate Change and Human Health*, 353 *NEW ENG. J. MED.* 14:1433–36 (2005), available at <http://content.nejm.org/cgi/content/full/353/14/1433>; Rosalind Stanwell Smith, *World Water Day 2001: Floods and Droughts* (WHO Report, 2001), <http://www.worldwaterday.org/wwday/2001/thematic/floods.html>; *Climate Change Futures: Health Ecological and Economic Dimensions* (Harvard Medical School, Swiss Re, & UN Development Programme [UNDP], Paul Epstein & Evan Mills eds., 2005), http://chge.med.harvard.edu/programs/ccf/documents/ccf_report_oct_06.pdf (all the foregoing last visited Mar. 21, 2008).

⁷ Jane Lloyd, “The Link Between Environment and Disease,” 63 *UN CHRON.* 1 (2006), available at <http://www.un.org/Pubs/chronicle/2006/issue1/0106p68.htm> (last visited Mar. 9, 2008).

⁸ Christopher Flavin, *Building a Low Carbon Economy*, in 2008 *STATE OF THE WORLD: INNOVATIONS FOR A SUSTAINABLE ECONOMY* 77 (Worldwatch Institute, 2008).

from climate change include the poorest of the poor on the South Asian continent and the Indian Ocean coast, South American Pacific coasts, as well as sub-Saharan Africa and small Island Nations.⁹

Rising temperatures, altered hydrologic cycles, and changing disease vectors all disproportionately affect the poor because they exacerbate existing inequities in health status, access to adequate food, clean water, safe work and living environments, quality health care and all other basic life and health supporting resources. Thirteen times more people die per reported disaster in countries/regions with high rates of poverty or low human development indicators than those with high development indicators.¹⁰ Similarly, because of their roles, dependent status, and physiologic differences, the women, young children, elders and chronically ill are each more vulnerable to any of the risks listed. It has been noted only recently that for any given disaster, many more women than men die.

In Conclusion, Working For a Healthier Future

As climate scientists, engineers, political and business leaders work out long term sustainable social and economic rearrangements for climate change mitigation and stabilization, medical and public health workers must begin to advocate for the development of comprehensive and universal, adaptive and protective measures to prevent the worst health outcomes. Regardless of the inequity of impacts, wealthier nations with their more robust health supporting infrastructure will not be immune to the direct and indirect health effects of climate change. Populations in these countries will likewise endure great suffering associated with heat waves, flooding, extreme weather events and associated changes in agricultural productivity and diversion of economies. There is no magical Shangri-la to shelter anyone. Either we all work together for our common survival or we will all suffer the consequences together. Safe guarding the life sustaining elements of our shared environment must be made our highest priority. After all, we have only one planet.

As weather systems become less predictable, the effects of climate change will be felt all over the planet in all sectors, not the least of which are its threats to our health. These changes will affect *all* of us; and, some of us more than others. This paper explores the pervasive, albeit unequal, insidious climate related threats to our individual and collective health and well being.

The discourse about climate change to date has been dominated by environmentalists, scientists, economists, business leaders, and policy makers debating and challenging one another's perceptions of what is or isn't occurring, what is or isn't significant or important, and who or what is responsible. They debate the risks or benefits of changes that will come or need to be made in our economy or lifestyles. To date the voice of public health and medicine has been missing in most discussions but is urgently needed to engage and motivate a broader citizenry.

The climate changes already occurring and threatening human health are not only real, they're rising, imminent, and universal. The most extreme, intense, destructive, and costly hurricanes have already doubled in frequency over the last 30 years. Oxfam International reports that small—and medium-scale disasters, floods, hurricanes, and other natural disasters have quadrupled in the last 2 decades. The dots connecting climate and environmental changes, and the associated disruptions in human health now and well into the future must be connected and made evident so that people are persuaded to take preventive action.

Climate change is a complex global phenomenon that interfaces with society, human rights, and public health in a multitude of ways—only some of which can be precisely described or foreseen. Health outcomes for any given

⁹ IPCC Fourth Assessment Summary, *supra* note 4, at 7–22.

¹⁰ Diarmid Campbell-Lendrum & Carlos Corvalan, *Climate Change and Developing-Country Cities: Implications for Environmental Health and Equity*, J. URBAN HEALTH (2007), <http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pubmed&pubmedid=17393341> (last visited Mar. 3 2008).

population due to any one of the predicted disasters-in-waiting depends on the configuration of local geography and geology layered onto pre-existing non-climatic economic, physical, social, and public health infrastructure. The heat waves, droughts and melting ice caps, altered rainfall patterns and increases in extreme weather events, floods and storm surges, the loss of many species, migration of others, and increased insect and rodent disease vectors, sea level rise with increased ocean acidity, salinity, and loss of ocean biodiversity are each associated with increased suffering, disease, and death directly and indirectly through a cascade of related secondary phenomena.

The differential impact on the world's most vulnerable populations may explain part of the difficulty in appreciating what is happening. We all share the atmosphere that is altering the earth's climate, but impacts are not uniformly distributed around the globe. The experiences of impoverished populations contrast starkly with those of the wealthy and more powerful. The sum of first world consumption patterns contribute most to the evolving changes in our atmosphere, environment and weather, but the poorer, less powerful, less consuming members of the human family are the victims of the heat. Rising temperatures disproportionately affect poor countries and the poor within all countries, exacerbating existing inequities in health status, access to adequate food, clean water and other basic life supporting resources. Thirteen times more people die per reported disaster in countries/regions with high rates of poverty or low human development indicators than those with high development indicators.

The enormity and complexity of changing climate related phenomena, the lack of precise predictions concerning the rate or degree of anticipated change contribute to the inability to take rapid or comprehensive ameliorative or adaptive action. Factors like the increasing global human population, water scarcity, resource depletion, environmental degradation, changing patterns of biodiversity, poverty, powerlessness, and the movement or displacement of people to marginal land areas, are themselves all complex and difficult to quantify much less predict their separate or interacting health impacts. And, individual behaviors and vulnerability vary widely.

Nevertheless, there are conditions that can be predicted with certainty. Increasingly severe heat and drought are deadly as experience in the widespread European heat wave of 2003 which killed an estimated 35,000 amply demonstrated. Heat can cause death by heat stroke or heat exhaustion for the elderly and those with chronic conditions including diabetes, high blood pressure and heart disease—vulnerable populations that are on the rise around the world. Others, including those on medications that depress the central nervous system or affect the ability to sweat, those with asthma, obesity, or heart problems, as well as infants and small children, the homeless, alcoholics and chronically mentally ill, and those who labor out doors, are all especially vulnerable to extreme heat.

Heat waves are mitigated to a great degree in wealthy industrialized nations by the ready availability of air conditioning, effective disaster response plans with cooling centers, and health services for effective care of dehydration, heat stroke and any underlying conditions including associated heart attacks. Unfortunately, these costly mitigating measures are unavailable for many—even within the U.S. Too often poverty, lack of air conditioning, and reduced access to adequate health care, all go hand in hand along with poor quality water supplies and the simultaneous risk of dehydration from both heat and water borne diarrhea.

Elevated CO₂ levels not only affect atmosphere but have direct effects on the production of air borne allergens and smog, both of which, especially when combined, adversely affect respiratory and cardiac function in vulnerable individuals. Rates of asthma in children are soaring.

Rising sea levels and the associated storm surges which cause injuries, ruin homes and community infrastructure, including water, medical and public health resources, and create a great number of environmental refugees will likewise prove to be grave. Currently 669 million people worldwide live in areas at/below sea level and/or subject to storm surges in island nations and along continental coastal areas. For the U.S., 16 of the 23 largest cities are also on the coast where 153 million Americans live.

Those living inland will not be spared however. Melting ice caps and altered hydrologic cycles bring yet other adverse health effects secondary to the break up of delicate interspecies networks. Shifting moisture levels means loss or movement of species and diseases. Again precise effects are difficult to predict for either agriculture or health, but to date, movement of pest species has been associated with the introduction of new diseases or the resurgence of formerly controlled diseases. Old diseases like Malaria, dengue fever, and cholera are all on the increase. Outbreaks of West Nile, Hanta and Nipah viruses and Lyme disease are examples of how altered interspecies networks effects human populations.

Increasing drought and rising temperatures challenge food production which will stress already inadequate food supplies and income generation in many parts of the globe which in turn lead to increasing hunger and malnutrition. They also lead to increasing intensity and frequency of forest fires in the U.S. and around the world.

Finally, for any given locale, it must be recognized that certain members of the population face more risk than others. Because of their roles, dependent status, and physiology, the women, children, elders and chronically ill are more vulnerable to any of the risks listed. It's been noted only recently that for any given disaster, many more women than men die.

Given the enormity and dimensions of risk, halting global warming is the only long-term cure. However, immediate actions, pre-emptive public health, to fight disease and improve access to health services as needed will help mitigate the impacts on the most vulnerable among us. Medical and public health workers must begin to advocate for the development of adaptive, protective measures to prevent the worst health outcomes.

Regardless of the inequity of impacts, wealthier nations with their more robust health care infrastructures will not be immune to the direct and indirect effects of climate change. Populations in these countries will likewise endure great suffering associated with heat waves, flooding, extreme weather events and associated changes in agricultural productivity and diversion of economies. There is no magical Shangri-la to shelter anyone. Either we all work together for our common survival or we'll all suffer the consequences together. Safe guarding the life sustaining elements of our shared environment must be made our highest priority. After all, we have only one planet.

CLI BACKGROUND PAPER NO. 1B

Health Consequences of Climate Change: Present and Future, Direct and Indirect

by Maureen F. McCue, M.D.*

Introduction: Climate and Health

The discourse concerning climate change has been dominated by environmentalists, scientists, economists, business leaders, and policy makers debating and challenging one another's perceptions of what is or isn't occurring, what is or isn't significant or important, and who or what is responsible. The debates tend to focus on the potential risks or benefits of changes that will come or need to be made in economies or lifestyles. These discussions engage small numbers of the general public and too often confuse or discourage the rest. Far too many, especially within the U.S. population, continue to be unconcerned about something they perceive to be happening far away in both time and place and about which they feel they have no control.

Observed changes in the climate continue to accumulate and predictions of a great number of disasters-in-waiting grow. As asserted elsewhere in this report, global warming is not just an environmental or economic issue. When weather systems become less predictable, everything from agriculture and fisheries, to the insurance industry, the economy, and health will be adversely affected. In fact, as climate change manifests in its many forms all over the planet in all sectors of human activity, most such forms pose a variety of direct and indirect threats to individual and public health. In effect, climate change is a complex global phenomenon that interfaces with national security, human rights, and human health in a multitude of ways, particular, personal, local, and collective—only some of which can be precisely described or predicted.

The voice of public health and medicine has been largely missing in most considerations of climate change. As global health challenges mount, too many health care providers and guardians of public health remain disinterested in or distracted by the politicized and polarized nature of the climate discourse. To engage the broader citizenry, the public health perspective urgently needs to be amplified. It is virtually certain that as extreme weather related events increase in frequency and intensity, so too will the associated injuries, diseases and fatalities. Whether or not caused by the changing climate, heat waves, storms, floods, droughts and melting ice caps are each well known to be associated with increased suffering, death, and disease directly and indirectly through a complex cascade of related secondary phenomena, social and physical. Before climate changes become even more dangerous, the dots connecting climate and environmental changes with their associated disruptions in human health must be made evident to persuade businesses, people and their governments to take effective preventive and adaptive action.

