**Chapter 1: Temperature Hazards**

**Background**

**What is a hazard?**

Frame clearly what a hazard is, a la ‘A **hazard** is any agent that can cause harm or damage to life, health, property or the environment’

**Why are hazards important?**

This section will detail the magnitude and dimensions of the problem.

**1.1: Hazard: Ambient heat hazard characterization**

Describe observed trends of increased warming, of high night time temperatures, extreme heat events, of heat hazards in combination with conditions of humidity/air quality.

**Which hazards?**

The hazards included will be of relevance to human health outcomes, including:

Heatwave prevalence metrics

Global mean temperature trends

Temperature index metrics

Comfort index metrics

Climate driver (ENSO) metrics

**What is happening to the metrics of interest over time?**

Report in the style of cf . Lancet Countdown metrics

**1.2: Hazard: Research**

What is the research/method used to inform how an extreme heat event is defined? Inclusion of mortality/morbidity/hospital admission data?

**How can hazard research volume be quantified?**

Quantification of research that has been published in terms of number of papers published

**What active research is taking place?**

Developments in temperature thresholds based on health data

How often are the threshold being updated?

New metrics of heat stress?

Development of new spatial/temporal resolutions?

**Particular research of interest?**

Developing country example

Developed country example

**1.3: Hazard: global, regional, and national temperature observation and monitoring systems**

of (climatological records, RCC capabilities eg: IMD Regional Forecast)

**What is the state of observation of hazards?**

Level of historical record available?

What scale are observations being made on (temporal/spatial?)?

**What are the developments in observation of hazards?**

New infrastructure?

New methodology in hazard observation?

**Which healthcare stakeholders are using of hazards observations?**

Who is using the hazard information?

**1.4: Hazard: Long-term forecast of hazards**

Change in hazard predictions from the present, under various scenarios

**Which predictions are being made about the future of heat hazard?**

Selected illustrative academic paper examples, e.g.

**1.6: Hazard: Case studies in innovation**

Feature case studies of member experience on hazards (more in-depth), particular country studies?

**Which examples of hazard work are worth going into more detail**

[Humid heat waves at different warming levels (see next page) (Nature)](https://www.nature.com/articles/s41598-017-07536-7.pdf)

[Surface heat assessment for developed environments: Probabilistic urban temperature modelling (Computers, Environment and Urban Systems)](http://linkinghub.elsevier.com/retrieve/pii/S0198971517300613)

[Evaluation of albedo enhancement to mitigate impacts of urban heat island in Rome (Italy) using WRF meteorological model (Urban Climate)](http://linkinghub.elsevier.com/retrieve/pii/S2212095517300652)

Lancet Countdown 2017 report (not yet published) but statistics about hazards to discuss

**Example case study summary**

**Chapter:** Hazard

**Name:** Humid heat waves at different warming levels

**Publication:** Nature Scientific Reports

**When published:** August 2017

**Overview:** A quantification of humid heat wave hazard in the recent past and at different levels of future global warming. Heat waves can be strongly amplified by humidity.

**Who involved:** - European Commission, Joint Research Centre, Ispra, Italy

- Institute for Environmental Protection and Research, Rome, Italy

- CICERO, Oslo, Norway

- Royal Netherlands Meteorological Institute (KNMI), De Bilt, Netherlands

**What is done:** Defines Apparent Heat Wave Index (AHWI), inclusive of relative humidity.

Takes previous perilous heatwaves (Chicago 1995, China 2003, Europe   2003, Russia 2010), and classifies them differently based on how much of a contribution humidity had on the impact.

Projects using various climate change scenarios how the AHWI.

**Why interesting:** Proposes a new heat wave index, Apparent Heat Wave Index (AHWI) to more effectively give warnings and better classify heat waves as a hazard.

**How potentially useful:** Highlights regions (particularly tropical and subtropical regions) as requiring an adequate understanding of how humidity may be a factor in future dangerous heat wave occurrence.

**Suggestions for future: ‘**This calls for respective adaptation measures in some key regions of the world along with international climate change mitigation efforts.’

**Key facts and figures:** ‘Humid-heat waves with these conditions were never exceeded in the present climate, but are expected to occur every other year at 4° global warming.’

‘At 4 °C warming the yearly probability of occurrence of a heat wave with magnitude greater than the RU2010 will be greater than 10% in Central Europe, India, and across many African regions. **The Eastern US, Northern Latin America and China are expected to experience such type of heat waves with an annual probability greater than 50%, corresponding to an average return period of two years**. This probability is greater than the one projected in the hottest world regions, such as the Arabian Peninsula, Australia and other dry-deserts’.

