

Climate Change and Health Preparedness in India: Protecting Local Communities in Ahmedabad, Gujarat from Extreme Heat

Summary Report from 2011 Kickoff Workshop on Climate Change: Heat and Health, Addressing Vulnerability



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ABOUT THIS REPORT

About Public Health Foundation of India

The Public Health Foundation of India (PHFI) is a public-private partnership structured as an independent foundation. PHFI is the hub of teaching, research, sharing knowledge and experiences in areas at the cutting-edge of public health in India. PHFI has launched four institutes of public health, including IIPH-Gandhinagar. <http://www.phfi.org/>

About Indian Institute of Public Health, Gandhinagar

The Indian Institute of Public Health, Gandhinagar (IIPH) is a leader on public health education, advocacy and research on public health. IIPH pushes the mandate of equity in public health, applying strategy, resources and networks to the issues and practice of public health in India. IIPH's programs aim to make education and research activities relevant to India in content and context.

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The Natural Resources Defense Council (NRDC) is one of the most effective environmental groups, combining 1.3 million members and online activists with the expertise of more than 350 scientists and other professionals. NRDC is a leader in public health research, policy, and advocacy—including building resilience in local communities and fighting climate change. In 2009, we launched our India Initiative focused on climate change and clean energy with projects on climate adaptation and energy efficiency. With our partners, we advocate for increased policy development and implementation to protect communities from environmental threats. <http://www.nrdc.org/> and <http://www.nrdc.org/international/india/>.

Acknowledgments

The authors would like to thank the Government of Gujarat and Ahmedabad Municipal Corporation for their partnership and support to realize the goals of this report. We would also like to thank the Indo-U.S. Science and Technology Forum (IUSSTF) for supporting the March 2011 Kickoff Workshop on heat health vulnerability in Ahmedabad, Gujarat, which has launched a series of exciting new scientific research focused on climate adaptation. Additionally, we would like to thank Cindy and Alan Horn for their support of NRDC's Global Warming and Health Project. Finally, we would like to thank the speakers and participants from the March 2011 Kickoff Workshop, whose contributions informed this report, including: Meteorological Centre of Ahmedabad, India Health Ministry, Department of Health, Dr. Shrawan Kumar Acharya, Dr. Rais Akhtar, Dr. Gulrez Shah Azhar, Dr. D.V. Bala, Mihir Bhatt, Sabina Bindra Barnes, Mirai Chatterjee, Dr. S. K. Dash, Dr. Paresh Dave, Dr. Paul English, Dr. Kristie L. Ebi, Dr. Manish Fancy, Dr. Amit Garg, Dr. J.D. Gajjar, Dr. I.P. Gautam, Radha Goyal, Dr. Rajiv Kumar Gupta, Shyamashree Das Gupta, Dr. Sharon L. Harlan, Dr. Jeremy Hess, Dr. Zakir Hussain, Anjali Jaiswal, Dr. Kim Knowlton, V.K. Kohli, Dr. S. P. Kulkarni, Prof. Dileep Mavalankar, Anjali Nag, P.K. Nag, Dr. Nimish Pandya, Dr. Prem Pangotra, Puja Parekh, Dr. Suresh Patel, Dr. K. J. Ramesh, Dr. Aiyagiri Rao, Dr. Kamaljit Ray, Dr. K. Srinath Reddy, Shravya Reddy, Dr. Karthikey Sarabhai, Professor Jay Satia, Dr. Asha Shah, Dr. Anju Sharma, Pramod Kumar Sharma, Dr. Perry Sheffield, Dr. Archana Singh, Ridhima Sud, Dr. Sunandan Tiwari, Dr. Atul Trivedi, Kathy Van Tran, and Dr. Vidhya Venugopal. We would also like to thank Gretchen Gordon, Avinash Kar, Miriam Rotkin-Ellman, and Mayu Sasaki for their assistance in preparing this report.

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COVER PHOTO: AHMEDABAD COMMUNITY MEMBERS, AUGUST 2011; CREDIT: KATHY TRAN/DR. GULREZ AZHAR

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I. EXECUTIVE SUMMARY

Current efforts to address global warming largely focus on mitigating climate change. However, in light of predictions of increased temperatures, rising sea levels, and changing disease patterns in India, there is a pressing need for increased scientific research and strategies on climate adaptation, focused on public health for the most vulnerable populations. Extreme heat already threatens the health of local communities, who suffer dehydration, heat cramps, heat exhaustion, heat syncope or heat stroke, and even heat-related death. Climate change will only intensify extreme heat events.

Ahmedabad, one of the top 10 fastest-growing cities in India, experiences dangerously high daily temperatures for several months out of the year. Recently, the city experienced its harshest heat wave season, with four months of extreme temperatures, including a peak temperature of 116° Fahrenheit (46.8° Celsius) in May 2010. Although national programs exist to address many effects of climate change in India, the country has yet to implement strategies to adapt to the extreme effects of increasing heat.

In response, the Public Health Foundation of India (PHFI) and the Indian Institute of Public Health, Gandhinagar (IIPH) along with the Natural Resources Defense Council (NRDC) are working with city officials and leaders in Ahmedabad to protect people from the city's extreme heat exacerbated by climate change. The project's priority is to promote improved health by implementing interventions that can help reduce heat related health vulnerabilities, designing an early warning system for dangerous heat events, and developing targeted climate change adaptation strategies.

In 2011, PHFI, IIPH, and NRDC brought together leading experts from India and the United States to kickoff discussions to develop heat-adaptation strategies in Ahmedabad. More than 40 expert scientists, municipal and state administrators, and health officials collaborated to develop recommendations addressing heat-health vulnerability, including:

1. Researching impacts of heat stress, community resources, and existing heat-coping measures through in-depth discussions with four groups: vulnerable people living in slums, workers in high-risk occupations, city department staff, and health care providers; and then analyzing data on local temperatures and corresponding deaths.
2. Identifying the most vulnerable populations in Ahmedabad through surveys assessing current heat awareness and susceptibility and distributing an informational pamphlet on reducing extreme heat's health risks to families with young children and the elderly.
3. Developing an actionable early warning system in Ahmedabad and integrating it into a local climate change preparedness plan to warn the population of impending extreme heat events.
4. Targeting heat-risk-reduction outreach to the most heat-vulnerable groups, including young children, elders, people with heart or lung illnesses, families living in poverty, and workers in high-risk occupations.
5. Conducting best-practices workshops with Ahmedabad

city departments, medical providers, workers in high-risk occupations, and community leaders to implement extreme heat strategies, build local capacity, and improve internal information sharing and communication.

Following those discussions, NRDC and IIPH collaborated with Emory University's School of Public Health in the summer of 2011 to conduct Ahmedabad's first heat vulnerability assessment survey. The in-depth survey assessed 12 slums on household member health history, heat-exposure adaptation, heat-stress knowledge, and access to resources.

As a result of PHFI's, IIPH's, and NRDC's communication with the Ahmedabad Municipal Corporation (AMC), Gujarat officials are now developing a climate change state action plan, and specifically, accelerating efforts to protect communities from extreme heat. Also, local officials announced plans to install several new weather gauges. The new temperature gauges will enable local government to examine historical weather trends, determine high-risk areas, and warn local communities about impending heat waves, which is critical to protecting the most vulnerable residents from heat exhaustion, heat stroke, and heat-related deaths.

In 2012, we—along with partners, local government, and civil society—will continue development of an early warning system and a climate change preparedness plan for Ahmedabad. This ongoing research and intensive outreach regarding the importance of heat adaptation has the potential to save lives from the increasingly severe effects of climate change.

GUIDE TO REPORT

PHFI, IIPH, and NRDC have partnered to identify and address climate-related health concerns in India. As part of our partnership with the state of Gujarat and the city of Ahmedabad, PHFI, IIPH and NRDC hosted a kickoff workshop in 2011. During the workshop, public health experts, scientists, policy makers, government officials, and local stakeholders from India and the United States shared their research and knowledge on heat stress and vulnerability and discussed methods to create heat-related interventions in Ahmedabad. The workshop resulted in a rich discussion of ideas and strategies that form the basis of this report, which includes both the policy discussion and the technical discussion.

This report provides the basic structure and elements of an effective heat vulnerability assessment, as tailored to the city of Ahmedabad, and identifies challenges and opportunities unique to Ahmedabad's municipal and health care sectors that may be adapted to other similarly-situated communities that are suffering the effects of extreme heat and have limited economic resources. It endeavors to provide a roadmap for other communities to conduct their own vulnerability assessments, tailor heat preparedness programs to protect their residents, and adapt to an increasingly hot climate.

