# Vulnerability to heat stress: A case study of Yavatmal, Maharashtra, India

ASSAR
Adaptation at Scale in Semi-Arid Regions

September 2018 www.assar.uct.ac.za

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**The five-year ASSAR project (Adaptation at Scale in Semi-Arid Regions, 2014-2018) uses insights from multi-scale, interdisciplinary work to inform and transform climate adaptation policy and practice in ways that promote the long-term wellbeing of the most vulnerable and those with the least agency.**

## KEY POINTS

- Over the past half century, heat wave frequencies in India have increased by a third, and the risk of morbidity and mortality related to heat stress is increasing.
- Housing material, particularly of roofs and cooling devices, plays an important role in regulating indoor temperature.
- Post-noon in the peak of summer, people in the rural agrarian Vidarbha region are exposed to high temperatures both outdoors and indoors.
- Preventative action is essential for the reduction of heat stress and requires coordination between government institutions, such as the departments of rural development, health, agriculture, and the National Disaster Management Authority (NDMA).

## Context and focus

In India, heat wave conditions are generally experienced during the summer months of April and May, and from time-to-time, deaths due to heat waves have been reported from several parts of the country. Between 2001 and 2012[1], heat stroke accounted for 4% of all deaths from natural calamities (see chart 1 on page 2), with a marked rise seen in recent years. According to the India Meteorological Department (IMD), over the past half century (1961 to 2010) heat wave[2] frequencies have increased by a third[3]. With the rise in average global temperature, a further increase in the number of hot days and greater frequency and severity of heat waves is expected. The risk of morbidity and mortality related to heat stress will continue to increase. Hence, effects of heat stress on human health are becoming an issue of growing concern in India.

Environmental factors that define exposure to heat, human thermal comfort and heat stress, are air temperature, airflow (wind speed), humidity and radiation. In an indoor environment, these factors are influenced by building style – characterised by type and construction of the roof and walls, and the application of cooling devices such as fans and water coolers. Besides these, the nature of work, physical activities and behaviour of individuals plays a role. Sensitivity to heat is related to personal factors, such as age and general health conditions, combined with the body's ability to respond to heat, which defines the vulnerability.

# Context and focus (continued)

Most epidemiological studies on heat and health rely on meteorological data from standardised weather stations that do not adequately reflect exposure to heat, for example inside houses and landscape characteristics of a location (other than the type where the weather stations are installed). It is unclear if the measurements from such stations are an under- or overestimation of the temperature of the various surroundings that vulnerable people are exposed to.

The impact of heat in rural areas has been a blind spot so far. While in earlier years agricultural activity was low during the hottest summer months, today, the increased intensity of agriculture combined with changes in timing of working hours (i.e. working even during the hottest time of the day) means that farmers and outdoor labourers are increasingly exposed to high outdoor temperatures.

**This study provides a pilot assessment of vulnerability to heat exposure in a rural context during the peak summer months of 2016 with a focus on indoor and outdoor temperatures.**

