Reducing health risks of rising temperatures in South Asia (RRR)

IDRC Grant Number 109220-002

Photo: Installing a data logger in a rural home

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Final Technical Report

Project duration: *March 2020 – December 2021*

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Outcomes and Results

The outcome sought under the CLARE program is:
"Actors in planning, programme implementation, policy and research use a range of evidence-based options to enhance and support communities' livelihoods in the face of climate challenges in ways that benefit the most vulnerable women and men."

- *In general, how did this project contribute to that outcome?*
- *Recount a "story of change" from your project towards this outcome: a narrative that illustrates a change that can be attributed, in full or in part, to the project, supported by evidence from which we can demonstrate a plausible contribution. A story should mention the situation before the project, the intervention conducted through the project, and the change that occurred.*
- *Complete the Annex identifying specific outputs generated under the project (knowledge products, engagement, and capacity strengthening)*
- *What were the most important results or consequences[1] arising from the project outputs and activities?*
  - *Why do these results matter?*
  - *How did the project advance knowledge and practice on climate adaptation?*
- *Compare intended and actual results - please comment on key results that were intended but not realized, and any unintended results that were realized.*

How RRR contributed to the general aim of CLARE

The outcome sought under the CLARE program is: "Actors in planning, programme implementation, policy and research use a range of evidence-based options to enhance and support communities' livelihoods in the face of climate challenges in ways that benefit the most vulnerable women and men."

The RRR project contributed to this aim by investigating real life heat stress experiences among the population of India, both in urban and rural settings. Climate change will lead to more frequent heat wave events, also in South Asian regions where high temperatures are already a regular feature of climate. Developing countries are particularly vulnerable, due to their location in the low latitudes. The study on heat stress in urban populations around the world clearly shows that south-east Asia is a hotspot in this respect (see Annex 2). Urban areas face additional risks from heat because their built density and reduced green cover amplifies temperatures through the urban heat island effect; and because of the conditions in and the design of unplanned 'informal' settlements, which exacerbate heat risks while their residents lack the financial means to mitigate the effects. In rural areas, those working in the fields have limited options to shield themselves from the sun. The poor, exposed and with limited access to cooling, are disproportionally affected because of where they live and the type of houses that they live in.

The impact of chronic heat exposure in both urban and rural areas on productivity and health was the topic of this project. We aimed to increase evidence based insights in heat stress exposure, developed and assessed tools for heat warnings, and published findings to raise awareness on chronic heat stress. Results were presented at Adaptation Futures in Delhi, October 2021. A better functioning heat stress warning system and raised awareness of the risk of heat can potentially lead to increased wellbeing for tens of millions of people, especially the poor and vulnerable. The project made another step towards

[1] Project outcomes include changes in behaviours, attitudes, practices, capacities, policies, relationships, technologies, etc. that contribute to climate resilience. They may result from the research process or the application of research findings. Consider the consequences (outcomes) that result from tangible achievements (outputs).

this goal, as part of an ongoing research effort that started with CARIAA[2] research. Due to COVID-19 some of the activities were delayed, so the heat advice needs further development before wide-spread communication can take place. The efforts will continue in future projects, for which a proposal was already submitted by one of the partners.

Story of change

As part of previous CARIAA funded research, a detailed monitoring approach to measure heat exposure in both urban and rural in South Asia was developed. A combination of temperature data loggers, placed inside people's homes, automatic weather stations in urban settings and transect drives with portable weather stations attached to cars was used to expand our knowledge of heat stress. Heat stress is caused by a combination of air temperature, relative humidity, solar radiation, air movement but also influenced by behavioural aspects such as the amount of physically demanding labour, clothing and access to drinking water. CARIAA research highlighted that the poor are disproportionally affected because of where they live and the type of houses that they live in. Houses usually are not insulated and have limited options for cooling.

The RRR project continued to collect temperature and humidity data here inside peoples' homes to gain further insight on factors influencing the difference between outside and inside temperatures. Forty indoor temperature data loggers were installed in a village to measure indoor temperature. In addition, to further assess the impact of heat in urban settings, particularly prolonged periods of night-time exposure, we used relationships derived from previous collected CARIAA data on the difference between officially observed and actually experienced temperatures indoors. Results confirm South Asia's status as a climate/heat hotspot, with projections indicating high to extreme night-time heat risk conditions for all of the major cities in the region.

More importantly, building on CARIAA knowledge, the RRR project wanted to further explore people's adaptive capacity and develop tools to improve people's response to extreme heat events. In recent years, after the success of the Ahmedabad heat action plan, heat advices have been developed for many of the large urban agglomerations in India and also surrounding countries. For In Delhi, targeting the urban population, we conducted a survey to see how the government's heat advice was used by the population in different neighbourhoods. Another survey was organized during the COVID crisis to see how working or staying at home impacted heat stress.

In rural areas, detailed heat advice and heat action plans are not yet available and people have to rely on generic news items and weather forecasts covering vast geographical regions. To fill this gap, we developed our own heat advisory, tailored on the agromet advisory system WOTR has in cooperation with the Indian Meteorological Department. Among the rural population of Jalna, a district in the Indian state of Maharashtra, a baseline survey was done to understand their knowledge, behaviour, information sources and perceptions on heat stress and related aspects.

[2] The Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) was a 7-year program (2012-2019) jointly funded by Canada's International Development Research Center (IDRC) and the UK's Department for International Development (DFID). The program supported collaborative research on climate change adaptation in climate hotspots.

After the baseline survey, a heat warning indicator- based on the WBGT[3] index - was developed using local weather data and tailored local weather forecasts provided by the IMD based on these weather data, expressing heat stress levels people could expect three days in advance. The indicator was accompanied with advice how people in rural areas might cope with extreme heat events. The advice was sent to the existing network of users of agricultural climate advice, aiming to improve the health of the extended families of the farmers. The heat-health advisories were pilot tested for a duration of six months (May- Oct 2021). These advisories were sent out twice a week through mobile SMS to about 2027 farmers, of which 296 (15%) were women. Setting up of the complete heat health advisory system and pilot testing with two thousand farmers was one of our main activities. It is to our knowledge the first service system of this kind in India.

A feedback survey (rapid assessment) was done by telephone among about 50 respondents to acquire farmers opinions on the heat stress indicator and the advice. The heat stress indicator was found to be accurate and the advice was considered useful by the majority of the respondents. The coping strategies of the persons reached with the survey were changing the daily schedule, enabling them to rest at the hottest time of the day. Survey results can be found in Annex 7. The method of the feedback survey in terms of numbers and response are mentioned in Annex 6.

COVID brought unique challenges, not only by delaying our research but also by providing an insight into people's exposure and coping at home, cut off from work environments, during extensive lockdowns. The synthesis of the survey conducted during the COVID pandemic with a very small sample of people in Delhi and the NCR indicates that people do respond to situations in the near term. When exposed with conditions of increased temperatures many who could afford resorted to using their cooling devices and paying higher bills. The 50 persons from the urban population of Delhi reached with the other survey used cooling devices inside the homes; but poor households use less advanced devices, and they struggle more to pay for the electricity. The poor could not afford to use the cooling devices to the extent that those with higher incomes could. This highlights the importance of economic inequality in assessing people's vulnerability and capacity to cope with heat stress, rather than looking purely at whether people own certain devices (as is often done in surveys). It yet again highlights the impact that better incomes have on the response abilities of populations to adapt to the risks imposed. For a country like India which is a Lower Middle Income economy, it highlights the challenges the country faces in improving the adaptive capacities of its population to thereby reduce the vulnerabilities. These coping strategies likely already existed, but our study illustrates the challenges for adaptation when a large fraction of the population still comprises a high vulnerability category. Collecting more data on actual coping possibilities and relating these to the advice given in the heat advisories seems important.

[3] WBGT: Wet Bulb Globe Temperature

Figure 1: Farmers at work in Maharashtra (Photo WOTR, 2016)

The intention of the project was to develop and pilot a method: go through the whole cycle of exploring peoples experience with heat stress, devising a tool, sending a heat advice, collect data on heat stress and evaluate both the data and the uptake of the tool. Due to several delays, the data loggers were installed at the end of the hot season of 2021. The surveys were delayed because of COVID-19. The heat advisories were sent, but the summer of 2021 was relatively mild. This means that the explorative part of the project was done, the methods are developed and the data collection process has started. However, the loop could not be closed with a full evaluation of the effectiveness of the tool to help reduce exposure of farmers during a heat period. The team carried out a rapid assessment to understand the appropriateness of advisories and the extent of use of the advisories by farmers in planning their work schedule. The results were published as blogs at the end of the project and the data is about to be published in a scientific paper. Sending the advisories, data collection and analysis will continue after the end of the RRR project. This will produce more clarity on actual change and potential for more change with the developed methods.

Most important results of RRR

The aims of the RRR project were:

1) Strengthen the scientific evidence of heat exposure in rural areas, and its impact on productivity and health, including the impacts in the current COVID-19 context.
2) Test heat stress advice for rural areas, as part of existing agromet-advisories.
3)
    a) Assess the effectiveness and inclusiveness of heat wave bulletins in India (focus on Delhi).
    b) Understand how high temperatures in the summer were dealt with during the COVID-19 lockdown (targeting Delhi and the NCR region).

4) Raise awareness on chronic heat stress at various policy levels, including an event at the Adaptation Futures conference in Delhi, October 2021.

A summary of the results for each objective is below.

1: Understanding exposure to heat in rural areas

The rapid assessment with telephone interviews among the rural population in the Jalna district by WOTR after the summer of 2020 found that the lockdown period greatly restricted economic activities. People were confined in their villages and landless agricultural labourers hardly had any work. Farmers and labourers shifted working hours to avoid the midday heat. At times, older people rest outside the house in the courtyards, under a tree during afternoons to avoid indoor heat. However, summer temperatures were on average not as extreme as during previous summers. Generally, community members experienced limited heat stress compared to previous summers. Figure 2 shows the average maximum temperature for Jalna district over the last ten years. With the pandemic situation expected to return to near normal in the coming years, outdoor workers will be exposed to increased heat stress again.

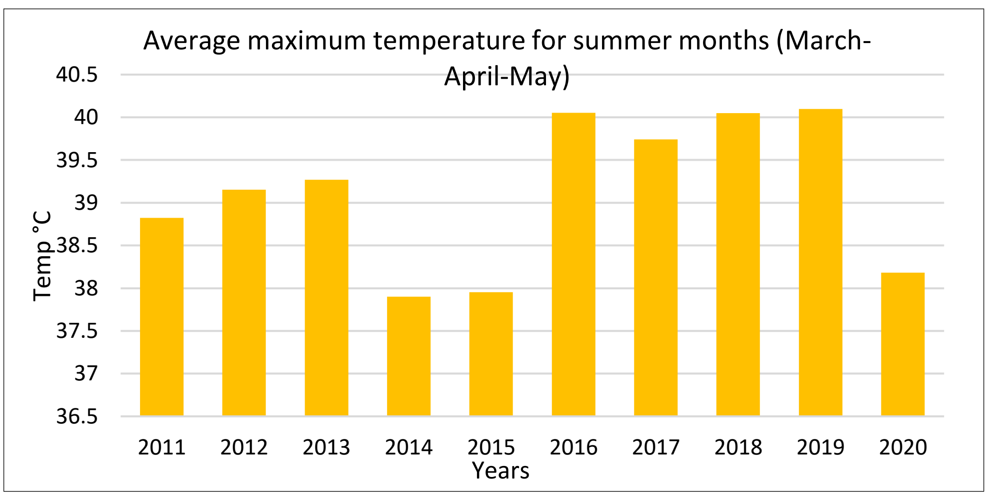

Figure 2: Average maximum temperature for summer months (March-April-May) for Jalna district

To reduce the heat-related vulnerabilities of the rural communities, it is essential that pre-emptive strategies are prepared. Several cities in Maharashtra state have a Heat Action Plan (HAP) and more are preparing them, but there is a need for a state-level HAP which considers the specific needs of rural communities. Local health and line departments need to coordinate and implement appropriate policies for building adaptive capacities and improving healthcare systems. Preparedness in rural communities should be increased through effective awareness and early warning systems. The public health and meteorological departments should coordinate to reach out to those most vulnerable to the heat-related risks. A blog on this rapid assessment was published in Down to Earth (see Annex 3).