II. EXTREME HEAT IN INDIA'S CITIES: A HEALTH ISSUE OF RISING CONCERN

A. CLIMATE CHANGE AND HEAT HEALTH VULNERABILITY IN AHMEDABAD, INDIA

The Health Effects of Rising Temperatures in India

(Highlights from Dr. Srinath Reddy's Presentation)¹

A direct relationship exists between increased temperatures and increased mortality and morbidity caused by heat stress. Evidence of this relationship can be seen throughout India, where hot temperatures are rising to extreme levels—climate change being a contributing factor—causing increased mortality and morbidity in India. Average temperatures are projected to increase by 5°C for all regions of the Indian subcontinent by 2100.² The frequency and duration of heat waves are also projected to intensify, according to global climate models.³ Clearly, these predictions are alarming as warming temperatures and variable precipitation can lead to drought, disease, floods, famine, extreme heat, and humidity, causing widespread fatalities.⁴

Extreme heat, heat waves, and drought also cause other severe direct and indirect health effects, including:

- malnutrition
- a decrease in water availability
- a rise in climate-sensitive diseases like diarrheal illnesses, dengue fever, chikungunya, and malaria
- dehydration
- heat cramps
- heat exhaustion
- heat syncope
- heat stroke

Increased rates of heat-related mortality and illness after heat waves are particularly pronounced in low-income cities, especially among workers with occupational exposure to extreme heat. The lack of mechanical air conditioning and limited infrastructure, including water treatment and distribution networks, make public health adaptation strategies for heat-related illness unique in these regions.⁵

Heat-related illnesses and deaths in India could be largely preventable through better communications about what makes people vulnerable to heat, helping people to avoid those conditions.

Heat and Health in the Ahmedabad Context⁶

(Highlights from Presentation by Dr. Dileep Mavalankar and Dr. Gulrez Shah Azhar Preparatory Materials)

The western Indian state of Gujarat has long experienced extreme heat, and is among the driest regions in India. Ahmedabad is the largest city in Gujarat, with a population of 7.2 million, according to the 2011 census, and is one of India's fastest growing cities.^{7,8} Ahmedabad houses a large migrant population from neighboring states, other parts of India, and abroad, and approximately 440,000 people lived in Ahmedabad's slums as of the 2001 census.⁹ More than 500,000 construction workers live in Gujarat; 50,000 live in Ahmedabad.¹⁰

Ahmedabad is located in a sandy and dry area on the banks of the Sabarmati River, which frequently dries up in the summer. Its predominately arid climate has its hottest weather in March to June. The average summer maximum temperature from March through October is 35 °C (90 °F), and the average minimum is 25 °C (77 °F).¹¹ From November to February, the average maximum temperature is 28 °C (82 °F) and the average minimum is 15 °C (59 °F).¹²

The Meteorological Centre, Ahmedabad (Met Department), a state government entity, identifies and declares heat wave conditions in Ahmedabad, yet, in terms of practice, internal communication amongst the state and local agencies could be improved. Existing records indicate that average summer temperatures for Ahmedabad have been increasing over the last several years. The Met Department's records also indicate that Ahmedabad is more prone to heat waves than other large urban centers in Gujarat, and Ahmedabad experienced a record number of heat wave days in 2010.

Consistent with global climate trends, in May 2010, temperatures rose to 46.8 °C (116.24 °F) in Ahmedabad, making it the highest temperature recorded in the last 40 years.¹³ These already high temperatures are projected to worsen as climate change continues. Ahmedabad's 2010 heat wave emergency increased the urgency of reducing heat vulnerability. Adding to environmental health concerns, in recent years, the city has suffered from increasing air, water, and soil pollution from neighboring industrial areas, textile, chemical industries, and lack of citizen awareness regarding pollution prevention. The city also suffered from a devastating earthquake in 2001, triggering the municipal government's first preparedness efforts for natural disasters. Members of the municipal preparedness network may be able to share lessons learned about community protection and response since 2001.¹⁴

B. IMPLEMENTING A HEAT-HEALTH VULNERABILITY ASSESSMENT¹⁵

(Summary of Presentations by Dr. Kris Ebi and Dr. Kim Knowlton)

Early action by municipalities, health officials, and national governments to help prepare for heat-health vulnerability is one of the most effective ways to build resilience and protect human health. A constructive heat-health preparedness program should incorporate several common elements including:

- Identification of local vulnerabilities within the specific population and geography
- Monitoring and tracking health threats and appropriate responses
- Educating health care practitioners and the general public about the health implications of climate change
- Creating emergency response plans

In Ahmedabad, as in most of India, heat has long been a health issue, and traditional culture has developed methods for individuals to cope with extreme heat. However, as urban populations soar and neighborhoods expand rapidly, temperatures are also rising under the influence of climate change. A new scale of proactive municipal responses is needed to contain and cope with the health effects of climate-change-related heat stress. To do so, it is critical to first identify who and where those most vulnerable to extreme heat reside and/or work, by conducting a heat-health vulnerability assessment.

What is a Heat-Health Vulnerability Assessment?

A heat-health vulnerability assessment ascertains a population's susceptibility to extreme heat in order to address the effects of heat stress through tailored preventative measures. A community's overall vulnerability is determined by its exposure to the changing climate, its population demographics, and its adaptive capacity, which includes community resilience and response capacity. Resilience from the effects of a heat wave, in this case, can be seen as the ability of an individual from the community to anticipate, absorb, accommodate, or recover in a timely and efficient manner, and preserve, restore, or improve their essential basic structures and functions. In this context, response capacity means the degree that the community can effectively prepare for and cope with the consequences of a heat wave. These assessment results can help decision makers enhance both these important qualities, and facilitate the development of effective public health interventions, such as providing targeted information, so that individuals can take the measures necessary to protect themselves and their family.

Framing a Climate (or Heat-Health) Vulnerability Assessment¹⁶

(Summary of Dr. Kris Ebi Presentation)

While climate change—or heat-health—vulnerability assessments are carried out through a wide variety of methodologies, and can include many distinct elements, the steps can broadly be classified into the following four stages:

1. Identifying the Scope of the Vulnerability Assessment

- Define the geographic region and health outcomes of interest
- Identify the questions to be addressed and steps to be included
- Identify the policy context for the assessment
- Establish a project team and a management plan
- Establish a stakeholder process
- Develop a communications plan

2. Assessing Climate-Health Vulnerability

- Describe the human health risks of current climate variability and recent climate change, and the public health policies and programs in place to address the risks
- Identify exposure and susceptibility factors that define and characterize vulnerable subpopulations and regions
- Describe the current risks of climate-sensitive health outcomes, including the most vulnerable populations and regions
- Describe the current capacity of health and other sectors to address the risks of climate-sensitive health outcomes

3. Assessing Climate-Health Impact

- Describe how the risks of climate-sensitive health outcomes, including the most vulnerable populations and regions, may change over coming decades, irrespective of climate change
- Estimate the possible additional burden of adverse health outcomes due to climate change

4. Assessing Climate-Health Adaptation

- Identify and prioritize policies and programs to address current and projected health risks
- Identify and prioritize additional public health and health care policies and programs to prevent or reduce likely future health burdens
- Identify human and financial resources needed for implementation of adaptations, and potential challenges to be addressed
- Estimate the costs of action and of inaction
- Identify possible policies and programs to reduce the potential risks of climate change being implemented in other sectors, such as water, energy, or agriculture, to coordinate efforts

Factors to Determine Heat-Health Vulnerability

(Summary of Workshop Discussions facilitated by Dr. Dileep Mavalankar and Dr. Kim Knowlton)

Tailoring a vulnerability assessment to address a community's exposure to heat stress hinges on collecting accurate data about local demographic characteristics. The following factors are among the primary contributors to a community's vulnerability to extreme heat, as tailored to Ahmedabad:

Geography

Heat-related symptoms and illnesses are higher in high-density neighborhoods with unplanned urban housing and in drought-prone zones. While vegetation—which creates shade and releases water vapor into the air—is a great source of cooling in urban environments, buildings and pavement have the opposite effect, absorbing and retaining heat from sunlight. East Ahmedabad has a great deal of industrial activity, leading to higher temperatures and potential air pollution sources. Rapid construction and urbanization—and a lack of, or reduction of green space—has led to an increase in vulnerable areas across the city.

Occupation

Construction workers, factory laborers, manual laborers who work outdoors (e.g., police officers, street vendors, masons and rickshaw drivers), and women working in poorly ventilated indoor kitchens are most vulnerable to heat stress. Although some safeguards and labor laws currently exist to protect Ahmedabadi workers, including site visits from labor officers and sanitary inspectors, there is an inadequate number of inspectors and protections in place. Enforcement coordination can also be difficult, as labor laws and implementation responsibilities are split between state and central government jurisdiction.