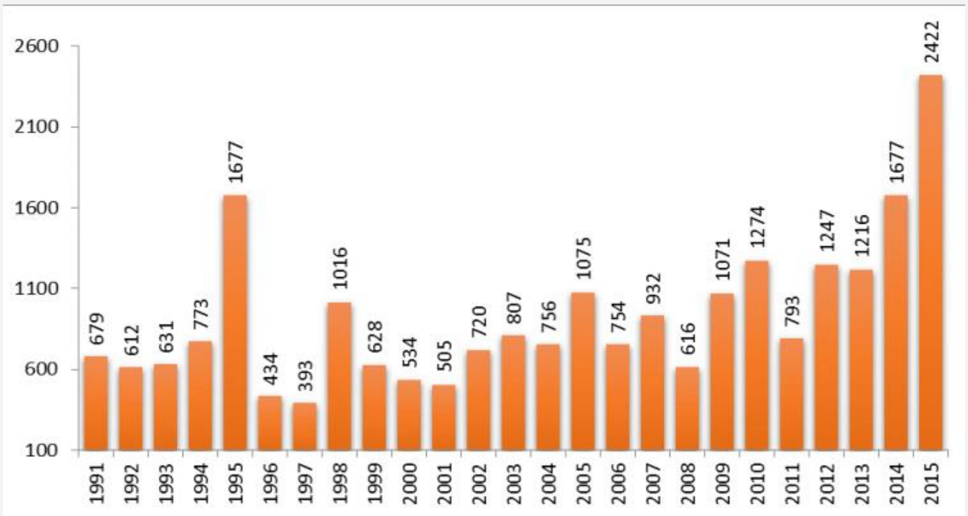
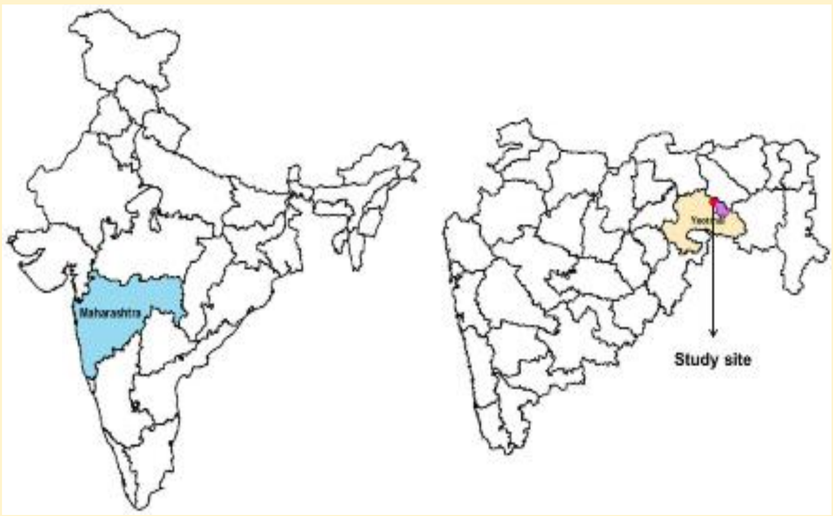



**Chart 1:** Reported heat stroke deaths in India from 1991 – 2015[4]

# Study area

The study site is located in Sonurli and Eklara villages in Yavatmal district, Maharashtra. Yavatmal district, in the Vidarbha region in eastern Maharashtra, experiences high summer temperatures up to 45°C in the peak of summer. Of its population, 78.4% live in rural areas and 79.2% are engaged in agricultural and other outdoor manual labour.

Houses in villages are earthen, or made of tin sheets or of brick with cement. Roof materials used for houses in the district are of tin, re-enforced cement concrete (RCC) and tiles (handmade or industrial). Census data (2011)[5] shows that in Yavatmal district as a whole, 64% of all houses have roofs made of tin sheets. Fans, and more recently coolers, are used to make houses more habitable during hot weather conditions.




Sonurli and Ekalara villages, Ralegaon block, Yavatmal district, Maharashtra

# Methodology

Outdoor temperature was measured by an Automated Weather Station (AWS) installed in Sonurli village (Photo 1).

**Photo 1:** Automated Weather Station (AWS)

Indoor temperature was measured using 20 data loggers[6] that recorded air temperature at fixed intervals of 10 minutes. Household selection for installing data loggers was based on roof type: tin sheets (67%, Photo 2), RCC (23%), and tiles (10%).

**Photo 2**: Tin roof houses in rural Maharashtra

The temperature loggers (Photo 3) were installed in rooms where household members spent most of their time when indoors. Through interviews and focus group discussions, people's perceptions on heat stress and human health, livelihood patterns and coping mechanisms were collected. A total of 70 sample households (326 individuals – 54% male and 46% female) were interviewed through a structured questionnaire.


**Photo 3:** Indoor data logger

# Key findings

- The indoor temperature in houses with tin roofs is higher throughout the day as compared to RCC roof houses; it even exceeds the outdoor temperature (Chart 2).