2: Developing a rural heat stress advice

WOTR already has an established system of providing agromet advisories to farmers in rural areas. WOTR, in collaboration with the IMD, has installed 103 automatic weather stations (AWS) in Jalna, Ahmednagar, Aurangabad, Pune, Nashik, Dhule, and Nandurbar districts of Maharashtra. The meteorological data received from these AWS stations are subject to quality control at WOTR and is then forwarded to the IMD. WOTR is provided by IMD with the expected maximum and minimum daily temperature, relative humidity and precipitation, for the next three days. Based on these short-term local weather forecasts, agricultural experts from WOTR prepare agromet-advisories which are disseminated through SMS and WhatsApp to mobile phones, and through wallpapers that are put up at prominent places in the project villages. Screenshots of the health advice is shown in Figure 4.

Figure 3: Farmer reading the SMS based heat and health advisory (Source, WOTR)

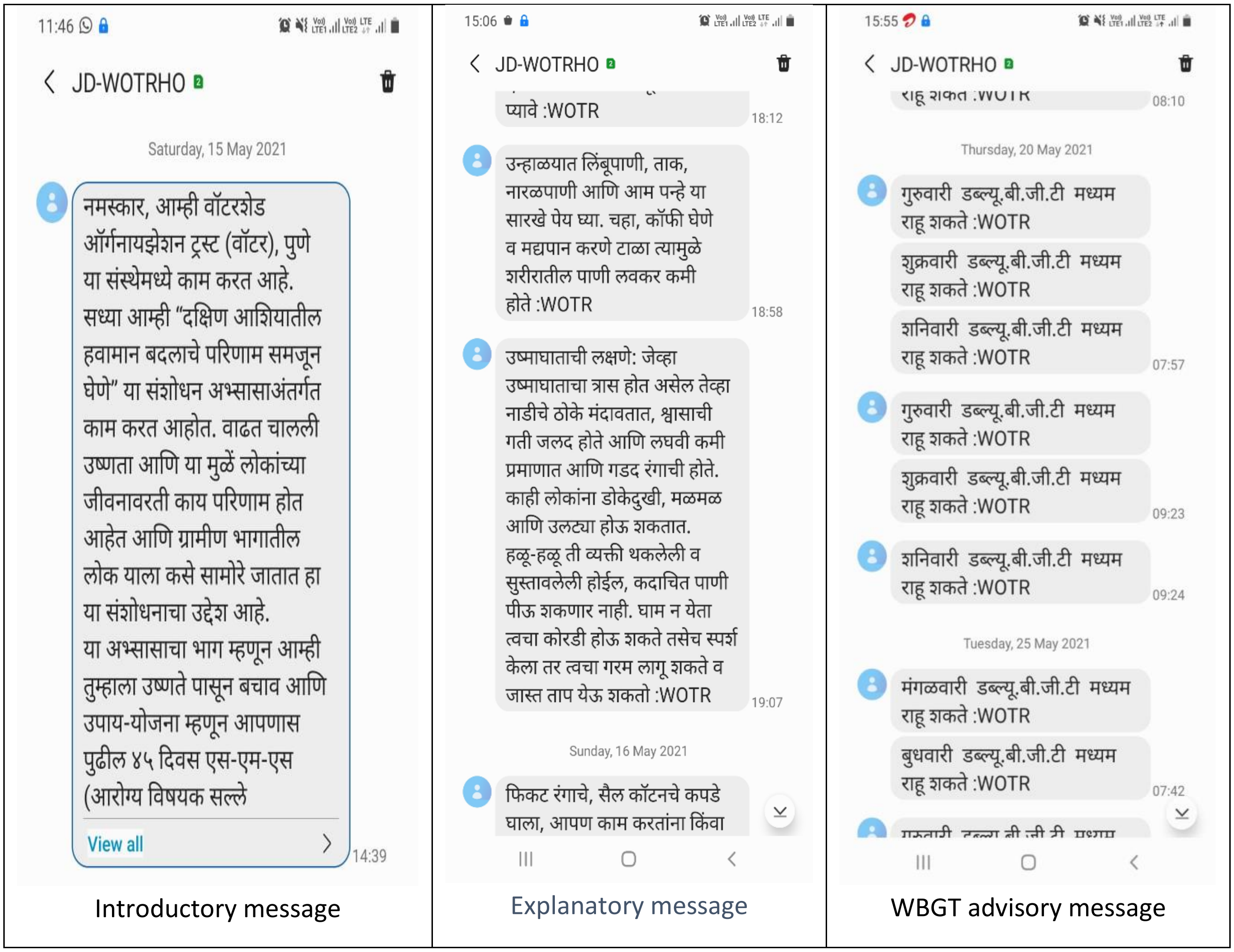

Figure 4: screenshots of the health advice. For translations see Annex 14.

For the RRR project, heat advisories were incorporated into this existing agromet-advisory system. It was piloted in 18 villages of Ambad, Bhokardan and Jafrabad blocks in Jalna district of Maharashtra. For the heat advisories, a heat stress indicator was developed, as shown in Figure 5. The heat and health advisory messages were attached in Annex 14 (in local Marathi language and the translated version into English).

The duration of heat matters for the warnings to be developed, as it gives an indication whether periods of rest would suffice or whether strenuous outdoor activities should be avoided as much as possible. An analysis of weather conditions during 2019 showed that the most extreme WBGT[4] threshold for acclimatized workers (WBGT > 32C) was exceeded for up to 7 - 8 hours a day during the last week of May and first week of June, and during an individual heat wave in mid-July. Between April and October, multiple episodes occurred during which the WBGT threshold was exceeded for up to 4 - 5 hours a day. Generally, high WBGT values were found to be a result of high temperatures, in some cases in combination with, or primarily driven by high humidity.

[4] WBGT: Wet Bulb Globe Temperature is a measure of the heat stress in direct sunlight, and takes into account: temperature, humidity, wind speed, sun angle and cloud cover (solar radiation).

The heat stress indicator needs to be developed further by including daily patterns with advice when to rest and other practical advice how to avoid damage to health, while taking into account the need to work. This is what was picked up from initial discussions with recipients regarding further fine-tuning of the SMSs. The team intends to disseminate the advisories in the coming summer season, as the system is now set for this geography. To upscale it in other geographies, further refinement in the indices and messages will be required. The team is already looking out for 'call for proposals' to obtain funding for the upscaling work.

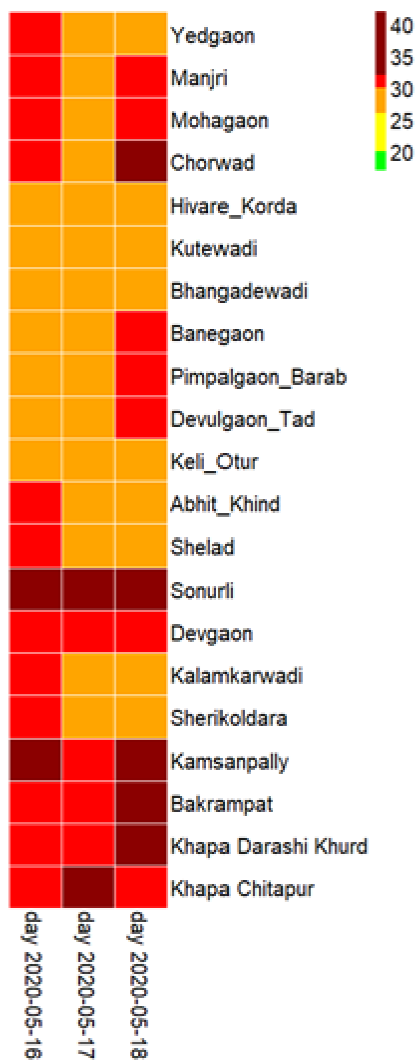

Figure 5: Three-day heat forecast indicator for 20 villages in Jalna

3a: Evaluating India's heat wave bulletins

Heat wave bulletins and heat warnings tend to focus on heat wave events, by definition focussed on high daytime temperatures and of short duration. Here we add another perspective and that is of prolonged nighttime heat, which we think is as important but more complex to cope with or adapt to.

A study on future night-time heat stress in megacities around the world shows that especially large cities in South- and South-East Asia are at risk (see Figure 6) (with co-funding from the Netherlands Environmental Assessment Agency, publication forthcoming). In 2010 only one large city, Chennai in South India, recorded an exceedance of 28 °C during 20% of summer nights. By 2050 many major cities like Bangkok, Hanoi and Guangzhou enter the medium risk category. At high risk are Chennai, Delhi, Kolkata and Dhaka, with WBGT not dropping below of 28 °C in over 40% of summer nights. The higher risk is caused by a combination of population density, a hot and humid climate exacerbated by climate change, extreme events due to climate variability, and the Urban Heat Island effect.

Figure 6: Exposure of urban populations to night-time heat (WBGT higher than 28 °C), at present (2010 – inner circle) and in 2050 (outer circle) for cities with a population of more than 2 million in 2010, in terms of Low (none)-Moderate (<20% of nights in summer), High (>=20% but <40%) and Extreme risk (>=40%)

Even this level of risk is an underestimation of actual conditions in low-income neighbourhoods. Indoor temperatures in the types of houses common here - poorly ventilated, not or only partly insulated and with no electrical air conditioning - were found to be on average about 4°C warmer in inner Delhi than outdoor temperatures as measured at the WMO station during the coolest moment of the night. Additional analysis based on earlier CARIAA data indicates that only part of this difference is explained by the Urban Heat Island effect – more important is the way houses trap heat during the day, which keeps temperatures high throughout the night.

Heat waves have caused many excess deaths in India over the past decades[5]. To cope with the increasing frequency of these events, the Indian Institute of Public Health and the India Meteorological Department (IMD) have developed heat action plans, which include better warning and advice for India's urban populations. The advisories include, for example, heat wave alerts via printed material, radio and TV, setting up of drinking water stations, and advice to change school and working hours[6]. For

[5] Eos / AGU: Specifically Tailored Action Plans Combat Heat Waves in India: https://eos.org/articles/specifically-tailored-action-plans-combat-heat-waves-in-india

[6] Heat wave advice March 2021: https://cdn.s3waas.gov.in/s39bf31c7ff062936a96d3c8bd1f8f2ff3/uploads/2021/06/2021061158.pdf

the RRR project, a survey was prepared to investigate people's experiences with heat waves in Delhi and the uptake of the heat advisories. The questionnaire can be found in Annex 11.