Age

The elderly are at risk for heat stress due to age-related physiological changes that make it harder to regulate temperature, sensitivity to dehydration, and limited mobility. Extremely young children and newborns are also a high-risk group, as their nervous systems are not fully developed to respond to extreme temperature fluctuations.

Medical conditions and co-morbidity

Individuals with existing chronic medical conditions, such as heart or lung ailments, are more vulnerable to heat stress. Disabled individuals may have lower mobility, making their ability to move to shade or cooler surroundings challenging. People with neurological disabilities, some mental illnesses, and individuals taking certain medications may have difficulty assessing when they are at risk for heat stress. Taking diuretics can also cause increased dehydration, which increases the risk of health impacts from extreme heat.



A community in Ahmedabad, Gujarat

Access to healthcare

Free or inexpensive healthcare is available in government hospitals, and most villages have primary healthcare centers and healthcare professionals, such as Anganwadi workers or auxiliary nurse-midwives.^{17,18} Despite this choice, some groups prefer traditional or faith healers and do not get conventional medical care during heat waves.

Access to places to cool down

Most parks, lakes, and swimming pools are centered around the northwest part of Ahmedabad, limiting poorer populations' access in older, congested parts of the city. The municipal government's efforts to popularize pools have therefore been controversial. Similarly, the Bus Rapid Transit System (BRTS) routes have shaded bus stations, but many people cannot afford to ride the BRTS. In addition, the BRTS is currently located only on the western side of the city (plans exist to extend it eastwards). Public libraries and shopping malls are usually cooler and can provide shelter, but they, too, more concentrated on the western side of the city.

How to Conduct a Heat-Health Vulnerability Assessment

(Summary of Dr. Kim Knowlton's Presentation)

In order to be successful, a heat-health vulnerability assessment must be adapted to local needs.

First, a collaborative scientific study in Ahmedabad should be organized to explore factors affecting vulnerability to extreme heat and their interactions in order to facilitate the AMC's adaptation efforts. Such an analysis should break vulnerability down into factors affecting exposure, susceptibility, and adaptive capacity in order to generate actionable information that can be quickly translated into public health interventions.

Local data can be gathered through: (i) a cross-sectional household heat-health vulnerability survey, (ii) several focus groups assessing vulnerability of specific community and occupational sub-populations, and (iii) focus groups assessing adaptive capacity in the public health and health care delivery systems. With the overall goal of characterizing vulnerability to extreme heat in the greater Ahmedabad area,

time-series data linking weather and all-cause mortality should be synthesized with the results of the surveys and focus groups.¹⁹ With enhanced understanding of the factors affecting heat vulnerability in the region, a heat-health early warning system (HHEWS), in addition to other public health interventions and health care management strategies, can be devised to enhance capacity to adapt to heat on a local level.

Featured Scientific Efforts on Heat-Health in India and the United States

The following studies highlight current scientific efforts to address heat-health-related issues both in India and the United States.

INDIA

WEST BENGAL

Dr. Shyamashree Dasgupta from the University of Jadavpur in West Bengal conducted an integrated economic analysis research study on heat stress and human welfare loss. The study's objective was to quantify human welfare loss that occurs through direct heat impacts—heat stress and labor productivity loss—and indirect impacts—such as water quality and quantity, and resultant health damage. Findings indicated that as humidity and temperature increase, productivity decreases. By adding new variables to the conditions of the study subjects—including providing more shade, indoor workspace, and comfortable clothing—there was an increase in productivity even under the same temperature and humidity conditions, thus demonstrating the effectiveness of these three adaptation strategies. Roy, J. et al., "Climate Change, Heat Stress and Loss of Labour Productivity: A Method for Estimation," 2011: <http://www.ecoinsee.org/6bconf/Theme%20C/CD.1.1%20Joyashree.pdf>

GUJARAT

To investigate the large number of heat-related illnesses in Gujarat during increased heat waves in the summer of 2009, P. K. Nag conducted an occupational health study analysis of the thermographic profile of the skin of study subjects. He was able to measure non-uniform heat exchange and temperature distribution among various body components. His study results indicate a necessity to redefine the reference population in different regions of the country for an accurate representation of vulnerability/susceptibility assessments. He also established that people in certain districts of Gujarat, including Ahmedabad and Kutch, have a lower heat tolerance in the summer months, and therefore higher vulnerability than most other parts of Gujarat. P.K. Nag, A. Nag, "Vulnerability to Heat Stress: Scenario in Western India," National Institute of Occupational Health, 2009: http://whoindia.org/LinkFiles/Climate_Change_Vulnerability_to_Heat_Stress_Scenario_in_Western_India.pdf

UNITED STATES

ARIZONA

S.L. Harlan conducted a study to investigate the social-economic structure of the microclimates in the city of Phoenix, Arizona, which have great temperature variations caused by spatial heterogeneity in types of built and natural materials. Their results indicate that heat-related symptoms and illnesses are higher in high-density neighborhoods. Since a large percentage of older and poorer people live in these neighborhoods, high temperatures during a heat wave could easily lead to a heat disaster associated with a large number of heat-related hospitalizations and deaths. Harlan proposes both top-down and bottom-up protection policies and programs for people in vulnerable areas. Top-down policies include: warnings, water provision, air-conditioned shelter, emergency response, city risk management plans for climate change, and public climate education. Bottom-up organizing includes landscaping neighborhoods to increase green cover and improving housing quality to provide cooler spaces. S.L. Harlan, et al., "Neighborhood microclimates and vulnerability to heat stress," *Social Science & Medicine* 63 (2006), pp. 2847–2863: http://www.geofaculty.org:16080/heat_waves/Doc4002_Harlan_Microclimates_Vulnerability_Heat_SocSciMed_2006.pdf

CALIFORNIA

California is prone to heat waves, droughts, and wildfires. During the 2006 California heat wave, there were 16,166 excess emergency department visits and 1,182 excess hospitalizations. As a result, in 2009, California adopted climate adaptation strategies to improve public health preparedness and emergency response, establish partnerships, research ways to protect human health, and implement policy changes. The strategies include: promoting community resilience to reduce vulnerability; implementing education initiatives to reduce vulnerability through mitigation and adaptation with public health co-benefits; and initiating surveillance of environmental conditions, climate-related illness, vulnerabilities, protective factors, and adaptive capacities. K. Knowlton, et al., "The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits," *Environmental Health Perspectives* (117) 1, January 2009:

<http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.11594>

NEW YORK

The ClimAid integrated assessment model projects that rising average annual temperatures in New York will increase the number of projected temperature-related deaths and will affect the child and adolescent populations, causing heat sensitive conditions like electrolyte imbalance and heat-related illnesses. The ClimAid model results indicate that higher temperatures and heat waves will increase cooling energy use and lead to fatigue of materials, including energy and transportation infrastructure, and will affect drinking water supply, changing the distribution of key crops like apples, cabbage, and potatoes and reducing dairy milk production.

Proposed levels of prevention of climate change risks include: urban planning to reduce green house gases from vehicular traffic; increasing pedestrian access, resulting in improved air quality and physical activity; relocation of low-lying island populations facing increased risks of flooding; distribution of mosquito nets; activating early warning systems before heat waves; and post-disaster restoration of chronic care services. C. Rosenzweig, et al., "Responding to Climate Change in New York State: Climaid," NYSERDA, 2010:

<http://www.nyserda.org/programs/environment/emep/clim-aid-synthesis-draft.pdf>

III. CHALLENGES AND OPPORTUNITIES TO IMPROVE ADAPTIVE CAPACITY IN AHMEDABAD

(Summary of Breakout Sessions and Discussions at Workshop)

Several gaps exist in the capacity of Ahmedabad's health care system and municipal government to effectively protect its local population from extreme heat. Both sectors have unique opportunities to overcome the gaps and strengthen resilience to extreme heat. Through a vulnerability assessment within the community, gaps in adaptive capacity can be remedied through proactive and targeted measures, as detailed below.²⁰

A. IMPROVING ADAPTIVE CAPACITY IN THE HEALTH CARE SYSTEM

In Ahmedabad, the health care system has limited capacity to recognize, diagnose, and effectively treat heat-related illness. Following a vulnerability assessment, proactive measures can be identified to remedy such challenges. These proactive measures include health care provider education, improved protocols, and facility improvements.

Challenges

Currently, many data gaps exist due to underreporting of heat-related illnesses. Neither health care workers nor residents often attribute illness, morbidity, or mortality to heat, even in hospitals. Currently, hospital death records do not list the patient's occupation or address, making it difficult to correlate heat stress with a person's profession or where they lived within the city. This information should be included to identify the most vulnerable populations geographically and occupationally.

Health impacts of heat waves usually become apparent only three days after the victim suffers from extreme heat. With the current Met Department definition of a heat wave—three consecutive days or more of above average temperatures—it becomes difficult for the health sector to anticipate the impacts.

