Developing Climate Adaptive

&

Gender Integrated Heat Action Plans

20 YEARS Integrated Research and IRADe Action for Development

APN ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

Prepared by:

Integrated Research and Action for Development

Funded by Asia Pacific Network for Global Change Research (APN)

Project Partners

This material is based on work supported by the Asia-Pacific Network for Global Change Research (APN).

For Citation: Magotra, R.; Jha, N, Desai, V.; (2023). Developing Climate Adaptive and Gender Integrated Heat Action Plans for South Asian Cities

Table of Contents

Executive Summary

The frequency and intensity of heatwaves is expected to rise in the 21st Century. It affects human health and often results in physiological stress in people even triggering mortality. The worrisome part is that heat waves affect a large population in a short span of time which may create health issues and produce cascading socio-economic impacts such as work loss and a decrease in labour productivity. To add to this, low heat-health risk awareness among the citizenry, preparedness of governance systems to respond to heat-related threats, and lack of policies to improve system preparedness are creating repercussions of health emergencies, wellbeing and economy of the cities.

The ongoing and exponential threats to the environment and the recent wake-up call in the 6th IPCC report on the heating of Earth's surface around 1.1 °C (2.0 °F) highlight that future global mean temperature and resulting heat waves are only expected to increase. The world's seven warmest years have all occurred since 2014, with 10 of the warmest years occurring since 2005 (NoAA, 2021).

In India, heat waves are a silent killer and cause the most deaths in cities compared to any other natural disaster in India. Cities are today experiencing an unprecedented increase in the number of heat waves, which along with the Urban Heat Island (UHI) effect produce disastrous consequences, particularly for the vulnerable population. Nearly 40 million households in cities reside in informal housing which makes them more susceptible to heat and other climate impacts. Street vendors, daily wage labourers, factory workers, women, senior citizens and |people with co-morbidities in slums are ultra-vulnerable and generally at a higher risk of heat-related morbidity and mortality. Here the role of the Urban Local Bodies (ULBs) is critical in laying down pre-emptive measures to respond to heat waves while working in tandem with a range of stakeholders such as local and regional administrations, non-profit organisations, planners, policymakers, experts and scientists, political institutions, media and academic and research institutions.

Integrated Research and Action for Development (IRADe) under its APN-funded project on "Gender Sensitive Heat Action Planning for South-Asian Cities" has developed this manual to sensitise the city-level ULB in the cities of Colombo (Sri Lanka), Rajshahi (Bangladesh) and Surat (India) about the need for immediate actions on heat wave prevention and management but also be better prepared to adapt to the situation and sustain functionality and contribution of people/citizens and makes the city future ready. The objective of the training manual is to help the stakeholders develop a gender-sensitive Heat Action Plan (HAP) for their city. It also

enables the stakeholders by building their capacities and understanding heat waves' implications on human health. It also seeks to develop enduring and efficient participation of the government govt institutions and non-govt government institutions in addressing heat waves.

This training manual will build the capacity and knowledge of the ULB and its stakeholders in the heatwave management of the city. This module uses exercises for the learners to help them better understand the process of the development Heat Action Plan development (HAP). These hands-on exercises along with key resources will ensure its effective implementation and better deal with heatwave challenges.

This manual may also be adapted to the needs and requirements of other cities that plan to undertake actions to mitigate and adapt to the heat waves. This will not only help other cities to strengthen heat wave preparedness for its vulnerable populations especially women by establishing approaches and pathways required for adapting and mitigating the risks of heat stress on the well-being of the citizens and productivity of the cities. It will help these institutions to have better capacities to deal with the extreme impacts of heat waves.

1. Introduction to the Training Module

1.1 Who is the training manual designed for?

This training manual is designed for government officials, especially those working in urban local bodies (ULBs) and city administrations, including their training experts. This manual is also designed for researchers and experts from the field of climate change, disaster management and public health. It provides a detailed understanding of vulnerability to extreme heat in urban areas, and how to cope with it. The manual also provides a deep understanding of the many ways in which women are particularly vulnerable during heat waves. Above all, it facilitates the development of a climate-sensitive heat action plan for cities, keeping the vulnerability of women at the centre, and also mindful of the vulnerability of children and the elderly.

This manual will be particularly useful for policy-makers. It will help them formulate a structured approach to integrate heat resilience into the disaster and climate action plans of the country.

1.2 What is the focus of the training manual?

The objective of the training manual is to help develop a climate-adaptive heat action plan. It also helps build capacity by creating an understanding of the implications of heat stress on the health, productivity and livelihood of vulnerable segments of the population. It also seeks to develop enduring and efficient participation of the government, and of government and non-government institutions, in addressing heat waves.

On completion of the module, the participants will:

1. Comprehend the risks, threats, and vulnerabilities of climate-induced heat stress and heat waves
2. Understand the features of a climate adaptive heat action plan, and the methodology to develop and implement it
3. Know the methodology for the identification of heat hotspots/urban heat islands and conduct vulnerability assessment of the poor
4. Be able to formulate better heat wave management protocols for the city's jurisdiction, and communicate it effectively among stakeholders
5. Be capable of training others on inclusive heat action plans
6. Will be able to sensitise and train stakeholders on emergency preparedness in hospitals and health centres
7. Know how to enhance the participation of stakeholders in addressing challenges posed by heat waves

1.3 How to make use of this manual?

This manual is easy to use as it builds participants' expertise component by component. Each training component is devised to provide a deeper understanding of:

- heat waves in the Context of climate change
- extreme impacts of heat waves in low-income and vulnerable households
- how to identify first, areas in a city most affected by heat waves and second, groups that are most vulnerable in these areas
- actions to be taken to build the mitigation-and-adaptive capacity of a city
- how to operationalise these plans

1.4 What are the learning outcomes of the training?

On completing this training participants will have:

1. Greater awareness of heat waves and their implications
2. Ability to prepare an effective heat action plan for a city
3. Capacity to manage morbidity and mortality related to extreme heat along with the development of an early warning system for the city
4. A clear idea of how to disseminate knowledge on the heat wave and its impacts with other stakeholders at the city, state and national levels of government

1.5 Scope and limitations of the training

This training manual covers the myriad impacts of a heat wave and its implications on people's health; it builds a city's capacity to adapt to and cope with extreme heat. This training is scientific in its approach; it is also gender sensitive and inclusive as it builds the capacity of participants to plan mitigation and coping measures for all social groups, (including, women, children, newborns and the elderly) and not just those who are most visible (outdoor labourers). Another important aspect of this manual is to guide on how to build an effective heat wave forecast system. The training manual though is not without limitations. Some of the key disadvantages include the following:

1. Its content, learning material, and resources will need to be updated from time to time, as heatwave conditions keep altering with continuously changing climate patterns.
2. Since the participants will most likely be from diverse disciplines, they will need to be brought to the same level of understanding of climate change, adaptation, resilience and heat waves.

2. Climate change impacts on heat waves

This module serves as an entry point to the topic of climate change and heat waves. It shares basic scientific knowledge of rising temperatures and how they increase risks and impact the health and survival of people.

2.1 Learning objectives

To share an updated knowledge on climate change related to extreme heat and significant extreme heat events in the past and their impacts

To develop a basic understanding on heat waves and their effect on human health

Vulnerability emerging from heat waves

2.2 Heat waves are frequent

Heat waves are now becoming a new normal around the world. An interplay of climate change, global warming and increased frequency of urban heat island effects are causing temperatures to soar in cities. The Intergovernmental Panel on Climate Change (IPCC) report of 2018 maintains that "human-induced warming reached approximately 1°C (*likely* between 0.8°C and 1.2°C) above pre-industrial levels in 2017, increasing at 0.2°C (*likely* between 0.1°C and 0.3°C) per decade." IPCC is a UN body that regularly releases scientific assessments on human-induced climate change.

Globally, hot days are getting hotter, becoming more frequent and lasting longer. Future climate projections depict scenarios where heat waves are more frequent and severe in certain locations (Zittis et al, 2019). Heat waves vary in intensity, frequency, duration, timing and spatial extent from place to place. Similarly, their impact on human life varies from population to population, as it is influenced by acclimatisation, occupation and socio-economic status.

Numerous studies have highlighted an increase in heatwave duration across South America, Africa, West Asia and South Asia (Perkins-Kirkpatrick and Lewis, 2020; IPCC, 2018). Heat waves are accelerating in trends globally with an average temperature rise of 1 °C-4.5 °C each decade but in some places, like West Asia, and parts of Africa and South America, the trend is up to 10 °C a decade (Perkins-Kirkpatrick and Lewis, 2020). Recent studies are increasingly pointing towards a rapid increase in heat waves over many regions. According to S.E. Perkins-Kirkpatrick and S.C. Lewis, climate change research scholars in Australia, this trend is most notably visible between 1950 and 2000 (*Nat Commun* 11, 3357, 2020. https://doi.org/10.1038/s41467-020-16970-7). Deadly heat stress conditions might become commonplace across South Asia even at 1.5 °C global warming (Sayeed et al, 2021). Future projections of temperature indicate a steady increase across three periods – the 2030s, 2050s, and 2080s – with anomalies reaching 4-5 °C for high emission scenarios by 2080.

The trend has already begun for some time now. World Health Organisation (WHO) states, the frequency, duration, and magnitude of extreme temperature events are increasing globally (2019). In India too, by the end of the 21st century, the frequency of heat waves is projected to increase 30 times[1] the current frequency whereas the duration of heat waves is expected to increase 92 to 200 folds. While India is accustomed to high temperatures, a large number of fatalities resulting from recent heat waves has highlighted the importance of this health risk. Heatstroke is the second most common contributing cause of accidental deaths due to natural causes. There have been 25,716 deaths from 1992 to 2016 due to heat waves in India[2]. The country recorded a 61 per cent increase in heat-related mortality between 2004 and 2013 (NRCB, 2014).

The impact on people's health is more severe in urban areas, where residents are exposed to higher, and nocturnally sustained, temperatures. This is because in cities heat is trapped near the earth's surface – concrete buildings, roads, and other city infrastructure absorb solar energy; rapid urbanisation causes a greater degree of energy-intensive activities, and at the cost of the city's green cover. All this results in higher temperatures in what is known as the urban heat island (UHI) effect. Since the majority of workplace settings are influenced by outdoor temperatures in developing countries, it can be expected that both indoor and outdoor workers

[1] 2-degree Celsius warming scenario of IPCC AR5 and 1.5- and 2-degree Celsius scenarios of AR5

[2] Guidelines for Preparation of Action Plan – Prevention and Management of Heat-Wave 2017 by NDMA and GoI

will experience increased heat stress due to climate change, urbanisation and other related factors.

Climate change is also causing a change in the rainfall pattern thereby increasing exposure to extreme heat among vulnerable groups. Exposure to a temperature beyond 37.3 °C continuously for a longer period causes heat stress in the human body.

Low-income populations, who cannot afford quality accommodation with basic quality of living, and those who are alone and cannot access cooling systems, are highly vulnerable to heat stress and related illnesses. Also, persons with chronic mental illness and pre-existing medical conditions (such as obesity, and cardiovascular and neurological diseases) are at increased risk of heat stress (NIOH, 2009).

2.3 Heatwave definition and criteria

As per India's National Disaster Management Authority (NDMA), a heat wave is a period of abnormally high temperatures, more than the normal maximum temperature that occurs during the summer season. According to India Meteorological Department (IMD), heat wave conditions occur when the maximum temperature of a weather data-gathering station reaches at least 40 °C or more in the plains, 37 °C or more in coastal stations and at least 30 °C or more in hilly regions.