The respondents are classified in to three categories – high income households (monthly income >INR 2 lakh), lower middle and upper middle class households (LMUM) (monthly income ranging between INR 20K to INR 2 lakh) and poor income households (monthly income <INR 20000). Around 60% of the respondent households fall in the LMUM class, 30% in the poor class and 10% in the high income class. More than 90% of the households in all the categories feel there has been a change in the weather of Delhi in the last 10 to 15 years. More than half of the households in high income class feel daytime temperatures have risen up in the recent past while the LMUM households are concerned about the nights getting warmer in the past years. Out of all the different challenges faced during a heat wave, water stress/shortage is the most worrisome for the high income households and power cuts and load shedding is the concern for the poor income households. The high income households are aware of the advisories that are issued by the government to address exposure to heat stress and have access of and learnt about it through different mediums such as television, text messages, radio, internet, newspapers etc.. However, more than 90% of the LMUM and poor income households are clueless about the government advisories and those who are aware of it have learnt it through text messages only and follow and share it further with family and friends also. This suggests that reaching more people is the first priority. As part of the recommendation on additional information to include in the advisory - all the income groups suggested advisories with specific content for vulnerable groups and suggestions for rescheduling outdoor work/activities as the priority amongst other suggestions Respondents were asked what could be some alternate sources through which information on heat waves could be disseminated. Responses indicated a strong preference (66%) towards voice messages, social media, text or WhatsApp messages. The remaining households believed that dashboards, graphics and imagery could also help in reaching a wider audience.

India is responding to the challenges of rising temperatures by issuing Heat Wave Bulletins in the peak period when temperatures cross certain thresholds. The advisories are issued by the Indian Meteorological Department. However, a very small fraction of population, less than 15 % from the survey conducted in Delhi, indicated to be aware of the advisories being issued and understanding the Standard Operating Protocols to be followed given the alert. A large fraction of more than 80 percent indicated not being aware of the advisories and the ensuing actions based on the level of risk. Considering Delhi is the capital of the country and the home to multiple tiers of governance such as Federal and State levels, including housing institutions to assist decision making in certain areas, the level of information and reach out to the population is seemingly limited. To be able to address the concerns the scales of implementation and community outreach are multifold. This indicates that, while measures are being developed and put in place for responding to climate risks, there is a need for far greater awareness to be raised in reaching out to communities. Additional effort is needed to inform the general population about the warning systems and the advisories that are being developed which may assist in them in choosing a better response to the developing temperature conditions. There may be a need in this process to also review the format in which the information is developed and communicated to find better ways of representation and reaching out. A mix of modes including electronic channels and social media could be used. A journal paper is being developed to report the findings but it is still being finalised for submission.

3b: Dealing with high temperatures during lockdown

In India, summer starts at the beginning of March and ends in June with the start of the monsoon rains. Temperatures rise above 30 degrees Celsius. During the COVID-19 pandemic of 2020, people across the country were confined to their homes with schools and office buildings closed. This has shifted the need to cope with heat during the day from the workplace to the home. An unprecedented combined impact of COVID-19 lockdown and extreme heatwaves has luckily been avoided when the heat of the summer of 2020 was interrupted by welcome rain, in Delhi and across much of India. Still, people have been effected. Especially in densely built, low-income urban neighbourhoods, with no open green spaces, there is little relief from the heat, even at night.

To understand the severity of the heat during the early months of the pandemic, and the impact it had on the different socio-economic groups in society, we conducted a small survey among employees of The Energy & Resources Institute, in Delhi, India. A sample of 40 respondents was taken from different locations corresponding to different socioeconomic status – classified by the localities they stay in, as well as income groups highlighting their living conditions and economic status. Results indicated that with increasing income people tend to shift to more expensive devices for cooling that also require more energy for operation. There is a positive correlation between income level and electricity consumption. A comparison of electricity consumption between 2019 and 2020 revealed that the Work From Home (WFH) policy that was adopted during the country wide lockdown corresponded with huge spikes in electricity consumption in the household sector. Part of the increased electricity consumption at the household level during the summer of 2020 appeared to be due to the extreme heat waves, another part to the work from home policy adopted during the lockdown. More information can be found in Annex 4.

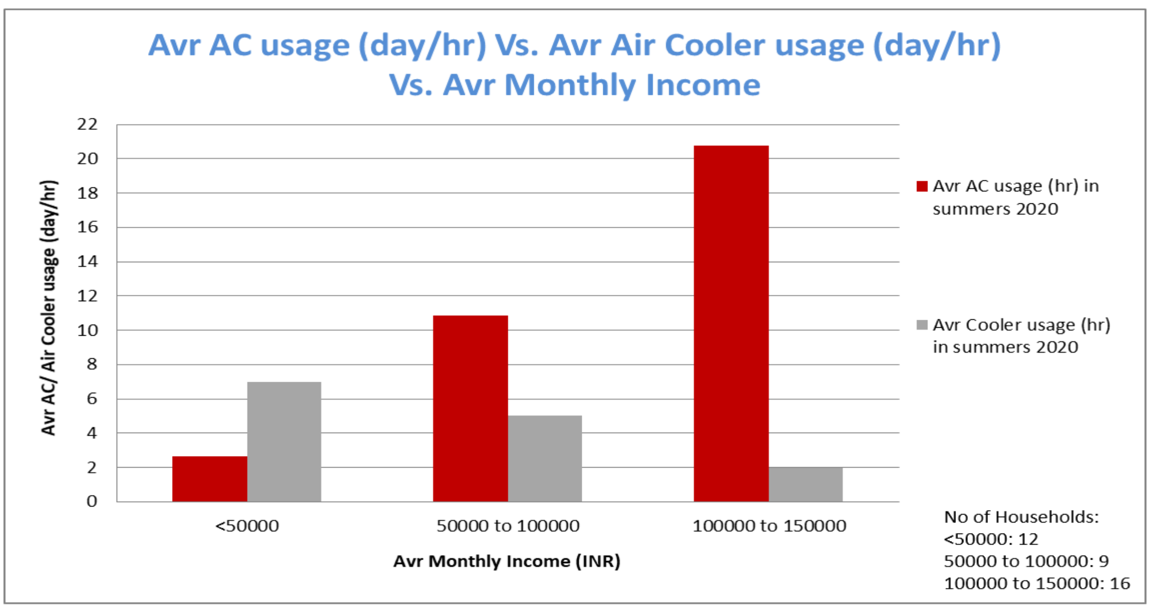

Figure 7: Average Air Conditioning usage and Air Cooler usage in hours per day in Delhi in the summer of 2020 in different income categories

4: Awareness raising

A working paper on urban-adjusted' and 'socio-economic differentiated' climate change impacts for the Delhi Metropolitan region was written. Interactions with policymakers/stakeholders in the rural context was no objective of the project. We were aiming to raise awareness more generally on the issue by dissemination of our research paper but the paper and its data collection could not be completed on time due to the COVID-19 pandemic.

The Adaptation Futures conference in Delhi was held 4 - 8 October 2021. TERI co-hosted the conference and organized a session 'Impacts of Heat Stress and its Management" in which RRR results were presented, together with the work on managing heat stress of other researchers. For the session program see the table below.

Session title	**Impacts of Heat Stress and its Management**		**Speakers/Abstract Presenters/Rapporteurs**
Time	Day 1: 5th October 2021 1130-1300		Ramiz Khan, Red Cross Red Crescent Climate Centre, Global perspectives on heat risks and management
Theme	Knowledge for action		Rohit Magotra, IRADe, Climate Adaptive Heat Action Plans for Vulnerable Communities
Submission ID	286		S C Bhan, IMD, Managing Heat Stress in India: Early Warning, Mitigation and Adaptation Plans
Organizers	Rohit Magotra; Suruchi Bhadwal; Aditi Kapoor		Christian Siderius, WENR and Premsagar Tasgaonkar, WOTR, Piloting of a Rural Heat Stress Warning System
Chairs	Prof. Jyoti Parikh, Executive Director, (IRADe), Dr Judith Klostermann (WENR)		Neha Bharti, TERI, Managing Heat Stress during the Lockdown

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Why do these results matter?

The study on future heat stress shows that India is going to be the global epicentre of chronic heat stress, due to both its hot and humid climate and its population density. The research done in RRR explores cheap, fast and accessible ways of coping with this heat stress: acquiring more precise short term weather information; developing means to bring this tailor-made information to a large number of the inhabitants; and building on the people's own adaptive capacity to cope with the heat stress. The results of WOTR show that it is indeed possible to develop such an information channel. However, the results of TERI show that, while options exist to cope with heat stress these are largely used by a very small fraction of the population with a larger proportion being still affected and bearing the brunt of the climate risks. The energy for cooling devices and the cooling devices themselves are unaffordable for many. Some first results of RRR indicate that roof materials matter too. Infrastructural measures should be explored further, such as better insulated housing (against heat) and shading by trees. Of course, this also shows that climate mitigation is more important than ever.

How did the project advance knowledge and practice on climate adaptation?

The project developed a system of acquiring detailed climate data; modelling them a few days into the future, designing an indicator showing the risk of heat stress, and providing this indicator together with detailed behavioural advice to a thousands of farmers on a 2-weekly basis. The system is operational and will be continued in the future. A quick evaluation round showed that it is in the 1.0 phase and can be improved, but it is already appreciated by the receivers of the information.

Comparison of intended and actual results

Key results that were intended but not realized, were a thorough testing of the developed warning systems, both in rural and urban environments, resulting in publishable research papers. Due to the COVID-crisis, several parts of the project were delayed such as the arrival of materials, traveling to case study areas and organizing large scale interviews. Piloting of the advisory system was achieved successfully. Testing was done only as a fast scan or preliminary analysis of interview data. The data could not be collected as intended due to covid restrictions. Hence we decided to use the present data as well as past data from ASSAR project to prepare an article which is still under way.

Unintended results that were realized, were two short surveys to find out how the COVID-19 crisis influenced heat stress and coping capacity. One was done for the rural areas, showing a shift in working hours that enabled people to rest during the hottest hours. As part of the extension activity, we prepared and published two blogs. Once is published in down to earth website whereas the other is published in CDKN website. The other survey was done in the urban context, showing that people's income has an influence on the cooling devices that they use.

Implementation

- *Project management:*
  - *Briefly describe the activities supported under the project, including the research methods, instruments[7] and analysis used.*
  - *What were risks that were managed, or challenges faced, over the course of the project? How did the project team respond to these?*
  - *Restate the specific objectives of the project from the grant agreement. To what extent were each of these met?*
- *Gender and social inclusion: Briefly describe how the project integrated considerations of gender and social inclusion through team composition, research methods & process, and outputs. Describe any significant results from these efforts.*
  - *Identify the steps taken to prevent harm from occurring (safeguarding[8]), along with any lessons learned from these efforts.*

[7] Add as an annex any questionnaires, interview guides, and other documentation useful to understanding the project

[8] Safeguarding is preventing and addressing any sexual exploitation, abuse and harassment of research participants, communities and research staff, plus any broader forms of violence, exploitation and abuse relevant to research such as bullying, psychological abuse and/or physical violence.

Research activities, methods, instruments and analysis

1: Understanding exposure to heat in rural areas

In the villages included in the study on exposure and vulnerabilities of rural communities, 24 telephonic interviews were conducted to understand the impact of summer temperatures in the current COVID-19 context. The experiences of the community were corroborated with meteorological data and indoor temperature observations in the village Adha. The historical trend of summer temperature for the past 20 years and future temperature projections were also analysed. In addition, remotely sensed land surface temperature was analysed for the past 15 years to understand the changing trend over the years and to identify possible hotspots of heat. The output of this rapid assessment was published as a blog in Down to Earth.

A baseline survey of 360 farmer households was conducted in the first week of May 2020 which helped us to understand the knowledge, behaviour, information sources and perceptions on heat stress and related aspects of the rural communities. We had planned for an endline assessment of the same farmers but the COVID-19 related restrictions did not allow us to do so. Instead the team carried out a rapid assessment with 50 recipients of the agromet advisories to understand the appropriateness of the heat advisories and the extent of use of the advisories by farmers in planning their work schedule.