While not yet as obvious to the general public as the threat of drowning faced by polar bears on disappearing sea ice, the climate changes already occurring are not only real, they're rising, imminent, universal. Climate change will affect everyone, but, some more than others! Stated most simply, climate change affects health principally through heat waves, rainfall variability/drought, the spread of infectious diseases, and by exacerbating extant unhealthy arrangements

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of social inequality and global environmental degradation. This deceptively simple account hides many known and suspected details and routes to adverse health outcomes, as well as those who are most likely to be most adversely impacted. In an effort to engage public health expertise and activism, this CLI Background Paper reviews the pervasive, albeit insidious climate related threats to individual and collective health and well being.

A. Climate and Health: An Evolving and Accelerating Picture

Climate change impacts do not occur or operate from a level playing field in either an ecologic or social vacuum. The parameters and health outcomes of any single event depend on the configuration of local geography, geology and the pre-existing state of well-being, public health or social infrastructure for a given population, or demographic within a population. In 2003, during the Kyoto negotiations, the World Health Organization (WHO) asserted that “Global warming killed 150,000 people in 2000.” These scientists described how for the year 2000, a further 5.5 million healthy years of life were lost worldwide due to debilitating diseases caused by climate change. They went on to note: “we see an approximate doubling in deaths and in the burden in healthy life years lost” by 2030 if current trends are not reversed.¹

United Nations Environmental Program (UNEP) scientists also predicted in 2003 that “50 million people worldwide will likely be displaced by 2010 because of rising sea levels, desertification, dried up aquifers, weather-induced flooding and other serious environmental changes.”² In 2005, UN University (UNU) experts asserted catastrophic weather-induced flooding has already contributed to large permanent migrations and could eventually displace *hundreds* of millions.³ Still others predict even larger numbers of environmental refugees.⁴ For example, Christian Aid predicts people fleeing untenable environmental conditions may grow exponentially to one billion by 2050 as the world experiences the combined effects of climate change, conflict, development pressures and associated phenomena.⁵

Climate change means altered rainfall patterns associated with increases in extreme weather events in both intensity and frequency. The most extremely intense, destructive, and costly storms (categories 4 & 5), which have already doubled in frequency over the last 30 years,⁶ are predicted to become yet more frequent and intense due to global warming. The insurance industry is already feeling this heat. The Environmental Defense Fund reports that insured losses caused by hurricanes in 2004 and 2005 in Florida alone cost \$35 billion.⁷

¹ Comments taken from WORLD HEALTH ORGANIZATION, CLIMATE CHANGE AND HUMAN HEALTH—RISKS AND RESPONSES (Dec. 2003), launched in Milan during the Kyoto discussions. This source is widely quoted and reviewed by multiple reporters and web sites. For more details and associated links, see <http://www.who.int/mediacentre/news/releases/2003/pr91/en/> and <http://www.who.int/globalchange/en/>.

² Molly Conisbee & Andrew Simms, *Environmental Refugees: The Case for Recognition* (2003), <http://www.neweconomics.org/gen/uploads/lpce0g55xjx5eq55mfjxb5523102003180040.pdf>, referenced in UN Environmental Programme Report [hereinafter “UNEP Report”], “The Environment in the News” (May 24, 2007), at 20.

³ Stephen Leahy, “Millions Flee Floods, Desertification,” IPS News Service Online, Oct. 12, 2005, <http://www.wbcsd.org/plugins/DocSearch/details.asp?MenuId=ODQ&ClickMenu=RightMenu&doOpen=1&type=DocDet&ObjectId=MTY3NzY> (last visited Mar. 7, 2008).

⁴ Norman Myers, *Environmental Refugees: A Growing Phenomenon of the 21st Century*, 357 PHILOSOPHICAL TRANSACTIONS: BIOLOGICAL SCIENCES 609–13 (2001), referenced in Robert Stojanov, “Environmental Migration—How Can [It] be Estimated and Predicted?,” http://www.vos.cz/imdr/documents/EM-How_can_be_predicted.pdf (last visited Mar. 7, 2008).

⁵ Christian Aid Report, *Human Tide: The Real Migration Crisis* (May 2007), http://www.christian-aid.org.uk/Images/human_tide3_tcm15-23335.pdf (last visited Mar. 18, 2008).

⁶ Kerry Emanuel, *Increasing Destructiveness of Tropical Cyclones Over the Past 30 Years*, 436 NATURE 686-88 (2005).

⁷ Environmental Defense Fund, *Climate, Storms and Insurance—A Costly Brew*, <http://www.edf.org/page.cfm?tagID=16139> (last visited Mar. 8, 2008).

All mass migrations, especially when effectuated on short notice like those indicated above are associated with health challenges. In the acute situation access to potable water and adequate nutritious food sources is compromised. Violence is often a close companion to people forced into unnatural and unaccustomed living arrangements. When people flee, disease vectors (especially rodents) also escaping damaged or flooded habitats follow, transporting their related disease risks. Flooding situations also bring increased water borne diseases, mosquitoes and increased cases of malaria, dengue and other mosquito borne illness. Chronically, mental health challenges including cases of post traumatic stress disorder (PTSD) are likely to be experienced.

When the WHO scientists made their predictions in 2003, they augmented their data by cautioning that “estimates of global deaths from climate change are minuscule when compared with the total number of deaths a year.” They noted, about ten times more people die each year from tobacco-linked illness. However, they concluded, that does not make these deaths any more acceptable—and it is likely to get worse. An important point they made about climate change is that unlike the situation with tobacco, people who are affected by the changing climate don't have the choice to stop.⁸

From the vantage of just a few years the initial WHO predictions could be considered narrow and conservative, indicating a deceptively low level of risk. For example, in Europe alone in 2003, depending on the inclusion criteria used by the investigator, an estimated 20,000–35,000 people died prematurely due to extremely hot temperatures during an unprecedented and prolonged heat wave. The attribution or denial of upwards of some 15,000 deaths in one relatively localized event provides an illustration of the difficulties encountered in determining or attributing causal factors.⁹ Inclusion or exclusion of various factors and/or attribution of causation carries political or economic weight implying some level of responsibility on the part of identified actors or agents. Thus, while biologists, physicians, and epidemiologists debate the inclusion/exclusion factors useful as indicators of climate related “excess deaths,” a number of scientific observers predict the frequency, duration, and intensity of heat waves—like major storms—is likely to double in coming years.

It is no less important to realize that the dramatic impacts of major storms and disastrous heat waves overshadow other less apparent effects of climate change. Small- and medium-scale disasters (those unlikely to receive world wide attention) are occurring more frequently than the kind of large-scale disasters that hit the headlines. In 2007, Oxfam International reported that “recorded floods, hurricanes, and other natural disasters have quadrupled in the last two decades.”¹⁰ According to several major international disaster response agencies, there were an average of 354 disasters (including extreme weather events, wind storms, and flooding) each year between 1991 and 1999, but between 2000 and 2004 this went up to as high as an average of 728 per year. Most recently, the World Watch Institute reported 874 weather-related disasters worldwide in 2007, claiming this marked a 13% increase over 2006 and the highest number since the systematic recording of disasters began in 1974.¹¹ Weather related disasters killed

⁸ Christian Aid Report, *supra* note 5.

⁹ For a good discussion of this lack of consistent criteria for determining heat wave mortality, see Silvia Chiang, *Heat Waves, the “Other” Natural Disaster: Perspectives on an Often Ignored Epidemic*, AMSA GLOBAL PULSE JOURNAL, http://www.globalpulsejournal.com/2007_chiang_silvia_heat_waves.html, (last visited Mar. 8, 2008). For more details on the European heat wave associated death count, see *infra* Section D (“Warming, Heat Waves and More: Direct and Indirect Health Impacts”)

¹⁰ *Climate Alarm: Disasters Increase as Climate Change Bites*, Oxfam Briefing Paper No.108 (Nov. 2007), available at http://www.oxfam.org/en/files/bp108_climate_change_alarm_0711.pdf/download (last visited Jan. 5, 2008).

¹¹ Petra Low, *Energy and Climate*, <http://www.worldwatch.org/taxonomy/term/514> (last visited Oct. 7, 2008).

over 443,000 in the decade (1995–2005) accounting for 98% of those affected by disasters, or 2.5 billion people—fully one third of the human family.¹²

Reflecting both the growing global population and the increasing occurrence of these disastrous events, Oxfam reported that the numbers affected have increased from 174 million to over 250 million per year.¹³ In mid 2007, the Worldwatch institute reported nearly 5.4 million people became homeless as a result of a disaster the previous year. The reports remind the reader that other "secondary" disasters often follow—with obvious health implications—including sexual harassment in temporary camps or shelters, domestic violence, child labor and trafficking, poor resettlement plans, and ongoing disabilities.¹⁴ The impoverished, women, children, and the elderly anywhere are among those most vulnerable to these secondary health effects.

Regardless of the precise number killed, maimed or made sick in any one extreme weather event, all such events are associated with immeasurable amounts of misery, pain and suffering that persists long after the weather calms. For many in the most vulnerable situations, like Haitians, small island dwellers, and Bangladeshis, the weather barely calms before the next challenging storm washes over. With the climate changes emerging, more are becoming increasingly vulnerable to a range of environmental catastrophes inexorably piling one on top of another in rapid succession. Oxfam experts noted each new disaster undermines the very development and infrastructure upgrades that could provide greater population resilience.¹⁵ In a parallel fashion, the cumulative impact of one shock after other activating stress hormone response systems in the affected population also leaves their immune systems much more vulnerable to infectious agents and other serious disease risks.

Unfortunately, heat waves and major storms are but two of a great number of interrelated, climate induced phenomena predicted to affect earth's life and health-support systems in the near future. Risks or numbers of people to be affected due to other important climate related effects are harder to typify much less quantify. For example, as reviewed elsewhere, global warming predicts the migration and shifting of many species, and in conjunction with increasingly degraded ecosystems, the extinction of many other species—many of whom provide poorly characterized but likely beneficial or protective ecosystem functions. Climate change also means sea level rise with increased acidity and salinity of the oceans, and consequent loss of ocean biodiversity. It is impossible to characterize the potential health impacts or disruptions due to such losses. Unfortunately, the very phenomena precipitating these losses are likely to contribute to increased numbers of pest and invasive species, including allergenic plant species, insect, avian, rodent, and marine based disease vectors.

B. Impaired Vision

Part of the difficulty in recognizing what is happening may be explained by the differential impacts on the world's more impoverished, marginalized populations versus the experiences of the wealthier and more powerful. While everyone shares the same polluted atmosphere altering the earth's climate, impacts are not uniformly distributed around the globe. The sum of emissions associated with First World consumption patterns contribute most to the evolving changes in our atmosphere, environment and weather, yet the poorer, less powerful, less consuming members of the human family are the ones feeling the most heat. The U.S. and China are the world leaders in the production of greenhouse gases from cars, power generation, and factories, however, the regions whose populations face the most risk

¹² *World Disasters Report 2006: Focus on Neglected Crises* (International Federation of Red Cross and Red Crescent Societies: Jonathan Walter ed., 2006).

¹³ Oxfam Briefing Paper No. 108, *supra* note 10.

¹⁴ "World's Spotlight Misses the True Cost of Disasters," Worldwatch E-Letter, June 5, 2007.