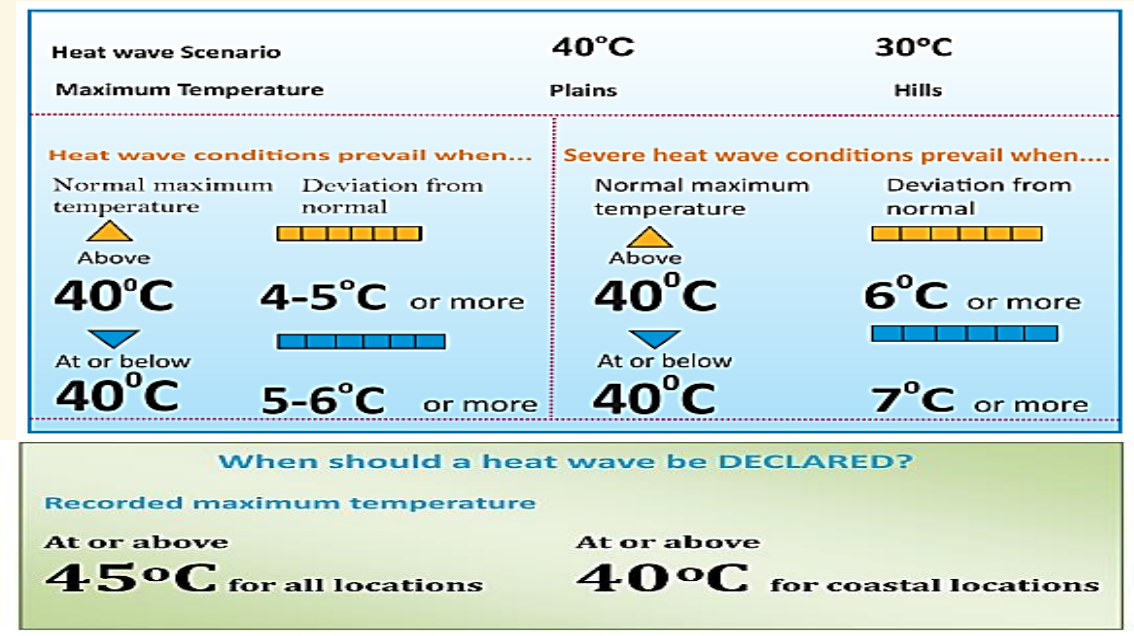


Figure 1 – Heatwave scenario in the plains, and coastal and hilly areas. Source: India Meteorology Department (IMD)

To go into more detailed criteria, IMD[3] declares heat waves based on the following:

i. **Based on departure from normal temperature**

- Heat Wave: when the departure from normal is an increase of 4.5 °C to 6.4 °C
- Severe Heat Wave: Departure from normal is more than 6.4 °C

ii. **Based on Actual Maximum Temperature (for plains only)**

- Heat Wave: When the actual maximum temperature is ≥ 45 °C
- Severe Heat Wave: When the actual maximum temperature is ≥47°C

To declare a heat wave, the above criteria should prevail in at least two data-gathering stations in a meteorological sub-division for at least two consecutive days. On the second day, IMD then declares it to be a heat wave.

2.4 Colour-coded signals for heat alerts

Based on the criteria for a heat wave, heat action plans (HAP) currently in use in India, have developed an early warning system which has three colour-coded heat alerts.

These alerts are issued by the nodal officer in the urban local body, or municipality, concerned based on the data received from IMD. Subsequently, different departments will activate their respective channels of communication and launch into predefined mitigation activities.

Figure 2: Colour System for Heat Alert, IMD

India has experienced several heatwaves, since 2006. The average temperature during 2018 was significantly above normal (41° C and above); 2019 was the seventh warmest year on record since nationwide record-keeping began in 1901. June and July 2019 have been the hottest months on record globally, with the US National Oceanic and Atmospheric

[3] http://imd.gov.in/section/nhac/termglossary.pdf

Administration (NOAA) confirming June 2019 being the hottest, at 0.95° C above the normal average.

We have already learned at the start of this module what the future holds, according to IPCC – that under the 2 °C global warming scenario, the frequency of heat waves in India is projected to increase 30 times the current frequency by the end of the century. The duration of heat waves is also expected to increase 92- to 200-fold under 1.5 and 2° C global warming scenarios. Coupled with widespread poverty in South Asia, the impact can be severe. Future projections of temperature indicate a steady increase with anomalies reaching 4-5° C for high emission scenarios by 2080.

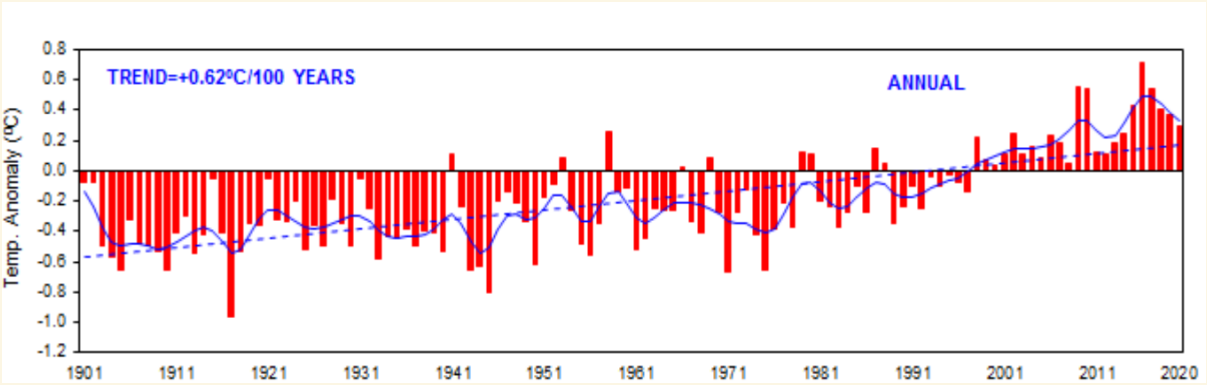


Figure 3: Annual mean land surface air temperature anomalies 190-2020. IMD, 2020

An interplay of climate change, global warming and increased frequency of urban heat island effects are triggering temperatures to rise in cities. Each city, however, differs in its heat pattern (Jacob, 2019)[4]. This calls for experts to work on heat and humidity trends of the last 30 years along with associated mortality and morbidity to re-evaluate the impact of heat waves on human health. More studies are needed as there is a knowledge gap on the matter.

As of now, the impact of a heat wave on health/society is universally measured in terms of temperature and all-cause mortality figures. Even city/area-specific cut-off range for a heat wave is assessed at the level of a statistically significant increase in all-cause deaths. In practice, specific morbidities are not looked into as the symptoms of early manifestations overlap; there is also a lack of uniformity and standardisation of health data.

[4] Cor Jacobs, Tanya Singh, Ganesh Gorti, Usman Iftikhar, Salar Saeed, Abu Syed, Farhat Abbas, Bashir Ahmad, Suruchi Bhadwal, Christian Siderius, Patterns of outdoor exposure to heat in three South Asian cities, Science of The Total Environment, Volume 674,2019,Pages 264-278, ISSN 0048-9697,https://doi.org/10.1016/j.scitotenv.2019.04.087

2.5 Mapping heat hotspots

Which is the hottest spot in the city?

1. **Built-up Environment**: A city's built-up environment mainly consist of houses, buildings and roads. These absorb and radiate heat due to the materials used – concrete, asphalt and steel. We have already learned earlier that this phenomenon is commonly known as the urban heat island effect.
2. **The density of structure**: The density of buildings with very little open space enhances the UHI effect. Then there are the informal settlements in several city municipal wards. Most of these settlements are of squatters; they are mostly families who have migrated from rural areas or smaller towns. This migrant population lives in makeshift structures made of walls of plastic sheets and with a galvanised iron sheet thrown in as a roof. In many instances, asbestos and plastic sheets are also used to serve as a roof for these shanties. Residents in these pockets are more likely to be exposed to intense heat and are at a high risk of heat-related morbidity and mortality.
3. **Minimal green cover**: The densely populated urban areas witness warmer temperatures during summer nights, compared to small towns and rural areas of India. The nights are warmer in urban areas owing to the absence of evapotranspiration and thermal storage in concrete structures. As a general estimation, areas with more green spaces tend to be cooler.

To sum up, the hottest spots in a city are areas that are densely populated with an overwhelming presence of concrete houses, buildings and highrises. The roads in these neighbourhoods are made of asphalt. And on the edge of such municipal wards are the ubiquitous squatter settlements. In many instances, shanties exist between concrete buildings and houses.

When working with local governments to develop interventions, it is crucial to think about how temperatures might change within the city, where they're higher, and where the most vulnerable individuals are. These variables not only help in developing targeted interventions but also help in reaching timely mitigation measures to minimise heat wave impacts. Partnering with stakeholders can be a helpful way to identify specific information about the city.

2.6 Heat wave impacts on human health

Heat-related stress can range from minor to life-threatening, depending on the overall health of the individual (physiological condition), acclimatisation status and exposure (intensity, frequency and duration). Heat Stress can be classified into the following five[5] types.

a. Heat Rash
b. Heat Cramps
c. Heat Exhaustion
d. Heat Syncope
e. Heatstroke

Heat Rash

Heat rash is a skin irritation caused by excessive sweating during hot, humid weather. Usually appears on the neck, upper chest, groins, under women's breasts, and in elbow creases. These areas keep the skin warm and moist and may make the condition worse. Treating heat rash is simple and usually does not require medical assistance.

Heat Cramps

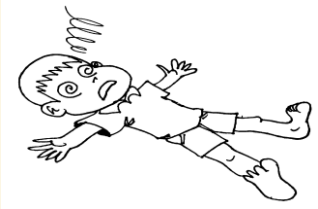
Heat cramps are painful muscle cramps caused by low salt levels in muscles. Excessive sweating and dehydration result in a loss of body salts.

Heat Exhaustion

Heat exhaustion is the body's response to excessive loss of water and salts through profuse sweating. Physical exertion in a hot environment can trigger such a condition.

[5] Heat Stress - Heat Related Illness by CDC, USA.
https://www.cdc.gov/niosh/topics/heatstress/heatrelillness.html

Heat Syncope



Syncope means fainting or dizziness. Heat syncope is a fainting episode that occurs in the heat, either due to prolonged standing or exercise, or when rapidly standing from a prone or sitting position. It typically occurs in individuals who are not acclimatised to the heat. Dehydration can also contribute to this condition.

Heat stroke

Heatstroke is the most severe form of heat-related illness which can sometimes lead to death or permanent disability if not treated at the proper time. It is a medical emergency and requires immediate hospitalisation. When heatstroke occurs, the body temperature can rise to 106 °F or higher within 10 to 15 minutes. A heatstroke occurs when thermoregulatory mechanisms fail.

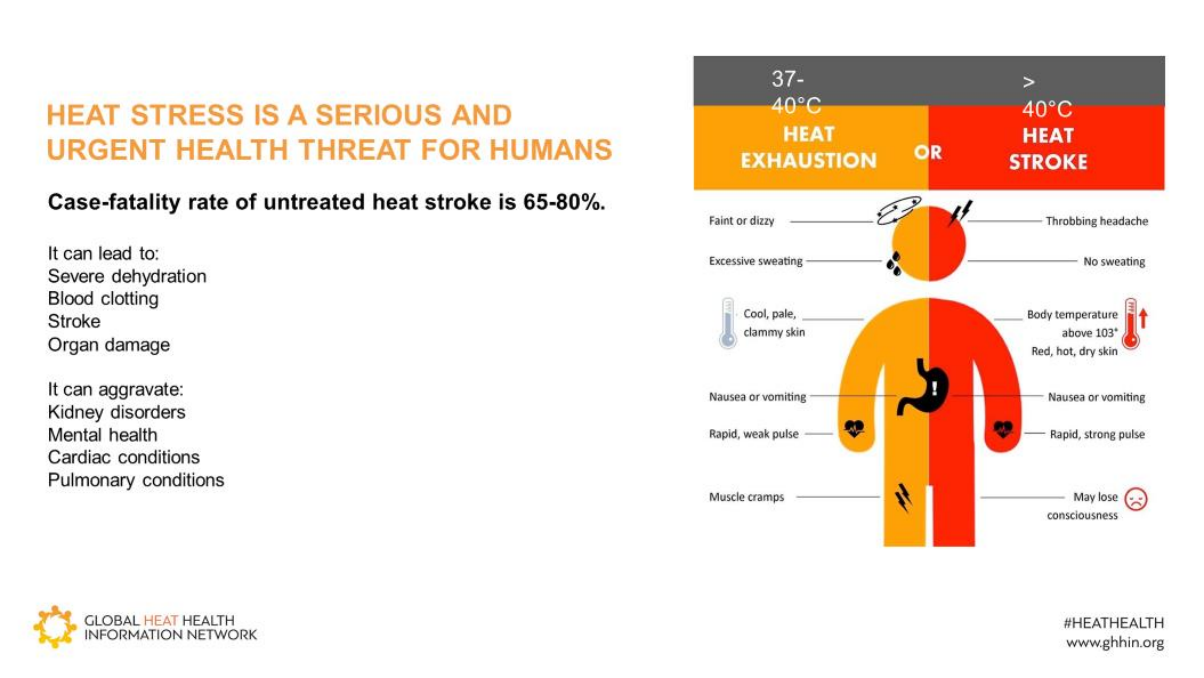


Figure 4: Heat Exhaustion and Heat Stroke due to Heat Stress

Table 1: Heat Illness - Typical Presentations

Clinical Entity	Age Range	Setting	Cardinal Symptom	Cardinal Signs	Pertinent Negatives	Prognosis
Heat Rash	All, But frequently children	Hot environment; +/- insulating	Itchy Rash with small red bumps at pores in the setting of heat	Diffuse maculopapular rash, occasionally pustular, at hair follicles; pruritic	Not focally distributed like a contact dermatitis; not confluent patchy; not	Full recovery with the elimination of exposure

		clothing or swaddling	exposure; bumps can sometimes be filled with clear or white fluid		petechial haemorrhages	and supportive care
Heat Cramps	All	Hot environment typically with exertion; +/- insulating clothing or swaddling	Painful spasms of large and frequently used muscle groups	Uncomfortable appearance may have difficulty fully extending affected limbs /joints	No contaminated wound/tetanus exposure; no seizure activity	Full recovery with the elimination of exposure and supportive care
Heat Exhaustion	All	Hot environment; +/- exertion; +/- insulating clothing or swaddling	Feeling overheated, lightheaded, exhausted and weak, unsteady, nauseated, sweaty and thirsty, inability to continue activities	Sweaty/Diaphoretic; Flushed skin; hot skin; normal core temperature; +/- dazed, +/- generalised weakness, slight disorientation	No coincidental signs and symptoms of infection, no focal weakness, no aphasia, /dysarthria, no overdose history	Full recovery with the elimination of exposure and supportive care; progression if continued exposure
Heat Syncope	Typically, adult	Hot environment; +/- exertion; +/- insulating clothing or swaddling	Feeling hot and weak; light-headedness followed by a brief loss of consciousness	Brief generalised loss of consciousness in a hot setting, a short period of disorientation if any	No seizure activity, no loss of bowel or bladder continence, no focal weakness, no aphasia/dysarthria	Full recovery with the elimination of exposure and supportive care, progression if continued exposure