The COVID-19 pandemic caused challenges for this project in several ways: the delivery of the data loggers was late; interaction with potential respondents was very limited; and traveling of researchers was difficult. We could not follow the original plans and therefore we had to improvise to at least achieve some of the results. There was a window of only one day to install the data loggers. This was not enough to install all of them, but with a demo video local staff was instructed to install the remaining devices. In the end, all 40 data loggers were installed in the Kouchalwadi village. To describe a part of this improvisation work, a blog was written on WOTRs experience with installing the data loggers. The blog can be found in Annex 5.

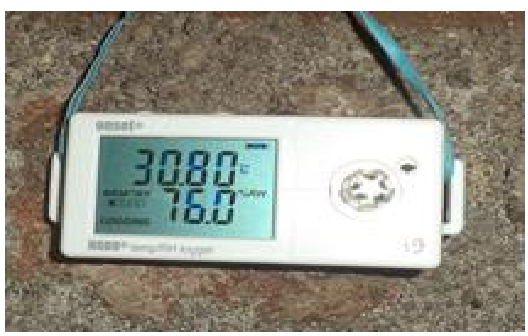

Figure 8: Temperature cum humidity data logger

2: Developing a rural heat stress advice

A Rural Heat Stress Warnings and Advisory service has been developed. Regarding the behavioural advice, we referred to the "National Guidelines for Preparation of Action Plan – Prevention and Management of Heat-Wave 2019" by India's National Disaster Management Authority and various Heat

Action Plans of different States. It was supplemented with WOTRs experience in working with heat stressed rural communities in rural areas of Maharashtra obtained during the CARIAA adaptation research programme. Also, the study team from WOTR's included a medical doctor, now working in the rural development sector.

Regarding the temperature indicator, we used data for 2019 and the beginning of 2020 from one of WOTR's Automated weather stations, installed in Adha village. We evaluated the variation in heat stress, as expressed by the Wet Bulb Globe Temperature (WBGT), to get a better understanding of the severity and duration of heat stress events. Data were checked, and WBGT scripts from earlier CARIAA work were updated to match the new .CSV data formats (as .CSV is becoming more the standard in meteorological data). They were also adjusted to calculate various indices, such as the exceedance of the most extreme threshold for acclimatized workers. An old 3-day forecast issued by IMD for mid May 2020 was used to develop an initial WBGT heat stress warning indicator for 18 villages included in the project.

In order to develop and test the Heat Health advisories mobile SMS based messages were disseminated to 2027 farmers in 18 villages. WOTR was already providing SMS based agromet-advisories to farmers in many villages and this existing platform was utilized to pilot the health advisories. A selection of the 18 villages was made, based on a classification in terms of socio-economic and bio-physical indicators, to create a sample for testing (see the RRR Second Interim report of April 2021, Annex 2 for more information on the classification and selection procedure).

3a: Evaluating India's heat wave bulletins

Shifted by one year due to the COVID-19 pandemic, survey tools were prepared in 2021, and rolled out in October-November 2021. A sample of 3000 respondents was taken from different localities in the 11 districts of Delhi. The surveys were conducted door to door covering 11 districts of Delhi covering different socio-economic groups. Descriptive statistical analysis has been performed on the data set.

A working paper on 'urban-adjusted' and 'socio-economic differentiated' climate change impacts for the Delhi Metropolitan region was written. The aim is to provide a better understanding of the increase in exceedance of relevant heat thresholds in the context of climate change, population growth, rapid urbanisation, and of the population particularly affected. It targets the most vulnerable groups. It also aims to assess the effectiveness of the recently implemented heat wave bulletins in India (specifically in Delhi). We wanted to understand how heat advisories are being understood by the different socio-economic classes and how useful it is for them in taking any actions against the exposure to heat waves. The perceptions of the respondents on promising ways to adapt to rising temperatures were analysed along with suggestions on the components to include in the advisories/bulletins.

3b: Dealing with high temperatures during lockdown

To understand how high temperatures in the summers were dealt with during the lockdown period a survey was developed targeting inhabitants of Delhi and the NCR region. A sample of 40 respondents was taken from different locations, corresponding to different socioeconomic status, classified by the localities they stay in as well as income group. The survey covered various aspects of the population in terms of their housing conditions, income and economic status, access to cooling devices, and affordability in terms of electricity consumption and electricity bills. For the questionnaire see Annex 12.

4: Awareness raising

Several blogs and popular articles were written, see the section on uptake. Results were presented at two CLARE Learning Review events (25^{th} of March, 2021 and 20^{th} of April, 2021) and at the Adaptation Futures conference on the 5^{th} of October, 2021, see the section on results, under objective 4.

Challenges faced

The COVID-19 pandemic and restrictions in India and elsewhere seriously impacted the project. Because of the lockdown that was proclaimed in India some core research and dissemination activities had to be postponed to 2021, since they were bound to the hot season. Project activities were adapted to the unprecedented situation as far as possible, also attempting to gain new information under COVID-19 conditions. In Delhi, an online survey has been carried out allowing a quick-scan of the impact of socio-economic status on heat exposure and energy use, and cost of cooling, with and without COVID-19. For the rural situation, data from previous years and imagery from remote sensing research have been analysed to kickstart further testing of a prototype rural heat-health warning system in 2021. A telephonic survey was held to explore consequences of the lockdown for heat exposure in rural settings. The Adaptation Futures 2020 conference (AF2020), was postponed to 2021.

With regard to the equipment: There is only one authorized vendor of the HOBO indoor temperature/humidity data loggers in India and we had placed our order with them some time ago. The data loggers were expected to be delivered to us by the first week of March 2021 but they got delayed. The reason the vendor gave us is the slow production in US factory due to COVID restrictions. Once the equipment was available, their installation was restricted by lock-down measures in India. Eventually, the data loggers were installed in the study villages in the fourth week of April 2021 by the study team members. Because of the delay, we missed the readings for most of the summer (even though readings for the peak summer month of May were captured). However, since their installation WOTR has been receiving data, which will be used for future analyses.

Risk faced

2020 and 2021 were not extremely hot years so the experienced heat stress was relatively mild. Therefore, the methods could not be tested under extreme conditions.

We trust that the tools and data will be used in the future, after the time frame of this project. WOTR decided to continue the advisories, and submitted a proposal as a follow up to RRR.

Specific objectives of the project in grant agreement	*Were they met and how*
1.1 Tailor and pilot through RTC*, a livelihood and activity-focussed heat stress advice for rural areas, as part of agromet-advisories currently being issued.	Yes: a heat stress indicator and a set of advice messages was developed, and this information has been sent through SMS to 2027 farmers from May- Oct 2021. Data from WOTR weather stations and calculations form the Indian Met Office were used for the three-day forecast.
1.2 Strengthen the scientific evidence of heat exposure in rural areas, and its impact on productivity and health, expanding on the pilot approach developed under CARIAA.	Yes: Additional Automatic Weather Stations were installed inside people's homes and data are continuously being collected by WOTR. An article analysing the data has been submitted.

1.3 Assess the effectiveness of the recently implemented heat wave bulletins in India, with a focus on urban areas (CARIAA heat stress pilot neighbourhoods in Delhi).	Yes: a survey was done in selected neighbourhoods in Delhi and a preliminary analysis of the data has become available.
1.4 Raise awareness on chronic heat stress at various policy levels, including IPCC's sixth assessment report, through project outputs and a high-profile event at Adaptation Futures in Delhi, 2020.	Partly: a successful event was organised at the Adaptation Futures conference, but due to the COVID-19 pandemic the conference was postponed to October 2021 and its influence on the 6th assessment Report of IPCC is unclear. Several blogs based on the project have been or will be published.

* RTC should be RCT: Randomized Control Trial

Gender and social inclusion

The research team included 4 male and 6 female researchers.

Female team members	*Male team members*
Judith Klostermann (WENR) Suruchi Bhadwal (TERI) Neha Bharti (TERI) Dhriti Pathak (TERI) Smita Chakravarty (TERI) Faiza Jamal (TERI) Komal Modhave (WOTR)	Cor Jacobs (WENR) Christian Siderius (Uncharted Waters Research) Dipak Zade (WOTR) Premsagar Tasgaonkar (WOTR)
7 female team members	4 male team members

TERI undertook an online survey to understand the means of coping with rising temperatures in Delhi as people were confined to their homes this summer. Out of the 40 respondents that undertook the survey, 21% were women.

As part of the extension activity, WOTR has conducted 24 telephonic interviews in the month of May 2020. Of these, 9 interviews were conducted with women. This was to ensure that gender differentiated experiences and perceptions of heat stress and exposure are captured in the study.

TERI collected data in live interviews. Of these respondents, 17% in high income classes, 21% in LMUM, and 17% in poor classes were female. While gender was not the focus of the surveys being planned, the TERI survey did highlight the differential vulnerabilities in responding effectively to climate risks across the social strata thereby discussing the poor and the marginalised and vulnerable populations which actually constitute the bulk of the population.

WOTR used the existing network of agromet services, to extend it with heat stress advice. Most of the Agromet advisory beneficiaries are men. Less than 10% of the beneficiaries are women farmers. This is a limiting factor while selecting women beneficiaries receiving the heat and health advisories. We cannot add new members from our side as it will not be compatible with the existing data base. This seems like an important gap and in rural areas, to ensure women (and children and elderly) are protected from impacts of heat, it would be important to ensure other ways of reaching these populations.

Women and men and people of different ages and with underlying health conditions will have different heat sensitivities, but there is not enough scientific evidence or information to derive these thresholds from. However, in the advisories accompanying the heat stress indicators, we do add specific advice to look after pregnant workers or workers with a medical condition during days of high to extreme heat stress.

Safeguarding

From the study context, the information provided by the participants is strictly kept confidential. Name of research participants and other information is kept anonymous. It is ensured that no findings can be related with the names of the informants.

At WENR, the general policy is to create a pleasant working climate for all employees and students. The working climate can be disturbed by conflicts and / or undesirable behaviour. In case of problems at work, employees can appeal to the department of Social Work. The social workers are all professional care providers who know the WUR organization well. In case of complaints about undesirable behaviour, employees can also request the help of a confidential counsellor. Confidential counsellors for undesirable behaviour have been appointed for each organizational unit. Undesirable behaviour is defined as: sexual harassment, bullying, aggression, intimidation and discrimination. The counsellor is there for immediate relief and guides the reporter in any subsequent solution process. Confidential counsellors also provide general information about preventing undesirable behaviour to staff and students and can provide solicited and unsolicited advice to the management boards and the organization regarding matters and problems surrounding undesirable behaviour.

WOTR has an 'Internal Redressal Policy' for the work place which has been followed in the project, wherever applicable. The Redressal Policy document is detailed and gives guidelines to prevent and address misconduct.

TERI's safeguarding policy covers many subjects, varying from a "Policy on equal opportunity, employment policy, and policy prohibiting discrimination & sexual harassment" to a policy statement on "Health, Safety and the Environment." The guidelines are made available internally in TERI's "Employee Handbook." Regarding research involving humans, an ethics committee has been formed at TERI. The committee's task is to perform an ethical review of the proposed research involving humans, including periodic monitoring. The committee will pay attention to "scientific design and conduct of the study; selection of subjects; inclusion/ exclusion criteria; participant information sheet and informed consent form in local language; protection of privacy and confidentiality; plans for data analysis and reporting; competence of investigators, research and supporting staff, facilities and infrastructure of study sites."