¹⁵ Oxfam Briefing Paper No. 108, *supra* note 10.

from climate change include the poorest of the poor on the South Asian continent and the Indian Ocean coast, South American Pacific coasts, as well as sub-Saharan Africa and small Island Nations.¹⁶

Additionally, rising temperatures disproportionately affect poor countries and the poor within all countries, exacerbating existing inequities in health status, access to adequate food, clean water and other basic life supporting resources.¹⁷ The Red Cross, Christian Aid, and Oxfam all agree that disaster incidence is more than doubling in recent years. While each organization reports a different number killed or affected, again depending on the criteria and timing used to measure impacts, each agrees the numbers affected to be in the many hundreds of millions people, with up to 98% of victims living in the developing world.¹⁸ Even though this data refers to large swaths of the entire global population, those most affected are not the ones responsible for the increasing emissions of green house gases.

On average, 13 times more people die per reported disaster in countries/regions with high rates of poverty or low human development indicators than those with high development indicators.¹⁹ Events like Hurricanes Katrina and Rita, those in Haiti in 2006 and 2008, Mitch in Central America in 1998, and the 2007 Bangladesh Cyclone Sydr are evident examples of this differential impact and compounding effect of vulnerability in disasters.²⁰ Four hurricanes in rapid succession pounded Haiti during the 2008 summer causing 800 fatalities and leaving several hundred thousand people homeless or in dire need of help. According to Haiti's president, the storms set back Haiti's economic development by several years. The death toll from the same storms that later pummeled the U.S. gulf states stand at far less than 50 as of this writing.²¹ Similarly, Cyclone Sidr which hit Bangladesh in November 2007, left over 3100 dead, and destroyed 30,000 hectares of protective mangrove forest. It is estimated that two decades will be required for a full recovery.²²

Adding insults to those who have done little to create the climate problem, the same people often find themselves repeatedly prone to a multiplicity of inter-related disasters. Climate-sensitive diseases like cholera, dengue, malaria and many others, are already more prevalent in these same regions. Coastal dwellers in a developing country like Vietnam or Bangladesh who may be adversely affected by a cyclone and flooding in one season may then find themselves

¹⁶ U.N. Env't Programme & World Meteorological Org., Intergovernmental Panel on Climate [IPCC], *IPCC Fourth Assessment, Climate Change 2007: A Report of the Intergovernmental Panel on Climate Change*, Summary for Policy Makers, Contribution of Working Group II (M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & Ce.E. Hanson eds., 2007) [hereinafter "IPCC Fourth Assessment Summary Report"]. The differences in impacts and emissions are well demonstrated graphically by Worldmapper. See maps #245 ("Those Affected by Disasters") and #295 ("Carbon Emissions"), <http://www.worldmapper.org/index.html>.

¹⁷ UN Framework Convention on Climate Change (2007) [hereinafter "UNFCCC Report 2007"], *Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries*, http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/txt/pub_07_impacts.pdf (last visited Mar. 3, 2008).

¹⁸ See several online reports from these and other organizations: Christian Aid (June 5, 2007), http://www.christianaid.org.uk/pressoffice/pressreleases/200707/reduce_impacts.aspx; International Federation of Red Cross and Red Crescent Societies, *World Disasters Report: Focus on Discrimination* (2007), <http://www.ifrc.org/Docs/pubs/disasters/wdr2007/WDR2007-English.pdf>; Oxfam Press Release (Nov. 25, 2007), "Disasters Escalating Four Fold as Climate Change Hits Poor Hardest, Says Oxfam," <http://www.oxfam.org/node/231> (all the foregoing last visited Mar. 3, 2008).

¹⁹ Diarmid Campbell-Lendrum & Carlos Corvalan, *Climate Change and Developing-Country Cities: Implications for Environmental Health and Equity*, J. URBAN HEALTH (2007), <http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pubmed&pubmedid=17393341> (last visited Mar. 3, 2008).

²⁰ World Bank, *Climate Change & South Asia: Poorest of the Poor are Most at Risk* (Nov. 28, 2007), <http://web.worldbank.org/Wbsite/External/Countries/Southasiaext/0,contentMDK:21567528-menuPK:2246552-pagePK:2865106-piPK:2865128-theSitePK:223547,00.html> (last visited Mar. 19, 2008).

²¹ CBS News Online, "U.S. Death Toll from Hurricane Ike Rises to 33," Sept. 15, 2008, <http://www.cbc.ca/world/story/2008/09/15/hurricane-aftermath.html> (last visited Oct. 11, 2008).

²² Graham Bowley, "Cyclone Toll Exceeds 3,100 in Bangladesh," N.Y. TIMES, Nov. 20, 2007, available at <http://www.nytimes.com/2007/11/20/world/asia/20bangladesh.html?r=1&oref=slogin> (last visited Mar. 26, 2008).

facing drought and extreme heat in the next. Such people are forced to cope with rapidly shifting severe weather while simultaneously coping with massive poverty, already rampant infectious diseases, inadequate and ineffective health care systems, and a host of other serious challenges to their quality of life.

C. Making Predictions from Climate to Health

Understanding relationships, cause and effect chains from climate change to changing health determinants and health outcomes is complex and inexact at best. Climate, geographic, and geologic interrelationships are themselves complex and not yet completely understood. Even as climatologists recognize effects are already felt and that future impacts and the magnitude of severity will be determined by what happens in the very near future, neither the IPCC international team of scientists nor any other experts can provide an exact time line or predict with precision or certainty the manifestations of, the rate of, or the severity of global warming changes and the anticipated health consequences. The human species has never experienced such an overwhelming circumstance.

Predicting epidemics, disasters and health outcomes using the conventional tools of epidemiology, surveillance, and medical science to this point has been based on relatively well defined simple, uncluttered, linear factors and known relationships. Adding to the climatic uncertainties, future effects on population health will be layered concurrently onto numerous pre-existing non-climatic economic, physical and social environmental factors. Wealth and income distribution, the status, capacity or resiliency of the local public health infrastructure, availability and quality of medical care resources, access to adequate and varied sources of nutrition, potable water, and sanitation will each have separate and interacting impacts on local public health above and beyond specific measures taken to prepare for, adapt to, or alleviate climate impacts.

Similarly, individual behaviors and vulnerability vary widely. Privileges or prejudice associated with gender, age, race, education, ethnicity, sexual orientation, and the like will all be layered over the challenges inherent to the increasing global human population and population density. Water scarcity, resource depletion, environmental degradation, changing local patterns of biodiversity, poverty, powerlessness, and the movement or displacement of people to marginal land areas, are themselves all complex and difficult to quantify much less predict their separate or interacting health impacts.

Finally, adding to the difficulty of accurate predictions, climate change phenomena appear to be accelerating. The existence and importance of several positive feedback loops are increasingly being recognized by climate scientists. These events occur when a small change leads to an even larger change of the same type. For example, a modest amount of warming which melts ice in northern climates exposes bare earth. This dark ground absorbs three times as much heat as ground covered by snow or ice, so the first change is amplified. Even more ice melts, more heat is absorbed, and the spiral grows much more rapidly than anticipated on initial inspection. Of particular concern is the feedback loop involving the melting of the Greenland and Siberian permafrost which would release enormous amounts of methane, a particularly potent green house gas that would prove catastrophic for all of humanity—regardless of public health preparedness.

D. Warming, Heat Waves and More: Direct and Indirect Health Impacts

Acute severe weather events like hurricanes, tornadoes and floods make for TV headlines, but chronic heat, heat waves, and drought are deadlier. While populations adapt to heat over time, unaccustomed, prolonged heat can cause death by heat stroke or heat exhaustion for the elderly and those with chronic conditions including diabetes, high blood pressure and heart disease. Such chronically ill and vulnerable populations are all on the rise around the world. Many others, including those on medications that depress the central nervous system or affect the ability to sweat, those with

asthma, obesity, or other heart problems, as well as infants and small children, the homeless, alcoholics and chronically mentally ill, and all those who labor out doors, are especially vulnerable to extreme heat and prolonged heat waves.²³

The widespread heat wave in Europe in August 2003 mentioned above, came as a surprise to the world. The magnitude of death in such a wealthy, developed region of the planet was phenomenal, much higher than was originally projected²⁴ and should serve as a warning for other developed and less developed parts of the world. The sustained temperatures and mortality in many European nations (especially in the UK, Netherlands, France, Spain, Italy, Switzerland, Portugal) led to approximately 35,000 excess deaths.²⁵ It is now expected that serious heat wave incidence will double (up to 70,000 excess deaths/event).²⁶ These increases will not be spatially uniform. They are projected to be greatest in North America, Europe, in Northern and Central Asia, areas which are not equally endowed with mediating infrastructure to protect their vulnerable citizens.²⁷ Regarding the U.S., Los Angeles for example, is projected to experience a four to eight fold increase in heat wave days by the end of the century, i.e. increase from 12 days a year to between 44 and 95 days. The number of heat wave days in Chicago—where between 500–700 died in the 1995 heat wave—is expected to increase by 25 percent.²⁸

Deadly as they are, heat waves in wealthy industrialized nations are usually mitigated to a great extent by the ready availability of air conditioning, effective disaster response plans with cooling centers, and health services for effective care of dehydration, heat stroke and any underlying conditions including associated heart attacks.²⁹ Such costly mitigating measures are unavailable for many—even within the U.S. and Western Europe—and especially elsewhere. Too often, poverty, lack of air conditioning, and reduced access to adequate health care, all go hand in hand.

For those in many parts of the developing world heat wave associated health risk factors complicate other public health threats like poor nutrition, poor quality water supplies or sanitation facilities. The risk of dehydration from excess heat and co-existent water- and/or food-borne diarrhea is particularly deadly in the developing world.³⁰ Already in 2003, WHO estimated climate change was to blame for 2.4 percent of cases of diarrhea because heat exacerbates any bacterial contamination of food—over and above impacts experienced as a result of severe meteorologic events. In Lima, Peru, a six-year study reported in 2000 that a clinic set up to treat diarrhoeal complaints showed a 12 percent increase in cases

²³ Christina Koppe, et al., “Heat Waves: Risks and Responses,” *World Health Organization Health and Global Environmental Change Series* (No. 2), <http://www.euro.who.int/document/e82629.pdf> (last visited Mar. 8, 2008).

²⁴ T. Kosatsky, The 2003 European Heat Waves, 10 *EURO SURVEILLANCE* 7:148-9 (2005), available at <http://www.eurosurveillance.org/em/v10n07/1007-222.asp> (last visited Feb. 16, 2008).

²⁵ See L. Grize, et al., *Heat Wave 2003 and Mortality in Switzerland*, 135 *SWISS MED. WKLY* 200–05 (2005), available at <http://www.ncbi.nlm.nih.gov/pubmed/15909237>; J. Garssen, C. Harmsen, & J. De Beer J., *The Effect of the Summer 2003 Heat Wave on Mortality in the Netherlands*, 10 *EURO SURVEILLANCE* 7:165–68 (2005), available at <http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=557>; H. Johnson, et al., *The Impact of the 2003 Heat Wave on Daily Mortality in England and Wales and the Use of Rapid Weekly Mortality Estimates*, 10 *EURO SURVEILLANCE* 7:168–71 (2005), available at <http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=558> (all of the foregoing last visited Feb. 16, 2008).

²⁶ See P.A. Stott, D.A. Stone & M.R. Allen, *Human Contribution to the European Heat Wave of 2003*, 432 *NATURE* 610–14 (2004).

²⁷ Kristie Ebi & Gerald Meehl, *Heatwaves and Global Climate Change. The Heat is On: Climate Change & Heatwaves in the Midwest*, (Pew Center on Global Climate Change, Dec. 2007); IPCC Fourth Assessment Summary Report, *supra* note 16; Jan Semenza, et al., *Heat-Related Deaths During the July 1995 Heat Wave in Chicago*, 334 *NEW ENG. J. MED.* 2: 84–90 (1996).