Heatstroke	All	Hot environment; +/- exertion; +/- insulating clothing or swaddling	Severe overheating, profound weakness, disorientation, obtundation, seizures or other altered mental status	Flushed dry skin (not always), core temperature ≥ 40-degree C, altered mental status with disorientation, possibly delirium, coma, seizures, tachycardia, +/- hypotension	No coincidental signs and symptoms of an infection; no focal weakness; no aphasia/dysarthria, no overdose history	25-50% mortality even with aggressive care, significant morbidity if survive

The heat wave impacts detailed in the table above have a high fatality rate. It needs to be highlighted here that the community in general experiences diarrhoea, headache, giddiness, and epistaxis, the common symptoms of heat wave impact on health.

2.7 Need for climate adaptive heat action plan

The IPCC 6th Assessment Report has underscored that climate change has already started to impact every corner of the world and its impacts will be severe. Climate change is already causing widespread disruption in every region in the world with just 1.1 ^{o}C (2 ^{o}F) of warming. In fact, some impacts of climate change are already too severe to adapt to[6]. The World Meteorological Organisation (WMO) consolidated data shows that the year 2021 is one of the seven warmest years on record[7]. Future projections of temperature indicate a steady increase across the three periods (the 2030s, 2050s, and 2080s), with anomalies reaching 4-5 °C for high emission scenarios by 2080. According to the Global Climate Risk Index 2020[8], countries in South Asia are among the most vulnerable globally to the impacts of climate change. India, ranked 5th in that list and having witnessed consecutive years of highest temperatures between 2015 and 2019, is highly susceptible to adverse impacts from extreme heat.

The heat stress impacts can also be found in other aspects of family life, such as health, work productivity, and livelihoods of the economically and socially marginalised population,

[6] https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/
[7] https://public.wmo.int/en/media/press-release/2021-one-of-seven-warmest-years-record-wmo-consolidated-data-shows
[8] Global Climate Risk Index 2020, Germanwatch

especially women. This, therefore, creates an imminent need for Climate Adaptive Heat Stress Action Plans for Vulnerable Communities in South Asia. The climate-sensitive heat action plans will help cities in establishing pathways required for heat adaptation by developing strategies for vulnerable groups, building stakeholder capacity and sharing learning at the regional level.

With temperatures breaking records around the globe, cities and regions across the country are taking concrete action to be better prepared and protect local communities from deadly heat. There are a number of evidence suggesting that heat-related risks could be reduced through the systematic development of Heat Action Plans which include an early warning system, community awareness and capacity-building strategies of various stakeholders.

The heat action plans will help the city not only prevent disease, productivity loss, economic damages and even death associated with heat waves but will also reduce the chances of illness due to extreme heat. The plan creates better preparedness for the hospitals/primary health centres, it prepares the community to adapt to the situation and sustain functionality and contribution of people and makes the city future ready. It also reduces loss of income by improving productivity and minimizing loss of job days.

Discussion questions:

1. How is climate change leading to warmer days in your location?
1. What are the key impacts of a heat wave on us?
2. Are heatwaves a local issue?
3. Why are cities facing these impacts the most?
4. Do the cities with different geographies experience heatwaves differently?
5. Are there any intra-city variations in heat waves?

3. Developing City-Level Heat Action Plan

This module is designed to guide the cities and their stakeholders to develop climate-adaptive and gender integrated heat action plans (HAP). In addition to the process, this module will help lay down a year-round clear allocation of roles and responsibilities of the stakeholders. It will also share key areas necessary for planning the prevention and management of extreme heat to minimise impacts on the health of people by transforming it into practice and efforts and sustaining it by its revision every year as the trend of heat (temperature) and its impact on health is not static.

3.1 Learning objectives

How to assess the climatological variance and its role in formulating HAP

Various components of a heat action plan and how develop one

How to assess heat vulnerability and map a city's thermal hotspots

Understand the city level institutional mechanism and identify stakeholders to cope with extreme heat

To understand importance of multi-stakeholder local team and public

3.2 Heat Action Plan

Heat action plans aim to provide a framework for the implementation, coordination, and evaluation of coping mechanisms for extreme heat. Heat action plans encompass the entire spectrum of planning, responses, and rehabilitation strategies in all three phases – before, during, and after heat wave incidents. A well-structured and well-implemented heat action plan can prevent thousands of heatwave-related mortality cases every year. It can also enhance

livelihoods among the most vulnerable communities and contribute to the overall health of a city or region. The action plans also help cities understand how heat health actions can support their efforts to achieve various goals under the Sustainable Development Goals framework.

3.3 Process of developing an action plan

The process includes the following steps:

KNOW YOUR CITY

City Overview - Socio-Demographic and Urbanization,
Historical Overview - Heat related Mortality and Morbidity

CLIMATOLOGICAL VARIANCE

City Climatological Analysis – Temperature (Tmax, Tmin) and Relative Humidity

THERMAL HOTSPOT MAPPING

Developing methodology
GIS mapping of thermal hotspots - city and municipal ward

VULNERABILITY MAPPING & ASSESSMENT

Vulnerable Group and Area Identification, City level Surveys and Vulnerability Assessment – Ward level

HEAT STRESS IMPACT ASSESSMENT

Impact on Health, Livelihood and Productivity

STAKEHOLDER MAPPING & CAPACITY BUILDING

City and State level stakeholder engagement and community participation

MITIGATION & ADAPTATION STRATEGIES

Key strategies, Pre-heat, during heat and Post Heat Strategies
Sector wise mitigation and adaption measures

DISSEMINATION, MONITORING & EVALUATION

Public out-reach, campaigns,
Heat Alerts & Early warning systems

Discussion Questions:

1. How do cities cope with heat waves?
2. In what way will HAP help the city to mitigate the impact of heat waves?

3. How is your city managing its response to heat waves?
4. What should be the process to manage heat waves in your city?
5. How will you prioritise your actions to manage heat waves in your city?

3.4 Know your city

Now that the goal of developing a community-responsive heat action plan for your city is clear, as a starting point, basic information on the city must be well known to all the stakeholders. The role of stakeholders is critical here as they are often the ones already working with the most vulnerable people. They are also aware of the adaptation barriers specific to the community and are critical players in the implementation of such policies.

The first step to developing a heat action plan is an up-to-date situation analysis of the city. This will include a city/zonal/ward level description in terms of location, socio-economic status, population break-up, heat wave trends, all-cause mortality, heatwave-related morbidity and mortality among the people of the city, and identify the city's most critical problems. The situation analysis will also elaborate on the significant initiatives undertaken to manage the impact of heat waves with details of activities and resources allocated for the task.

Box 1

Key information for the city overview

About the city

Location, climate, demography covering economy focus and population composition

Table on infrastructure services (Water supply, housing, sanitation, electricity)

Heat Stress - Definition of heat waves by the city or state or region or country

Incidence of heat waves - 30 years

Climatological average of the city

Impact of climate change on heat wave incidences in city (based on AR6 /any other forecasts) and gather forecast in other studies

Heat wave management practices in the city

Gaps and recommendations

This first step helps identify areas where the action plan needs to look for the identification of vulnerable sections of the city. See Box 1 for details of the situation analysis.

Information Source

You can access information on the city from the ULB, Census data, Metrological Department, district census handbooks, Department of Health, hospitals/clinics, secondary data sources

including death registration, IDSP (Integrated disease surveillance programme), sick leave records and the reports/documents of the ULB.

Check List
1. Collect information on city population, location, topography and socio-economic status 2. Availability of infrastructure services 3. Heat wave morbidity and mortality data 4. Climate profile of the city 5. Review documented impacts of a heat wave in the city and climatology forecast (based on the AR6/any other forecasts) 6. Measures to manage heat wave 7. Action areas, suggestions

Discussion Questions:

1. What are the past trends in heatwave management in your city?
2. How will city-level information help you in developing HAP?
3. What are the experiences of your neighbouring cities with regard to managing heat waves?
4. What action areas are of the most priority in your city?
5. Is key resource allocation enough to manage heat waves in your city? If not, then what is it your city proposes to do about it?

3.5 Climatological Variance

The next step is to study the changing climate pattern of your city. The heat action plan needs to also consider the city's anticipated climate projections. It is equally important to understand how temperatures and relative humidity can vary within the city. When the temperatures are higher, the city's concrete-asphalt environment can absorb heat, radiate it, and make pockets in the city hotter than other areas in what we have already understood as the urban heat island effect. Urban heat islands are to be found in the dense parts of the city with very few green spaces. These may include office areas, the central business district, informal settlements, and other areas with high population density. Key points to be covered in the climatological analysis are listed in **Box-2**.

To analyse the climatological variance of your city you will need to access local climate data available from Meteorology Department. The climate analysis of your city should involve a long-term assessment (30 years) of the climate parameters and if not available for more than 30 years a decadal data assessment can be used as well. These data sets need to be interpreted and analysed to understand the climate pattern. Maximum Temperatures (Tmax), Minimum Temperature (Tmin) and mean monthly humidity data can be collected from the city/state/national meteorological department to understand the climate deviations and prepare the climate variability trends maps (Tmax, Tmin and RH) for the summer season.

Based on the analysis of the climate parameters, you will need to identify the city's hot months and analyse variations in mean monthly relative humidity and seasonal patterns throughout the year. This data should also be discussed with the stakeholders to verify past trends. It is very important that the secondary data sources are summarised to form climate scenario statements that can also be looked at to give a broad idea of the climate risks the city faces. This may also include a review of the temperature thresholds that declare heatwaves in your city. It might be possible that your city's specific climate trends may call for a review of these thresholds.

This process helps to understand the climate variability of your city and its impact. It will help recognise the risks to infrastructure, and services, natural resources due to heat waves. A detailed list of heatwave impacts on city-level services and infrastructure should be developed. This assessment of the system's fragility will give a clear understanding of the changes and their interlinkages to climate change. It will help local policymakers and stakeholders to describe the principal climate threats facing your city. This process will also help remove significant barriers in your ULB to developing responses to heat wave impacts. It will establish a general understanding in the ULB that heat waves are causing significant disruptions in the city.

Information Source

The data on climatic parameters for an identified period – temperature (Tmax, Tmin) and relative humidity – can be procured from the state/national meteorological department. Secondary data may be gathered from the literature available for the city to allow comparative analysis.

Check List

1. Collect the climate data on temperature (T max, Tmin) and relative humidity (10-30 years) from state and national meteorological departments
2. Chronicle the extreme heat events, duration of summer and changes in frequency
3. Understand the climate sensitivity and analyse the climate patterns
4. Impact of the heat wave on the city systems and highlight its fragility
5. Climate projection of the city and lay down pre/during/post hot months of the city
6. Review and if necessary revise the criteria of the city to declare a heat wave
7. Identify the possible effects attributable to climate change

Discussion Questions:

1. What type of climate variations does your city face during summer?
2. Do you think it is due to climate change or any other factor? If yes, how?
3. In what ways has it is affecting the city?
4. What are the variations you observed over the last few decades?
5. Has your city defined criteria to declare a heat wave?