Uptake

- *Describe project efforts, challenges and successes on supporting uptake[9] of research results.*
- *Recount specific examples of:*
    - <u>*Demand*</u> *"requests by stakeholders and target actor groups to brief on, produce, partner in, or provide technical assistance to apply evidence, outputs, recommendations or follow-on projects based on the work conducted by your project"*

[9] Research uptake refers to efforts and outcomes in increasing the reach and use of research, such as in policymaking processes

- *Endorsement "indication of a binding use (formally or officially communicated by users, for example in office orders, meeting minutes or official messages that have been formally documented and announced) of any products, recommendations or communications from the project research"*

WOTR has ongoing contacts with all major stakeholders involved in rural development in the states of India it works in, including NABARD (National Bank for Agriculture and Rural Development), the Maharashtra government and institutes like IMD. The IMD was involved in developing local forecasts for the heat stress indicator, based on data from WOTR stations, as part of the wider agromet service agreement. At a local level, key stakeholders and decision makers such as village leaders were directly involved in the research.

For TERI the purpose of the project was to assess the government's response mechanism to help adapt and therefore the effectiveness of it was being assessed from a users perspective. The findings on the effectiveness of the heat bulletins for dissemination will be shared through different mediums.

Results of the Rapid Assessment among the rural population on COVID-19 and heat stress were first published as a blog on Down to Earth here:

https://www.downtoearth.org.in/blog/climate-change/covid-19-how-heat-stress-affected-livelihood-health-of-maharashtra-s-rural-communities-77073

and then reposted on 'Global Heat Health Digest'

https://mailchi.mp/ghhin.org/digest-august2021-14809172?e=4836ebe242

And next on the South Asia Heat Health Information Network newsletter (Fortnightly Issue #5, Volume I: September 2021) here:

https://mailchi.mp/8bcad399f2c3/sahin-newsmailer-4963218?e=63d4c53c48

Simultaneously, it was disseminated through WOTR's monthly Newsletter:

https://mailchi.mp/wotr/rejuvenate-wotr-monthly-newsletter-may-2021

Results of RRR were presented at Adaptation Futures on the 5th of October, 2021 and at two CLARE learning Review events (25th of March, 2021 and 20th of April, 2021).

The Hindustan Times published two articles on extreme heat events in India, with contributions from project members. They can be found here: https://www.livemint.com/mint-lounge/features/is-extreme-heat-making-india-unlivable-11601034638011.html

https://www.hindustantimes.com/india-news/implement-cheaper-sustainable-cooling-strategies-lancet-series-101630479537752.html

WOTR, with support from Christian, is analysing the indoor and outdoor temperature data collected since ASSAR period (2016- 2021) and spread across three sites in Maharashtra. This will help understand differential exposure to indoor heat stress (based on housing structure- especially based on roofing types). Results could be published it as a scientific article, hoping to reach an audience as wide as possible, so as to increase impact. A summary of the draft text is included in Annex 13.

Results from the survey in Delhi and the NCR during the COVID-19 lockdown period will be published as a blog piece on the TERI website.

Additional Insights

- *What lies ahead for your team in terms of future research directions and collaboration? If relevant, mention additional activities or research questions that emerged from this project.*
- *Provide any feedback to IDRC and FCDO as research funders:*
  - *Candid observations about the overall experience with the project are encouraged.* [10]
  - *We welcome recommendations and advice on future research needs or opportunities.*
- *How can we reduce the environmental and climate impacts of research activities in future project design and implementation? (optional)*

Future research

WOTR plans to continue disseminating the heat health advisories to the farmers in the summer of 2022. The data loggers are in good working condition and hence they will be removed at the end of December 2021 and reinstalled in the summer of 2022. This will help us to collect longitudinal data of the study villages to give a deeper insight into indoor heat exposure.

The health advisories were piloted and the first results show that it is well-received. Both the indicator and the health advice can be evaluated further to understand their usefulness and scope of improvement. In depth interviews can reveal how they are perceived by the users, and the perceptions can be compared to the intended meaning. With this, an improved indicator. Possibly with a different visualisation, might be developed. The health advice itself can be updated with the latest scientific knowledge regarding people's responses to heat stress.

Upscaling and diversifying the heat stress advice is another direction of future research. The heat advice could become more diversified towards different vulnerable groups such as children, pregnant women and/or elderly people. As it is now using an existing user base of farmers receiving agricultural advice, the distribution of the diversified advice would need more thought. As we upscale and diversify, we will need involvement of different stakeholders and new partners who are best able to reach other populations.

WOTR is actively searching for future funding opportunities to continue the dissemination of heat health advisories and upscale the activity in other regions/states also. A research proposal was submitted to a potential donor, which unfortunately did not process to next round of selection. The team is actively in lookout for newer opportunities.

The research indicates that people in rural and urban settings struggle with extreme heat events, and that it is partly due to the housing infrastructure. They try to solve it with cooling devices that require electricity, which then burdens the household finances. More research is needed into structural solutions such as better roofing and better (and greener) urban design.

[10] Any sensitive or confidential information should be addressed through a direct exchange with the program officer, and documented and filed separately.

The preliminary results of the survey on heat bulletins in Delhi show that middle and low income groups are not reached sufficiently yet. More research would be useful into new methods of providing these households with advice on coping with extreme heat.

Feedback to IDRC

We had to operate under difficult circumstances caused by the COVID-19 pandemic, causing several delays in the work. We appreciated the flexibility and compassion under these circumstances very much.

We also experienced quick responses and assistance to our questions, both on technical and financial issues.

CLARE is an advanced system that can be a bit intimidating at first.

From TERIs perspective of having used CLARE, it was a new platform that was introduced during the Transition stage projects and given the bulk of the work that the teams already had, there was a challenge we faced in uploading information onto CLARE due to time constraints. Our primary objective focussed on getting the work aligned.

Reduce the impact in environment and climate

Online tools have advanced during the past year, also due to the COVID-19 situation. Everyone is used to having online meetings and it is a great tool to reduce impact, especially when working in an international 9global) context. However, we believe meeting live at least once or twice during a project should remain part of the mix.

Annex 1: Project outputs

Please include a list of all project outputs, engagement activities, and capacity[11] strengthening from the project in tables such as those below. You can find a list on the online CLARE monitoring centre at your project review link (contact [Erika Malich] if you do not have this link).

As relevant, add further materials (e.g. agendas, meeting minutes, reports) that are relevant to this report.

Output Type (Journal article, blog post, etc.)	**Title**	**Authors**	**Where it was published**	**Date of publication**
Newspaper article - interview	Is extreme heat making India unlivable?	By Bibek Bhattacharya with input from Christian Siderius	Hindustan Times - Mint	26 Sep 2020
Newspaper article - opinion	Implement cheaper, sustainable cooling strategies: Lancet series	Jyoti Shelar with inputs from Premsagar Tasgaonkar	Hindustan Times	1 Sep 2021
Blog	Managing Heat Stress during the COVID Lockdown.	By Neha Bharti, Dhriti Pathak, Suruchi Bhadwal and Christian Siderius	draft Febr 2021	April 2021
Blog	COVID-19: How heat stress affected livelihood, health of Maharashtra's rural communities	By Dipak Zade, Premsagar Tasgaonkar, Christian Siderius	Down to Earth	24 May 2021
Blog	Experiences from the field - Installing temperature data loggers: Learning from pre-lockdown	By Premsagar Tasgaonkar	CDKN	12th January 2022
Blog	Heat & Health Advisories in Rural Areas of Jalna – A Heat Detector System	By Premsagar Tasgaonkar, Komal Modhave and Yogesh Shinde	CDKN	12th January 2022
Data article	Indoor and outdoor temperature measurement data	Premsagar Tasgaonkar, Dipak Zade, Sana Ehsan,	Submitted to "Scientific Data" journal	

[11] Capacity strengthening includes award recipients (individuals) and activities run through projects (typically in a group setting, such as training or workshops).

	from the rural-urban part of South Asia	Ganesh Gorti, Nabir Mamnun, Christian Siderius and Tanya Singh		

Engagement event with stakeholders (event name and description)	**Number of participants (% female)**	**Country where event took place** (for virtual events, select the location of the main event organizer)	**Date of engagement**
Adaptation Futures	25	India / online	5th of October, 2021

Capacity activity (award, training, etc.)	**Name of activity**	**Participants** (total participant number or awardee name)	**Duration (in days / months)**

Annex 2: Report nighttime heat exposure global map and case Delhi

Global map of Urban Night-time Heat stress by 2050

Christian Siderius, Uncharted Waters

Background

Climate change is raising temperatures, increasing the frequency, intensity and duration that people are exposed to heat (IPCC 2021). Exposure to extreme heat can lead to increased mortality and morbidity (Hajat et al. 2010), even in regions where people are used to being exposed to hot conditions and therefore can be expected to have adapted to it (Azhar et al. 2014). There is concern that by 2070, a large part of the human population will be living in regions outside the temperature niche in which societies have developed (Xu et al. 2020) and that even the physical adaptability limit to heat may be reached in some regions (Sherwood and Huber 2010). An analysis of documented heat events showed that many regions of the world already experience lethal heat conditions in the present climate and climate change will result in many more days with such conditions, notably in tropical and sub-tropical regions (Mora et al. 2017).

Across the tropics, heat waves are expected to continue to increase in frequency, duration and intensity. Their impact will cover almost half of South Asia within the coming decades, reducing economic growth in one of the world's poorest regions, according to the World Bank (Mani et al. 2018). Not only do heat waves cause fatalities; prolonged high temperatures, especially during the night, also affect people's health, wellbeing and productivity. Climate change is compounded by the impact of ongoing urbanisation. The conversion from natural land cover to dense concentrations of pavement, buildings, and other heat-absorbing surfaces leads to higher temperatures in urban areas, the so called "Urban Heat Island" effect (Oke 1982, Peppler 1929, Schmidt 1927). High minimum temperature has an effect on sleep (Obradovich et al. 2017), and sleep in turn is vital for healthy human functioning. Measurements in three major cities in South Asia reveal that summer night temperatures already cross indoor thermal comfort thresholds in lower socio-economic income households for months on end (Jacobs et al. 2019).

Heat stress is a complex phenomenon, driven by high temperatures, in combination with higher humidity which reduces the ability to regulate body temperature through transpiration, and an absence of wind – either natural air flow or induced by fans - which could have helped a person to cool down. Exposure to direct radiation from the sun also increases heat stress. Numerous empirical and process-based risk indicators have been developed to estimate heat stress under different conditions, of which the Wet Bulb Temperature and the Wet Bulb Globe Temperature (Lemke and Kjellstrom 2012, Liljegren et al. 2008, Yaglou and Minaed 1957) are two of the most widely used.

Recent research has focused on heat waves based on exceedance of acceptable levels of ambient temperature or Wet Bulb temperature, the maximum values of which tend to occur during the day. Similarly, research into occupational or exercise risk due to heat has focussed on daytime exposure. Relatively little is known about long-term exposure to chronic heat, at night-time when people spend most of their time indoors.

Aim

We develop a global map of urban heat stress by 2050, for capitals and large cities (e.g. > 1 million inhabitants) at risk of (extreme) heat. The map provides a general image on global urban heat stress by 2050, with 3 categories (high/medium/low risk). Results are based on RCP 6.0., using the ISIMIP 2b projections which contain not only temperature data (T_{min} and T_{max}, daily) but also humidity data, which is required to calculate heat risk indices. The Wet Bulb Globe Temperature (WBGT) heat indicator will be used;

a. We focus on the rise in night-time (minimum) temperatures and the (increasing) duration of night-time heat exposure, with urban areas heating up fast and cooling down slower at night;
b. Expansion of urban areas is taken into account, using the 2UP SSP2 urban expansion scenario developed at PBL. This data not only provides information on the increase in urban population and number of people exposed, but can also be used to estimate the increase in urban heat island effect (UHI) using simple relationships reported in literature;
c. A differentiation is made between different landscapes (drylands; coastal zones and deltas; humid (sub)tropical regions of transboundary river basins), e.g. in the form of a table listing temperature changes and changes in population at risk per landscape;

To get a better understanding of the severity of indoor heat stress , i.e. in the place where people actually live and rest, we zoom in on Delhi, one of the largest metropoles in the world. Combining World Meteorological Organization standardized observations (on which climate model data is based), with neighbourhood indoor measurements, we derive relationships between 'official' temperatures, and the heat index values on which these are based, with the indoor exposure as experienced by people living in urban areas in the tropics. This indoor-specific heat exposure is even more relevant for low-income/informal residential areas where people cannot afford air conditioners to control their indoor living environment. The case study for Delhi will showcase exposure and risks and the contribution of different factors (e.g. temperature rise, urban expansion and increase in population), under the BAU scenario.