²⁸ U.S. Environmental Protection Agency, *Climate Change—Health and Environmental Effects* (referring to findings in the IPCC Fourth Assessment Report, *supra* note 16) (last visited Mar. 8, 2008).

²⁹ Koppe, *supra* note 23.

³⁰ See Ulisses Confalonieri, et al., “Human Health,” *IPCC Fourth Assessment Summary Report*, Contribution of Working Group II (2007), *supra* note 16, at 391–431. See also Sudha Ramachandran, “India’s Rite of Summer: Death from the Heat,” *Asia Times*, available at http://www.atimes.com/atimes/South_Asia/HE24Df01.html (last visited Mar. 8, 2008).

for every 1°C rise in temperature in cooler months and a 4 percent increase in the hotter months. Similar results were found in a survey of 18 Pacific islands.³¹ Again, in December 2003 the UK *Guardian* reported findings that Salmonella rises steeply in hot months. A 12 percent increase in salmonella food poisoning is reported to health authorities for every 1°C rise in temperature, starting as low as 5°C.³²

Intensifying this effect, burgeoning and increasingly crowded cities around the world are well known producers of the urban “heat island” effect, wherein buildings and asphalt absorb and retain more heat than do trees and plants. This additional urban heat keeps temperatures high around the clock unlike more rural areas that cool down at night. Thus, residents of increasingly crowded impoverished urban areas with inadequate monitoring of food and water quality are likely to experience more severe health problems because of the interaction of these phenomena. When combined these heat effects make a very bad situation just that much worse.

E. Increased CO₂: Direct and Indirect Health Effects

The relationship between rising levels of CO₂ and other green house gases, rising global temperatures, and climate change is clear. Less appreciated is that rising CO₂ levels themselves may pose other direct threats to human health even though some observers consider it a positive aspect of rising CO₂ that plants grow larger and use water more efficiently when exposed to higher levels of carbon dioxide.

1. Allergies

An allergy is an exaggerated immune response or reaction (sneezing, coughing, wheezing, and itching) to substances that are not usually considered harmful to the general population. Molds and ragweed are some of many agents known to induce asthma attacks in allergen sensitive individuals. People suffering from air borne allergies and asthma have been rapidly increasing over the past 40 to 50 years—probably due to a number of factors, not the least of which may be increased amounts of ragweed and other invasive pest pollens, as well as the fine particulate matter released by the burning of fossil fuels in transportation and industrial processes.³³

Allergen producing plant species like poison ivy and ragweed are likely expressing increasing allergenicity, expanded range and longer growing season, thriving because of the earlier, warmer, springs and longer summers associated with rising carbon dioxide levels as well as the increased CO₂ itself. In experimental settings, ragweed pollen production was 61 percent higher in elevated versus ambient CO₂ environments. Additionally, humidity effects, included in the heat index, and associated with warmer temperatures and heavy rains, encourage the growth of molds further exacerbating warm weather allergies. These findings suggest that the incidence of hay fever and related respiratory

³¹ Anthony J. McMichael, et al., *Global Climate Change*, in *COMPARATIVE QUANTIFICATION OF HEALTH RISKS: GLOBAL AND REGIONAL BURDEN OF DISEASES ATTRIBUTABLE TO SELECTED MAJOR RISK FACTORS*, 2:1571–74 (World Health Organization: Majid Ezzati, et al. eds. 2004), available at <http://www.who.int/publications/cra/chapters/volume2/1543-1650.pdf> (last visited Mar. 21, 2008).

³² Paul Brown, “Global Warming Kills 150,000 A Year: Disease and Malnutrition the Biggest Threats, UN Organisations Warn at Talks on Kyoto,” UK GUARDIAN, Dec. 12, 2003, available at <http://www.guardian.co.uk/environment/2003/dec/12/climatechange.climatechangeenvironment> (last visited Mar. 2, 2008).

³³ See Paul Epstein & Christine Rogers, *Inside the Greenhouse: The Impacts of CO₂ and Climate Change on Public Health in the Inner City* (Report from the Center for Health and the Global Environment, Harvard Medical School, 2004), <http://chge.med.harvard.edu/publications/documents/green.pdf>. See also Paul J. Beggs, Paul J. & Jane Bambrick, *Is the Global Rise of Asthma an Early Impact of Anthropogenic Climate Change?* 113 ENVTL HEALTH PERSPS. 8 (2005), available at <http://www.medscape.com/viewarticle/510992>; Gautam Naik, “Global Warming May Be Spurring Allergy, Asthma,” WALL ST. J., May 10, 2007 (the entire foregoing last visited Mar. 22, 2008).

diseases will increase in the future, however, exact relationships and harms, especially given other interacting and increasingly prevalent factors like smog, ozone and particulates (described below), are yet to be determined.³⁴

2. Smog

Rising CO₂ and other green house gas levels like nitrous oxides and sulfur dioxide increase the sneeze-inducing pollen counts often in the very same regions where they interact with rising temperatures to worsen air quality, especially in heavily populated and industrialized metropolitan areas around the world. Primarily by increasing ground-level pollution, high levels of green house gases simultaneously lead to increased levels of smog. At ground level, ozone and smog are created by chemical reactions involving the volatile organic carbons and nitrous oxides released by cars and industrial pollution, sunlight, and increasing temperatures.

Smog damages lung tissue directly and increases the severity of asthma, bronchitis, contributing to increased respiratory and heart disease and death in vulnerable populations. Even modest increases in smog can cause asthma in children. Smog, together with increased levels of particulates in urban areas, and increased allergens are the important factors contributing to soaring rates of asthma and damaging impacts on lung and heart health in general. Researchers from a multi-center study published in 2004, predicted global warming alone could prompt the rise of smog-related deaths in the New York City region by 4.5 percent by the middle of this century, compared with the 1990s.³⁵ They predict health-alert days will go up by 68 percent over the next few decades. Campbell-Lendrum and Corvalan also noted that urban ambient air pollution was already causing approximately 800,000 deaths per year worldwide by 2002.³⁶

F. Indirect Warming Associated Effects on Global and Local Health

Global warming means much more than just an increase in hot weather and heat waves that directly impact health. The phenomena predicted for our warming planet that will indirectly or secondarily challenge our health, are many, especially those associated with rising sea levels, changing hydrologic cycles, and melting ice caps. These changes mean not only a different set of challenges to agriculture, but destruction of property, injuries and death in fast moving water, and the increased risk of water borne diseases and diarrhea as a natural accompaniment to flood induced destruction of water and sanitation infrastructure. Around the world lack of potable water is already the greatest killer of children under five.³⁷ As with all climate related phenomena, health challenges in the wake of drought, flooding and storm surges will vary in character and in the size, density, and vulnerability of the populations impacted. For any region, the exact outcomes depend on pre-existing conditions in the communities affected, robustness of physical infrastructure, prior preparedness planning, and effective early warning systems.

G. Coastal Crowding as Sea Levels Rising—Unhealthy Synergies

The global sea level is closely linked to earth's climate. As described elsewhere in this report, given the extant levels of atmospheric CO₂ and other green house gases, their long life, as well as their predictable warming effects, the

³⁴ C.A. Rogers, C.A. et al., *Interaction of the Onset of Spring and Elevated Atmospheric CO₂ on Ragweed . . . Pollen Production*, 114 ENVTL HEALTH PERSPS. 865–69 (June 2006), available at <http://www.ehponline.org/members/2006/8549/8549.pdf> (last visited Feb. 19, 2008).

³⁵ Kim Knowlton et al., *Assessing Ozone-Related Health Impacts of a Changing Climate*, 112 ENVTL HEALTH PERSPS. 15:1557–63 (2004), available at <http://www.ehponline.org/members/2004/7163/7163.html> (last visited Mar. 22, 2008).

³⁶ Campbell-Lendrum, *supra* note 19.

³⁷ *Water for Life: Making it Happen* (WHO & UNICEF, 2005), http://www.unicef.org/wes/files/JMP_2005.pdf (last visited Mar. 21, 2008).

best estimates suggest that sea level may rise approximately another 19 inches in this century (1–2 feet or 28–58 cms in the next 100 years),³⁸ primarily due to expanding warmer ocean water even if global greenhouse gas emissions are stabilized. The rise will be even greater if emissions are not soon reduced.

Sea level is rising primarily because of the expansion of warmer ocean water (thermal expansion) as well as the contribution of melting polar and glacial ice. Possibly no expected impacts will prove so acutely deadly and far reaching as those to be associated with the coupling of rising sea levels, extreme weather, and their related massive storm surges. Even small increases in sea level can magnify the impact of coastal storm surges, which themselves will increase in frequency as storms increase in frequency and intensity.

Currently an estimated 669 million people worldwide live in areas at/below sea level and subject to storm surge (less than 33 ft above sea level) in island nations and along continental coastal areas.³⁹ By 2001 investigators were already predicting 26 million in Bangladesh, 12 million in Egypt, 73 million in China, 20 million in India, and 31 million from small island nations and elsewhere were all at risk from sea level rise.⁴⁰ By 2007, World Bank investigators noted that sea level rise in this century could reach as much or more than 1–3 meters, inundate even further, and that for some countries, the consequences are potentially catastrophic.⁴¹ Each of these cities are threatened by tidal surges and floods which would ruin houses and community infrastructure, and create a significant number of environmental refugees as was seen with Hurricane Katrina. As the World Bank study demonstrates however, those most likely to be affected will be in developing nations. However, the relative numbers affected by rising seas in the less developed world versus those in wealthier nations could change rapidly depending on national priorities and the rate, nature and adoption (or not) of effective adaptive infrastructure and disaster response planning.

Floods, heavy winds and storm surges imply not only economic losses, and costly clean up, but a long list of potential immediate, emergency, and chronic storm related personal and public health concerns⁴² even in the best case scenarios. These include injuries associated with rapid mass evacuations, increased infectious disease threats, especially if sewage and water treatment facilities or infrastructure is compromised leading to the release of bacterial contaminants into the air and water, vector and rodent borne diseases, increased rates of mental distress and domestic violence, post traumatic stress disorder (PTSD) and increased rates of suicides that may persist long after an acute disaster situation resolves.⁴³

³⁸ UNEP Fact Sheet (Sept. 2007), http://www.unep.org/Themes/climatechange/PDF/factsheets_English.pdf (last visited Mar. 11, 2008); National Assessment Synthesis Team, *Climate Change Impacts on the United States*. U.S. Global Change Research Program (updated Oct. 12, 2003), <http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overviewcoastal.htm> (last visited Mar. 20, 2008).

³⁹ E. Lynn Usery, *Modeling Sea-Level Rise Effects on Population using Global Elevation and Land-Cover Data* (U.S. Geological Survey, 2007), <http://cegis.usgs.gov/pdf/aag-2007.pdf> (last visited Mar. 11, 2008).

⁴⁰ See Myers, *supra* note 4. See also Norman Myers, “Environmental Refugees: An Emergent Security Issue” (paper presented at the 13th Economic Forum, Prague, May 23-27, 2005), available at http://www.osce.org/documents/eea/2005/05/14488_en.pdf (last visited Mar. 8, 2008).

⁴¹ Susmita Dasgupta et al., “The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis” (World Bank Policy Research Working Paper No. 4136, 2007), available at http://econ.worldbank.org/external/default/main?pagePK=64165259&theSitePK=469372&piPK=64165421&menuPK=64166093&entityID=000016406_20070209161430 (last visited Mar. 11, 2008).

⁴² National Assessment Synthesis Team 2003, *supra* note 38.