3.6 Thermal Hotspot Mapping

The city overview and the knowledge of the climatic conditions help us understand the exposure and risks to heat waves. These exercises help identify possible local or global factors leading to heat stress. At this point, thermal hotspot mapping will strengthen the understanding of variations in heatwave conditions within the city, which will further help formulate targeted intervention strategies to cope with the heat wave. Thermal hotspot mapping helps to understand the complexities of a city's spatial heterogeneity, which are largely due to the inherent characteristics of urban environments, i.e., the city form, shape, population density, topography, characteristics of urban elements, and materials used, vegetation, and infrastructure services. Maps have proven useful evidence in multi-stakeholder discussions for deliberations over adaptation planning. This is particularly relevant in developing countries where geographic information may not be easily accessible to all stakeholders. For a detailed step-wise exercise, please see box-3.

To carry out this process, first map thermal hotspots through remote sensing using land surface temperature (LST) images from Landsat 8, an American earth observation satellite. Further, validate the LSTs with ambient air temperature recorded by IMD weather data gathering stations, known as automatic weather stations (AWS), that have been put in place in your city by your ULB. Then superimposing the surface temperature maps on a municipal ward-boundaries map, mark the wards with temperatures above the city's pre-determined temperature threshold levels, to get a picture of the thermal hotspots.

Box-2

Thermal hotspot mapping of the city

Collect information on land surface temperature (LST) and ambient air temperature

Wet and dry bulb temperature at the municipal ward level to determine intra-city variations

Analyse spatial heat estreme variability with the various influencing factors of the urban environment in the city

Develop heat maps using remote sensing

Build scenarios with temperature variations

Map climate change patterns

Identify wards/areas that may become heat hotspots due to temperature variations in future

These hotspots were identified based on the surface temperature recordings obtained from your ULB. The data relating to municipal wards and slum locations can also be obtained from the ULB. To understand the intracity variations, a ward-level campaign to assess the wet and dry bulb temperatures should be carried out. This will help to understand the intracity variations in temperature and identify the heat hotspots in the city along with future scenarios with temperature variations. It will support the development of time and location-specific long-term planning for heat wave mitigation and adaptation. For a detailed step-wise process, please refer to box-3.

The hotspot maps so generated are helpful for policymakers and city administrators to analyse the local factors contributing to heat stress in different wards and devise mitigation options to reduce heat stress in these areas.

Information Source

- Land surface temperature (LST) using GIS and remote sensing
- Automatic weather stations (AWS) installed within the city by the ULB

- Use psychrometers to measure humidity by taking both a wet-bulb and a dry-bulb temperature reading
- Ward-level data may be procured from the city ULB

Check List
1. Collect the climate data on temperature (T max, Tmin) and ambient air temperature (30 years) from the state and national meteorological departments 2. Carry out a dry and wet bulb temperature analysis in identified wards 3. Develop a map that contains the key features (transport system, building, land use, utilities etc) of the city 4. Identify the city-level heat hotspots and list them based on different temperature scenarios 5. Identify the time and location-specific impacts faced by the city

Discussion Questions:

1. Will identification of heatwave trends in your city help you better plan for heat waves in your city? If yes, how?
2. Are intra-city variations important in managing heat waves? How will it aid your city's heatwave management?
3. Does your city have to know how to develop such maps?
4. If IMD or any other agency shares these maps, will your city be able to interpret them? If the answer is no, what will you do?
5. How will heat spot identification help you plan better for heat waves?

3.7 Early Warning System

Heatwave early warning systems (EWS) are an approach to reducing the consequences of heat waves on human health. This involves forecasting the heat wave event, predicting possible health outcomes, triggering effective and timely response plans targeting vulnerable populations, notification of heat wave events, communication of prevention responses and evaluating and revision of systems[9].

The climatological analysis and the thermal hotspot mapping of your city provide a comprehensive overview of the heat wave and intra-city variations in heat waves. There are pre-existing EWS on heat waves. According to *WMO-WHO – Heat, Health Guidelines, 2015*, there are two or three separate warning categories: a low-level announcement to warn the population of impending stressful weather; a higher-level issuance to warn people of the dangers to health, and the highest level of warning wherein a variety of measures are adopted. In all cases, warnings must be disseminated rapidly to the public, and responsible stakeholders or the effectiveness of the heat health warning system is greatly diminished (WMO, 1999).

An EWS reduces the consequences to the health, livelihood and productivity of households from heat stress. Timely notification of prevention measures to vulnerable populations will strengthen the heat stress prevention and management measures by the ULB.

- The India Meteorological Department has an interactive heat wave warning map and issues an impact-based forecasting system for heat waves.

Based on the criteria for heat waves, which we discussed in Module 1, Integrated Research and Action for Development (IRADe), developed an early warning system which has colour-coded heat alerts. IRADe is a leading research institute and think tank that has helped develop heat action plans in Indian cities. Here are a few examples of the colour-coded early warning system.

Table 2: Heat alert for the city of Bhubaneswar

Heat- Health Temperature Warning for Bhubaneswar City		
Green (No Action)	Normal Day	Maximum temperatures are near normal

[9] Ebi K.L., Teisberg T.J., Kalkstein L.S., Robinson L., Weiher R.F. Heat watch/warning systems save lives: Estimated costs and benefits for Philadelphia 1995–98. Bull. Am. Meteorol. Soc. 2004;85:1067–1073.

Yellow (Be updated)	Hot day advisory	36.2°C
Orange Alert (Be prepared)	Heat alert day	39.1°C
Red Alert (Take Action)	Extreme heat alert day	Above 41.4°C

Table 3: Heat alert for the city of Delhi

Heat- Health Temperature Warning for Delhi City		
Green (No Action)	Normal Day	Maximum temperatures are near normal
Yellow (Be updated)	Hot day advisory	>= 40 °C
Orange Alert (Be prepared)	Heat alert day	>= 45°C
Red Alert (Take Action)	Extreme heat alert day	>= 47.4°C

Table 4: Heat alert for the city of Rajkot

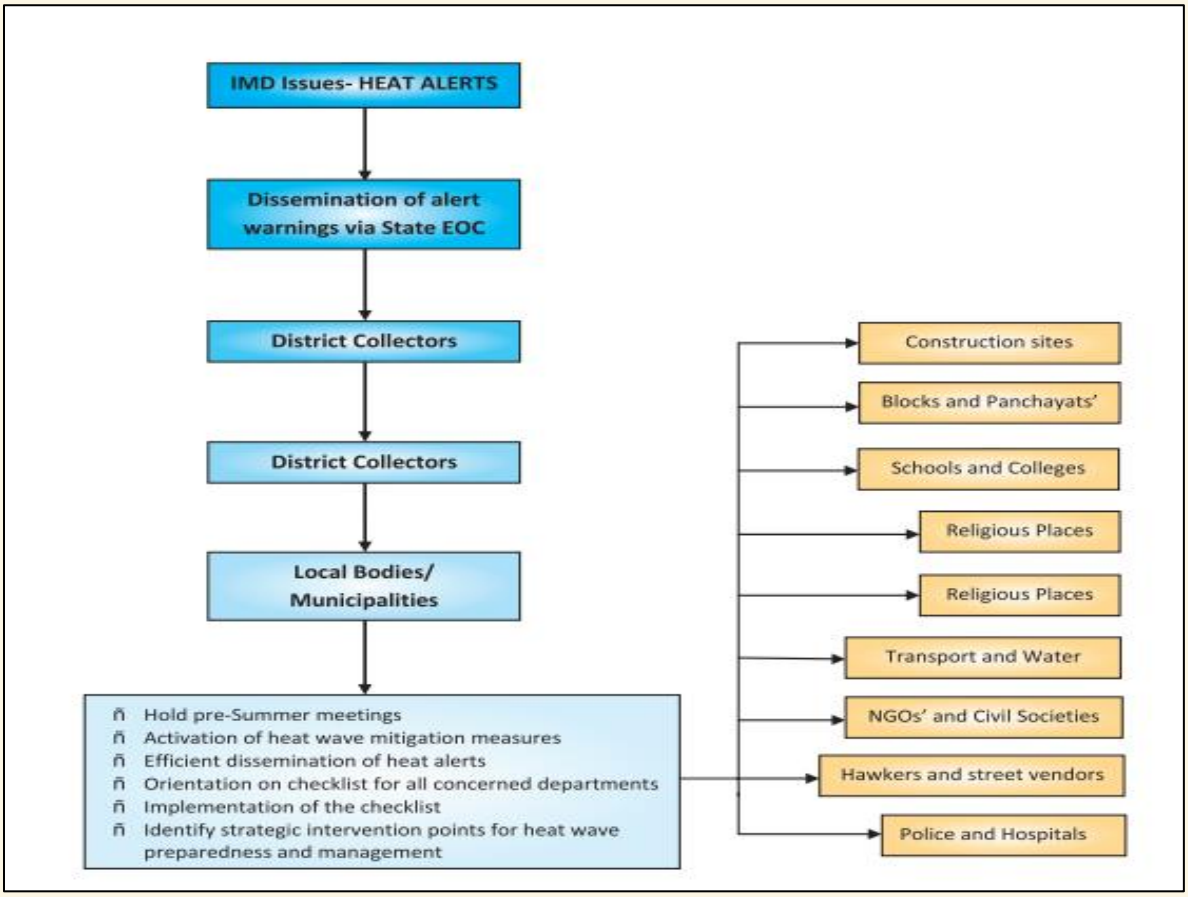
Heat- Health Temperature Warning for Rajkot City		
Green (No Action)	Normal Day	Maximum temperatures are near normal
Yellow (Be updated)	Hot day advisory	40.5 - 43 °C
Orange Alert (Be prepared)	Heat alert day	43.1 – 44.9°C
Red Alert (Take Action)	Extreme heat alert day	>45°C

The various prediction and warning mechanisms include:

Warning Mechanisms	Information Provided / Temperature Forecast	Information For
Seasonal Outlooks	Provides Information on maximum and minimum temperatures for Summer Months (March, April & May)	Country level
Extended Range	Provides Information on maximum and	Country Level

Forecasts	minimum temperatures for 2 weeks	
Medium Range Forecasts	Colour-coded warnings issued daily for up to 5 days	36 meteorological sub-divisions and 739 districts
City Forecast for ~ 470 Cities/Towns	Maximum and minimum temperatures and Heatwave for up to 5 days	470 cities/towns

Heatwave forecasting and its communications include the following steps:



Source: IMD

The colour-coded warning is used to properly sensitise state/district/city level institutions and health professionals. It also helps health professionals with a diagnosis of heatwave-related symptoms and serves as a rationale for starting an appropriate line of management by the ULB. In case of extreme heat, the planning may include sounding the red alert and developing

effective response planning, especially for the vulnerable population. Box-4 lists the steps for developing an early warning system for the city.

Based on the heat wave trends in your city, develop a heat threshold for your city using the city-level mortality data. This process will help the city administration devise appropriate measures to minimise impact. The predicted higher and extreme temperature will facilitate early warnings.

Box- 3

Early warning system

Collect information on real time weather data of the city (maximum temperature)

Collect ward level intracity climate variation

List time and location specific impacts faced by the city

Note mortality figures during high heat periods

Share information with key officials in the ULB and all the relevant departments at the city level

Determine the process of communicating risk information and early warning both internally and with the general public

Check List
1. Collect the real-time weather data from IMD (maximum temperature) 2. Collect all-cause mortality data 3. City-level weather forecast 4. List of key people in ULB for communication with information and urgent contact

Discussion Questions:

1. Does your city have mechanisms to warn the general public about heat waves? If yes, what are these?
2. Do you also collect information from automatic weather stations to identify the intracity variations and devise location-specific heat wave measures?
3. Does your city receive real-time weather data from IMD? If yes, how do you use it?
4. Do the city-level institutions have officials dedicated to ensuring the prompt flow of information? If yes, please describe how this mechanism works and who are the key people.
5. Who issues heat wave advisories and how often are these reviewed?

3.8 Vulnerability Mapping and Impact Assessment of Heat

What is vulnerability?

In developing the heat action plan for your city, it is essential to determine the links between climate change and vulnerability and what this could mean for the city, including its landscape and population. According to IPCC, vulnerability may be understood as "the degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes."