Methodology

Our method combines climate change with projections of urban expansion and urban population between 2010 and 2050. We focus on night-time heat, i.e. prolonged duration of heat stress conditions, with climate change trends exacerbated by increases in the UHI.

Data

Climate: We use ISIMIP 2b projection on min and max daily temperature (T_{min} and T_{max}), Specific humidity (*SS*) and Wind speed (*Sf*). T_{min} represents the early morning temperature, just before sunrise, which is generally the coldest moment of the 24h measurement period. Assuming SS does not fluctuate much over the day we calculate a relative humidity (RH) at T_{min}, using *SS*, T_{min} and the mean global air pressure (1013 kPa).

Wind speed tends to be higher during the day than during the night. Following Ephrath et al. (1996), we estimate night-time wind speed as half of daily mean Sf. We did not correct for the potential impact of buildings and other structures in urban areas that might further reduce wind speed compared to the observed values from (often) rural areas or open landscapes, typically airports near cities. While there is evidence of daytime reduction due to the urban landscape, during night-time – depending on conditions – UHI might affect the wind flow over a city differently, with the urban temperature excess creating a convergent “sea breeze” into the warm city, or a reduced night-time stability of the urban atmosphere increasing wind speed (Bornstein and Johnson 1977, Pooler Jr 1963). These wind speed enhancing effects, however, are likely to be higher in the (early) evening than at the time of T_{min}. Observations of wind speeds in Chennai, for example, the city most at risk in our sample and known for its hot and humid climate, show a sea breeze picking up at the end of the day and peaking in the early evening after which it strongly reduces (Boreddy et al. 2021).

Urban expansion: 2UP (Andree and Koomen 2017) gives projections of population expansion over the 21st century on a 1km by 1km scale. From this dataset we get estimates of the size and spread of urban populations. We combine this with UN world population estimates and projections for all major cities in the world, which also provides the latitude and longitude of the centre of each city (United Nations 2019). We select only those cities with a population of at least 1 million in 2010 to calculate the total population at risk, and plot those with a population of 2 million and more. Apart from population size, the urban expansion data provides us with city shape and form, which we use to correct the temperature data for the UHI effect at night.

Method

WBGT

The WBGT formula for indoor and/or night-time conditions (Bernard and Pourmoghani 1999, Lemke and Kjellstrom 2012) was applied. Under these conditions, without a solar radiation component, the original WBGT formula based on Natural Wet Bulb temperature, Globe temperature and air temperature changes to:

$$WBGT = 0.7\,T_{pwb} + 0.3\,T_a \text{ for v >= 3 m s}^{-1} \qquad \text{Eq.1}$$

$$WBGT = 0.67\,T_{pwb} + 0.33\,T_a - 0.049\ \log_{10} v\,(T_a - T_{pwb}) \text{ for v > 0.3 m s}^{-1} \text{ \& < 3 m s-1}$$

where T_a is air temperature (°C) and T_{pwb} is the Psychometric Wet Bulb temperature which at wind speed higher than 3 m s^{-1} is equal to the Natural Wet Bulb temperature (Bernard and Pourmoghani 1999, Lemke and Kjellstrom 2012). The Wet Bulb temperature represents the cooling of the body via sweat evaporation. Similarly, at wind speeds above 3 m s^{-1}, T_a is considered equal to the Black Globe temperature (°C). The Black Globe temperature accounts for the effect of radiation on the body, mainly from the sun, which at night is absent. For lower wind speeds, a correction is added to account for the difference between the Natural Wet Bulb temperature (unventilated and unshaded) and Psychometric Wet Bulb temperature (shaded and ventilated). T_{wb} is calculated through iteration, from standard meteorological data, based on fundamental principles of heat and mass transfer (Liljegren et al. 2008).

Indoors, people often use electric fans to reduce heat stress. Many public health organisations discourage their use at extremely high temperatures, due to the risk of actually increasing stress by moving warm air towards the body or enhancing dehydration, especially when people are sleeping. Recently studies have suggested, however, that fan use might be beneficial across a larger temperature and humidity range (Morris et al. 2021, Morris et al. 2019). So in addition to the natural urban air flow (assuming houses can be well ventilated and indoor air flow resembles our urban adjusted wind speed), we tested for a minimum wind speed of 2 m s^{-1} resembling the average wind speed 1m away from a ceiling fan (Singh et al. Forthcoming), and for the absence of wind speed (i.e. a minimal wind speed under which equation 1 is still valid of 0.3 m s^{-1}).

There is not yet an accepted threshold to define night-time comfort under conditions of prolonged exposure to heat. To facilitate heat loss through the skin, which results in a necessary drop in core body temperature before falling asleep (Kräuchi et al. 1999), cool room temperatures in the lower 20ies are generally advised. In the tropics, people seem to have adapted to higher minimum temperature and WBGT levels, though this often relies on considerable effort to control indoor WBGT through evaporative cooling (water coolers or even simple wet cloths) or the use of fans, and the high adoption rate of Air Conditioning devices suggests that people without are merely enduring an uncomfortable situation, especially in the summer. While the WBGT is originally designed for the US military to assess safe levels of activity and duration (Yaglou and Minaed 1957), it has also been tested for cognitive performances, which – in terms of physical activity - could be considered the closest activity level to comfortable sleeping conditions. Performance decrements for sedentary cognitive tasks were observed at WBGT thresholds in the range between 30-33^{o}C (Hancock and Vasmatzidis 2003). These threshold levels, however, represent short-term tasks and exposure. It seems unlikely that people should be exposed to such conditions for hours on end during the night. In controlled studies where humidity and wind speed are kept constant, an ambient temperature threshold of 28 ^{o}C is a commonly reported lower bound of the high end spectrum, with 32^{o}C the upper bound (Candas et al. 1982, Lin and Deng 2008, Macpherson 1973, Tsuzuki et al. 2008). Here, since we focus on chronic, prolonged exposure we take a WBGT threshold value of 28 ^{o}C.

UHI

For calculating the UHI at night for urban areas we use the approach by Zhou et al. (2017). They show that surface UHI (the difference in surface temperature between the urban grid cells and the surrounding non-urban area, i.e. the temperature of soil, stones, rocks or vegetation as measured by satellite) is dependent on the size of the city and its shape; whether it is stretched or circular (the anisometry) and whether its edge is smooth or rigged (which can be estimated by the fractal dimension). The larger and more circular the higher the UHI. If a city outline is rigged, temperature build up gets interrupted which lowers the UHI.

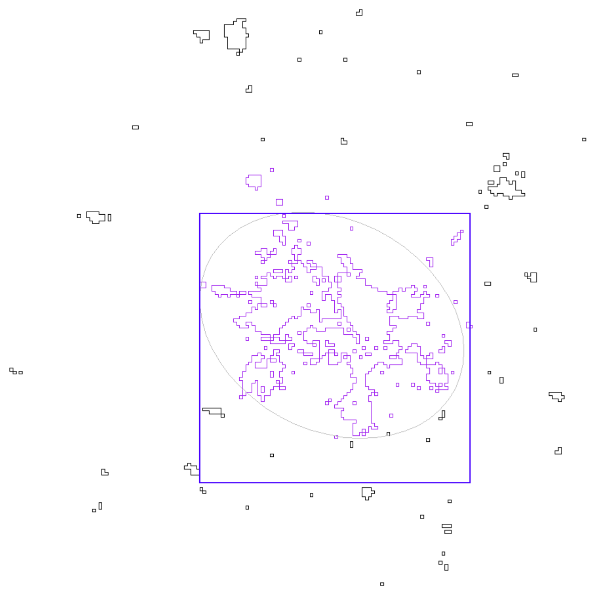

Figure 1 Size and shape of Delhi in 2010, with selected urban area (purple outline within the ellipse, on which the anisometry value is based) and the square box used for determining fractal dimension

Zhou et al. (2017) present a regression equation calibrated for both night-time and daytime, based on data of 5000 clusters across Europe, including the whole of Turkey. For night-time the best fit found is:

$$\Delta T = 0.33 + 0.17 lnS_c^* + 0.09 D_f^* + 0.01\ lnA^* + 0.01\ D_f^*\ lnS_c^* - 0.01\ D_f^*\ lnA^* \qquad \text{Eq. 2}$$

where night-time surface UHI intensity, ΔT, is a function of the logarithm of urban cluster size lnS_C, fractal dimension D_f, and the logarithm of anisometry, lnA, with Sc, Df and A all normalized against their mean values.

Surface temperature is merely a proxy of real UHI based on ambient (air) temperature. Especially during the day, with considerable air movement, UHI based on ambient temperature is much lower than the surface UHI would suggest. At night, especially a couple of hours after sunset, surface UHI and ambient UHI are expected to converge. We use the relationship by Huang et al. (2019), which indicates an almost linear relationship ($T_{ambient}$ is 1.06 $T_{surface}$) between summer surface temperature and ambient temperature at night for 1074 urban stations globally.

Results

Global urban heat stress

Future projections of exposure of urban populations to night-time heat show a dramatic increase in large cities in South- and South-East Asia (Figure 2). While in 2010 only one large city, Chennai in South India, recorded an exceedance during 20% of summer nights, by 2050 many major cities in the Indo-Gangetic plain and along the Indian Ocean coast and Bay of Bengal and megacities like Bangkok, Hanoi and Guangzhou enter this medium risk category. At high risk are Chennai, Delhi, Kolkata and Dhaka, with WBGT not dropping below 28 ^{o}C in over 40% of summer nights. At (low) risk are most cities along the Chinese coast and megacities in Japan, The Philippines and Indonesia. Beyond Asia, risk is increasing mainly in cities in West Africa, Dar Es Salaam in Tanzania and cities along the northeast coast of Brazil and the Caribbean. Khartoum, in Sudan, and Accra in Ghana are two cities at medium risk.

The increase in exposure roughly matches the projected expansion of extremely hot regions, expressed by a mean annual temperatures over 29 ^{o}C, by 2070 covering large parts of the tropics, as presented by Xu et al. (2020), though our map suggests additional risk along the east coast of China.

Humidity matters; a city like Hanoi does not often feature in projections of heat but in our sample, the combination of high humidity during summers leads to a high risk in future. Contrary to other studies focussing on daytime heat (Li et al. 2020) we do not find particularly high exposure in the United States' South and Mid-West or continental South America. Northern Australia does not feature in our map because of the absence of larger cities.

Cairo, one of the upcoming megacities, is not particularly at risk at night despite high temperatures during the day. The same accounts for several other desert cities (such as Las Vegas) that experience frequent heat waves but tend to cool down during the night. Higher elevation also plays an important role, as exemplified by the difference between Bangalore in South India (low risk) and nearby Mumbai or Chennai (high and extreme risk).