Many hospitals do not have adequate cooling systems, including air conditioning, internally. Those few hospitals that do have air conditioning usually concentrate it solely in the obstetrics and gynecology wards for newborns. Also, installed air conditioning that is not adequately calibrated can cause hyperthermia or hypothermia in patients.

Opportunities

Primary health centers and community health centers could be leveraged more by holding trainings for skilled workers employed at healthcare centers. The Ministry of Health and Family Welfare; Ministry of Women; Child Welfare Department; and Emergency Management and Research Institute could potentially help initiate such trainings or

integrate heat stress into existing trainings.²¹ Also, doctors could be sensitized to know when to attribute morbidity and mortality to heat as well, in order to provide accurate records.

The Ahmedabad Health Commission has an operational Medical Information System (MIS) system, and the Gujarat state government has a Health and Family Welfare Commission, each of which sends its computerized data to the national Government of India monthly. When a higher incidence of mortalities indicates a potential epidemic, the national government can hold a public awareness campaign through its public information office.

Many networks of health practitioners can be tapped into, such as the Anganwadi systems and the auxiliary nurse-midwives in village primary healthcare centers.²² The Anganwadi program coordinates with the Indian Government's Integrated Child Development Scheme, which targets children aged three to six years. These effective channels have already helped reduce individuals' malnutrition levels and can be employed to address heat vulnerability through training and education.

B. IMPROVING ADAPTIVE CAPACITY IN THE MUNICIPAL GOVERNMENT

The AMC and Met Department face many organizational and capacity challenges that must be addressed to protect residents from extreme heat and successfully launch a HHEWS. Using locally-available data and established methods, the AMC can develop and operate an effective HHEWS for the Ahmedabad area.

Challenges

As of March 2011, there was only one weather monitoring system for all of Ahmedabad, providing very limited data on which areas may be high-risk. More weather monitoring systems could be set up across the city to more accurately report temperature and humidity in the city's microclimates.

The Met Department falls under the Gujarat state government, while the health department falls under the municipal government. This split jurisdiction can create challenges in information flow and communication between these entities during heat waves and other emergencies.

Opportunities

Infrastructural Opportunities

There are several infrastructural opportunities that currently exist in Ahmedabad. Highly predictive short and longer term weather forecasting could be developed for the

region. An effective HHEWS could be calibrated with heat-related hospitalization or emergency room visits, as well as mortality data for the AMC, using locally-derived heat-health response functions.

On a smaller scale, the traditional exhibition of wealthy residents' philanthropy through providing roadside water fountains or pias could be better encouraged. Old mills are now being redeveloped, often into shopping malls. These sites could provide shelter or at least more cool, air-conditioned spaces for residents.²³ Finally, traffic police often must stand in traffic booths or covered boxes on their work shifts, and some have been recently fitted with oxygen to improve health in work settings. Additional oxygen-enhanced traffic booths could be rolled out across the city.

Educational Opportunities

Many educational opportunities exist to teach adaptive strategies to Ahmedabad's residents. For example, the city of Ahmedabad could establish a heat health awareness month like California's Earthquake Awareness Month. A color-coded flag system could be adopted to alert people to high temperatures, like the U.S. Department of Homeland Security's threat level system. The AMC could also send SMS text messages to residents warning of impending heat waves and tips for staying cool.

In New Delhi, schools are closed during heat waves, and the Directorate of Education has the capacity to recommend a change in school timings to avoid the hottest temperatures. A similar policy could be adopted in Ahmedabad's school system. Employers could also structure work hours similarly to avoid the hottest time of day.

Occupational and Legal Opportunities

Many legal and policy changes could be implemented to increase the municipal capacity to build occupational resilience to working in extreme heat conditions. A detailed study of various labor-related laws could be undertaken to investigate whether specific laws exist regarding heat (including central acts, local rules and bylaws), what occupations they cover and how implementation and enforcement can be strengthened. Additionally, it is recommended that local labor institutes research how many businesses are registered in the city, to determine where labor laws apply.²⁴ Such institutes might also provide information and training to occupational workers.

Labor officers could also disseminate pamphlets to provide information on labor conditions in extreme heat. Even the most informal sectors such as manual laborers and rickshaw pullers often have associations or are members of labor unions. Leveraging these associations and memberships to collect data, and disseminate educational materials on heat coping strategies, could be an effective communication channel.

Architectural Opportunities

Energy efficiency buildings, green building design, and Leadership in Energy and Environmental Design (LEED) is becoming increasingly popular with some buildings designed for the local climate. Encouraging these efforts and working with architects and designers to try to popularize design elements that do not require artificial cooling would be constructive. For instance, the new Torrent building uses smart building design inspired by Egypt's pyramids in order to keep indoor temperatures low.

IV. HEALTH EXPERT RECOMMENDATIONS TO ADDRESS THE VULNERABILITIES OF CLIMATE CHANGE, HEAT, AND HEALTH IN AHMEDABAD

Health experts have identified several recommended actions following the 2011 Kickoff Workshop to address heat vulnerabilities and improve adaptive capacity in Ahmedabad that can be adopted immediately or in the longer term. The AMC has initiated implementation of several measures to protect Ahmedabad's citizens during the heat season. In addition to those immediate measures, the following overall recommendations addressing heat-health vulnerability will need to be staged over time:

1. Researching impacts of heat stress, community resources, and existing heat-coping measures through in-depth discussions with four groups: vulnerable people living in slums, workers in high-risk occupations, city department staff, and health care providers; and then analyzing data on local temperatures and corresponding deaths.
2. Identifying the most vulnerable populations in Ahmedabad through surveys assessing current heat awareness and susceptibility, and distributing an informational pamphlet on reducing extreme heat's health risks to the elderly and families with young children.
3. Developing an actionable early warning system in Ahmedabad and integrating it into a local climate change preparedness plan to warn the population of impending extreme heat events.
4. Targeting heat-risk-reduction outreach to the most heat-vulnerable groups, including young children, elders, people with heart or lung illnesses, families living in poverty, and workers in high-risk occupations.
5. Conducting best-practices workshops with Ahmedabad city departments, medical providers, workers in high-risk occupations, and community leaders to implement extreme heat strategies, build local capacity, and improve internal information sharing and communication.

These overall recommendations were parsed into specific activities and next steps to be accomplished by the municipal government, health organizations, and other community leaders within Ahmedabad. Varying levels of administrative coordination are needed before certain actions can get underway. These recommended activities have been prioritized into short term and long term recommendations within the following four categories of action:

- Engagement and Capacity-Building within Government Agencies
- Assessing the Most Heat-Vulnerable Communities in Ahmedabad

- Assessing Current Adaptive Capacity in Ahmedabad
- Implementing Climate Change Adaptation Interventions

Building Engagement and Capacity-Building within Government Agencies

The following actions can be taken to build a collaborative and effective network with local and international partners:

Short-term Actions

1. Deepen engagement and partnerships with local stakeholders, including:
 - Meteorological Centre, Ahmedabad
 - Department of Health
 - India Health Ministry
 - AMC
 - Government of Gujarat
 - Hospital and health care workers, clinicians, doctors, and administrators
 - Air pollution experts
 - Ward (municipal neighborhood) leaders
 - Urban planners and architects
 - Occupational and community organizations
 - Energy delivery, water supply, and utility managers
 - Landscapers and park and roadway managers
 - Advocates for children, the poor, and new arrivals to Ahmedabad
2. Further develop network of multidisciplinary professionals, including public health professionals, clinical medical specialists, urban planners, environmental experts, occupational health experts, and administrators locally and internationally, to discuss and develop recommendations for actionable heat-health-related programs.
3. Secure additional funding and resources to support assessments and adaptation.

Long-term Actions

1. Set up a system to collect, share and correlate data between different agencies, particularly medical colleges and AMC hospitals, regarding morbidity, mortality, ambulance use, weather, power and water consumption, and AMC outreach efforts to collaborate on efforts and track their effectiveness.

2. Open communication channels between the Met Department and health care sector to institute heat-health alerts and deepen network collaboration to share data on extreme heat events and resulting health effects.
3. Form partnerships with other cities and states in India to build a heat health preparedness network across the country.
5. Begin aggressive data collection on heat-related illnesses at Ahmedabad's urban health centers, since they collect daily case data at the household level for patients who do not go to the public hospitals.
6. Collect data prospectively on heat-related cases from private hospitals where most residents go in for medical services.²⁵

Assessing Heat-Vulnerable Communities in Ahmedabad

The following actions can be taken to determine who is most affected by heat in Ahmedabad:

Short-term Actions

1. Identify the most heat-vulnerable locations and neighborhoods through vulnerability mapping of heat-related illness incidence, from available retrospective data from 2001 onwards.
2. Conduct a focused literature review on heat stress in India and other developing country settings, strategies for its diagnosis (e.g., methods for determining body core temperature), and for cooling (e.g., evaporative, ice and air conditioning units or ceiling fans), to make sure IIPH, AMC, and other involved groups in Ahmedabad are apprised of all the relevant heat-vulnerability research.
3. Undertake a detailed chart review of the 2010 heat-related deaths, to determine what risk factors increased victims' heat vulnerability.
4. Provide temperature measurement gauges throughout the city to measure and collect temperature and humidity data on different wards' microclimates.