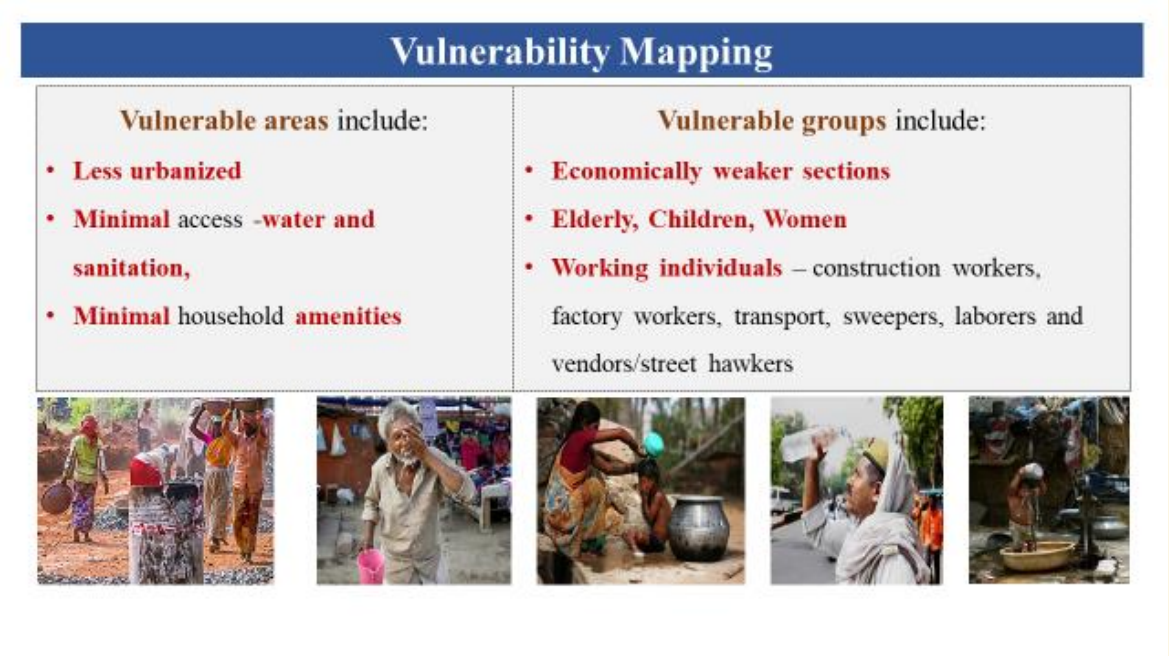
Who is vulnerable?

Identifying the people who are most vulnerable to heat waves and the municipal wards in which they are located, are key to developing a heat action plan. The city plan needs to factor in the level and extent of exposure to extreme heat to assess vulnerability. A household's vulnerability to extreme heat can be both health-related and economic; families dependent on street vending, for example, incur a substantial loss of income during heat waves.

Ward-level vulnerability mapping, therefore, forms the basis for planning appropriate targeted adaptation strategies. To enable identifying vulnerable areas, the ULB should have adequate information about the population distribution, slum areas, public service distribution, and topography of the city. When assessing vulnerability, it is critical to look at the issue from women's perspective, because in most cases it is women, whether they are working or not, are working at chores that increase heat exposure, like fetching drinking water from public taps, cooking under a hot tin/asbestos roof, staying indoors with a poor thermal comfort increases their chances of heat-related illnesses.

Extreme heat is even more unbearable when a woman is pregnant. A pregnant woman is more likely to suffer heat exhaustion or heat stroke because her physiological system has to work harder to cool down her body and the foetus. Pregnant and lactating women are more prone to dehydration. These groups need special attention and hence the plans need to be specific about the measures and interventions.

The image below illustrates vulnerability mapping and its essential components.



Mapping vulnerability to extreme heat

Vulnerable areas

During a heat wave, some parts of the city are hotter than the rest. This results in considerable discomfort for the people living in these areas. A majority of the households in these areas live in just one or two small rooms that accommodate four to eight family members. The cramped living space aggravates symptoms of heat stress. The design of the structure, poor ventilation, and use of materials for the roof trap heat and increases temperatures indoors. This means the dwelling unit does not protect households from heat exposure. Women, children and the elderly, who spend long hours indoors are therefore more vulnerable at home.

Vulnerable areas within the city are classified as under:

Slums: The poor in these areas are affected much more due to their poor coping mechanisms and the limited ability of the inhabitants especially women to respond to health challenges during hot weather. The night-time outdoor microclimatic conditions along with

poor housing structure and no access to services make it extremely difficult for people to cope with heat stress. Women in these areas have to bear the brunt of such extreme heat for reasons we discussed in the previous section.

Low-income neighbourhoods: The inhabitants of these neighbourhoods constantly suffer from heat stress due to poor built-up environment, limited access to basic services and heat-trapping housing material. It has been observed that people living on higher floors, with poor ventilation and bad housing material, have it worse. People with disabilities and chronic diseases also have a hard time coping with extreme heat. Women in some localities don't even leave their front doors open as they fear for their safety.

Vulnerability hotspots: The thermal hotspots identified during the vulnerability assessment of heat waves undergo a significant rise in temperatures as compared to the rest of the city. These areas are most likely to have a higher number of residents experiencing heat-related health implications.

Vulnerable groups

Heat waves impact people's health. Certain groups of people are more vulnerable than others. Among these children, including newborns and infants, women, the elderly, construction workers working outdoors, factory workers, traffic police personnel and people from economically weaker sections are affected the most.

Identification of these groups is necessary as it allows medical professionals to efficiently prioritise actions to effectively treat heat-related illnesses. This makes it even more essential to identify these vulnerable groups in order to mitigate the impact of heat waves.

The vulnerable groups are as follows:

Groups to include in HAP

Vulnerable group	Risk Factors
Infants	Particularly sensitive to heat due to different metabolism and poor ability to adjust to changes in temperatures. Infants sweat less which considerably decreases their ability to cool their bodies. Infants are more susceptible to heat-related deaths due to their high metabolism rate and inability to remove sheets or clothing.
Children	Unlike adults, children are physiologically more vulnerable to heat-related illnesses. Their vulnerability is associated with their physical activity, production of more metabolic heat/kg, in comparison to body weight, dehydration and lower cardiac output. Strict vigilance is required during a heat wave to avoid exposure to children.
Women	They are more at risk of heat-related morbidity or mortality even. They are vulnerable to heat stress as their ability to thermoregulate is compromised. There are increasing pieces of evidence of stillbirths during periods of extreme heat. Women's risk of heat-related illnesses is further intensified due to social norms and gender discrimination embedded in society. Lack of timely access to information on heat alerts increases their risk of heat stress.
Elderly Citizens	They are at great risk of morbidity and mortality during heat waves. With growing age, there is a considerable reduction in the cardiac output and capacity to circulate blood to the skin, and intestinal and renal circulatory beds. Age compounds these problems reducing the body's ability to dissipate heat.
Working Individuals	They perform activities both indoors and outdoors in factories, construction and other labour-intensive jobs. They are at greater risk of dehydration and heat stress; exposure to heat for a long duration leads to dehydration, compromised normal activities, chronic kidney disease, and cardiovascular and pulmonary illnesses. The choice of clothing may also hinder a worker's ability to cool the body through sweat. Use of Personal Protective Equipment (PPE) used by people in pandemics/epidemics during heat periods in absence of cooling could be fatal.
Economically Weaker Sections	These households often lack awareness, and also the means to adopt measures to prevent heat-related illnesses. A large number of people already suffer from some kind of chronic disease, which gets aggravated during a heat wave. Poor quality housing, and lack of access to basic services like drinking water supply, health services and sanitation further compound their vulnerability during heat waves.
People with Disabilities	They are highly vulnerable to heat waves as their ability to receive or respond to heat alerts is challenged substantially. In certain cases, such as in persons with spinal cord injury, the body does not sweat;

	this inhibits cooling, making the individual susceptible to overheating. Any form of physical or mental challenge increases the individual's vulnerability to the heat wave. Heatwave messages are not always designed or delivered in a way that makes it easy for, say, a person with hearing loss, or visually challenged to comprehend. This makes such persons largely dependent on their caregivers.
Chronic Disease Patients	Such individuals are highly prone to stress caused by extreme heat. Their medication not only impacts their ability to gauge changes in temperatures, but it also tends to make worse the effects of hot weather. Persons with a heart condition, mental illness, poor blood circulation, and/or obesity are more at risk of heat-related illnesses. Overweight people often tend to retain body heat which makes them vulnerable to heat stress and its associated impacts.

Tracking vulnerability

Vulnerability issues	Information needed	Gathering the information
Spatial impact of heat waves	-Identify areas impacted by heat waves -Identify intracity variations	Use GIS
Status of and impact on various groups	-Identify vulnerable population -Collate differentiated vulnerability impacts on groups due to the environment inside homes	Field survey, meetings/interviews with household members
Socio-economic factors	- Availability of services such as water, sanitation, etc. - Housing/Settlement - Livelihood and productivity loss - Health impacts	Field survey
Institutional preparedness	- Assess the local government actions/plans - Heatwave management capacity	Stakeholder meetings and consultation
Issues and challenges due to heat wave	-List the issues and challenges - Prioritisation of these issues	Stakeholder meetings and consultation, field survey

Assessment of vulnerability

Vulnerability assessment may be carried out by a household survey in 4-5 locations in the slums or slum-like low-income areas of the city. Several slums and low-income squatter settlements generally experience temperatures higher than the city average as they are located in what is known as thermal hotspots. An assessment of the vulnerability to heat waves of the communities living in these locations helps city-level stakeholders to identify in advance the people whose health is likely to suffer due to heat waves. This further helps implement targeted public health interventions to minimise risks from heat waves. A household survey will help gauge the impact of extreme heat events on the health, productivity and livelihoods of the vulnerable population. It will also help to understand how localised contextual factors such as housing characteristics, availability of services, and climatic factors interact with individual factors such as awareness levels of the urban poor. How to go about the household survey for vulnerability assessment is shared in Box-5.

Box-4

Survey to assess vulnerability

Carry out ward-level household survey to check the impact of heat waves on the health, livelihood and productivity of the community

Understand how the communities/groups are mitigating and adapting to extreme heat

Draw out key challenges faced by specific groups such as outdoor workers, women, among others

Understand the working conditions of the people due to which they lose their productivity and livelihood. Try to quantify the loss in monetary terms

Do a comparative analysis of different locations and develop a list of key approaches that are needed to manage heat stress

IRADe recommends the survey use a comprehensive index of 12 factors that intensify the impact of climatic heat stress.

The table below lists the 12 sectors and corresponding sub-sectors in the index

Vulnerability sector	Corresponding sub-sector	Survey tool
Housing	– Ownership, number of rooms, – Housing structure, and material used for floor, walls, roof – Number of windows, and exterior wall colour – Overcrowding	A structured questionnaire, site visit, interviews, focus group discussions (FDG)

Water	– Water source, water supply (in litres)	A structured questionnaire, site visit, interviews, focus group discussions (FDG)
Sanitation	– Access to toilet	A structured questionnaire, site visit, interviews, focus group discussions (FDG)
Transport	– Transportation mode used for commuting (workplace/school), Preferred Mode of Transport	A structured questionnaire, site visit, interviews, focus group discussions (FDG)
Electricity	– Electricity supply and frequency of outages during summer – Electricity bill and electrical appliances used	A structured questionnaire, site visit, interviews, focus group discussions (FDG)
Health	– Mapping high heat period, time of heat discomfort, – Heat stress symptoms, access to health infrastructure, – Distance from the nearest health facility, – Age-wise symptoms of heat stress, – Health insurance, – Source of health insurance, – Reasons for not using government health facilities, – Differential impact of heat on women and men	A structured questionnaire, site visit, interviews, focus group discussions (FDG)
Heat stress symptoms	– Impact on households/community/workspaces – Who bears the brunt of household chores that increase heat exposure, and how	A structured questionnaire, site visit, interviews, focus group discussions (FDG)
Awareness	– Awareness of the term “heatstress” – Awareness of medical facilities treating heat stress, – Awareness of mitigation strategies adopted by ULBs,	A structured questionnaire, site visit, interviews, focus group discussions (FDG)

	– Heat exhaustion, heat cramps	
Livelihood/Wage and Productivity loss	– Average wage loss – Gender-wise wage loss – -Occupation-wise wage loss	A structured questionnaire, site visit, interviews, focus group discussions (FDG)
Productivity Loss	– Gender-wise productivity loss, – -Occupation-wise productivity loss	A structured questionnaire, site visit, interviews, focus group discussions (FDG)
Adaptation	– Coping with heat-related discomfort at work, – Initiatives at the household level to combat extreme heat	A structured questionnaire, site visit, interviews, focus group discussions (FDG)
Communication	– Preferred communication strategies, – Preferred medium of communication for alerts	A structured questionnaire, site visit, interviews, focus group discussions (FDG)

Activity Table: **Designing targeted interventions**

The vulnerability assessment exercise also involves understanding the impacts of heat stress on people, what they are doing to cope with it and what the challenges are. Filling in the following table will help heat action planners develop a list of key approaches that are needed to manage heat stress – this exercise is designed to enable them to envisage better their targeted interventions.