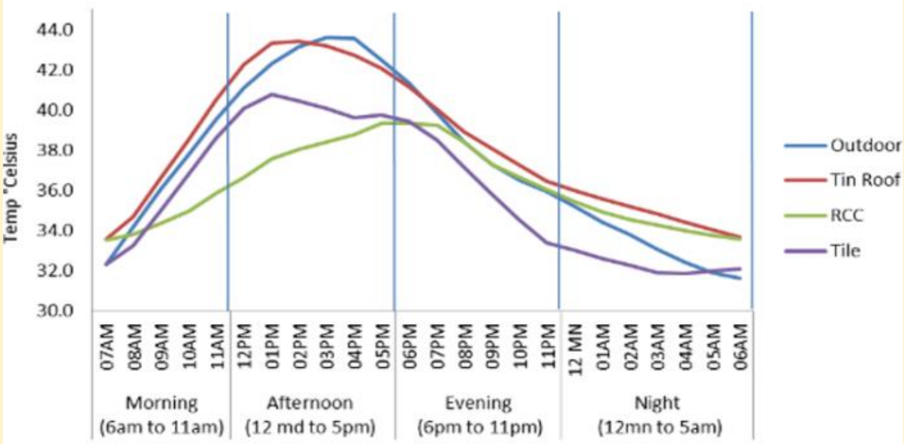



**Chart 2:** Average diurnal temperature of the outdoor temperature and houses with different roof material.

- With an outdoor average temperature reading of 42.5°C, the temperature under tin roofs was the hottest (average 45.8°C) between 12 noon and 6pm. A layer of crop residue over the tin roofs reduced the temperature by 4°C. Under RCC roofs the indoor temperature is substantially lowered (by 9°C) by using coolers (Chart 3). Under both roof types, the night temperature indoors was found to be warmer than outdoors.

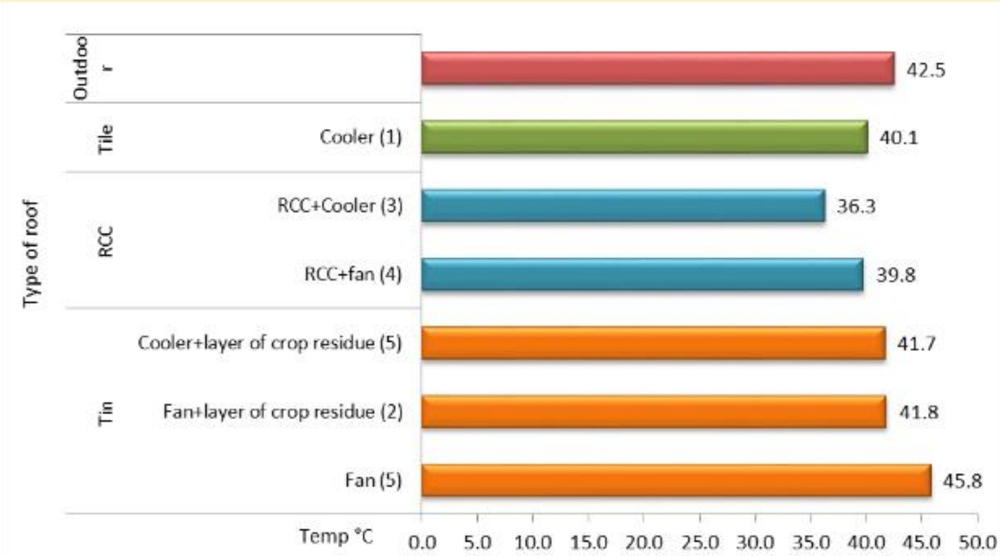



**Chart 3:** Average air temperature measured outdoors and indoors under different roofs (20 data loggers)

- The maximum temperature under tin roofs generally occurs in the early afternoon, before the maximum in the outdoor air temperature. This may be indicative of a strong correlation with solar radiation, which may be expected because of the low heat capacity of the tin roofs in comparison to RCC roofs. The maximum incoming solar radiation usually occurs well before the maximum air temperature.
- During the hottest period of the day in summer, i.e. between 11am and 5pm, when people are generally indoors, it was found that for a duration of 10 consecutive days, the outdoor readings ranged from 42°C to 45°C, while within the tin roof houses people were exposed to temperatures ranging from 45°C to 48°C, which was even higher than the outdoor temperature.

- Chart 4 shows the average diurnal variation of indoor temperature in the 20 houses. The indoor temperature between 12 hrs to 16 hrs inside tin roof houses recorded up to 49°C. The temperature peaked in the afternoon in all house types. In general, the indoor room temperature was highest between 12 noon and 4pm in all types of roofs.