Long-term Actions

1. Conduct epidemiological case review to link heat death and illness cases (including emergency room visits and hospitalizations, to the extent possible) in 2010 to daily and weekly temperatures, based on both general hospital and emergency room admission information and neonatal care records.
2. Identify the most heat-vulnerable neighborhoods needing additional heat-vulnerability assessment mapping after determining other heat risk factors, such as locations with the greatest numbers of elderly, and neighborhoods with the least number of hours of water service per day. The most heat-vulnerable locations will be prioritized for educational outreach on heat vulnerability reduction.
3. Begin more extensive epidemiological studies, such as geomapping and spatial analysis of 2010 heat-death and heat-illness cases.
4. Conduct a prospective study for 2011 onward of heat-related illness and death, setting up systems to gather information from the AMC's emergency medical service calls, clinic visits, hospital emergency departments, hospital admissions, labor and neonatal wards.

Assessing Current Adaptive Capacity in Ahmedabad

The following actions can be taken to determine current adaptive capacity to reduce heat vulnerability and adapt to climate change:

Short-term Actions

1. Conduct a focused household survey about traditional heat adaptation practices, including behavioral and dietary practices that people currently use. Also survey current heat awareness, including how individuals recognize heat illness and from what sources people get heat wave information. This survey ideally would cover the individuals' demographics and health care-access as well.
2. Set up a health information and advice hotline as an essential resource for information during the hot season.²⁶ Train operators on how to respond to heat stroke victims, and provide tips for heat-vulnerability reduction.
3. Establish an early notification system warning of impending heat waves (an aforementioned HHEWS), coordinating communications between the Department of Health, hospitals, clinics and the Met Department. Alternatively, provide access to sources of Met Department data online to inform the public of forecasted extreme heat events.

Long-term Actions

1. Create a heat wave advisory threshold definition to trigger the heat wave alert issued by the local Met Department to the Health Department.
2. Create a map of community resources, including green space, public libraries and health care providers, to help urban planning officials identify which resources should be built in closer proximity to more vulnerable communities.

Implementing Adaptation Interventions

The following actions can be taken to improve local residents' capacity to reduce heat vulnerability and build resilience to climate change:

Short-term Actions

1. Distribute a bilingual educational brochure for the general public in English and Gujarati on heat stress-avoidance tips, including when to seek medical attention and how to regulate heat.²⁷ Include information for the elderly and for schools on preventing children from playing outdoors during the hottest part of the day.
2. Engage local press and media outlets, including newspapers, radio, and television, to issue three-day

heat wave warnings. Also, collaborate with the press to produce newspaper, television, and radio ads on heat health awareness and protection strategies, for example, what to do to prevent heat stress and which treatment to seek if heat stroke is suspected.

3. Display the temperature and weather forecasts—including heat waves—to warn people of high temperature zones and hot times of the day, so that unessential travel or work can be avoided in that area or time period. Select site locations in the city where the possibility of heat-island effect is likely due to lack of trees, large amounts of paved area and local heat-generating sources.
4. Provide drinking water fountains, preferably cold water, in all BRTS bus stops, near all other bus stops, near major crossroads, gardens, and public places. Collaborate with local non-governmental organizations and businesses to set up water stations.
5. Keep public parks open later during the summer to provide cool resting spaces for the public.
6. Provide additional cooling places and shade by opening public gardens, malls, government buildings, and cooling rooms. Provide rented air conditioners or ceiling fans to the public and laborers who must work in the heat during summers, including traffic police, construction workers, street vendors, and handcart and rickshaw pullers.
7. Provide additional and uninterrupted water supply to the city residents during the summer, possibly using tankers. If a water shortage occurs, stop all non-essential use of water, including public and private swimming pools, water fountains, and water parks.
8. Train paramedic and link workers in the health department to enable them to help in case of heat wave.²⁸
9. Provide a train-the-trainers session for primary medical officers so they can offer heat-specific advice to their medical staff.
10. Train voluntary community “buddies” to help the elderly and children during heat waves.

Long-term Actions

1. Share the results of the heat-health vulnerability study with partners, including ward leaders; advocates for children, the poor and new arrivals to the city who may be marginalized; occupational organizations; hospital and health care workers, clinicians, doctors, administrators, and community organizations.
2. Develop AMC “Heat Vulnerability Reduction Communication Strategies” for the community, informed by the heat vulnerability assessment results. The communications strategies should include who are the cooperating agencies, which agency will take the lead, which heat-vulnerable communities to target first for informational outreach and distribution and what appropriate materials to distribute. Within Ahmedabad, community groups should focus on the following actions:

- Elderly living centers—Train institutional staff to increase their awareness of how to recognize and treat the early warning signs and symptoms of heat-related illnesses.²⁹
- Schools and child caregivers—Train educators and caregivers to recognize children as among the most heat-vulnerable, increase their awareness of how to recognize heat-related illness, and give schoolchildren materials on heat-vulnerability reduction to take home.
- Occupational groups and representatives—Perform outreach to at-risk occupational groups to develop heat-health awareness and protection materials. Include the following occupational groups:
 - Rickshaw drivers
 - Street vendors
 - Traffic Police
 - Construction workers
 - Foundry, kiln, quarry workers
- 3. Develop a second set of “Heat Vulnerability Reduction Communication Strategies” for health care providers, including the following actions:
 - Give informational materials to healthcare providers to increase awareness, recognition, and diagnosis of heat illnesses, and guidelines for treating heat illness—such as temperature-taking, cooling, lab work, maintenance and long term follow-up. Materials should also include how to counsel patients, what threshold temperatures apply for different levels of treatment, when to increase staffing to handle hospital capacity, and surveillance protocols.
 - Create a training program or multi-day workshop for health care providers on climate change, heat and health, as well as specific heat case management and diagnosis.
 - Educate women in maternity wards on heat stress before leaving the hospital, since newborns make up a high proportion of heat-related deaths. Investigate moving the maternity ward from the upper floor of the municipal hospital (where temperatures tend to be higher) to a lower floor of the building. Possibly measure maternal and newborn health outcomes in both locations to evaluate the effect of intervention.
 - Establish an air-conditioned treatment room or ward in one hospital (or install ceiling fans), and measure before and after installation effects in both patient and health care worker populations. Also determine if having 1 to 2 hours per day of cool air improves healthcare worker productivity levels.
 - Conduct an in-hospital scenario of a heat wave and disease outbreak simultaneously, once capacity is available, to ensure proper preparation amongst hospital workers.
- 4. Implement urban planning programs such as a cool roofs initiative to paint roofs white and thereby reflect heat, or plant trees and other greens on roofs to absorb the sunlight and keep buildings cool.

Top 10 Initial Steps to Protect Ahmedabad Citizens

The following “Top Ten Initial Steps” were identified for as steps that could either be taken immediately, or for which implementation support could be identified immediately, following the 2011 Kickoff Workshop:

1. Increase awareness of how to recognize and treat heat-related illness among medical and health professionals, new parents, and persons who provide care for the elderly.
2. Train the trainers, such as primary medical officers, so they can give heat-specific advice to others.
3. Train or build the capacity of paramedical staff such as Anganwadi workers or link workers, to act as necessary during a heat wave.
4. Collect data on daily hospital admissions and emergency room visits from both public and private hospitals, at urban health centers and the household level to capture those who do not go to the hospital.
5. Tap into the potential of call centers and hot lines to act as an essential resource during the hot season.
6. Distribute materials on heat-vulnerability reduction to schoolchildren to take home to families.
7. Create a heat vulnerability communication strategy and identify whom to target.
8. Identify the current and possible future resources that the AMC, PHFI, IIPH, and NRDC can bring to bear on a heat-health vulnerability assessment for Ahmedabad.
9. Identify heat vulnerable groups, including elderly and poor populations.
10. Conduct a formal case analysis study of heat-related deaths and illness, to determine what factors increase people’s vulnerability.

Traditional Adaptive Methods to Combat Heat in Ahmedabad

The following methods represent a partial list of the local traditional strategies for reducing heat stress in Ahmedabad. These behavioral and dietary adaptations are specific to the Indian setting, yet some of them hold promise as low-cost means of providing relief for other communities facing extreme heat, who also lack access to air conditioning or the economic means to employ other higher-cost technological heat adaptation resources.