Sector	Sub-sectors	Impacts due to heat wave	Vulnerability reducing activities		Challenges
			Short-term Actions	**Long-term Actions**	
Housing	Ownership, number of rooms, Housing structure, and material used for floor, walls, roof				

	Number of windows, and exterior wall colour				
Water	Water source, Water supply (in litres)				
Sanitation	Access to toilet				
Transport	Methods used for commuting (workplace/school), Preferred Mode of Transport				
Electricity	Electricity supply and frequency of outages during summer Electricity bill and electrical appliances used				
Public health	Mapping high heat period, time of heat discomfort, Heat stress symptoms, access to health infrastructure, Distance from nearest facility, Age-wise symptoms, Health insurance, Source of health insurance, Reasons for not using government health facilities, Differential impact of heat on women and men				
Heat stress symptoms					
Awareness	Awareness of the term 'heat stress', awareness of medical facilities treating heat stress, awareness of mitigation strategies adopted by ULBs, Heat exhaustion, heat cramps				

Gender impacts of heat stress	Differential Impact on heat stress symptoms				
Livelihood – Wage and Productivity loss	Average Wage Loss Gender-Wise Wage Loss Occupation-wise Wage Loss				
Productivity Loss	Gender Wise Productivity Loss, Occupation-wise Productivity Loss				
Adaptation	Coping with heat-related discomfort at work, Initiatives at the household level to combat the heat				
Communication	Preferred communication strategies, The medium of communication for alerts				

Check List

1. Identify the vulnerable groups and their respective health risks
2. Identify heat wave-sensitive services in the city
3. Develop a questionnaire and carry out a vulnerability assessment survey in 4-5 locations that are in heat hotspots of the city
4. Carry out a ward-level cumulative heat wave vulnerability study in the city on the scale of low to high vulnerability to devise specific interventions
5. Develop a list of top-priority wards that are vulnerable to heat waves and identify areas of intervention
6. The questionnaire will include an assessment of people's health, livelihood, and productivity
7. Assess the quantum of wage loss due to heat stress

Discussion Questions:

1. Who are the most vulnerable to heat waves in your city?
2. Where are vulnerable areas located in your city?
3. While devising HAP does your city look into the aspects discussed in this section? If yes, what is the mechanism?
4. How do vulnerable populations cope with heat wave conditions?
5. Are any key measures already under execution in your city? If yes, what are these?

3.9 Stakeholder Mapping & Capacity Building

To develop a comprehensive, practical, and inclusive Heat Action Plan for the city, the involvement of various stakeholders is critical. Key stakeholders can include representatives of the State Disaster Management Authority, NGOs, community-based groups, media, health departments, private hospitals, departments of labour, water and sanitation, transport, power supply and distribution, private institutions, and religious groups.

All stakeholders need to be brought together to help develop a citywide strategy in planning for preventive, mitigation and adaptive measures to check heat-related debility. The participation of ward-level community-based groups in the planning process is important. Usually, there already exist women's thrift-and-credit self-help groups, and Mahila Arogya

Samitis (MAS), a women's group that meets every month to discuss health-related matters. This latter group is nurtured by the community health worker, known as ASHA(accredited social health activist); she serves as a link worker between her assigned ward/s and the health facilities. The State Health Mission coordinates the activities of MAS and ASHA. Both their inputs will be valuable in the consultative process for a heat action plan.

The table below lays down the stakeholder group in your city. This will also help ensure that the identified stakeholders represent different socio-economic and cultural backgrounds.

Table: Stakeholder Mapping in the City

Stakeholder	Govt. Local/ State/National	Private sector	Academic institutions	Community (city-level)	NGO (Local)
Primary stakeholders: Actors who are directly affected by the heat stress					
Secondary stakeholders: Actors whose involvement in the project is only indirect or temporary					
Key stakeholders: Actors who are able to use their skills, knowledge, or position of power to develop HAP					
Veto Players: support and participation in the targeted results is essential					

The table above will help understand the interplay between stakeholders and the role they play in different stages of developing the heat action plan. Discussions may be carried out separately with all the stakeholders that identify the capacity gaps and critical interventions required to build the stakeholder's capacity. This calls for targeted capacity-building activities such as training, workshops, public outreach etc., for various stakeholders, including the general public and medical stakeholders.

Medical stakeholders need to be aware of heat stress and protocols for heat-related diagnosis and treatment. Similarly, the community needs to be made aware of heat wave-related morbidities and mortalities.

Check List
1. Identify stakeholders in your city 2. The list of stakeholders should be developed based on their role at different stages of HAP 3. Identify the capacity needs and priorities for interventions 4. Carry out targeted intervention activities such as dissemination workshops, discussions, training etc.

Discussion Questions:

1. Who are the critical stakeholders in your city for HAP?
2. What are their roles and responsibilities in managing heat waves?
3. What are the processes to engage with stakeholders?
4. Are they well-equipped to help manage the impact of heat waves? If not, what are their capacity gaps?
5. Has your city done anything to build stakeholder capacity? If yes, what are these?

3.10 Mitigation & Adaptation Strategies

Once the planners have identified the risks and issues related to heat waves and their impact on the vulnerable population, the city will need to work on a mitigation and adaptation strategy. The strategy is a series of activities to be undertaken throughout the year so that the city is better prepared when a heat wave strikes. A well-thought-out strategy will list a year-round calendar of measures, to be carried out before, during and after the onset of summer.

The strategy will need to be developed through a consultative process, be gender-inclusive and incorporate traditional knowledge already in practice in the community. The Heat Action Plan can include hard (infrastructure) and soft (services, policy changes, capacity building)

measures. The plan must concentrate on improving the resilience of the most vulnerable groups (especially women and children) and vulnerable areas already identified. Each intervention and action listed needs to be accompanied by its financial implications and benefits. These inputs will enable early acceptance and implementation by the city administration.

As extreme heat affects multiple aspects of life its coping measures need a multi-sectoral approach. For smooth implementation of a climate-adaptive heat action plan on an annual basis, the city's municipal corporation (ULB) will need to institutionalise a heat action component in the yearly plan of several government departments. Through a series of workshops, the ULB will need to bring about a well-coordinated action plan on the ground. The purpose of these workshops is to help the following departments formulate an annual heat action plan of their own and make it official by including it in the coming year's budget of the department. The key departments the city's ULB needs to coordinate with are:

- Drinking water and sanitation
- Electricity
- Transport
- Labour
- Health and the National Urban Health Mission
- Women and child development department that runs the child development (Anganwadi) centres in the community

Once the ULB brings the above government departments to formulate and own an annual heat action plan it will bring these different sectors on the same page with regard to mitigation measures for extreme heat. Such a coordinated approach will pave the way for the smooth implementation of a multi-sectoral heat action plan at the ward level.

Check List
1. Develop a list of gender-sensitive interventions and actions following a consultative process 2. Address all the identified risks and vulnerabilities 3. List actions/interventions, their financial implications and the benefits 4. A year-round calendar of mitigation and adaptation measures should be developed, which could be divided into pre/during/post-heat waves

Discussion Questions:

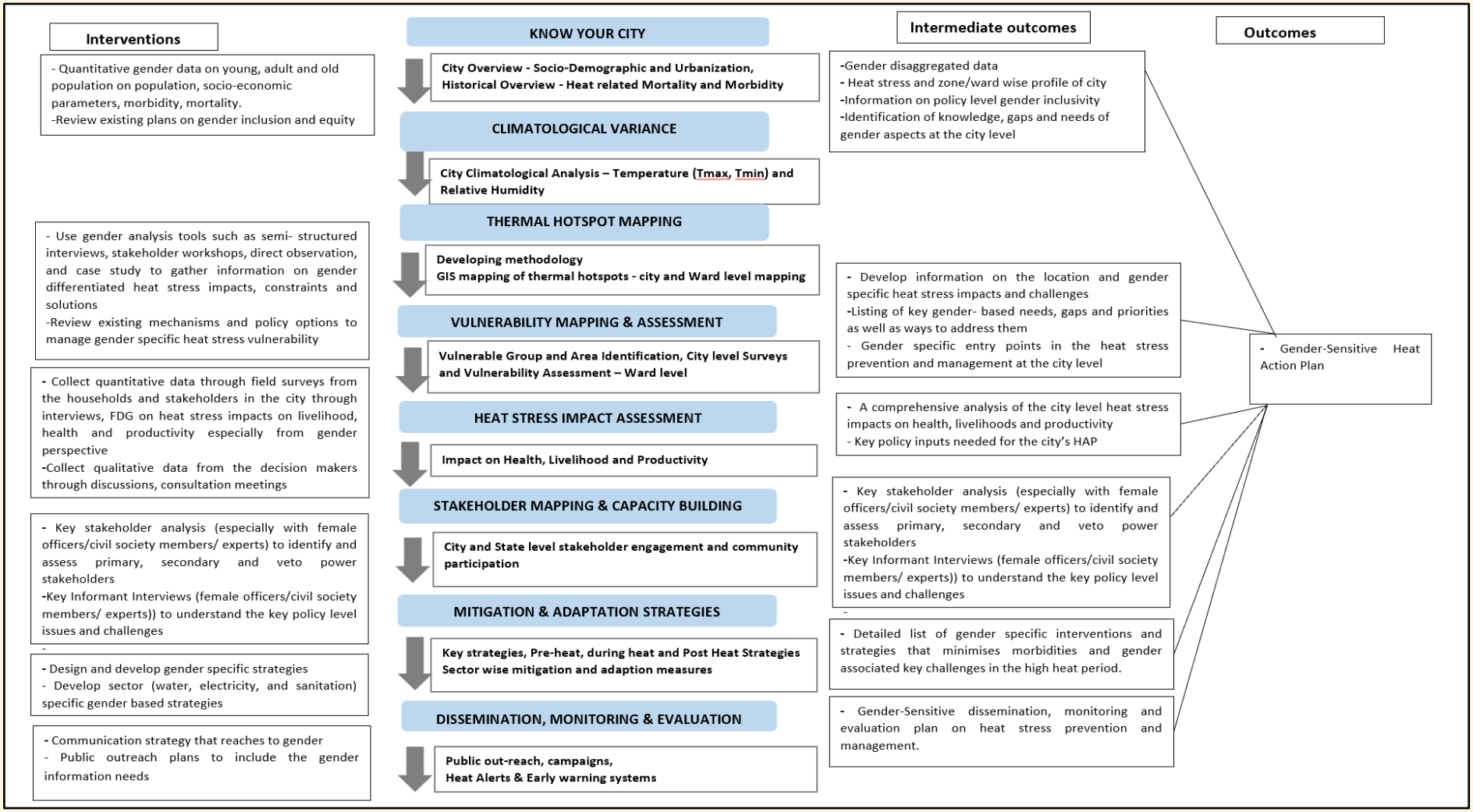
1. What are measures undertaken by your ULB to manage heat wave impacts?

2. What are mitigation and adaptation measures with regard to heat waves? Can you identify measures under each category?
3. Are these measures inclusive? And how so?
4. Can you identify the benefits these measures bring to your city?
5. Are adequate financial measures being undertaken by your city? If not, what are the reasons?

3.11 Gender Integration Framework of HAP

While you are in the process of developing a heat action plan for your city, it is very important that issues specific to gender are addressed and their demands are articulated. The flow chart below lays down step-by-step the methodology to incorporate the gender-sensitive measures.