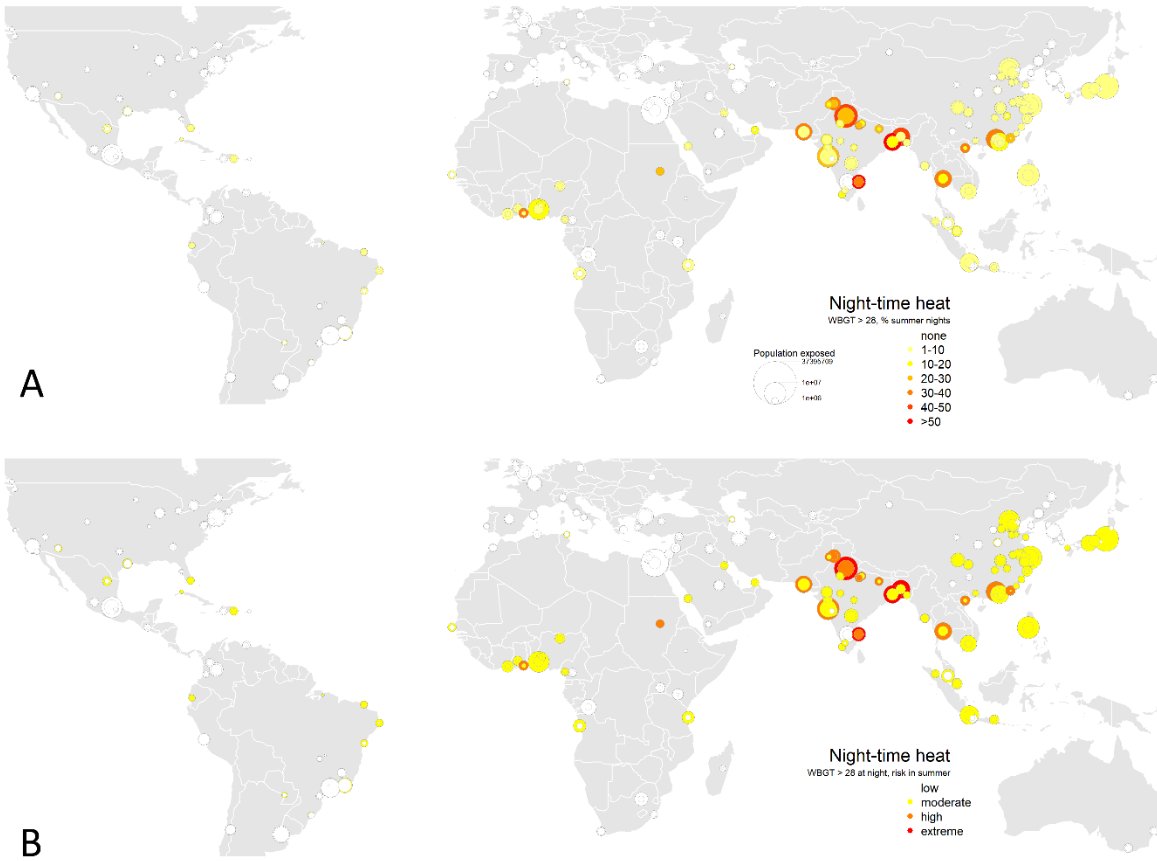

Figure 2A Exposure of urban populations to night-time heat (WBGT higher than 28 °C), at present (2010 – inner circle) and in 2050 (outer circle) for cities with a population of more than 2 million in 2010, in percentage of nights, and B in terms of Low (none)-Moderate (<20% of nights in summer), High (>=20% but <40%) and Extreme risk (>=40%)

The total number of people at risk, in the urban cores of cities with more than 1 million inhabitants in 2010 is given in Table 1.

Table 1 People at risk of extreme night-time heat (number of nights in summer months in which WBGT >=28 °C) in different global landscapes, for 2010 and 2050, in million people

	no risk	*moderate*	*high*	*extreme*
2010				
delta	6	116	-	-
river	140	87	30	-
dryland	107	46	-	-
coast	193	129	7	-
other	114	27	-	-
2050				

delta	6	125	25	33
river	207	112	32	32
dryland	137	76	14	-
coast	160	233	67	10
other	141	62	3	-

We did not find a significant difference in WBGT between the urban wind speed and a minimum wind speed of 2 m s^{-1} resembling the use of a ceiling fan. This was to be expected. With a mean night-time urban wind speed of 1.5 m s^{-1} across all cities, the difference in wind speed between the two was generally small. The effect of a change in wind speed beyond 1 m s^{-1} on WBGT was found to be fairly minimal under night time conditions, in absence of radiation (Lemke and Kjellstrom 2012), which is also reflected in the modest impact the wind speed correction component has in Equation 1 under normal conditions. This seems to contradict recent findings on the effectiveness of fans, and the common sense of many people using fans across the tropics. However, the absence of air flow (v = 0.3 m s^{-1}) did increase the risk of WBGT exceedance by up to 10% and suggests this to be a more likely baseline representation of indoor wind speed conditions against which to compare the effectiveness of fans (as was done in the modelling studies by Morris et al. (2021), which also used a higher fan speed of 3.5 m s^{-1}).

Changes in night-time heat stress in the megacity of Delhi

Drivers of future WBGT exceedance

Delhi is one of the largest megacities with the highest exposure to heat. The exceedance of WBGT28 at night is expected to almost double between 2010 and 2050, with over 40% of summer nights classified as extremely hot in 2050 according to the ensemble of four climate models (Table 2). The population within the urban core exposed to this extreme heat is projected to increase by 50% to over 27 million people, which is a conservative estimate given projections of a total population of over 43 million in the metropolitan area of Delhi by 2035 (United Nations (2019). Extrapolating these projections from the UN population to 2050, fitting a second order polynomial through the 2000-2035 period, would give a total population of over 50 million. While the Delhi population rises strongly, the urban extent is only expanding moderately, according to the urban projections, though open spaces are filling up (Figure 3), increasing the heat island effect both during the day and the night. The main driver behind the increase in heat exposure is the increase in temperatures due to climate change.

Table 2 Indicators of change between 2010 and 2050 for Delhi and exceedance of WBGT28 according to four climate models (based on ISIMIP 2b)

indicator	*2010*	*2050*
Population in urban core	19.317.658	27.492.764
Area (km^2)	1153	1525
Night ΔT_{air}	0.73	0.88
Day ΔT_{air}	1.23	1.46
WBGT 28 exceedance (projection)		
in % summer nights (three hottest months)		
GFDL model	30	47
HADGEM model	19	53
IPSL model	32	50
MIROC model	10	19
Mean	23	42

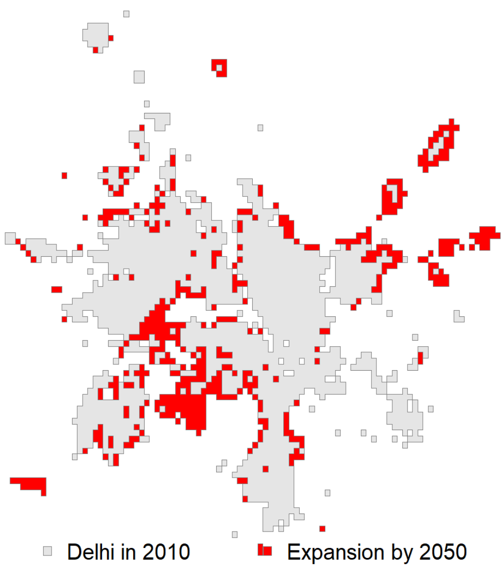

Figure 3 Expansion of urban areas of Delhi between 2010 and 2050 (source: 2UP). One grid cell represents 1 km²

Variation in UHI

Evaluating UHI after midnight (1:30PM) and as an average for the total urban area might hide important intra-urban and temporal differences. While our approach finds mean UHI effects of about 1 °C at night, Jacobs et al. (2019) found UHI intensities of up to 8 °C for individual neighbourhoods along transects through inner city of Delhi (Table 2). Measurements along this transect, with sensors attached on top of a car, where taken in the early evening when differences in UHI are expected to be most pronounced as rural surroundings, green spaces and open areas are cooling down quickly while the buildings and roads in the urban core release their heat more slowly.

UHI thus raises the minimum night time temperature level, and delays the moment of relief over the course of the night. The presented global heat exposure (Figure 1) thereby represents the lower bound of actual experienced heat, with conditions even more severe during the evening and onset of the night, at times when people try to get to sleep.

Table 2 *UHI intensities [K] during periods of transect measurements. Reference temperature used here was obtained from weather stations run by national meteorological services ("WMO stations"). "Mean UHI" refers to temperature differences averaged over the analysed parts of all transects. "Max UHI" refers to temperature differences between the WMO station and the warmest part of a transect. Average, max and min denote the seasonal averages, maxima, and minima, respectively (source: Jacobs et al. (2019)).*

	Day (n = 17)	*Night (n=13)*
Average mean UHI	1.0	3.4
Max mean UHI	3.2	5.7
Min mean UHI	-1.3	1.5
Average max UHI	2.5	4.9
Max max UHI	5.0	8.0
Min max UHI	0.1	2.8

Indoor heat exposure

UHI is just one aspect affecting heat exposure of the urban poor. In urban areas, at night, people spend most time indoors where temperatures remain higher as houses tend to cool down slower than the outdoor surroundings. Indoor temperatures, thus, differ from outdoor temperatures because of building characteristics, exposure of buildings (shaded or not) and behaviour (cooled artificially, e.g. through fans, evaporative coolers or AC, or through enhancing natural ventilation).

We used the data from extensive indoor measurements conducted in Delhi, Dhaka and Faisalabad during the summer of 2016, using temperature loggers (HOBO UX100-001, Onset, USA) and temperature-humidity loggers (HOBO UX100-011, Onset, USA), respectively. For a detailed description of these measurements we refer to Singh et al. (Forthcoming). Here, we briefly investigate the relationship between indoor temperatures from the loggers and outdoor temperatures measured at the WMO station in Delhi, for naturally ventilated houses in our sample with uninsulated tin roofs, tin walls or both, or simple stone slab roofs – the type of houses in which the low-income to lower middle income classes in Delhi live.

The indoor conditions of such houses, which are common to most informal neighbourhoods but are also found in more upmarket neighbourhoods, e.g. housing domestic servants and security personnel, are on average about 4 °C warmer than outdoor temperatures as measured at the WMO station during the coolest moment of the night (i.e. at *Tmin,* Figure 4A). Of this difference, about ~1 °C is explained by the UHI (see AWS WMO difference plot – Figure 4B, and in line with our UHI correction). This illustrates that, while important, the UHI effect is only one driver of increased night-time heat exposure for the urban poor. Cramped, badly ventilated and insulated housing, with no outdoor escape and lack of artificial cooling, has an even stronger impact on heat stress.