⁴³ See E.G. Krug et al., *Retraction: Suicide after natural disasters* 340 *NEW ENG. J. MED.* 340 20:148–49 (1999); James Shultz, Jill Russell & Zelde Espinel, *Epidemiology of Tropical Cyclones: The Dynamics of Disaster, Disease, and Development* 27 *EPIDEMIOLOGIC REVS.* 1:21–35 (2005), available at <http://epirev.oxfordjournals.org/cgi/content/full/27/1/21> (last visited Mar. 11, 2008); Zhao-Xiong He, *A Suicide Belt in China: The Yangtze Basin*, 4 *ARCH SUICIDE RES.* 3:287–89 (1998); Richard Weisler, James Barbee, & Mark Townsend, *Mental Health and Recovery in the Gulf Coast After Hurricanes Katrina and Rita*, 296 *J. AM MED. ASS'N* 5:585–88 (2006).

Not the least of many concerns, hospitals, allied medical and public health facilities which tend to be concentrated in large population centers are especially vulnerable. Even if local populations escape immediate injury or disease associated with large storms, there is long term need for properly functioning hospitals and medical facilities. Loss of such facilities in any single disaster contributes to longer lasting secondary disasters especially if primary care, maternal health, neonatal or other forms of specialty care and resources are lost. Recovery, replacement or repair of highly skilled and technology based systems is especially costly, but absolutely necessary to provide needed services after any acute event.⁴⁴

The experience in New Orleans during and after Hurricane Katrina provides a powerful example of how hospitals, clinics, laboratories, and academic institutions risk destruction or at least experience loss of invaluable resources, clinical research materials, and supplies when waters rise and especially if electric power is compromised. Dr. Tyler Curiel, a Tulane oncologist, explained during a PBS interview⁴⁵ his motivation and efforts to save his life's work. His testimony vividly demonstrates how if electrical generation and refrigeration is lost, so are fragile lab reagents, medications, blood supplies, patient specimens, and intravenous fluids. Lack of electricity renders hemodialysis units, ventilators, and other life support equipment inoperative. Physicians and hospital staff who find themselves as part of a skeleton crew trapped and unable to vacate medical facilities are unlikely to be well prepared to handle triage style decision making in the worst case scenarios. The ethical lines between preservation, care and protection can become blurred rapidly in massive emergencies.⁴⁶

Coastal populations also face other more complicated threats that may be co-terminus including the release of tons of toxic chemicals from the break down or destruction of factories, pipelines, oil platforms, chemical containment facilities, or waste depositories in the line of storms or located in the areas affected by storm surges. Substances in such sites are released directly into the air and water, and eventually find their ways into local soils and water tables. Toxic chemicals released to the environment can be anything from common household chemicals and paints, to pesticides, acids, corrosives, heavy metals, diesel, crude oil, petroleum, and countless others depending on the storms' location and intensity. Katrina alone released from 7–9 million gallons of oil—depending on the source and timing of reporting the spills.⁴⁷ Around the world, many major industrial sites, including chemical factories and oil refineries are not infrequently found in coastal areas. Such toxic releases and their clean-up pose both acute and chronic threats to the human population and other members of local ecology, plants, animals, insects and fishes.⁴⁸

⁴⁴ *Hospitals Safe From Disasters: Reduce Risk, Protect Health Facilities, Save Lives*, World Disaster Reduction Campaign (2008-09), http://www.searo.who.int/LinkFiles/Hospitals_Safe_from_Disasters_SEARO_Safe_Hospitals_Brochure.pdf (last visited Oct. 11, 2008).

⁴⁵ See Ask the Expert, <http://www.pbs.org/wgbh/nova/sciencenow/3302/08-ask.html> (last visited Mar. 1, 2007).

⁴⁶ Tyler Curiel, *Murder or Mercy? Hurricane Katrina and the Need for Disaster Training*, 355 *NEW ENG. J. MED.* 20:2067–69 (2006).

⁴⁷ See “Hurricane Katrina–Gulf of Mexico Oil Spills,” *Skytruth* (Dec. 12, 2007), available at <http://blog.skytruth.org/2007/12/hurricane-katrina-gulf-of-mexico-oil.html>; Julian Borger & John Vidal, “Katrina Oil Spills May Be Among Worst on Record,” *UK GUARDIAN* (Sept. 16, 2005). See also IP gallery display of multiple sites of contamination at <http://www.katrinadestruction.com/images/v/damaged+energy+facilities/> (all the foregoing last visited Oct. 11, 2008).

⁴⁸ The concerns related to chemical contamination and climate change are many and well beyond the issue of sudden dispersal. In fact, given the range of chemical contamination found all over the globe, and the potential range of complex interactions with changing weather patterns, delineating health harms is beyond the scope of this short review article. It has yet to be studied by anyone in a systematic fashion. For a brief overview, however, see *Managing Chemicals in a Changing Climate to Protect Health*, WHO Intergovernmental Forum on Chemical Safety 2008, http://www.who.int/ifcs/documents/general/clim_change_chem.pdf (last visited Oct. 10, 2008).

H. Glaciers, Ice Caps Melting, Rivers Disappearing

The world is increasingly aware of the loss of glaciers in the arctic regions, but tends to forget that climate change brings a mix of dangerous outcomes for other Northern latitudes and higher altitudes as well. Paradoxically, warming over the next several decades is expected to bring more moisture and winter storms inland in the form of snow with subsequent increased risk of avalanches, mud slides, and sudden loss of walls containing high altitude lakes. These phenomena put lower lying settlements, facilities and roadways in all the world's mountainous areas in serious danger.⁴⁹

More importantly warns Achim Steiner, Under-Secretary General of the UN and executive director of the UNEP, loss of the highest snow caps has a much greater long range impact. "Millions if not billions of people depend directly or indirectly on these natural water storage facilities for drinking water, agriculture, industry and power generation during key parts of the year."⁵⁰ This loss of glaciers and ice caps, and subsequently a loss of their associated surface river water flows is already underway. Glacier melt in the Himalayas, across Europe and other glaciated, snow capped areas around the world is projected to affect local water resources and the health of local populations in very different ways reflecting altered agricultural productivity, loss of fish stocks, recreational resources, and the movement of infectious diseases.

Within the next two to three decades warming will initially increase dangerous flooding and rock avalanches from destabilized melting slopes. These difficult events will then be followed by decreased river flows as the glaciers recede. Within North America, for example, warming in western mountains is projected to cause decreased snow pack, more winter flooding, and reduced summer flows, exacerbating competition for already over-allocated regional water resources.⁵¹

These altered river flows and loss of natural habitats predicted with warming will also contribute to an accelerated loss of biodiversity in turn exacerbating the already significant species losses associated with increased human populations, pollution, habitat loss, and development pressures. According to prominent biologists, 20–30 percent of all species face increased risk of extinction by 2050.⁵² As climate changes, some species will be able to migrate forestalling significant loss for a while, but others, especially those in mountainous areas, islands, continental tips, and some forests, will not. Species that currently share a given eco-niche may not be able to migrate together. The effect associated with the break up of delicate interspecies networks is difficult to predict for either agriculture or health.

While species have always gone extinct and will continue to do so, humans have accelerated the natural loss of species by more than 100-fold.⁵³ Their demise alters the planet and our well being in myriad ways related to our food and

⁴⁹ See Walter J. Ammann, "Avalanches in View of Climate Change" (report presented at International Disaster Reduction Conference of the International development Research Council (IDRC, Aug. 27-Sept. 1, 2006), available at http://www.astra.admin.ch/dokumentation/00109/00115/00370/index.html?lang=en&download=NHZLpZeg7t,lnp6I0NTU042l2Z6ln1ad1IZn4Z2qZpnO2Yuq2Z6gpJCDdH9_gmym162epYbg2c_JjKbNoKSn6A-- (last visited Mar. 20, 2008).

⁵⁰ "Meltdown in the Mountains: Record Glacier Thinning Means No Time to Waste on Agreeing New International Climate Regime," UNEP Press Release, Mar. 16, 2008, <http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=530&ArticleID=5760> (last visited Mar. 18, 2008).

⁵¹ Barry Nelson et al., *In Hot Water: Water Management Strategies to Weather the Effects of Global Warming* (Nat'l Resources Defense Council Report, 2007), <http://www.nrdc.org/globalWarming/hotwater/contents.asp> (last visited Oct. 10, 2007).

⁵² Jay R. Malcolm et al., *Global Warming and Extinctions of Endemic Species from Biodiversity Hotspots* 20 CONSERVATION BIOLOGY 2:538–48 (2006). See also many UNEP sites, especially those developed in conjunction with the Convention on Biological Diversity and the UN International Year of planet Earth.

⁵³ See Global Biodiversity Outlook (GBO) at <http://www.cbd.int/gbo2/> (the website for activity pertinent to the June 5, 1992 Convention on Biological Diversity) (last visited Mar. 21, 2008). For the Convention itself, see 1760 United Nations Treaty Series

health. As Jerald Schnoor notes, “when crops are no longer pollinated by bees, when coral reefs collapse to only a few species, and when disease vectors are no longer kept under control naturally, we may begin to understand the consequences.”⁵⁴

The public health discussion and concern in recent years has focused on the changing climate primarily as it affects the behavior and range of mosquitoes and all the diseases they are known to carry. There are other less well identified concerns about emerging diseases and the resurgence of old diseases like cholera, and others potentially carried by vectors newly introduced or expanding into human habitats. For example, when an animal like several bat species currently confined to its rapidly disappearing rain forest biomes, is forced to migrate and find new sources of nourishment or shelter, it is likely to be found closer to human habitats. Such animals potentially carry with them microbes previously not present in an environment inhabited by a human population. The nature of such diseases, their transmission rate, route, or impacts are impossible to predict. Just like no one predicted the relationship between Lyme disease, ticks, and deer when they came into close contact with humans, such future threats have yet to be appreciated.

A rapidly changing ecology also means the movement and unusual mixing of other more resilient species. Even as many benign or beneficial species unable to adapt to a warming climate disappear, others, possibly more troublesome will increase their range and threat to human health as already noted for rag weed and poison ivy. An increase in vector borne disease is predicted to occur on a global scale in association with a simultaneous increase in a number of weed and pest populations. Recent outbreaks of disease related to movements of West Nile, Hanta, and Nipah viruses are just a few examples of this phenomenon.⁵⁵

Around the world, vulnerability is also on the increase due to the rapid development of poorly planned megacities in coastal and inland areas. Migrants from rural areas seeking employment are overwhelming cities many of which are sorely challenged to handle with any degree of effectiveness the demands of burgeoning populations. The new arrivals crowd into hastily constructed flimsy shanties without access to adequate sanitation or potable water. Combine this trend and its increased risk for rapid spread of infectious disease with rising sea levels and the growing number and intensity of storms and it is the recipe for a disaster-in-waiting, adding to the enormous potential for climate change to create waves of environment-driven migration.

I. Changing Hydrologic Cycles—Altered Infectious Disease Risks

As the planet heats, climatologists predict more severe weather episodes will deposit more water in some places, less in others. Increasingly frequent and intense episodes of flooding and droughts are both expected. The health impacts resulting from droughts and heat could be as significant as those associated with the increased flooding predicted elsewhere. As the climate and rain fall patterns change, so do outbreaks and risks of infectious diseases. Malaria, dengue fever, and Lyme disease are all on the increase. Global warming induced changes in hydrologic cycles will increase the range and intensity of transmission of vector-, tick-, and rodent-borne diseases, and food- and water associated diarrheal illnesses. Heavy rains produce new breeding sites for insects, drive rodents from burrows and contaminate clean water

(UNTS) 79, reprinted in 31 INT'L LEG. MATS. 818 (1992) and 5 International Law and World Order: Basic Documents V.H.22 (Burns H. Weston & Jonathan C. Carlson eds., 1994) [hereinafter “Weston & Carlson”].