‘Our results show that some of **the most densely populated regions are among those that are most exposed to humid heat waves**.’

**Links:** https://www.nature.com/articles/s41598-017-07536-7

**Chapter 2: Population Exposure**

**Background**

**What is the definition of exposure?**

Frame clearly what exposure means, in terms of overlay of hazard and vulnerable populations:

‘Exposure represents the people and assets at risk of potential loss or that may suffer damage to hazard impact.’ **Science for DRM 2017**

**Why is exposure significant?**

Detail how the overlay of hazard and vulnerable populations (i.e. exposure) is important to understand the magnitude of the issue, i.e. without vulnerable population, hazard is not directly relevant to human health (although could be indirectly relevant).

**2.1 Exposure: Characterization**

Introduce the metrics that define quantifiable exposure

**Which exposure metrics?**

The exposure metrics included will be of relevance to human health outcomes, including

* Person-days of exposure to high temperature (cf Jones et al.)
* Projected population change
* % population in urban areas
* Exposure of demographic groups

**What is happening to the metrics of interest over time?**

Report in the style of cf. Lancet Countdown metrics

Mapping of key examples of exposure metrics

**2.2 Exposure: Research**

What is the current state-of-the-art in terms of quantifying exposure? Share good examples:

**How can exposure research volume be quantified?**

Quantification of research that has been published in terms of number of papers published.

**What active research is taking place?**

Development of new techniques of exposure (cf paper with SVMs)

Research on new metrics to measure exposure (cf German AT)

Exposure research in new locations

**Particular research of interest?**

Example of good exposure research which could be used in other parts of the world with improving infrastructure

**2.3 Exposure: Long-term forecasts of exposure**

Change in exposure predictions from the present, under various scenarios

**Which predictions are being made about the future of heat exposure?**

Selected illustrative academic paper examples, e.g. Forzieri 2017 (see image below)

**2.4 Exposure: Who is vulnerable/at risk from exposure?**

Detailing quantitative studies on who will be vulnerable under exposure to heat hazards. Segue into next chapter (vulnerability)

**New research on**

Young, Old, Pregnant women, Socioeconomic background etc.

[Development of the Korean Climate Change Vulnerability Assessment Tool (VESTAP)— Centered on Health Vulnerability to Heat Waves (Sustainability)](http://www.mdpi.com/2071-1050/9/7/1103)

[Heat Wave Vulnerability Mapping for India (International Journal of Environmental Research and Public Health)](http://www.mdpi.com/1660-4601/14/4/357/htm)

[Planning Resilient and Sustainable Cities: Identifying and Targeting Social Vulnerability to Climate Change (Sustainability)](http://www.mdpi.com/2071-1050/9/8/1394)

[Association between high temperature and work-related injuries in Adelaide, South Australia, 2001-2010 (BMJ Occupational and Environmental Medicine)](http://oem.bmj.com/content/71/4/246)

[Heat fatalities in Pima county, Arizona (migrant vulnerability)](http://climate-action.engin.umich.edu/heat_waves/Doc7003_Keim_Heat_Pima_Health&Place_2007.pdf) (Health and place)

**2.5: Exposure: Case studies in innovation**

Feature case studies of member experience of exposure (more in-depth), country studies?

**Which examples of exposure work are worth going into more detail**

[Global risk of deadly heat (Nature Climate Change)](http://www.nature.com/nclimate/journal/v7/n7/full/nclimate3322.html)

[Estimating population heat exposure and impacts on working people in conjunction with climate change (international Journal of Biometeorology)](https://www.ncbi.nlm.nih.gov/pubmed/28766042)

[Deadly heat waves projected in the densely populated agricultural regions of South Asia (Science Advances)](http://advances.sciencemag.org/content/3/8/e1603322)

[Opportunities and Challenges for Personal Heat Exposure Research (Environmental Health Perspectives)](https://ehp.niehs.nih.gov/wp-content/uploads/2017/07/EHP556.alt_.pdf)

[Future population exposure to US heat extremes (Nature Climate Change)](http://www.nature.com/nclimate/journal/v5/n7/full/nclimate2631.html)

**Chapter 3: Population Vulnerabilities**

**Why**

**Why are vulnerabilities important?**

**Who is Vulnerable**

**This section will outline identified categories which encompass individuals and communities that are vulnerable to extreme ambient heat conditions, and represent target populations for protection. It should describe geographic, social, temporal and physiological sensitivities.**