Table: Gender-inclusive Interventions and Outcomes in Heat Action Plan



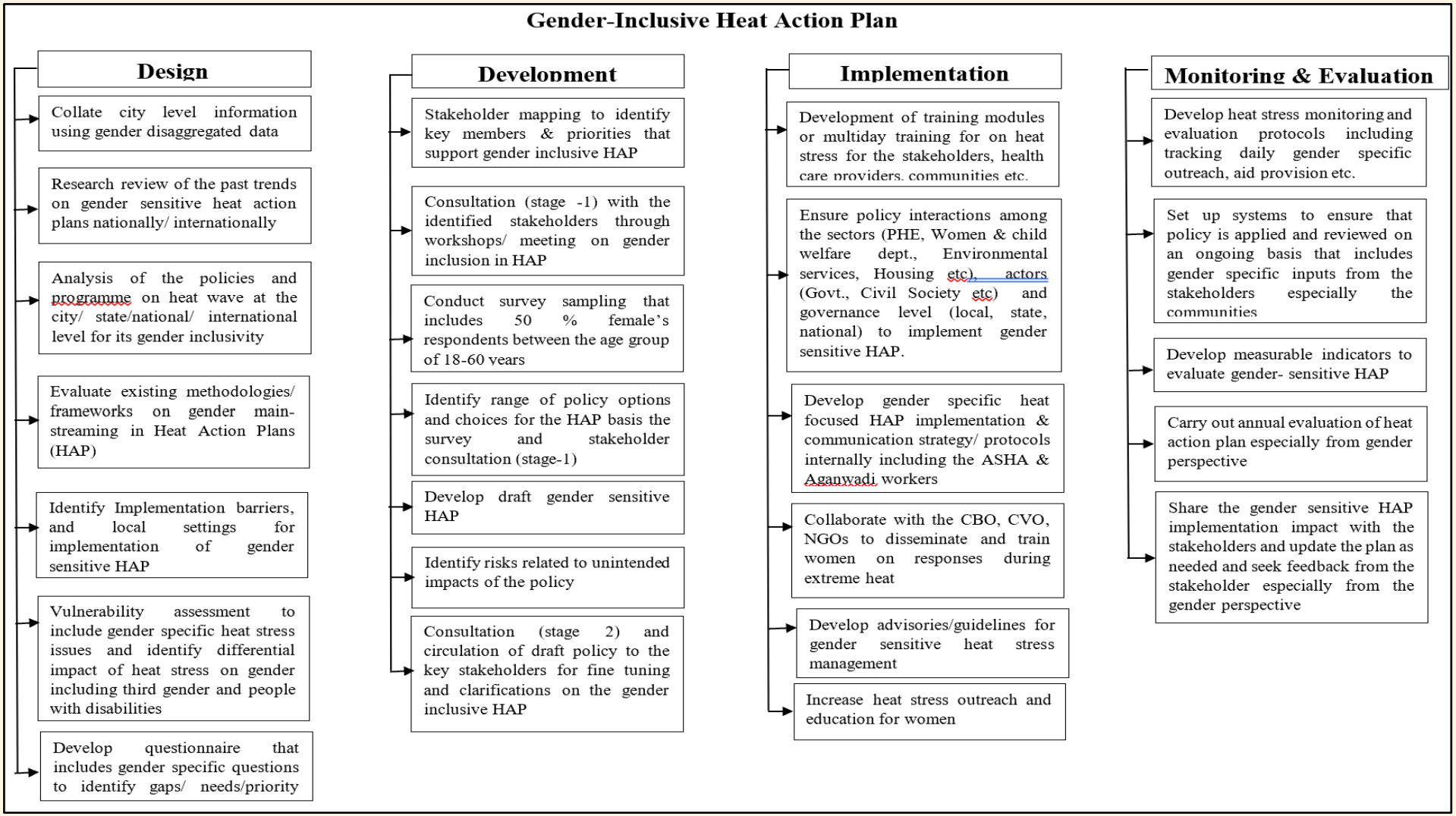


Table: Stages in the development of Gender-Inclusive Heat Action Plan development

Check List
1. Identify gender-specific issues faced by women, girls and elderly women 2. Gender disaggregated data should be collected from the ULB 3. The vulnerability assessment survey should have a percentage allotted for gender-inclusive responses to document the key issues and challenges faced by women 4. The nodal person in the ULB responsible for the communication of heat alerts and external communications should be gender inclusive and it should reach women as well 5. The language of the advisories and messages should be understandable to people of all levels of understanding

The table above shows ways in which gender issues may be addressed at all stages of the planning process.

Discussion Questions:

1. What are the gender gaps in your city and how does it impact the community?
2. What are the ways in which gender-inclusive development be incorporated into the climate policy of the city?
3. Are the stakeholders aware of the importance of gender-sensitive policies and actions on heat stress? If not, please explain
4. How do you plan to build the capacity of the city stakeholders in developing gender-sensitive plans?
5. What are the ways to address the demands of communities especially women in city-level heat action planning? If yes, what are those?

3.12 Training and Capacity Building

A heat action plan is dynamic because it continuously requires refreshing and bringing it up to date with the changing circumstances – these would include temperature levels, state of infrastructure and public services (particularly health services), and community practices. It, therefore, becomes important that the city's nodal official responsible for HAP implementation and relevant stakeholders are also brought up to date. Hence the ULB will need to develop its training and capacity building programme that identifies and addresses key capacity building and training requirements. It will help strengthen institutional capacities,

support stakeholder engagement and capacity needs assessments for the development and implementation of the Heat Action Plan.

This may be carried out by collaborative planning and in alignment with HAP to identify the common goals and opportunities that will enable stakeholders' buy-ins and help better coordination among them. This will enable better multi-stakeholder partnership work.

Here, in the local context and language becomes extremely critical as the capacity building and training must be tailored according to the type of language used and the level of technical details and it should be adjusted in line with the role, focus and background of the respective stakeholder groups. Moreover, it has to be offered in a way that connects to the intended audience. Box-6 lists the steps required in the process of training and capacity-building of the city-level stakeholders.

Box-5

The training and capacity building at the city- level should collaborative with common goals and responsibilities that connects with the intended audience.

It is important for the city to identify its training and capacity needs by way of Training Needs Analysis (TNA).

The training initiative needs to adopt appropriately targeted and structured training for enhancing knowledge and skills

Local context and language become extremely critical as the capacity building and training

Training and capacity building initiatives may be carried out with in the city at multiple levels on identified subject areas and the target groups

Training modules to be developed for the delivery of HAP trainings for different stakeholders

One of the critical steps here is to improve the organisational capacity of the ULBs for enabling them to perform effectively. This entails the presence of the required knowledge, skills and right attitude among individual members of the staff, groups and the organisation as a whole. For this purpose, it is critical that Training Needs Analysis (TNA) is carried out for the city-level stakeholders. This way, the capacity building and training get linked to organisational vision and objectives and are conducted on a regular basis.

The training and capacity-building initiatives may be carried out at multiple levels on identified subject areas and target groups. The training and capacity-building programmes may be as follows:

a. The **city-level stakeholder** and ULB staff and official workshops to disseminate and sensitise city-level stakeholders about the need for policy development on minimising managing the impact of heat waves at the city level.

b. Training programme at the:

-**Ground level**: community health workers such as ASHA workers, ANMs, Mahila Arogya Samiti volunteers etc,

- **City level**: Medical practitioners such as hospitals and Urban Health Centres (UHC), private clinics, and private hospitals.

- **Training of civil society leaders** to ensure effective implementation of HAP in coordination with the line department in the ULB.

Check List

1. Develop a list of common goals and responsibilities among the ULB-level staff and officials along with the city-level stakeholders
2. Conduct training needs assessment
3. Develop a training module for the delivery of the training and capacity needs
4. Training and capacity-building initiatives may be carried out within the city at multiple levels on identified subject areas and the target groups

Discussion Questions:

1. What are the training and capacity-building gaps and needs of your city-level ULB and its stakeholders?
2. What are the various mechanisms in your city for training and capacity building?
3. Are these trainings as per the job description or just generalised training?
4. How do you utilize the knowledge gained during these trainings in your work related to heat wave impact management of your city?
5. Do you have any feedback mechanism to improve the training and capacity-building activities? If yes, what are these?

3.13 Dissemination of HAP and its Messages

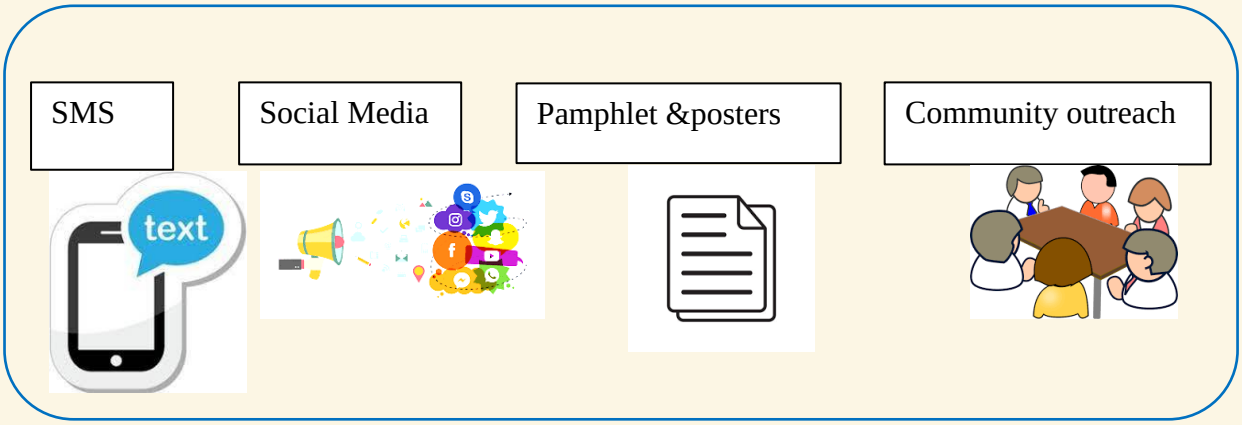
Once the heat action plan has been prepared and approved by the ULB, the next step is its dissemination among all the government departments and other stakeholders. It should also be shared with community volunteer organisations and NGOs, especially those working in close cooperation with the community and vulnerable groups. The ULB will also need to carry out a citywide communication campaign to alert the general public about the severity of exposure to extreme heat and the preventive measures to adopt to minimise the impact of heat waves.

As we have discussed earlier, the ULB will need to work with the health department and the National Health Mission. Heat stress in the communication tools should be provided to the community health worker (ASHA) to raise awareness of the health of pregnant women and children. These two groups are also among the more vulnerable to heat stress. Since these awareness sessions encourage the participation of men, they provide a good platform to teach the community about heat stress and its early detection.

The ULB also needs to work with civil society and community-based organizations to develop IEC material and raise awareness through various methods, including posters, wall paintings, messages from a roving microphone, mobile phone messaging, and interpersonal communication. Several NGOs working on maternal and child health have their own community health workers, who can be roped in for interpersonal communication on heat stress and its early detection, and coping mechanisms.

The mode of communication will vary depending on the target group, availability of resources, and the amount of time in hand before the start of the heat wave. For example, communication could be via bulk SMS messaging, social media, and printed posters. The message may need to be in multiple languages to reflect those spoken by different groups, including migrant workers, living mostly in squatter settlements. In addition, some people may have difficulty reading or have hearing or a visual impairment, so combining visual and textual media is most helpful. Specific messaging protocols should be designed for internal messaging (in the ULB, ward office, and between organisations), health centre, school etc. and public messaging.

Modes of communicating heatwave alerts and advisories to citizens



The heat wave early warning must be communicated within the ULB to appropriate city departments and stakeholders for appropriate actions. Similarly, a public message must be issued to alert the citizens and raise awareness about the impending heat risk due to rising temperatures. An internal warning should go to the Department of Health, city officials, emergency management, and press offices, among others. It is also essential that the messaging be tailored appropriately for quick understanding and actions.

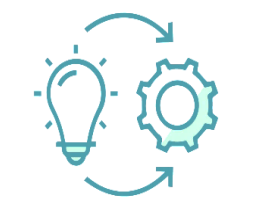
The ULB will be responsible for disseminating the warning throughout their departments to mitigate heat stress. For example, when a ULB receives a heat wave warning, it may contact the local TV and radio stations and send out a press release on the warning with messages for the public. The Public Health Department (PHD) in the ULB shall distribute the message to hospitals and healthcare workers who can start to prepare for a potential surge in hospitalisations by increasing the availability of healthcare staff and using the information for further dissemination.

Channels ULB can use to get the message across

Check List
1. Develop a communication plan internally for the ULB and the public 2. The plan should be a target-group specific, realistic assessment of resources, and time-bound 3. Use multiple languages to communicate the heat alerts and advisories 4. Appoint a nodal person in the ULB responsible for the communication of the heat alerts internal and external communications. 5. The language of the advisories and messages should be understood by people of all levels of comprehension

Discussion Questions:

1. Does your city have any communication plan for heatwave management? If yes, who are the key officials?
2. How are heat wave warnings and advisories communicated to the communities, especially women?
3. Is the communication in the local language and target group specific?
4. Does the ULB first circulate the information related to heat waves internally and among the stakeholders for input?
5. Are the health advisories updated as per heat wave warnings in your city? If yes, can you give examples?



3.14 Implementation, Monitoring, and Evaluation of HAP

The Action Plan may divide the responsibilities into pre-, during- and post-event categories, detailing preparation for a heat wave (pre-event responsibilities), steps to be taken to reduce heat stress during a heat wave (during-event responsibilities), and measures to incorporate lessons learned and fill gaps found in the management of heat stress (post-event responsibilities). Typically, the heat wave minimisation interventions in the pre/during and post-season may be classified as follows. It may, however, vary in your city based on the climate assessment.

Phase-I: Pre-Heat Season (February to March) Pre-Heat Season is devoted to developing early warning systems, and communication plans of alerts to the general public, health care

professionals, and voluntary groups (caregivers) with emphasis on training and capacity building of these groups.

Phase-II: During the Heat Season (April to June) High alert, continuous monitoring of the situation, coordination with all the department's agencies concerned on the one hand and the general public and media, on the other hand, is the focus of this phase.