⁵⁴ Jerald Schnoor, *Comment: Seven Ideas Lost on America*, ENVTL. SCI.& TECH. (Feb. 13, 2008), available at <http://pubs.acs.org/doi/abs/10.1021/es0870754> (last visited Feb. 17, 2008).

⁵⁵ Jane Lloyd, “The Link Between Environment and Disease,” 63 UN CHRON. 1 (2006), available at <http://www.un.org/Pubs/chronicle/2006/issue1/0106p68.htm> (last visited Mar. 9, 2008).

systems. A classic example of this phenomenon came with the six feet of rain that fell in three days in Central America during Hurricane Mitch and caused an upsurge of all three: insect, rodent and water-borne diseases.⁵⁶

Malaria, already endemic and deadly for most peri-equatorial regions, is sensitive to climate and hydrologic changes and is spreading north and south into currently temperate regions, particularly those with high rainfall. Several investigators point to possibly millions of extra cases in recent years as a result of climate change while others question the impacts of land use, public health performance, and population growth factors.⁵⁷ It is unclear to what degree the changing climate is behind current cases, but increased rainfall has created new breeding grounds for the mosquitoes and may be responsible for outbreaks in highland areas previously free of the disease. Epidemics are also triggered by high soil moisture content associated with altered rainfall patterns, allowing insects to survive long after floods have receded. The Hadley Center estimates that an additional 40–60 million more people will be exposed to malaria in Africa each year with an enlargement of range and increase of 2°C or 80 million more with an increase of 4°C.⁵⁸

In highland regions, as permafrost thaws and glaciers retreat, mosquitoes and plant communities are migrating to higher ground. Mosquitoes, which can carry many diseases besides Malaria, are very sensitive to temperature changes. Warming of their environment boosts the mosquitoes' rates of reproduction, the number of blood meals they take, prolongs their breeding season, and shortens the amount of time it takes for the Malaria parasite, for example, to mature to an infectious state.⁵⁹

In 2005, WHO officials reported that warmer temperatures and heavy rain in South Asia led to the worst outbreak of dengue fever (also known as “bone break fever”) there in years. The mosquito-borne viral illness, infected 120,000 South Asians and killed at least 1000. This is likely just one episode in a rapidly increasing incidence of this painful so-called tropical disease which appears to be on the rise worldwide—nearly doubling in less than a decade, to 900,000 cases per year. As reported in the *National Journal* cover story in July, 2007, dengue which is native to Southeast Asia, is growing most rapidly in Central America and the Caribbean.⁶⁰ In humans it causes severe joint pain, high fever, headaches, vomiting, and rashes. Hemorrhagic dengue—the most dangerous form—breaks down blood vessels, causing internal bleeding that can be fatal. As this reemerging disease spreads, many experts predict, the U.S. too, will be affected.⁶¹

⁵⁶ See Paul Epstein, *Climate Change and Human Health*, 353 *NEW ENG. J. MED.* 14:1433–36 (2005), available at <http://content.nejm.org/cgi/content/full/353/14/1433>; Rosalind Stanwell Smith, *World Water Day 2001: Floods and Droughts* (WHO Report, 2001), <http://www.worldwaterday.org/wyday/2001/thematic/floods.html>; *Climate Change Futures: Health Ecological and Economic Dimensions* (Harvard Medical School, Swiss Re, & UN Development Programme [UNDP], 2005), http://chge.med.harvard.edu/programs/ccf/documents/ccf_report_oct_06.pdf (all the foregoing last visited Mar. 21, 2008).

⁵⁷ M. Van Lieshout et al., *Climate Change and Malaria: Analysis of the SRES Climate and Socio-economic Scenarios*, 14 *GLOBAL ENVY. CHANGE* 1:87–99 (2004), available at <http://www.geography.ryerson.ca/jmaurer/716art/716Climatechg malaria.pdf> (last visited Mar. 23, 2008); Jonathan Patz & Sarah Olson, *Malaria Risk and Temperature: Influences from Global Climate Change and Local Land Use Practices*, 103 *PROCEED. NAT'L ACAD. SCI.* 15:5635–36 (2006).

⁵⁸ Numbers taken from Table 3.1 of the *Stern Review on the Economics of Climate Change* (a/k/a the Stern Report), Part II, at 57, <http://sapiens.revues.org/index240.html> (last visited Mar. 23, 2008).

⁵⁹ Epstein, *supra* note 56.

⁶⁰ Marilyn Werber Serafini, *Rapidly Spreading Threats* (National Journal Group Inc., July 6, 2007), <http://news.nationaljournal.com/articles/climate/disease.htm> (last visited Mar. 2, 2008).

⁶¹ See David Morens & Anthony Fauci, *Dengue and Hemorrhagic Fever: A Potential Threat to Public Health in the United States* 299 *J. AM. MED. ASS'N* 2:214–16 (2008). See also Joan M. Brunkard et al., *Dengue Fever Seroprevalence and Risk Factors, Texas-Mexical Border*, 13 *EMERGING INFECTIOUS DISEASES* 10 (2004), available at <http://www.cdc.gov/eid/content/13/10/1477.htm> (last visited Mar. 21, 2008).

J. Heat, Drought and Fire

At the opposite extreme of altered rainfall patterns and droughts, forest fires have been and will continue to be increasing in intensity and frequency in the U.S. and around the world. The costs associated with wild fires are often underappreciated but include both short- and long-term health impacts, large releases of carbon dioxide further contributing to global warming, the financial costs of population evacuation, response and material losses, and long lasting secondary effects such as those associated with soil erosion, landslides and flooding⁶² and again as in so many other climate related challenges, the mental health problems resulting from the associated uncertainty, fear and loss.

According to University of Arizona researchers, “almost seven times more forested federal land burned during the 1987-2003 period than during the prior 17 years.”⁶³ The U.S. fire season steadily increased by 78 days over the past 20 years—tied closely to increased temperatures and earlier snow melt.⁶⁴ Over the four years from 2003–07, seven million acres of forests burned in the National Forest System each year at a cost of \$1.3 billion. The fire in California during the fall of 2007 cost nine lives, destroyed over 2000 homes and 500,000 acres of trees.⁶⁵ Finally, during the summer 2008, officials noted that the California fire season is now year round.⁶⁶ Global warming is predicted to cause even more frequent and more severe forest fires in the U.S. West. The expanding loss of protective and mitigative ground cover only contributes to the further unraveling of the climate.

K. Agriculture Food Production–Famine/Malnutrition

As the climate changes, populations grow, and competition for shrinking fresh water resources increases, serious concerns about their impacts on agricultural productivity are felt around the world. Just as rising temperatures, changing rainfall patterns and extreme weather events adversely affect individuals through all the mechanisms noted above, food sources too are impacted by these and still other mechanisms related to inequitable global trade regimes. All food crops are sensitive to drought, floods, temperature, and changing plant and insect pests. Drought brings loss of crop land and increased fires; irrigation becomes more difficult and more costly. Floods and storms destroy crops. Some export crops such as coffee or cocoa are very temperature specific. Other crops like grapes, orchards and potatoes can be quite temperature sensitive.

For any of the changes predicted, the most devastating effects will occur in countries that cannot afford the new or different seed stocks for their staple crops like wheat, rice or corn required by the altered climate. The UN Food and Agriculture Organization (FAO) estimated in 2007 that 854 million people around the world already suffer from hunger and malnutrition. Most of these hungry people live in rural areas of developing countries facing increased crop failures and loss of livestock. Fishery dependent and forest dependent peoples are likewise highly vulnerable to diminishing

⁶² Crystal Davis, *Climate Change Increasing Intensity, Extent of Wildfire* (World Resources Institute: EarthTrends Environmental Information, June 1, 2007), <http://earthtrends.wri.org/updates/node/203> (last visited Feb. 17, 2008).

⁶³ University of Arizona, “More Large Forest Fires Linked To Climate Change,” ScienceDaily, July 10, 2006, <http://www.sciencedaily.com/releases/2006/07/060710084004.htm> (last visited Feb. 17, 2008).

⁶⁴ A.L. Westerling et al., “Warming and Earlier Spring Increases Western U.S. Forest Wildfire Activity,” Scienceexpress, July 6, 2006, <http://www.sciencemag.org/cgi/rapidpdf/1128834v1.pdf> (last visited Feb. 17, 2008).

⁶⁵ Scott Pelley, “The Age of Mega-Fires,” CBS News online (updated Dec. 30, 2007), <http://www.cbsnews.com/stories/2007/10/18/60minutes/main3380176.shtml> (last visited Feb. 17, 2008).

⁶⁶ Michael Gardner, *Drought Growth Making Blazes Year-round Threat* (July 6, 2008), <http://www.signonsandiego.com/news/state/20080706-9999-1n6fireredy.html> (last visited Aug. 8, 2008).

sources of food. Food security is not only challenged directly by the changing climate, but also by the competition induced by the rapidly growing biofuels industry.⁶⁷

With rising temperatures and CO₂, there may be a small increase in agricultural productivity in more northern latitudes benefitting many US farmers,⁶⁸ but the sum impact is predicted to be decreased productivity on a global scale. Crop yields could increase as much as 20 percent in East and Southeast Asia, but they may simultaneously decrease up to 30 percent in Central and South Asia by the mid-21st century. The fate of rice is of critical significance since it is the staple grain for a large portion of the global population. Yields fall by 10 percent for every 1°C rise in night-time temperature. But, as noted earlier for other crops, elevated CO₂ levels may augment growth and offset the challenge of rising temperatures to some extent. The final outcome of these two contrary trends on global rice yields is yet to be determined.⁶⁹ When rice is a country's leading source of food or cash, the loss of suitable areas for growth with a 2°C temperature rise could potentially be devastating for global food supplies, and significantly contribute to the growing number of impoverished and hungry rural populations.

For some food insecure African and Near Eastern countries⁷⁰ where people already face high rates of hunger and malnutrition, yields from rain-fed agriculture could be reduced by as much as 50 percent by 2020. If as many scientists now believe will occur, a rise of 4°C is reached by 2100, droughts would be felt across Africa, with a consequent fall in harvests of 15 percent to 35 percent and global crop yields falling 10 percent.⁷¹ The worst affected areas are projected to be Southern Africa and South Asia, home to large numbers of already hungry and malnourished people.⁷² Wide spread hunger and malnutrition contribute to weakness, and loss of productivity as well as a long list of otherwise easily preventable diseases and disabling health conditions.

Finally, if the outbreaks of violent conflict already associated with competition for control over scarce resources, including water and productive farm land, and camp life in other refugee situations are indicators, the environmental refugees to be displaced by or otherwise impacted by the many manifestations of climate and environmental changes outlined, could result in rapidly and massively increasing global violence. Britain's foreign secretary highlighted the threat of climate change to the UN security council saying, "[i]n climate change we have a new and potentially disastrous dynamic . . ." He goes on to assert that it was an underlying factor in the Darfur crisis with the potential to escalate many other existing conflicts.⁷³ The areas most likely to feel the worst effects of the changing climate are already unstable

⁶⁷ See Christopher Matthews, "Rome UN Agencies Urge Immediate Climate Action to Avert Hunger: FAO Director-General announces High-Level Conference," FAONewsroom Online, <http://www.fao.org/newsroom/en/news/2007/1000731/index.html> (last visited Mar. 22, 2008). See also detailed discussion in LESTER BROWN, PLAN B 2.0 RESCUING A PLANET UNDER STRESS AND A CIVILIZATION IN TROUBLE (2006); Arjun Makhijani, "Carbon Free and Nuclear-Free: A Roadmap for U.S. Energy Policy," Institute for Energy and Environmental Research (IEER) Press (2007), at 45–50 & 58–59.