TRADITIONAL DESIGN AND ARCHITECTURAL CONCEPTS

Historically, all homes used to be built in the North-South orientation to avoid direct sunlight, and were built in narrow lanes, keeping most neighborhoods cool because direct sunlight reached the street for barely a few hours a day. Traditional houses were built with thick walls and high ceilings made of low conductivity materials like clay and wood. Walls were whitewashed with slaked lime (calcium hydroxide) and chalk to keep the interiors cool.

CULTURAL PRACTICES

Local traditions to combat the heat include providing free cold water to passersby from temporary roadside dispensing stations (piaus); providing resting places for laborers, and an accepted norm of an afternoon break or siesta for construction workers and laborers, when they rest in the shade during peak afternoon heat and then recommence work in the early evening after the temperature starts to dip. In fact, the daily schedule of many Gujaratis used to include an afternoon siesta, to reduce physical activity in the afternoon when the body is most prone to exhaustion. Similarly, many Gujaratis traditionally made their outdoor plans for later at night in the cool air, after dinner. Even now, certain outdoor shopping areas open at 8:00 pm and conduct business until 11:00 pm.

CUISINE

Diet also plays a role in protecting against heat stress: Ahmedabadis traditionally eat sorghum, raw onion, and raw sour mangoes to combat heatstroke, and drink a thin buttermilk yogurt-like drink called chhaas. To rectify the body's pH and restore equilibrium after losing salt through sweat, many people also traditionally enjoyed salty and spicy drinks like jal jeera, a cold drink of rock salt, cumin powder, coriander powder, black pepper, mint, and lemon juice. Today, the proliferation of soda pop bears testimony to the continuing popularity of cold drinks as a means to beat the heat.

CLOTHING

In the summers people dress in lighter colored clothing, and in thin Indian cotton that allows the body to breathe and absorbs sweat while keeping the body cool. Traditional dress styles used to emphasize covering the head—turbans for men and stoles (dupattas) for women. A fascinating local apparel innovation, the “Sola Hat”, was popular in the region during the eighteenth century. It was a safari-helmet made of Indian cork (shola) that was ubiquitous in colonial India, used both by the British and local government employees and civilians.

V. MOVING FORWARD TO ADDRESS HEAT VULNERABILITY IN AHMEDABAD

Since the 2011 kickoff workshop, PHFI, IIPH, and NRDC along with city officials have made significant progress towards implementing some of the expert recommendations. For example, during summer 2011, a joint Indo-U.S. vulnerability assessment community survey, the first of its kind in Ahmedabad, was conducted by NRDC, PHFI, IIPH, and the School of Public Health at Emory University. This survey identified the most heat-vulnerable populations in Ahmedabad by in-depth assessments in twelve slums on household member health history, heat exposure adaptation, current heat-stress knowledge, and susceptibility and access to resources. The survey administrators also distributed an informational pamphlet on reducing extreme heat's health risks to the elderly and families with young children.³⁰

Ongoing research on the impacts of heat stress, community resources, and existing heat-coping measures is being collected through in-depth discussions with four groups: vulnerable residents of slums, workers in high-risk occupations, city department staff, and health care providers. Analysis of data on local temperatures and corresponding heat-related deaths and illness is also ongoing.

As a result of communication between PHFI, IIPH, NRDC, and the AMC, Ahmedabad officials are now developing a climate change state action plan, and accelerating efforts to protect communities from extreme heat. Also, local

officials announced plans to install several new weather gauges throughout the city. The new temperature gauges will enable local government to record and identify historical weather trends, determine high-risk areas, and warn local communities about impending heat waves, which is critical to protecting the most vulnerable residents from heat exhaustion, heat stroke, and heat-related deaths.

Looking ahead, in 2012, PHFI, IIPH, and NRDC, along with the AMC and local civil society will continue to conduct research and outreach on extreme heat. Based on our research, we will develop an actionable heat-health early warning system and strategies to protect local populations. Heat-risk reduction outreach will target the most vulnerable groups, including young children, elders, people with heart or lung illnesses, families living in poverty, and workers in high-risk occupations. A best-practices workshop will also be held with Ahmedabad city departments, medical providers, workers in high-risk occupations, and community leaders to implement extreme heat strategies, build local capacity, and improve internal information-sharing and communication. This ongoing research and intensive outreach regarding the importance of heat adaptation has the potential to save lives from the increasingly severe effects of climate change.

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- Includes extensive discussion of public health adaptation measures.

Stratus Consulting, D. Mills, K.L. Ebi, "Vulnerability White Paper: In Support of the National Climate Assessment's Vulnerability Assessment Workshop," January 7, 2011.

- Discussion paper prepared in preparation for US National Climate Assessment.
- Summarizes and synthesizes the definitions of vulnerability and vulnerability assessment frameworks that have been proposed and applied in the relevant literature.

R.S. Kovats, K.L. Ebi, B. Menne, "Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change," World Health Organization Europe, 2003: http://www.euro.who.int/__data/assets/pdf_file/0009/91098/E81923.pdf

- Provides an overview of the methods available to assess vulnerability to climate variability.

- Proposes methodologies and tools to identify vulnerable populations, and appropriate and effective adaptation strategies, policies and measures.

eds. P. Glick, B.A. Stein, and N.A. Edelson, "Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment," National Wildlife Federation, 2011: <http://www.nwf.org/Global-Warming/Climate-Smart-Conservation/Safeguarding-Wildlife/~//media/PDFs/Global%20Warming/Climate-Smart-Conservation/ScanningtheConservationHorizon.ashx>

- Provides a how-to for conducting vulnerability assessments, focusing on ecosystem analyses.
- Presents several assessment case studies.

E.L. Malone, A.L. Brenkert, "Uncertainty in resilience to climate change in India and Indian states," *Climatic Change*, 91, 2008, pp. 451-76.

- Uses Vulnerability Resilience Indicators Model (VRIM) to project resilience to 2095 and performs uncertainty analysis on climate resilience results.
- Ranks Indian states as to vulnerability

W.J.M. Martens, "Health impacts of climate change and ozone depletion: An eco-epidemiological modeling approach," National Institute of Environmental Health Sciences, *Environmental Health Perspectives*, 106, 1998: <http://ehp.niehs.nih.gov/docs/1998/Suppl-1/241-251martens/abstract.html>

- Proposes paradigm for analyzing health impacts, focusing on eco-epidemiologic models.
- Uses three examples: effect of climate change on vector-borne diseases, effect of climate change on thermal-related mortality, effects of increasing ultraviolet levels on skin cancer.

Y. Honda, M. Ono, "Issues in health risk assessment of current and future heat extremes," *Global Health Action*, 2, 2009: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2799309/>

- Proposes a methodology for assessing health risks of current and future extremes.

E. VULNERABILITY ASSESSMENTS FOCUSING ON HEAT-HEALTH

P.K. Nag, A. Nag, "Vulnerability to Heat Stress: Scenario in Western India," National Institute of Occupational Health, 2009: http://whoindia.org/LinkFiles/Climate_Change_Vulnerability_to_Heat_Stress_Scenario_in_Western_India.pdf

- Scope: Western India; ceramics, pottery and iron workers
- Timeline: Completed
- Heat vulnerability assessment focusing on occupational groups.
- Undertook area environmental surveillance,

physiological measurements and morbidity assessment of heat related effects and disorders, and based on the environmental and physiological/biophysical data, estimated heat exchanges and determined heat susceptibility limits of workers.

A. Rahman, "Climate change and its impact on health in Bangladesh," World Health Organization, *Regional Health Forum*, 12, November 1, 2008, pp. 16-26:

http://www.indiaenvironmentportal.org.in/files/Regional_Health_Forum_Volume_12_No_1_RHFvol12.pdf#page=24

- Scope: Bangladesh
- Timeline: Completed
- Assesses health vulnerability, including from heat, flooding, disease, and malnutrition.
- Explores existing health responses and strategies, and future policy priorities.

C. Koppe, S. Kovats, G.Jendritzky, B. Menne, "Heat-waves: Risks and Responses," World Health Organization Regional Office for Europe, 2004: http://www.euro.who.int/__data/assets/pdf_file/0008/96965/E82629.pdf

- Scope: Europe
- Timeline: Completed
- Reviews the effects of heat stress on health, including physiology of acclimatization.
- Reviews literature on heat epidemiology, and urban bioclimatology.
- Reviews potential strategies to reduce vulnerability, including various watch-warning systems and urban planning strategies, their health benefits and costs.