1. **Physiological**
2. **Socioeconomic**
   1. **Labor**
   2. **Lack of resources**
   3. **Lack of social support**
   4. **Stigma, Marginalization, exploitation**

**3.   Environmental**

**Vulnerabilities of interest**

1. **Incarceration**
2. **Migrants**
3. **Workers**
4. **The overlap of the three! (Often migrants work in detention centers, have few protections when hired [construction, farm], and are isolated, marginalized, and discriminated against. Incarcerated people are often workers, have few protections, etc.)**

**Who can take protective actions**

**Decision makers who have the ability to take protective actions for these high-risk groups**

|  |  |
| --- | --- |
| **Decision makers** | **Groups to protect** |
| **Business Owners/employers, unions** | **Workers** |
| **Physicians/Psychiatrists/**  **Pharmacists:** | **Psychotropic pharmaceutical patients, people with underlying health conditions** |
| **Governing bodies:** | **all** |
| **Law enforcement & Correctional facilities:** | **prisoners and migrants** |
| **Families/Social Services:** | **elderly, homeless** |
| **School Administration:** | **children, athletes** |
| **Community** | **all** |

**What actions are being recommended to reduce vulnerabilities**

**Decision maker actions**

**Social actions**

**Governmental actions**

**Community level actions**

**Where/When**

**ASAP**

**Points for future research,**

**Intersectional vulnerabilities (syndemic vulnerabilities)**

**Innovations**

**What do we need to know?**

**Case Study**

snapshot characterizing local action

<http://africatimes.com/2017/07/09/48-egyptian-migrant-workers-found-dead-in-libyan-desert/>

**Chapter 4: Human Health Impacts**

**1. How is heat affecting people?**

**Current research/findings on impacts**

**How are trends changing?**

**The need to study important**

**2.  What are being used as key indicators and sources to track impacts**

**Morbidity**

**Mortality**

**Productivity, etc.**

**What else do we need to know?**

**Standardize indicators?**

**3.  Who is tracking indicators and impacts?**

**DRR Community**

**EM-DAT**

**Met Services**

**Health services**

**Research universities**

**4.  Human health impacts of interest**

**Direct**

**Morbidity, Mortality, etc.**

**Projected**

**Morbidity, Mortality, etc.**

**Recent 150k excess deaths in Europe study**

**5. Points of interest:**

**Indirect**

**Cascading failures**

**Forest Fires**

**Pollution**

**Drowning**

[**Landslides\***](http://www.sciencedirect.com/science/article/pii/S0012825216302458#f0010) **(need more evidence)**

[**Storms**](http://www.themalaymailonline.com/world/article/after-heatwave-three-dead-as-storms-ravage-italys-north#qUsrHC1hJSokA5sV.97)

**Need more research**

**6. Innovations**

**In impact research, and in utilizing impact research for adaptive responses**

**7. Case Study**

snapshot characterizing local action

**Chapter 5: (Heat-Health Warning Systems) HHWSs**

**Background**

**What is a HHWS?**

Frame clearly what a HHWS is and does

**Why are HHWSs important?**

This section will briefly detail (based perhaps on HIWeather framework for need for advanced notice of hazard to maximise preparedness).

**5.1: HHWSs: Definitions of Extreme Heat Event (EHE)**

State of the science in how heat hazards are classed as extreme

**How are EHEs being defined?**

Heat stress metrics

Trigger threshold methodology

Mortality/morbidity data used?

**5.2: HHWSs: Short-term EHE Prediction**

State of the science in products, sources of predictability, by timescale: climate predictions, climate outlooks, forecasts, warnings); indices

**How are forecasts made?**

National/regional partners?

**What is the state of capabilities of hazard prediction?**

Skill of forecast/Validation made?

Maximum length of forecast

Spatial resolution

**5.3: HHWSs: Structure**

Diverse priorities across timescales: reference table of comparative heat alert systems; parameters, definitions

**Quantification of HHWSs**

Number of HHWSs currently aware of globally

**What is the architecture of current Early Warning Systems?**

Level of government of assessment (regional/national/international)

How long active?

Spatial resolution of warnings?

Early warning triggers changing intra-seasonally?

Levels of warnings

Real-time surveillance during extreme heat?

Evaluation period?

Reassessment of early warning system every few years?