Phase-III: Post-Heat Season (July to October), the concentration is on evaluation and updating the plan. It is important to evaluate whether the heat-health action plan has worked at the end of the summer. Continuous updating of the plan is a necessity. Global climate change is projected to increase further the frequency, intensity, and duration of heat waves and attributable deaths. Public health preventive measures need to consider the additional threat from climate change and be adjusted over time.

The roles and responsibilities for the Heat Action Plan implementation should be laid down during the pre, during, and post-heat wave phases. This process will further help monitor and evaluate the heat action plans and improve its preparedness to deal with the heat waves and their associated risks. The HAP monitoring systems will routinely help gather information on all aspects of heat wave management. This process includes systematic observations, monitoring activities' progress, and a goal-oriented approach. The evaluation of the Heat Action Plan during the post-summer should consist of the following:

1. Review the morbidity, mortality, and temperature pattern of the season to plan for next summer
2. Audit the deaths in the institutions to understand service needs
3. Prepare a heat action plan for the institution/ Hospital for next year
4. Participate in the annual evaluation of the heat action plan
5. Review the revised heat action plan

It also helps hugely in better heat wave planning, further improvising the monitoring processes, and making informed changes to implement stated goals and objectives in the Heat Action Plan (HAP). Since this process will involve multi-sector stakeholder participation, their roles and responsibilities should be clearly defined based on yearly reviews. The ULB should have an institutional task force that not only disseminates the HAP implementation and its impacts but also reviews and shares next year's HAP planning along with detailed tasks for each department/ stakeholder.

Check List

1. Develop ToR/assign roles and responsibilities of the key official for the implementation of HAP
2. Monitor the HAP implementation to help routinely gather information on all aspects of heat wave management.
3. Review the post-HAP implementation and evaluate its key achievements, what worked well, and what could have been better
4. A process of follow-up and reporting on the changes should be outlined in the HAP, and stakeholders (horizontally and vertically) should be consulted for its finalisation
5. Communicate the updated HAP for the next heat wave period.

Discussion Questions:

1. What are the ways and mechanisms to address heat wave threats in your city?
2. Which are the departments and officials in charge? Is it only one department or more? Can you name a few?
3. Are the measures specific to high heat periods or are these year-round? If yes, what are those measures?
4. What are the HAP implementation mechanisms? Name the key officials/departments involved.
5. Is HAP updated every year in your city? If yes, what is the process?

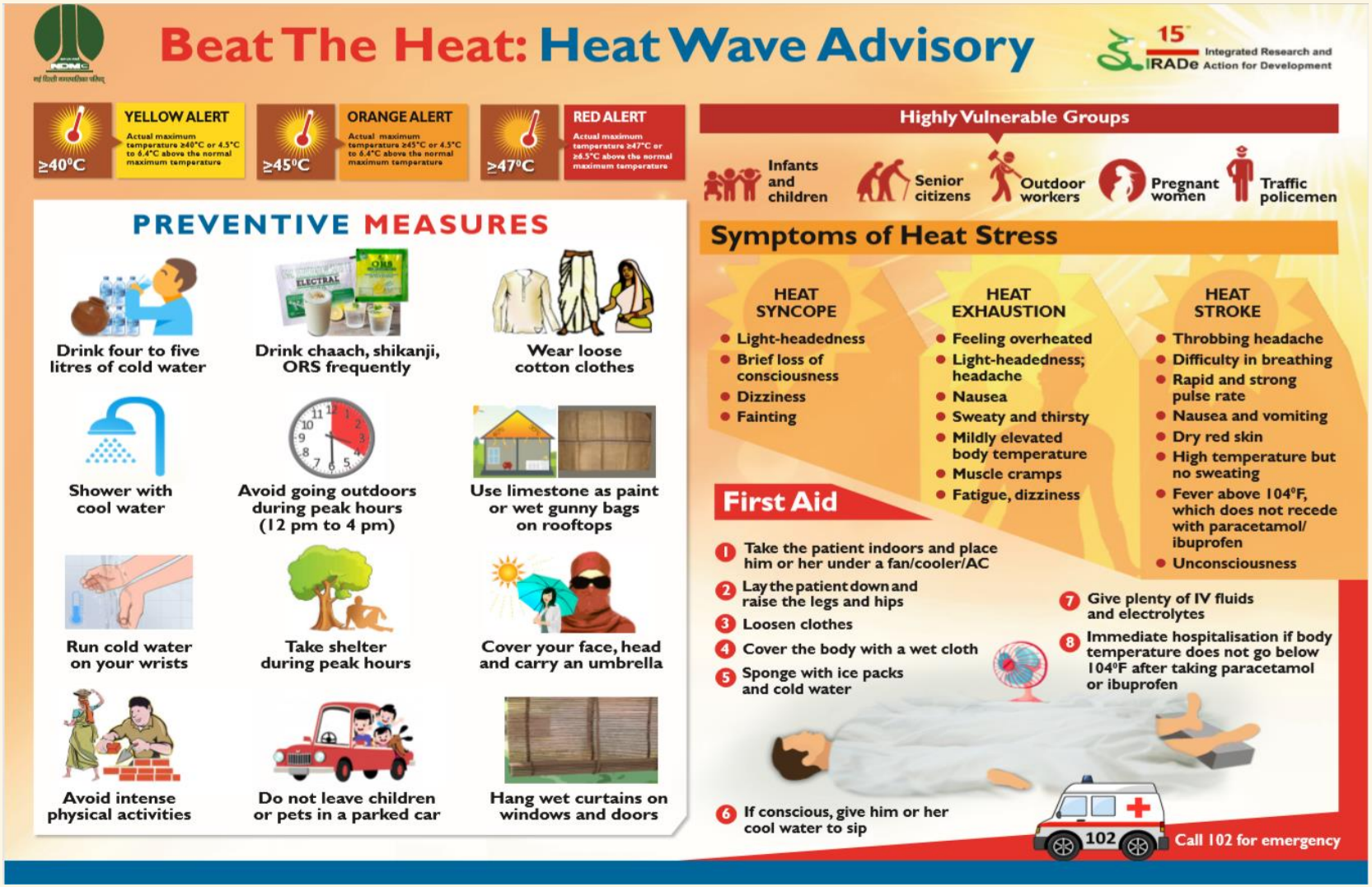
Annexure

Template for daily Heat Mortality/Morbidity data collection

Name of the Urban Primary Health Centre/ hospital Ward no-									
	No of cases	**Gender**			**Pregnant women if any**	**Age Group**			
		No of male	**No of Female**	**Other**		**0-14**	**15-35**	**35-60**	**60 Above**
Heat Cramps									
Heat Exhaustion									
Heat Stroke									
Mortality due to heat stroke									

Dissemination, Monitoring & Evaluation

Heat Health Advisory in Gujarati


Beat The Heat: Heat Wave Advisory
15 Integrated Research and Action for Development
IRADe
YELLOW ALERT
≥40°C
Actual maximum temperature ≥40°C or 4.5°C to 6.4°C above the normal maximum temperature
ORANGE ALERT
≥45°C
Actual maximum temperature ≥45°C or 4.5°C to 6.4°C above the normal maximum temperature
RED ALERT
≥47°C
Actual maximum temperature ≥47°C or ≥6.5°C above the normal maximum temperature
PREVENTIVE MEASURES
Drink four to five litres of cold water
Drink chaach, shikanji, ORS frequently
Wear loose cotton clothes
Shower with cool water
Avoid going outdoors during peak hours (12 pm to 4 pm)
Use limestone as paint or wet gunny bags on rooftops
Run cold water on your wrists
Take shelter during peak hours
Cover your face, head and carry an umbrella
Avoid intense physical activities
Do not leave children or pets in a parked car
Hang wet curtains on windows and doors
Highly Vulnerable Groups
Infants and children
Senior citizens
Outdoor workers
Pregnant women
Traffic policemen
Symptoms of Heat Stress
HEAT SYNCOPE
Light-headedness
Brief loss of consciousness
Dizziness
Fainting
HEAT EXHAUSTION
Feeling overheated
Light-headedness; headache
Nausea
Sweaty and thirsty
Mildly elevated body temperature
Muscle cramps
Fatigue, dizziness
HEAT STROKE
Throbbing headache
Difficulty in breathing
Rapid and strong pulse rate
Nausea and vomiting
Dry red skin
High temperature but no sweating
Fever above 104°F, which does not recede with paracetamol/ ibuprofen
Unconsciousness
First Aid
1 Take the patient indoors and place him or her under a fan/cooler/AC
2 Lay the patient down and raise the legs and hips
3 Loosen clothes
4 Cover the body with a wet cloth
5 Sponge with ice packs and cold water
6 If conscious, give him or her cool water to sip
7 Give plenty of IV fluids and electrolytes
8 Immediate hospitalisation if body temperature does not go below 104°F after taking paracetamol or ibuprofen
102
Call 102 for emergency

गर्मी/लू के प्रकोप से बचाव

15 IRADe Integrated Research and Action for Development

≥40°C	≥45°C	≥47°C
येल्लो अलर्ट	ऑरेंज अलर्ट	रेड अलर्ट

गर्मी/लू से बचाव के उपाय


4–5 लीटर ठंडा पानी पीएं


छाछ, लिकंजी, ORS बार बार पीएँ


ढीले–ढाले सूती कपड़े पहनें


ठंडे जल से स्नान करें


दोपहर 12 बजे से 4 बजे तक बाहर न निकलें


छत पर चूने का पेंट करें या गीले बोरों का उपयोग करें


अपनी कलाई को ठंडे पानी के नीचे रखें


छाया में बैठें


सिर और चेहरा ढककर रखें और छाता लेकर चलें


अत्यधिक शारीरिक श्रम से बचें


बच्चों या पालतू जानवरों को पार्क की गई कार में न छोड़ें


खिड़कियों/दरवाजे पर गीले पर्दे लटकाएँ

अत्यधिक संवेदनशील समूह

गर्मी/लू लगने के लक्षण

गर्मी से बेहोशी
- सिर चकराना
- बेहोशी
- चक्कर आना
- मूर्च्छा

गर्मी से थकान
- बेहद गर्मी महसूस होना
- सिर चकराना, सिरदर्द
- उबकाई
- पसीना और प्यास
- शरीर का तापमान बढ़ जाना
- माँस–पेशियों में ऐंठन
- थकान, चक्कर

लू लगना/ हीट स्ट्रोक
- तेज सिरदर्द
- साँस लेने में कठिनाई
- तेज चक्कर
- उबकाई और उल्टी
- सुरख लाल त्वचा
- बुखार बढ़ने पर पसीना न आना
- बुखार 104°F से ऊपर, जोकि पैरासिटामोल/इबुप्रोफेन से कम नहीं हो रहा
- बेहोशी

फर्स्ट एड

1. व्यक्ति को अंदर ले जाएँ और पंखे/कूलर/AC रूम में रखें
2. रोगी को नीचे लिटाएँ और उसकी टांगें और कूल्हें को ऊँचा रखें
3. कपड़े ढीले करें
4. शरीर को एक गीले चादर से ढकें
5. बर्फ और ठंडे पानी से पोंछें
6. यदि सचेत है तो थोड़ा थोड़ा ठंडा पानी पिलाएं
7. ब्रेन स्ट्रोक में आईवी फ्लूइड और इलेक्ट्रोलाइट दें
8. फौरन अस्पताल में भर्ती करवाएँ अगर बुखार 104°F से ऊपर है, जोकि पैरासिटामोल/इबुप्रोफेन से कम नहीं हो रहा

102 आपात चिकित्सा सहायता हेतु कॉल करें

About IRADe

Integrated Research and Action for Development (IRADe) is an autonomous advanced research institute. Its research covers many areas including energy and power systems, urban development, climate change and environment, poverty alleviation and gender, food security and agriculture, and the policies that affect these areas. Since its inception, IRADe has been working on addressing these with a focus on the components of socio-economic and health vulnerability of people, using a variety of data and methodologies which include vulnerability assessment by observing indicators, sustainable livelihood approaches as well as using state-of-the-art advanced technologies such as remote sensing and GIS for different projects.Since 2008, it is a Centre of Excellence (CoE), Urban Development and Climate Change of the Ministry of Housing and Urban Affairs. For more details visit www.irade.org

About APN

The Asia-Pacific Network for Global Change Research (APN) is an intergovernmental network of 22 countries working towards pursuing an Asia-Pacific region that is successfully addressing the challenges of global change and sustainability. For more details please check: www.apn-gcr.org

Integrated Research and Action for Development (IRADe)

C-80 Shivalik, Malviya Nagar, New Delhi - 110017

☎+91 (11) 2667 6180, 26676181, 26682226

✉r.magotra@irade.org

@IRADeNewDelhi @IRADe_Delhi

www.irade.org