Gorakhpur Environmental Action Group, UN Development Programme Delhi, "Climate Change Adaptation Activities in India," November 2008: <http://www.indiaenvironmentportal.org.in/files/climate-adapt-india.pdf>

- Scope: Chattishargh, Jharkhand, Uttar Pradesh, Rajasthan, Bihar, Orissa, Madhya Pradesh
- Timeline: Completed
- State-based health assessment and Institutional review of climate change adaptation and disaster response programs by NGOs and state agencies.
- Contextualizes vulnerability assessment as disaster risk management, using methodology of composite risk assessment and adaptation planning

Climate Change Public Health Impacts Assessment and Response Collaborative, California Department of Public Health and the Public Health Institute, "Public Health Impacts of Climate Change in California: Community Vulnerability Assessments and Adaptation Strategies, Heat-Related Illness and Mortality," 2007: http://www.ehib.org/papers/Heat_Vulnerability_2007.pdf

- Scope: California
- Timeline: Completed
- Assesses Community vulnerability to heat within the state of California, identifying locations and populations with highest risk.
- Explores adaptation capacity and strategies.

K.L. Ebi, G. Meehl, "The Heat is on: Climate Change and Heatwaves in the Midwest," Pew Center on Global Climate Change, December 2007: <http://www.pewclimate.org/docUploads/Regional-Impacts-Midwest.pdf>

- Scope: Midwestern US
- Timeline: Completed
- Discusses changes in heatwave duration and frequency.
- Identifies populations at increased risk and adaptation options.

E. ADDITIONAL CLIMATE VULNERABILITY/ADAPTATION ASSESSMENTS

Announced Assessments by Britain's Department of Environment, Food and Rural Affairs (DEFRA) and the Indian Ministry of Environment and Forests (MoEF).

- Scope: India, sectoral
- Timeline: Second phase announced in 2007, Orissa and Madhya announced in 2009
- Includes: Impact of Climate Change on Human Health, National Physical Laboratory, New Delhi (focuses on malaria); Impact of Climate Change on Industries, Energy and Transport, Indian Institute of Management, Ahmedabad.
- Future projects: Development and Dissemination of High Resolution Climate Change Scenarios for India - to be carried out by Indian Institute of Tropical Meteorology, Pune; State-level Vulnerability and Adaptation Assessment, Madhya Pradesh - to be carried out by Development Alternatives, New Delhi; State-level Vulnerability Assessment and Adaptation Strategies, Orissa - to be carried out by Winrock International India.

R. Kumar, P. Jawale and S. Tandon, "Economic impact of climate change on Mumbai, India," Regional Health Forum, 2008: http://www.searo.who.int/LinkFiles/Regional_Health_Forum_Volume_12_No_1_Economic_impact_of.pdf

- Scope: Mumbai
- Timeline: Completed
- Looks at impacts of climate change on Mumbai, including impacts of temperature rise, rains and floods, and their effects on health.
- Makes a simple calculation of economic costs and loss of disability-adjusted life years (DALYs) due to of

extreme events, flooding, and vector-borne illness.

Oak Ridge National Laboratory and Cochin University of Science of Technology, "Possible Vulnerabilities of Cochin, India, to Climate Change Impacts and Response Strategies to Increase Resilience," June 2003: http://pdf.usaid.gov/pdf_docs/PNACX944.pdf

- Scope: Cochin
- Timeline: Completed
- Identifies and evaluates climate impact issues for the city of Cochin, emphasizing interactions between possible climate changes and existing stresses on urban systems
- Considers strategies for reducing impact vulnerabilities that concentrate on reducing stresses on existing systems, therefore making sense for other reasons than climate change alone.

A.P. Mitra, S. Bhattacharya, R.C. Dhiman, K. Krishna Kumar, C. Sharma, "The impact of climate change on health: A case study of malaria in India," in *Climate Change and India: Vulnerability Assessment and Adaptation*, eds. P .R. Shukla, S.K. Sharma, N.H. Ravindranath, A. Garg, S. Bhattacharya, Universities Press, 2003: http://books.google.com/books?id=fvPq_NSZUIC&dq=Climate+change+impacts+on+human+health+in+india&lr=&source=gbs_navlinks_s

- Scope: India, sectoral
- Timeline: Completed
- Compilation of papers on vulnerability of different sectors in India. Health chapter focuses on malaria. Discusses sectoral analysis methodology for vulnerability assessments.

eds. D.S. Lemmen, F.J. Warren, J. Lacroix, E. Bush, "From Impacts to Adaptation: Canada in a Changing Climate 2007," Government of Canada, 2008: http://adaptation.nrcan.gc.ca/assess/2007/index_e.php

- Scope: Canada, regional and sectoral
- Timeline: Completed
- Includes vulnerability assessment survey of adaptation initiatives.
- Includes discussion of heat stress and air pollution.

TERI, Met Office, Government of Maharashtra Dept of Environment, "Assessing climate change vulnerability and adaptation strategies for Maharashtra State," <http://www.ccmaharashtra.org/>

- Scope: Maharashtra
- Timeline: Ongoing
- Goal: to develop a cross-sectoral adaptation strategy for the State of Maharashtra based on the analysis of projected climate change impacts and the assessment of vulnerability in the four key sectors. Will also include impact assessment in human health sector.

- Will develop a district level “vulnerability index” composite. Climate change hotspots will then be identified based on the index, aiding in preparation of case studies.

Asian Cities Climate Change Resilience Network (ACCCRN), Institute for Social and Environmental Transition, “Responding to the Urban Climate Challenge,” November 2009: http://www.rockefellerfoundation.org/uploads/files/2d4557bc-6836-4ece-a6f4-fa3eda1f6c0caccrn_cop15.pdf

- Scope: Surat (Gujarat), Indore (Madhya Pradesh), Gorakhpur (Uttar Pradesh)
- Timeline: Phase 3 (2010 - 2012): Implementation of urban resilience building projects.
- Goal: to develop a network of Asian city partners who will experiment with adaptation strategies spanning health, infrastructure, water, disaster, urban planning/development issues, and disaster management and preparedness strategies.
- Surat has vulnerability assessment presentation online at: <http://www.rockefellerfoundation.org/uploads/files/ca8d984b-4c35-4fca-ba19-2517d2c02bdb-indiasurat.pdf>
- Health study group is largely focused on floods. Shared Learning Dialogues (SLDs) by Gorakhpur Environmental Action Group
- Scope: Gorakhpur district
- Timeline: Reported in 2010
- The project used focus group discussions at the village, district and state level on general climate challenges and adaptation, supplemented with scientific information.
- Suggested strategies include: better access to climate and weather information and early warnings (e.g. village information centers, SMS-based text services); development of points of refuge.

High Noon: Adaptation to Changing Water Resources Availability in Northern India with Respect to Himalayan Glacier Retreat and Changing Monsoon Pattern, European Union http://www.eu-highnoon.org/templates/dispatcher.asp?page_id=25222858

- Scope: Northern India
- Timeline: Ongoing
- Goals: Complete impact assessment of Himalayan glaciers retreat and possible changes of the Indian summer monsoon on the distribution of water resources, and generate recommendations for appropriate and efficient adaptation strategies to hydrological extreme events.

“Drought in Andhra Pradesh: Long term impacts and adaptation strategies,” World Bank, September 2005: <http://www.wassan.org/apdai/documents/Drought,%20Andra%20Pradesh%20Vol-I.pdf>

- Scope: Andhra Pradesh
- Timeline: Reported 2005
- Goal: to enhance state’s capacity to assess long-term impacts of drought and raise resilience by: (a) developing an analytical framework for simulating the long-term impacts of drought, (b) conducting a quantitative probabilistic risk assessment of the impacts under different scenarios; and (c) assisting the Government of Andhra Pradesh in the development of an adaptation strategy.

“Climate Change Vulnerability and Adaptation Experiences from Rajasthan and Andhra Pradesh,” Swiss Agency for Development and Cooperation V&A Programme, 2009: <http://www.intercooperation.org.in/images/Climate%20Change%20-%20Introduction%20to%20V&A%20Case%20studies.pdf>

- Scope: Andhra Pradesh and Rajasthan
- Timeline: Completed
- Goals: to promote adaptation measures for the rural poor.
- Presents adaptation studies of Rajasthan and Andhra Pradesh using farmer participatory research.
- Project trained local climate risk managers.

“Addressing vulnerability to climate variability and change through an assessment of issues and options,” The Energy and Resources Institute (TERI), supported by The World Bank, December 2006.

- Scope: Preliminary basin selection: Pennar in Andhra Pradesh, Mahanadi in Orissa, Godavari in Maharashtra
- Timeline: Ongoing
- Goal: Identify issues and opportunities that enhance the coping capacities of agricultural communities in dealing effectively with climatic extremes, including droughts and floods.
- Reviewing coping strategies being employed by communities in India and assessing issues and opportunities for adaptation, focusing on drought and flood affected regions.