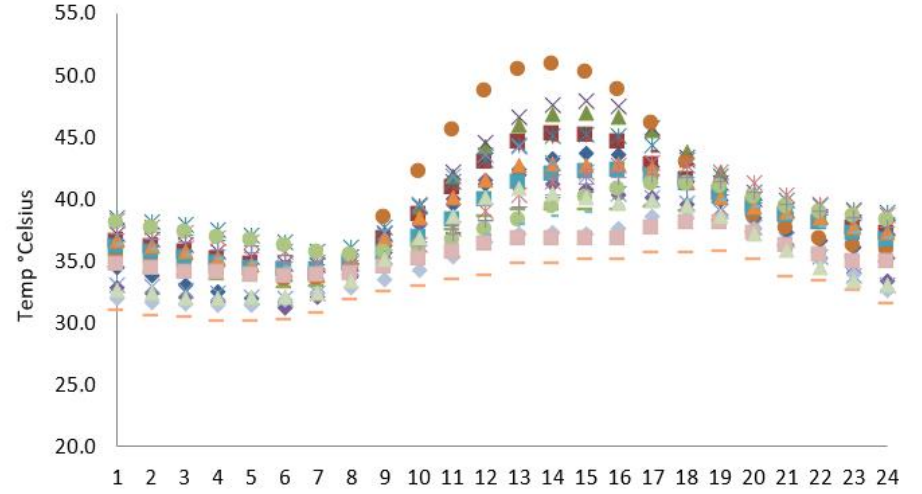



**Chart 4:** Diurnal variation of temperature within the different roof types

- Of the 326 individuals interviewed, 152 (47%) individuals reported at least one heat-related symptom; 67% of these were people who resided in tin roof houses. A higher percentage of men (57%) reported heat-related symptoms than women (42%). Among age groups, the 19-45 group (Chart 5) reported more heat-related symptoms as they spend long hours outdoors, performing livelihood activities which expose them to high temperatures and direct sunlight.

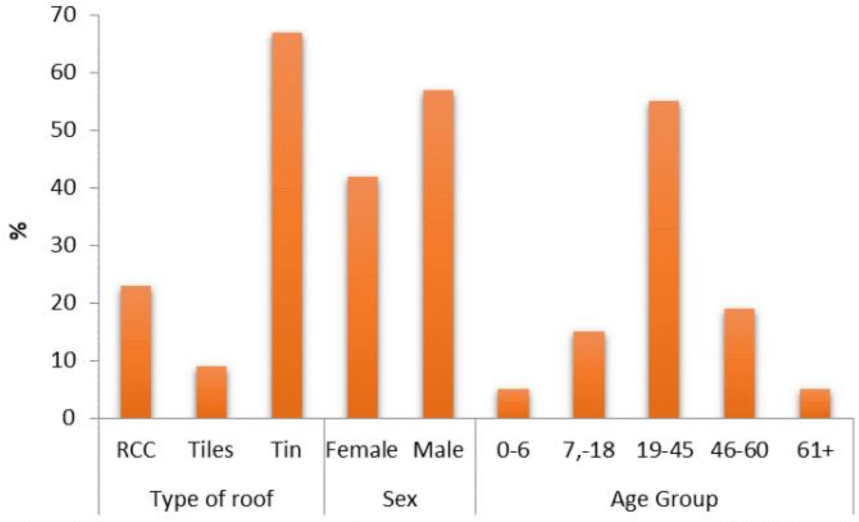



**Chart 5:** Percentage of individuals reporting heat-related symptoms

- The main heat-related symptoms reported during the summer of 2016 in the study sample are: heavy sweating, leg cramps, intense thirst, fatigue and disorientation (Chart 6).