⁶⁸ National Assessment Synthesis Team, U.S. Global Change Research Program, *Climate Change Impacts on the United States: The Potential Consequences Of Climate Variability and Change* (first published 2000, updated Oct. 12, 2003), <http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overviewagriculture.htm> (last visited Mar. 22, 2008).

⁶⁹ "Coping with Climate Change," *Rice Today*—Newsletter of International Rice Research Institute (July–Sept. 2007), available at <http://www.irri.org/publications/today/pdfs/6-3/10-15.pdf> (last visited Mar. 23, 2008).

⁷⁰ "Agriculture in the Near East Likely to Suffer from Climate Change," FAO Press Release, Mar. 3, 2008, <http://www.fao.org/newsroom/en/news/2008/1000800/index.html> (last visited Mar. 24, 2008).

⁷¹ Ian Sample, Global Meltdown: Scientists Isolate Areas Most at Risk of Climate Change, UK Guardian Online, Feb. 5, 2008, <http://www.guardian.co.uk/environment/2008/feb/05/climatechange?gusrc=rss&feed=environment> (last visited Mar. 19, 2008).

⁷² David Lobell et al., *Prioritizing Climate Change Adaptation Needs for Food Security in 2030* 319 SCIENCE 5863:607–10 (Feb. 2008), <http://www.sciencemag.org/cgi/content/abstract/319/5863/607> (last visited Mar. 22, 2008).

⁷³ John Vidal, "Climate Change to Force Mass Migration," UK Guardian Online, May 14, 2007, <http://www.guardian.co.uk/environment/2007/may/14/climatechange.climatechangeenvironment> (last visited Mar. 18, 2008).

and environmentally degraded, thus they have the least ability to adapt to an ever increasing loss of social cohesion, altered availability of adequate food sources, and competition over other scarce and shrinking resources.⁷⁴

L. Special Circumstances—Special Risks for Special People

As implied throughout this report, everywhere in the world some people face even greater risks from the environment and changing climate related extreme weather events. Everywhere these special people tend to be the youngest children and infants, the elders, the disabled, chronically ill, the women and those who inhabit the most geographically fragile areas.

1. Women and Children First

Disasters are particularly deadly to women. Around the world women's social status means they lack mobility and access to resources, are more susceptible to physical danger, occupy a more tenuous position in society, and have substantial care giver responsibilities. Oxfam International, International Medical Corps and the 2007 Red Cross World Disasters report each indicate that after the Indian Ocean tsunami, three times more women than men died in some affected areas.⁷⁵ Soroptimists report even higher disproportionate rates of death for women and children in natural disasters.⁷⁶ Women must not only deal with the trauma of the given disaster itself, but violence against women and rape of those displaced from their homes also rises sharply after disasters. A 2006 post Hurricane Katrina survey found that the rape rate after the disaster was 54 times higher than the baseline rate for the state of Mississippi.

Similarly, children are more sensitive to harm because of their dependent position, physical and cognitive immaturity, developing lungs and outdoor play. Small children are at increased risk of death and injury from all extreme weather events. The vector borne and water borne diseases described are particularly deadly to young children around the world—especially if they are also malnourished. Childhood exposure to air borne allergens, particulates, and air pollutants described earlier, leads to increased infections, asthma, and premature mortality due to decreased lung growth and permanent reduction in pulmonary function.⁷⁷ Around the world rates of asthma in children are increasing rapidly.

Also, because of their dependent position and lack of understanding, children experience and show unique signs of mental distress in disaster situations, with some reported to become very aggressive after floods. Children between 2–9 have been found to experience changes in behavior and bed wetting, or show other signs of distress.

2. Elders, Chronically Ill, Disabled, Mental Illness

As mentioned in many of the reports cited here, and in CDC and WHO summary reports on climate change, for any given disaster, dependent elders, the disabled, and chronically ill represent a higher proportion of those left behind, dying or injured. Given the increasing likelihood of new vector borne diseases and deadly heat waves, elders

⁷⁴ See several references on the website of International Alert, including the report by Dan Smith & Janani Vivekananda, *A Climate of Conflict: The Links Between Climate Change, Peace, and War* (Nov. 2007), <http://www.developmentgateway.com.au/jahia/Jahia/pid/5984> (last visited Mar. 10, 2008). See also comments from FAO Press Release 3, *supra* note 70; Christian Aid Report 2007, *supra* note 5.

⁷⁵ 2007 World Disasters Report, *supra* note 18.

⁷⁶ Soroptimist White Paper: Reaching Out to Women When Disaster Strikes (no publication date provided, but contents imply early 2007), http://www.soroptimist.org/whitepapers/wp_disaster.html (last visited (Mar. 24, 2008).

⁷⁷ Katherine Shea & Sophie Balk, *Climate Change and Children's Health: What Health Professionals Need to Know and What we Can Do About It* (Institute for the Environment, UNC Chapel Hill, 2007), <http://www.healthandenvironment.org/?module=uploads&func=download&fileId=418>.

and chronically ill will not fare well for a variety of economic and social, as well as physical reasons. With aging comes a natural diminishment in immune responses, the body's ability to control internal temperature, as well as the likelihood of medications that decrease the body's ability to adapt. For many elders, reduced economic security is also a challenge to taking needed health protective steps. The disabled, chronically ill, and many elders may become social isolates and be out of touch with the social networks that help develop adaptive strategies for climate associated challenges.

Similarly, while hundreds of millions of poor people around the world face hunger and malnutrition in the wake of climate change, the risk is not uniform, even among the impoverished. According to the WHO, the number of people dying from malnutrition in poorer countries is more than 50 percent higher among the over-60s than in children under 14. Elders and the disabled anywhere experience functional limitations to food procurement, preparation, and unique nutrient-energy needs. Even in the U.S., impoverished elders face more food insecurity than younger cohorts.⁷⁸

3. Circumpolar Peoples

Rising temperatures have already decreased the amount of the ocean that is covered by ice in 2007 to the lowest amount ever recorded. Depending on the model cited, the Greenland ice cap and other Arctic glaciers could disappear in summers by 2060–2100 with the resulting rise in ocean levels causing flooding at ocean coasts all over the world, as described earlier. All this bodes particularly dire consequences for the health and well-being of all the peoples of the circumpolar region which is home to almost 4 million.⁷⁹

The Arctic, with an approximate area of 7 million sq. km (i.e. 13 times larger than France), is home to a variety of indigenous peoples like Saami, Inuits, the Dene, the Chukchi, and Aleutians as well as a variety of Canadians and Europeans from Scandinavia, Siberia, and Greenland. Greenland, with a population of 56,648 (Jan. 2007), is the world's largest non-continental island, almost all of which is an ice sheet 3 km thick,⁸⁰ estimated at about 30 percent higher than any earlier generation.

4. Bangladesh, Vietnam, Other Deltaic and Island Nations

Situated in the low-lying Ganges River delta, Bangladesh is expected to be one of the worst climate change affected nations. With a population of between 140–150 million living on a land mass the size of Iowa, it is the most densely populated country on earth. Bangladesh is home to some of the poorest people in the world over 40 percent of whom earn less than \$1 U.S. per day. The impacts of climate change will only exacerbate the problems already facing this impoverished nation.

The threats Bangladeshi face include sea level rise (one fifth of the country is low-lying coastal zones), droughts, floods, cyclones and salt water intrusion—all of which will drastically affect crop productivity and food security in an already fragile situation. Given the lack of attention to the seriousness of the threat, approximately 130,000 people were killed in the cyclone of April 1990 and many thousands more have perished since in less intense storms. The most recent cyclone, Sidr, struck Bangladesh on 15 November 2007, bringing torrential rain and winds of up to 240 km per hour.

⁷⁸ Hunger Issue Brief, *Hunger and Food Insecurity Among the Elderly* (Center on Hunger and Poverty, Brandeis University) (Feb. 2003), <http://www.centeronhunger.org/pdf/Elderly.pdf> (last visited Mar. 24, 2008).

⁷⁹ Arctic Climate Impact Assessment, "Overview: Impacts of a Warming Arctic" (from larger report published in 2004), <http://www.amap.no/acia/index.html> (last visited Feb. 23, 2008).

⁸⁰ See Statistics Greenland, <http://www.stat.gl/>, together with an earlier 2002 report titled "Comparative Statistics for the Circumpolar Region," <http://inchr.com/Doc/February05/chapter%252023.pdf>; Henry Huntington et al., "The Changing Arctic: Indigenous Perspectives," *ACIA Scientific Report* 63 (2005), http://www.acia.uaf.edu/PDFs/ACIA_Science_Chapters_Final/ACIA_Ch03_Final.pdf (both of the foregoing last visited Feb. 23, 2008).

More than 8.7 million people were affected and 31 out of 64 districts in the south and southwest of the country devastated by the torrential rains and winds. Crop damage affected over 2.2 million acres; and 2,400 educational institutions were destroyed. As of 7 December, 3,328 deaths were reported, 871 people remained missing and 52,810 injured.⁸¹

Dr. Mujibur Rahman, Director of a local disaster response NGO, adds that after sea levels rise, salt water intrusion into the ground water will become a major problem. Dr. Atik Rahman of the Bangladesh Centre for Advanced Studies, noted that fields up to 40km from the new coastline were already rendered useless for growing crops back in 2004 due to the encroaching sea. Given the multitude of threats to be visited upon those who have done so little to produce the problem, he even goes so far as to refer to this horrific situation as “climate genocide.”⁸²

Bangladesh emits less than 0.1 percent of global greenhouse gas emissions compared to 24 percent for the United States which underscores the ultimate unfairness of its precarious position. Many have no electricity and use candles for light. Most Bangladeshis get about by walking, biking or in a boat powered by a single oar at the stern. Nevertheless it is taking steps to reduce its future emissions through the development of renewable energy and other efforts at mitigation. Together with other severely threatened least developed nations, Bangladesh needs to play a still more important role in international negotiations on climate change and demand appropriate attention to its precarious position.

Like Bangladesh, the populations of the small island nations are among the least responsible for climate change. However, they too face many of the same challenges, to health and survival as those being faced by the people of Bangladesh. Given the limitations of this CLI Background Paper, the reader is referred to the Background Papers to the UNFCCC for details on the situations faced by populations of the Small Island Developing States (SIDS).

Conclusions and Recommendations

1. Conclusions

The evidence of increasingly catastrophic harms to global health in the wake of climate change is overwhelming. The systems adversely affected by climate change, human, physical, biologic and hydrologic, are vast, varied, and cross all borders. Despite all the evidence, Kyoto, Al Gore, and valiant efforts by many individuals to reduce consumption globally, green house gases continue to increase.⁸³ Already there are very real victims, and the number grows as the climate heats up. The magnitude of destruction and adverse health impacts of each interrelated challenge noted in this report depends on the rate and degree of global warming moving forward, which in turn depends directly on actions taken or not taken by the global community in the immediate future.

Ensuring environmental health means everyone must work together within their training and capacity to reduce green house gases. Halting global warming is the only long-term cure. Continuing down the path of the status quo by expanding the sources or use of high carbon based fossil fuels, pursuing more oil drilling, coal fired power plants,

⁸¹ See *Comprehensive Disaster Management Programme of the Bangladesh Government* on the website of the UN Office for the Coordination of Humanitarian Affairs, at <http://ochaonline.un.org/News/Emergencies/Bangladesh/tabid/2707/Default.aspx> (last visited Mar. 24, 2008).