**5.4: HHWSs: Research**

Work which is being done on new methods of evaluation of HHWSs

**New HHWSs**

Details of new HHWSs

**Updated HHWSs**

If HHWSs are re-evaluated, what has been done?

**5.5: HHWSs: Case studies in innovation**

HHWSs which warrant a focus for progress and innovation

**Case studies of HHWSs**

[Defining and predicting heat waves in Bangladesh](http://journals.ametsoc.org/doi/pdf/10.1175/JAMC-D-17-0035.1) (Journal of Applied Meteorology and Climatology)

[Heat-Health Action Plan to prevent the consequences on the health of the population in the former Yugoslav Republic of Macedonia (WHO)](http://www.euro.who.int/en/countries/the-former-yugoslav-republic-of-macedonia/publications3/heat-health-action-plan-to-prevent-the-heat-wave-consequences-on-the-health-of-the-population-in-the-former-yugoslav-republic-of-macedonia)

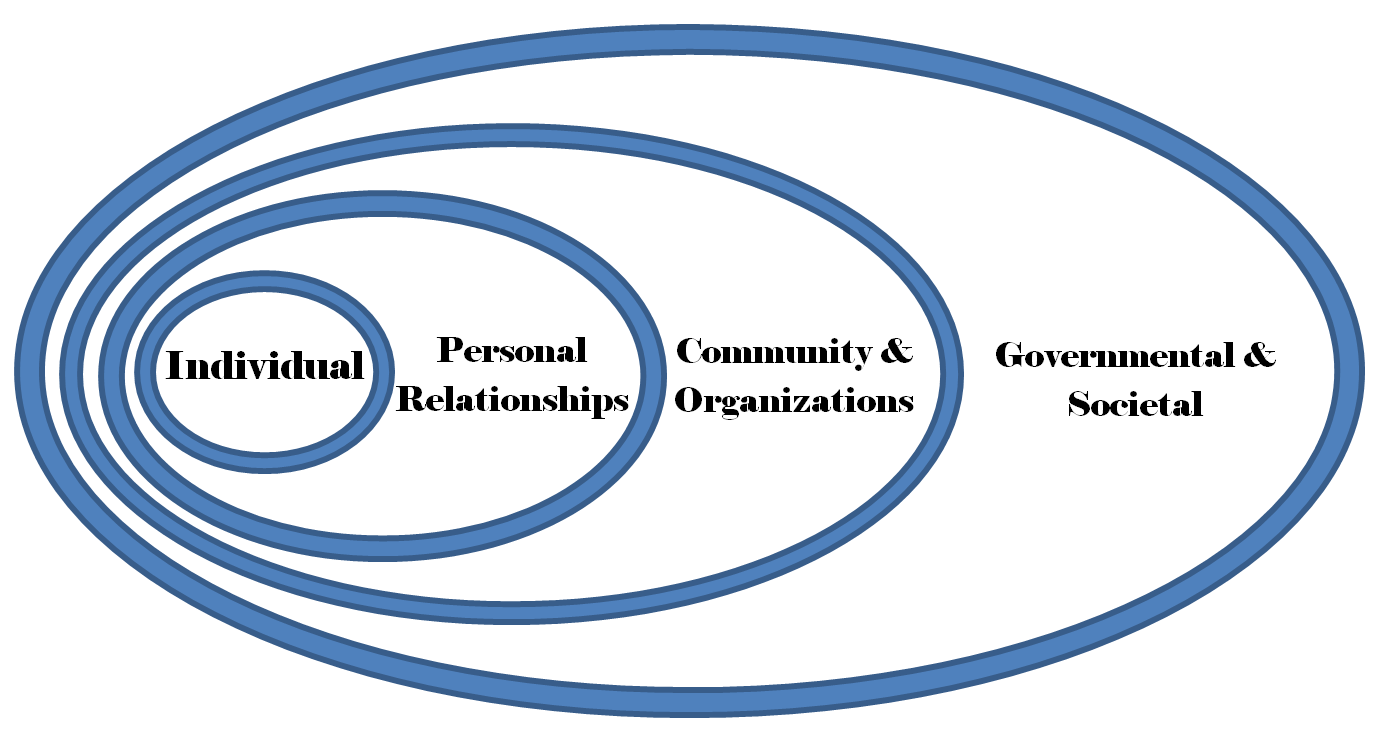
[Ahmedabad Heat Action Plan](https://www.nrdc.org/sites/default/files/ahmedabad-heat-action-plan-2017.pdf)

[Validation of a Temperature Prediction Model for Heat Deaths in Undocumented Border Crossers (Journal of Immigrant and Minority Health)](https://link.springer.com/content/pdf/10.1007%2Fs10903-012-9619-1.pdf)

**Chapter 6: Adaptive Responses**

**What actions are being recommended to reduce risk of increasing and extreme heat?**

The social ecological model[1] provides a clear framework for understanding the four interacting levels of extreme ambient heat adaptive action.