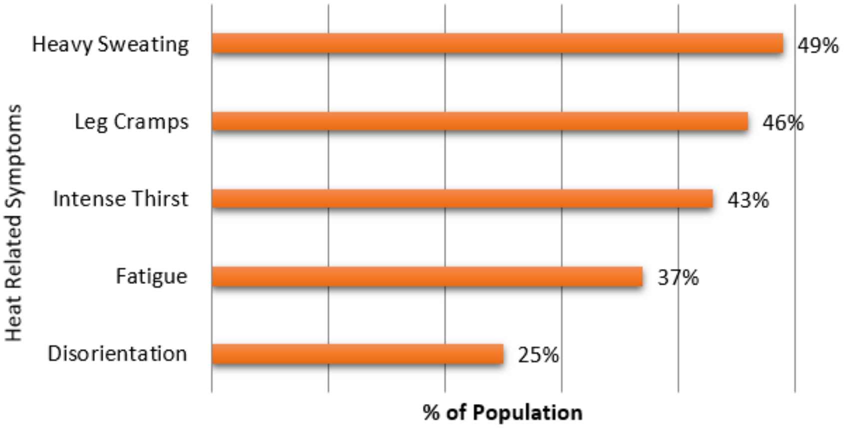



**Chart 6:** Major heat-related symptoms reported during the summer of 2016 in the study sample.

# Conclusion and recommendations

- The findings of this pilot study show that a large rural population is exposed to heat stress both outdoors and indoors. Besides working men, the other people affected by heat stress are: the ill, the elderly and women, particularly when cooking (using firewood based cooking stoves), fetching drinking water and collecting firewood.
- Tin roofs contribute most to indoor heat stress during peak summer months. Heat-related symptoms need to be identified early and precautionary measures taken in order to avoid extreme heat stress.
- Urgent measures are required to reduce exposure to heat stress: e.g. the promotion of crop residue layers on tin roofs; and the construction of community halls to provide space to rest during the hottest hours of summer months. The use of coolers greatly reduces indoor temperature, but the availability of water and electricity, as well as funds to purchase them are required. Heat stress may be reduced by improving housing design, adjusting work hours in summer e.g. in the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and providing drinking water for labourers during work hours.
- Heat stress in rural areas is an overlooked problem. This pilot study highlights the urgency for wider and more in-depth studies to better understand heat stress and thermal comfort, ventilation and radiation, and how rural areas are affected by these. This in turn will help identify appropriate responses. While addressing heat stress-related symptoms is essential and rests with the health department, its prevention will reduce morbidity and mortality. However, its prevention falls in the domain of other government departments e.g. rural development. Findings from such studies will call for various government departments to work together towards this end.

Villagers and cattle taking shelter under a tree during the hot days of summer.

## References


1. Compiled from 'State-wise distribution of accidental deaths by natural causes'. Available at: https://data.gov.in/catalog/stateut-wise-distribution-accidental-deaths-natural-causes
2. A heat wave in India is declared when there is an excess of 5° Celsius over a normal daily historical maximum temperature (30 year average) of less than 40°Celsius; or an excess of 4°Cover a normal historical maximum temperature of more than 40°C. If the actual maximum temperature is above 45°C, a heat wave is declared irrespective of the normal historical maximum temperature.
3. http://raghu.umd.edu/pressmentions/Heat-Waves-India.pdf
4. Compiled from 'State-wise distribution of accidental deaths by natural causes' Available at: https://data.gov.in/catalog/stateut-wise-distribution-accidental-deaths-natural-causes (The mentioned figures are recorded in National Crime Records Bureau (NCRB) and Open Government Data (OGD) Platform India)
5. All figure are taken from Census 2011. Available at: http://www.censusindia.gov.in/2011census/Hlo-series/HH2A.html
6. 18 HOBO UX100-001 for temperature and 2 HOBO UX100-011 for temperature and relative humidity (Onset, USA).

# ABOUT ASSAR

ASSAR uses insights from multiple-scale, interdisciplinary work to improve the understanding of the barriers, enablers and limits to effective, sustained and widespread climate change adaptation out to the 2030s. Working in seven countries in Africa and South Asia, ASSAR's regional teams research socio-ecological dynamics relating to livelihood transitions, and the access, use and management of land and water. One of four consortia under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA), ASSAR generates new knowledge of climate change hotspots to influence policy and practice and to change the way researchers and practitioners interact.

This policy brief is an outcome of a pilot research project 'Combating Heat Stress in South Asia' conducted in the Vidarbha region of Maharashtra (India). The pilot study was implemented in collaboration with the Wageningen Environmental Research (Alterra) Team Climate Change WUR, Netherlands, under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA), with financial support from the International Development Research Centre (IDRC), Canada, and the UK Government's Department for International Development (DfID). The WOTR Centre for Resilience Studies (W-CReS) carried out the research titled 'Heat Stress and Human Health, in Vidarbha, Maharashtra' to understand the impact of heat stress on human health. (The views expressed in this work are those of the creators and do not necessarily represent those of DfID and IDRC or its Board of Governors.)

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