⁸² Roland Buerk, “Flooded Future Looms for Bangladesh,” BBC News Online, Dec. 7, 2004, <http://news.bbc.co.uk/1/hi/sci/tech/4056755.stm> (last visited Feb. 24, 2008); *NGO Forum Stands Beside the Survivors*, on the website of NGO Forum for Drinking Water Supply and Sanitation, <http://www.ngoforum-bd.org/news.htm> (last visited Mar. 24, 2008).

⁸³ As reported by the World Watch Institute (Aug. 7, 2008), in LA Times, Sept. 26, 2008, and elsewhere, http://www.worldwatch.org/node/5839?utm_campaign=vitalsigns_online&utm_medium=email&utm_source=carbon_emissions#toc and <http://www.latimes.com/news/science/environment/la-na-warming26-2008sep26,0,6690604.story> (last visited Oct. 6, 2008).

resource wars, and energy, chemical, and greenhouse gas intensive industrial agriculture, is to move ahead to public health, economic and environmental disaster, in essence, collective suicide.

The changing climate and all that it implies is poised to markedly exacerbate and enlarge existing inequities in exposure to environmental pollutants and access to life supporting infrastructure. As illustrated throughout this CLI Background Paper, global warming is a complex phenomenon with differential impacts on the rich and empowered versus on social isolates, the poor and marginalized, on those living on rural farmland or in crowded congested urban areas, on stronger and weaker members of the human family everywhere because of circumstances existing before and well beyond the reach of the climate. Already the health of over two billion people is compromised because of lack of access to safe water and adequate sanitation systems. Already tens of millions live displaced and huddled in crowded, pest and violence infested refugee camps because of violent conflict and various environmental disasters; over 33 million in our human community are living with AIDS but only 28 percent of them receive life saving therapies,⁸⁴ 218 million children still labor as virtual slaves in dangerous and exploitive situations,⁸⁵ and at least 72 million children still lack access to even basic education.⁸⁶ The lives and circumstances of each of those who already face nearly insurmountable obstacles to healthy or fulfilling lives will only be made worse as our climate changes and life supporting environment degrades. As world leaders struggle to find solutions to existing hardships, the ranks of the poor and marginalized are likely to swell rapidly and produce spill over effects on the rest of the world's population. If the global community does not quickly change course to prioritize health and well being over unsustainable material consumption, our global social fabric may unravel. The quality of the future will depend on how effectively the international community rises to the challenge of reducing poor people's vulnerability to drought and water scarcity, storms, floods and sea-level rise, and implements strong disaster-response strategies. In other words, our future depends on the degree to which the world will focus not only on reducing green house gases, but on climate justice.

Regardless of the inequity of initial impacts, wealthier nations with their more robust health care, social and physical infrastructures will not be immune to the direct and indirect effects of climate change. Wealthy populations too will endure great suffering associated with heat waves, flooding, extreme weather events, changes in agricultural productivity, diversion of their economies, and increasing violence. There is no magical Shangri-la or shelter. People either work together for common survival or suffer the consequences together—sooner or a little later. No one is immune to the effects of climate change already set in motion, but neither is anyone impotent to do something to turn this behemoth around—everyone can and must take measures to reduce greenhouse gas pollution.

Medical and public health workers must immediately begin to advocate for the development of adaptive, protective measures to prevent the worst health outcomes while at the same time supporting others in their efforts to mitigate climate changes. To effectively respond to and prevent the most devastating impacts of climate change, the role and centrality of public health and its functions must be much more visible. Decision makers and community leaders need to be better informed about the connections between social organization, life styles and consumption patterns, and the health of populations, the environment and climate. Strengthened and enhanced public health systems will contribute to a lessening of the threat inequities faced by the marginalized and impoverished while others concentrate on

⁸⁴ Worldwide HIV & AIDS Statistics, as of the end of 2007, <http://www.avert.org/worldstats.htm> (last visited Mar. 3, 2008).

⁸⁵ See ILO, International Programme on the Elimination of Child Labor (IPEC) Report, *IPEC Action against Child Labour 2006-2007: Progress and Future Priorities* (Feb. 2008), available at <http://www.ilo.org/ipecinfor/product/viewProduct.do?productId=7650> (last visited Mar. 3, 2008). For extensive treatment of child labor from a human rights perspective, see CHILD LABOR AND HUMAN RIGHTS: MAKING CHILDREN MATTER (Burns H. Weston ed. & contrib., 2005).

⁸⁶ See UNESCO 2008 Report, *Education for All: Will We Make It?*, <http://unesdoc.unesco.org/images/0015/001547/154743e.pdf> (last visited Mar. 3, 2008).

climate mitigation efforts, on developing and deploying alternative sources of energy and sustainable social infrastructure. Prioritizing the function of public health to address climate change is a win-win situation for all.

Public health practice dictates first responding to end immediate suffering. But responses must be about more than applying Band-Aids. While promoting preparedness, world leaders must simultaneously go to root causes and address them. Obviously, large investments in disaster response and risk reduction are urgently needed. Simultaneous efforts to redesign global energy sources and mitigate existing green house gas loads, capacity building for local public and medical health infrastructure as well as civil physical infrastructure are all required to save lives and property in the near future. Locally and regionally, it will be necessary to check and reinforce dams, levees, bridges and culverts for safety. Governments everywhere have to strengthen and enforce development rules to better protect people and homes from wild fires or flooding; consider elevating and/or buying out properties already impacted by fires or flooding rather than rebuilding in vulnerable areas; increase protection for wetlands, forests and other natural habitats that will not only significantly reduce disaster risks but simultaneously contribute to stabilizing green house gases.

Beyond these most basic and essential “must dos,” as climate changes already set in motion advance, a host of related policies and actions are required to protect global health. Each needs financial and political support and integration within a framework that includes many additional public and private actors. For example, hospitals and allied public health facilities need to be made safe from disasters by ensuring all new hospitals are built with a level of resilience that strengthens their capacity to remain functional in disaster situations. At the same time, to improve preparedness for epidemics of infectious diseases—whether or not related to climate change, there is need for the establishment and support of a globally integrated, and responsive, climate-based early warning system for infectious diseases.⁸⁷ This in turn requires strong national public health systems and capacity and an effective, and respected international system for coordinated response.

Public Health workers must be included and collaborate in coalitions and partnerships with other vital human services and activities responding to climate threats. Health challenges associated with climate change emerge from its many impacts on the full compendium of human activity. The effectiveness of any given intervention depends on addressing public health perspectives and concerns in tandem with those of other stakeholders responding to climate change. Interventions for either mitigation of or adaption to, climate change, including those pursued within agricultural, business, educational, urban and rural planning, and energy sectors, among others, must all address and include the concerns of public health.

At the same time, the world cannot afford to ignore the challenges posed by the inadvertent release of toxic chemicals during extreme weather events. The potential health risks posed by inadvertent releases of dangerous chemicals and interactions with the changing climate must be addressed—this risk is far more real and pervasive than any potential chemical or biological attack by a terrorist. A precautionary approach to the development, use and management of new chemicals must be prepared; green chemistry promoted. Adequate information, training and application of new chemicals, in new locations, or for new applications; and at all stages of the life cycle, must be made to operate within a context of transparency, partnership and accountability among and for all sectors of society.

Lastly, climate change makes it even more important to combat diseases of the poor, many of which are highly climate-sensitive, and always risk spreading into the general population.⁸⁸ Social factors like literacy and life expectancy may influence vulnerability more profoundly than hurricane frequency or intensity. Many, especially those working on

⁸⁷ For details, see WHO, *Using Climate to Predict Disease Outbreaks: A Review for Such A System*, <http://www.who.int/globalchange/publications/oeh0401/en/index.html>.

⁸⁸ Jonathan Patz et al., *Impact of Regional Climate Change on Human Health*, 438 NATURE 310–17 (2005).

the international stage and committed to the Millennium Development Goals, would agree that to effectively manage climate related risk especially in the most vulnerable regions and countries, do it primarily through human and social development.

None of these tasks is simple, none is cheap, but safe guarding the health and life sustaining elements of the shared environment must be made the highest social, political and economic priority. After all, humanity has only this one planet. As this CLI Background Paper outlines, there are many steps that individuals, public health professionals, local, state, federal and international policymakers working together, can take to protect citizens and reduce the risk of the worst outcomes from climate change. Taking these actions now will bring about not only a more manageable, but a more just, healthy and sustainable future for all.

2. Specific Recommendations for Public Health: Preventing Adverse Health Outcomes

The systems adversely affected by climate change, human, physical, biologic and hydrologic, are vast, varied, and cross all borders. While children, the elderly, poor and those with chronic conditions are most vulnerable, health risks related to climate changes are inescapable and will be experienced to a greater or lesser degree by all. The range and severity of current and future climate change related health impacts far exceeds the capacity of effective individual level response. A primary role of all governments is to assure the conditions in which people can be healthy, thus a number of important recommendations for public health systems are suggested.

1. Public health system functions around the world must be prioritized, supported, enhanced, and interconnected

Public health infrastructure and interventions are vitally important to prevent unnecessary and excess injury, death or disability from the broad range of climate change health risks identified. Essential public health personnel, programs and services including disease and injury prevention, surveillance, monitoring, identification, preparedness, and investigation of public health threats, and evaluation for intervention effectiveness and accessibility must all be supported and enhanced at all levels of social organization from local, to regional, national and international.

2. Public health workers must be included and collaborate in coalitions and partnerships with other vital human services and activities responding to climate threats

Health challenges associated with climate change emerge from its many impacts on the full compendium of human activity. The effectiveness of any given intervention depends on addressing public health perspectives and concerns in tandem with those of other stakeholders responding to climate change. Interventions for either mitigation of or adaption to, climate change, including those pursued within agricultural, business, educational, urban and rural planning, and energy sectors, among others, must all address and include the concerns of public health.

3. Healthy behaviors must be promoted at the level of the individual that also positively impact the climate

Public health systems will be frontline responders in emergencies, however, they also have a key role in educating and empowering the public to make the personal changes required to mitigate climate change. There are several obvious examples. Encouraging people to walk, bike, or use public transportation positively impacts individual health as well as that of the climate—such endeavors can be supported by community design that reduces reliance on cars. Similarly, encouraging people to eat less meat will have salutary impacts on land use, the need for fossil fuel based agricultural products, and the production of methane from animals and manure as well as improved cardiovascular health.

4. Public health systems must be designed with the flexibility, resiliency and redundancy necessary to respond to specific threats faced in specific locales

Each locale faces different threats depending on geography, population density, water resources, and social and political organization. Systems must be designed to reflect and respond to these differences. For example, more Northern communities may face increased threat from heat waves and thus require heat wave response plans, while other areas face threats related to either excessive water, i.e., flooding, or droughts, diminished water and food availability. Simultaneously, the chaotic and unpredictable nature of extreme weather events means demands for response or service may originate elsewhere outside the usual service area at any time. Redundancy for surge capacity must be built into each system.

To effectively respond to or prevent the potentially devastating impacts of climate change, the role and centrality of Public Health must be much more visible. Decision makers and community leaders need to be better informed about the connections between social organization, life styles and consumption patterns and the health of populations, the environment and climate. Strengthened and enhanced public health systems can not only help mitigate and adapt to climate changes but also contribute to the co-benefit of lessening the threat inequities faced by the marginalized and impoverished. Prioritizing the function of public health to address climate change is a win-win situation for all.