**Figure 1: Social Ecological Model for Extreme Ambient Heat Adaptive Action**

These actions can be organized according to their level of organization [figure 1], which dictates who carries out the action, and often where the adaptive actions takes place. Additionally, these categories can be further divided into temporal subcategories:

* Actions to take when a heat wave is announced (HHWS) or during a heat wave.
* Actions to take prior to a heat wave being announced (seasonal, or annual)
* Actions to take continuously (actions to be maintained over time, long-term).

Recommended extreme heat adaptive actions fall into 7 categories:

Individual/Personal Relationships

* 1. Individual behaviors: dos and don’ts.
  2. Awareness (of heat and health information, temperature, and signs of heat stress.)
  3. Environmental changes
  4. Social measures

Community & Organizations/Governmental:

    E. Management

    F. Policies

    G. Information Dissemination

***Points of interest, differences?***

* A wide variety of suggested actions, (total of 186 identified possible actions)
* The social ecological model as a way to understand not just what actions are available to each level, but also how each level can influence the others. The example is civic engagement for individuals can influence community level, community level civic engagement can influence governmental.
* Recommended vs. mandated regulations (curfews, occupation breaks, sending certain people home).
* Level of detail (which foods to eat, versus - just eat snacks).
* More focus on the short term, less emphasis on the long term - long term may be more impactful.
* Although a few HHAP acknowledged cascading failures (power outages) - none provided cascading failure specific actions to be taken. For example, what to do if your power goes out.

***Innovations***

Recognizing heat waves as disasters

Create guidelines for when a heat wave constitutes a legal “disaster”.

The US federal government has only declared a heatwave disaster once.\*

Vulnerable population specific actions/policies

Individual

Health conditions (and medication)

Relationship

Buddy systems which target the vulnerable and elderly

HK, Philly

Community/Org

Actions specific locations which provide services to the vulnerable

Governmental/Societal

Occupational health regulations

The support for community/org, relationship, and individual actions

Traditional architecture - climate matching according to projections.

Information on projected regional climate change can help communities prepare for “the heat of tomorrow”, before a catastrophic extreme heat event, by engaging stakeholders in adopting traditional, low energy technologies utilized by regions with climates similar to the projected climates.

|  |
| --- |
| According to the ‘Summer in the City’ Climate Central, WMO  With RPC8.5 & RPC 4.5, Havana Cuba could have a climate similar to Multan or Lahore Pakistan.  Traditional passive cooling technologies:  **Wind towers** or wind catchers are small towers installed on top of buildings. Wind towers have different shapes and structures. For centuries wind towers have been used for ventilation and cooling of buildings in the hot and arid or humid areas [[1]](http://www.sciencedirect.com/science/article/pii/S1364032114008351#bib1). Wind towers are still used in some areas of Middle East and Egypt ([Figs. 1 and 2](http://www.sciencedirect.com/science/article/pii/S1364032114008351#f0005)). By leading the outside air into the building, wind towers serve as a natural ventilation system for workplaces and houses.  <http://www.sciencedirect.com/science/article/pii/S1364032114008351#bib1>  **Stepwells**: While the exterior appears very much in keeping with the trends of contemporary design, at the base of the building is a vast pool of water -- a cooling concept taken directly from the stepwell structures developed locally over 1,500 years ago to provide refuge from the desert heat.  <http://edition.cnn.com/2012/02/28/world/asia/ancient-air-conditioning-architecture/index.html> |

***What do we need to know?* Science-Information- Decision-making:**

* Are adaptive actions supported by research?
* Do long term interventions/larger level policies etc. have a greater impact than short term?
* Do mandated actions versus recommended lead to improved health outcomes?
* Research to support specific responses? (may want to talk to Kris about this)
* Acclimatization

***Case Study***

snapshot characterizing local action (source: members) Commentary on what is being reported as effective (or what is not) Advances in science and application. Showcase new approaches  (source: new publications + member inputs to database/forum)

Buddy Systems - HK, Philly

OSHA’s heat safety tool: <https://www.osha.gov/SLTC/heatillness/heat_index/heat_app.html>