G. CLIMATE ADAPTATION IMPLEMENTATION FRAMEWORKS

“National Action Plan on Climate Change,” Government of India: <http://pmindia.nic.in/Pg01-52.pdf>

- Discusses national government strategy for addressing climate change mitigation and adaptation.
- Focuses on eight national missions (e.g. Solar, Water, Sustainable Habitats etc) that will carry out National Action Plan, and institutional arrangements for implementing mission strategies.

D. Sharma, S. Tomar, "Mainstreaming climate change adaptation in Indian cities" *Environment and Urbanization*, 22 (2), 2010, pp. 451-465: <http://eau.sagepub.com/content/22/2/451.abstract>

- Reviews the adaptation initiatives underway in India.
- Discusses obstacles and needs for effective mainstreaming of adaptation within urban development and urban governance.
- Concludes that municipal authorities may be engaged if they can see the co-benefits between adaptation and measures to address development and environmental health concerns.

A. Revi, "Climate change risk: an adaptation and mitigation agenda for Indian cities," Sage Publications, *Environment and Urbanization*, 20(1), 2008, pp. 207-229: <http://eau.sagepub.com/content/20/1/207.full.pdf+html>

- Describes a possible urban climate change adaptation framework, including changes needed at the national, state, city and neighborhood levels, and linkages to mitigation.
- Highlights the importance of infrastructure investments, and of urban management engaging

with changing risk profiles, including the need to connect official adaptation initiatives to existing natural hazard risk assessment, management and mitigation capacity.

"Disaster Management and Climate Change: India's risk management policy frameworks and key challenges," Centre for Social Markets (India), January, 2011: http://www.indiaclimateportal.org/images/pdf/Swiss_Re_Disaster_Management.pdf

- Describes Indian national institutional frameworks and initiatives for climate action and for disaster risk management.
- Proposes greater integration of disaster and climate risk management policies, programs, and institutions.

H. INDIA HEALTH PROFILES (NATIONAL, MUNICIPAL, ETC)

"Capitalizing on the Demographic Transition," Tackling Noncommunicable Diseases in South Asia," World Bank, February 2011: India factsheet: <http://siteresources.worldbank.org/SOUTHASIAEXT/>

VII: ATTACHEMENTS

1. **IUSSTF Report Form**
2. **Articles**
3. **Workshop Agenda**
4. **Workshop Photographs**
5. **Blogs**
6. **List of Attendees**
7. **Resources/Bibliography**
8. **Survey Questionnaire**

Endnotes

- 1 Dr. K.S. Reddy, Summary of Keynote Speech, March 2011 Kickoff Workshop, Ahmedabad, India.
- 2 K.R. Kumar, et al., "High-resolution climate change scenarios for India in the 21st century," *Current Science* 90(3), February 2006: <http://www.ias.ac.in/currsci/feb102006/334.pdf>
- 3 *See id.*
- 4 In the U.S., for example, heat waves contribute to more fatalities, on average, than all the hurricane/tornado, flooding, wildfire, and drought events combined.
- 5 J. P. Majra and A. Gur, "Climate change and health: Why should India be concerned?" *Indian Journal of Occupational & Environmental Medicine*, 13(1), 2009, 11-16: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2822161/>
- 6 Dr. Dileep Mavalankar Presentation and Dr. Gulrez Shah Azhar Preparatory Materials, March 2011 Kickoff Workshop, Ahmedabad, India.
- 7 Government of India, *Census of India 2011: Provisional Population Totals, Population and Decadal Growth Rate by Residence—Persons*. Census of India Website: Office of the Registrar General & Census Commissioner, India: http://www.censusindia.gov.in/2011-prov-results/paper2/data_files/Gujrat/6-pop10-28.pdf
- 8 Jitendra Dave, "Ahmedabad realty boom is music to Mumbai builders," *DNA*. May 10, 2010: http://www.dnaindia.com/money/report_ahmedabad-realty-boom-is-music-to-mumbai-builders_1381272
- 9 Government of India, *Census of India 2001 (Provisional) Slum Population in Million Plus Cities (Municipal Corporations): Part A*. Census of India Website: Office of the Registrar General & Census Commissioner, India: http://censusindia.gov.in/Tables_Published/Admin_Units/Admin_links/slum1_m_plus.html
- 10 Self Employed Women's Association (SEWA), "Labouring brick by brick: A study of construction workers," SEWA, June 2010: http://www.sewaresearch.org/pdf/researches/labouring_brick_by_brick.pdf
- 11 Weatherbase.com, Weather for Ahmadabad, India, Last accessed: January 18, 2012: <http://www.weatherbase.com/weather/weatherall.php?s=74624&refer=&units=metric&cityname=Ahmadabad-Bihar-India>
- 12 Hong King Observatory, Climatological Information for Ahmedabad, India, Last accessed: January 18, 2012: http://www.hko.gov.hk/wxinfo/climat/world/eng/asia/india/ahmedabad_e.htm
- 13 Ashok Patel. "Maximum Temperature Record Broken At Many Places In Saurashtra, Kutch & Gujarat" Weather Forecast by Ashok Patel, May 21, 2010: <http://www.gujaratweather.com/forecast/index.php?m=05&y=10&entry=entry100521-220006>
- 14 Himansh Dhomse. "2001 Gujarat earthquake: Structural design now at the 'epicentre.'" *DNA*. Jan. 26, 2011: http://www.dnaindia.com/india/report_2001-gujarat-earthquake-structural-design-now-at-the-epicentre_1499343
- 15 Dr. Kris Ebi & Dr. Kim Knowlton, Summary of Presentation, March 2011 Kickoff Workshop, Ahmedabad, India.
- 16 "Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change," R.S. Kovats, K.L. Ebi, B. Menne, World Health Organization Europe, 2003: http://www.euro.who.int/_data/assets/pdf_file/0009/91098/E81923.pdf; Dr. Kris Ebi & Dr. Kim Knowlton, Summary of Presentation, March 2011 Kickoff Workshop, Ahmedabad, India.
- 17 The Anganwadi Program was started by the Government of India in 1975 as part of the Integrated Child Development Scheme (ICDS). It is a grassroots program that reaches out to women in rural areas and urban slums, to educate them on matters of basic health and hygiene, nutrition, pre-natal and post-natal maternal and childcare and child rearing. See The Anganwadi Workers Training Centre on the Delhi Council for Child Welfare website at <http://dccw.org/anganwadi.html> for more details.
- 18 Auxiliary nurse-midwives are the key field-level health care providers who interact directly with the community and are the central focus of all the reproductive child health programs, particularly in the rural health care system. For more information, see Mavalankar, Dileep V. & Vora, Kranti S. "The Changing Role of Auxiliary Nurse Midwife (ANM) in India: Implications for Maternal and Child Health (MCH)." *eSocial Sciences Working Papers Series*. August 21, 2010: <http://ideas.repec.org/p/ess/wpaper/id2755.html>
- 19 Using multiple methods to collect data, such as both surveys and focus groups, is valuable because relying on one method may not capture everything the evaluator wants to understand.
- 20 The challenges and opportunities listed in this section were identified in anticipation of the 2011 Kickoff Workshop on heat health vulnerability in Ahmedabad. The information was gleaned through discussions with local stakeholders and research and analysis of available data and reports.
- 21 The Emergency Management and Research Institute trains emergency medical responders and maintains data for all emergency calls.
- 22 See footnotes 20 and 21 above for more information.
- 23 Note that cultural norms may still restrict impoverished residents' access to these redeveloped mills and shopping centers. Addressing these cultural and class issues is beyond the scope of this report.
- 24 For example, the Gandhi Labor Institute in Ahmedabad may be an appropriate body to take on this research.
- 25 In Ahmedabad, most residents go to private hospitals rather than urban health centers for medical services. Further investigation is needed to determine what percentage of residents use private hospitals and why.
- 26 The local "104" hotline is the equivalent of paramedics' emergency "911" telephone service in the U.S.
- 27 Providing written materials raises literacy issues and developing alternative approaches to communicate with the illiterate population warrant further discussion, but these issues are beyond the scope of this report.
- 28 Link workers are contractual employees within Ahmedabad's health department who provide visiting or in-home nursing care. Link workers' duties include visiting individual homes to administer medicines to patients and carrying out door-to-door surveys to monitor the city's health.
- 29 Although this phenomenon of the elderly living in old age homes is currently uncommon, further research is required to determine (i) what the approximate number of such old age homes is, and (ii) how many people occupy these old age homes, both in Ahmedabad and India in general.
- 30 As of the publishing of this report, mapping of survey results or analysis of findings had been completed.