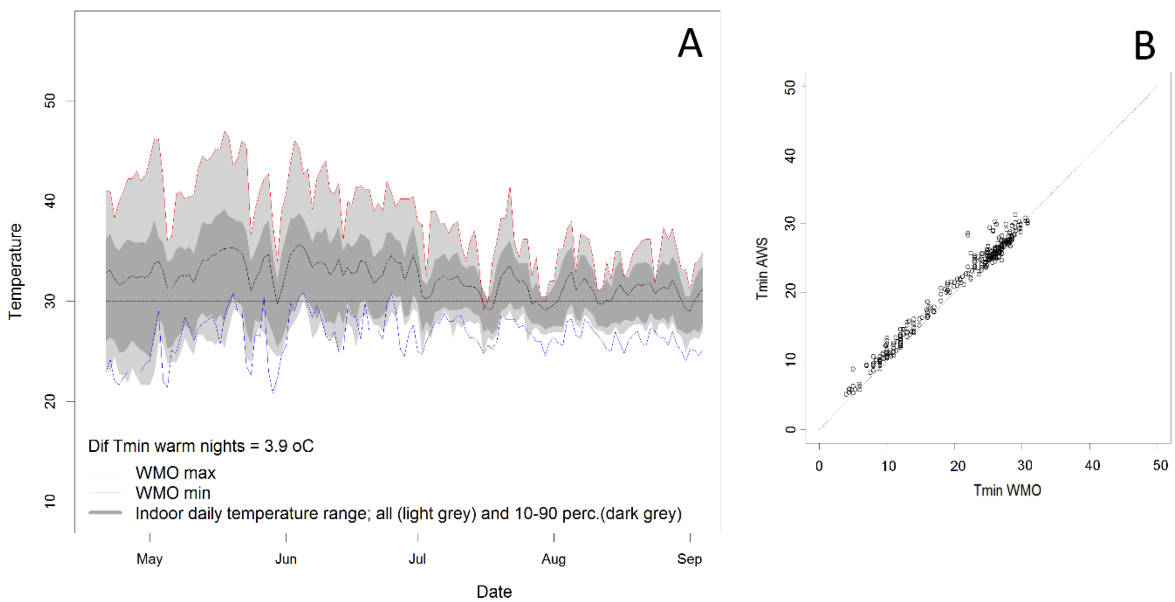

Figure 4A Differences between night-time temperatures in Delhi measured at the official WMO station (IGA international airport) and the indoor temperatures as measured by indoor temperature loggers during the summer months of 2016, and; B the difference between the WMO station observed minimum temperatures and those at an urban automatic weather station (AWS) in Delhi, located near the Teri University campus.

Future indoor temperatures

While being warmer at night on average, indoor conditions of such (uninsulated) houses are expected to show strong, consistent relationships between indoor and outdoor temperature conditions. Examples for specific neighbourhoods and house types (with tin roofs and with 'other', mostly tile or simple cement, roofs) are given in Figure 5. Linear relationships were found between night-time minimum indoor and outdoor temperature. Not only does this indicate that indoor minimum temperatures are higher than those measured outdoors at WMO stations, it also gives an indication of the response of indoor temperatures to projected increases in temperatures in the future. Corresponding slopes for neighbourhoods in Delhi are given in Table 3. For each degree increase in WMO temperature, night-time indoor temperatures increase by approximately 0.5 °C. Inversely, when WMO temperatures drop by 1 °C, indoor temperatures only follow by 0.5 °C reflecting the observation that indoors it stays warmer for a longer time.

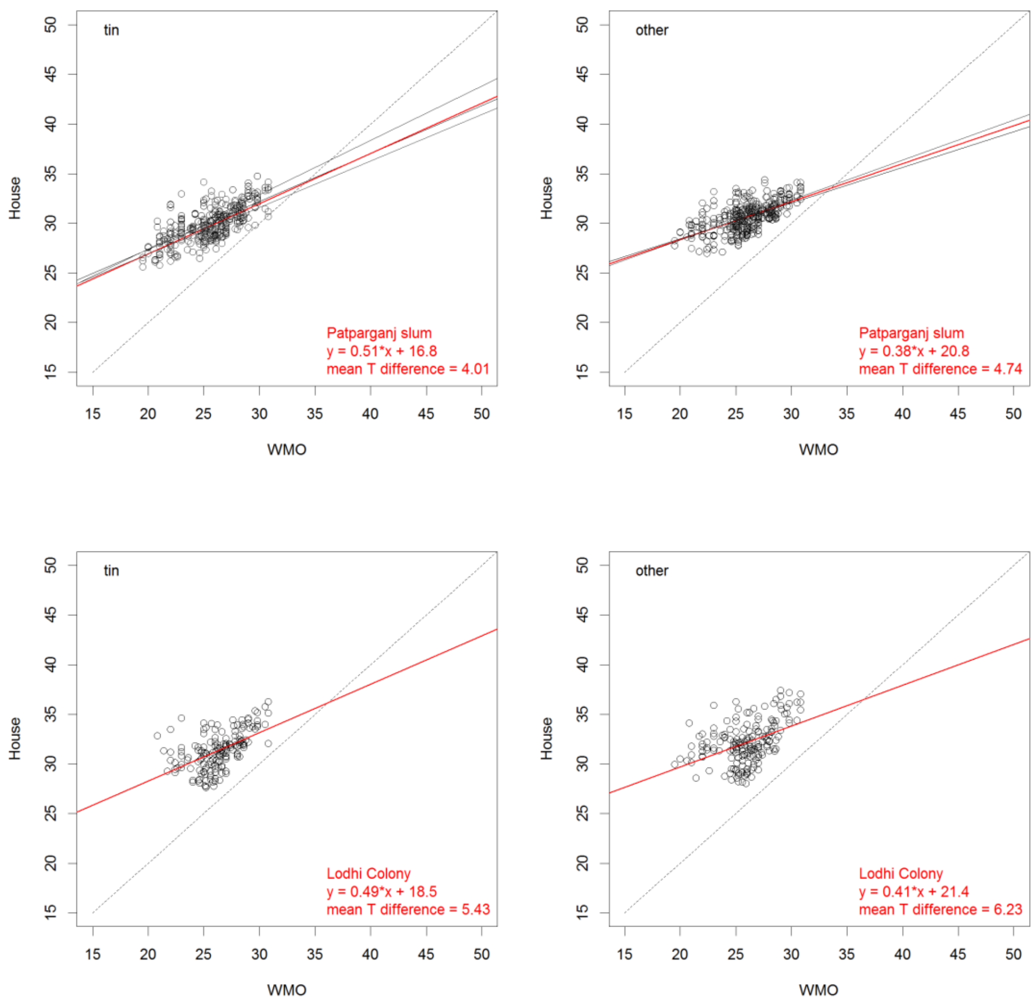

Figure 5. Example of the observed relationship between indoor (cluster of houses) and outdoor (WMO) temperature of houses with a tin roof (left) and brick or other material based roof (right) in Delhi, for minimum temperatures.

Details on the measurements can be found in Singh et al. (2019). Combined slopes, also for houses in other neighbourhoods are given in Table 3.

***Table 3** Slope of the relationship between indoor and outdoor minimum temperature (T_{min}) in Delhi, for all houses with a tin, brick or other single-layer exposed roof and without electrical air conditioner or air cooler*

Neighbourhood	*Slope T_{min}*		
	Tin	*Other*	*All*
Patparganj slum	*0.51*	*0.38*	*0.45*
Lodhi Colony	*0.49*	*0.41*	*0.40*
Sarai Kale Khan	*0.47*	*0.39*	*0.46*
Laxmi Nagar	*0.64*	*0.48*	*0.57*
Average	*0.54*	*0.43*	*0.49*

Discussion and conclusions

Our analysis shows significant increases in night-time heat risk, especially in South Asia and to a lesser extent across South-East Asia, in eastern China and the coast of West Africa. In our analysis we only included cities above 1 million inhabitants (and in the maps only those with more than 2 million inhabitants) so this is by definition an underestimation of the population exposed, even if the UHI effect can be expected to be somewhat less intense in smaller urban areas.

Historically, the expansion of urban areas and resultant UHI has had a stronger effect on night time heat risk than the change in temperature due to climate change. The projected increase in heat risk, however, is mainly driven by climate change, with the additional UHI effect due to further urban expansion being relatively modest. This, in part, rests on assumptions made in the development of the land use dataset, whereby densification of existing urban areas slows further horizontal expansion. As a consequence, the UHI effect will be much higher in certain densely built parts of the cities compared to the overall mean (see also Jacobs et al. 2019), an aspect we have ignored in our analysis. Irrespective of the precise change in heat risk in future, the number of people exposed to such risks will increase greatly due to the growth of the urban population in regions of high risk.

We relied on the relationship between urban size, form and UHI effect by Zhou et al. (2017) which was derived from the characteristics of a large number of cities, sampled from a more confined geographical area than in this study. The resolution of the land use map from which city clusters outlines are derived by Zhou et al. (2017) differs from ours (250m by 250m in CORINE versus 1km by 1km, 2UP, used in this study) and the way urban land use is classified in these datasets might also lead to differences in shape parameter values for the same city clusters. We expect, however, any bias to be smaller for larger cities such as those analysed in this study, though this should be confirmed by a comparative study of the outcomes for cities overlapping in both datasets.

The urban heat island effect covers only one aspect of increased urban exposure to heat in urban areas. The effect of enclosed, often poorly ventilated housing means indoor temperatures remain higher indoors at night (in contrast to daytime conditions when shading means temperatures and WBGT values are generally lower indoors), which is beneficial during colder seasons but detrimental during the warm summer.

Innovative solutions show potential to reduce the risks of heat stress for the most vulnerable groups. Still, only individual solutions to cool indoors might not be sufficient. Better spatial planning is needed to prevent the streets and outdoor spaces in South Asia's expanding cities from heating up.

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Annex 3: WOTR Down to Earth blog: COVID-19: How heat stress affected livelihood, health of Maharashtra's rural communities

DownToEarth

CLIMATE CHANGE

COVID-19: How heat stress affected livelihood, health of Maharashtra's rural communities

The COVID-19 situation may improve with increased vaccinations, but temperatures will continue to rise for the foreseeable future, putting outdoor workers at risk of heat stress

By Dipak Zade, Premsagar Tasgaonkar, Christian Siderius

Published: Monday 24 May 2021

The novel coronavirus disease (COVID-19) has upended lives across the world, but has not been the only catastrophe to do so. Over 50 million people have been hit by both COVID-19 and climate-related disasters such as floods, droughts, storms and extreme temperatures in 2020 alone.

In May 2021, Cyclone Tauktae hit Maharashtra and Gujarat — just as these states were dealing with most severe COVID-19 wave in India.

Out of 128 countries, India has been the most affected by climate- and weather-related disasters in recent years. Climate change is gathering strength; the average temperature rose by around 0.7 degrees Celsius during 1901-2018. It is anticipated to increase further by more than 4°C in the absence of significant mitigation efforts by the end of the 21st century.

Exposure to excessive heat creates occupational health impacts for workers, both outdoor and indoor, affecting their performance and efficiency.

India is projected to lose 5.8 per cent of working hours in 2030 and the equivalent of 34 million full-time jobs due to heat stress in South Asia, according to an International Labour Organization report. The agricultural sector will be impacted the most.

The Watershed Organisation Trust (WOTR), Pune, a non-profit engaged in community development, conducted a rapid assessment after the summer of 2020 in rural areas of Jalna district (Ambad and Jafrabad blocks) in central Maharashtra. This was to understand people’s perceptions and experiences of COVID-19 lockdown, their exposure to heat and its impact on health.

At least 24 telephonic interviews were conducted with people aged between 25 and 45 years, all engaged in farming and related livelihood activities.

Impact of COVID-19 on livelihoods: In general, the initial COVID-19 lockdown period was characterised by stress, fear and anxiety for the village communities. The restrictions resulted in the freezing of most economic activities in nearby cities and towns.

Out of fear and anxiety, many villages shut their boundaries and imposed restriction on movement in and out of the villages, except for essential reasons (such as medical care, banking needs, etc).

Agriculture is the primary livelihood activity in these villages with few households engaged in non-farm activities, such as construction and sugarcane cutting labourers. Due to restrictions on movement, people were confined within their village. The selling of agricultural produce to the market outside the villages was also disrupted.

Outdoor heat exposure: For landless agriculture labourers, the lockdown was a difficult time as they had almost no work. Public works under Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) were initiated after regular follow up by WOTR. This enabled several poor and landless households to survive during the lockdown period.

Farmers and labourers started work earlier, both to avoid the heat at the peak of day and each other. While this altered work schedule enabled social distancing, it did reduce work duration.

Construction of roads and watershed works adhered to all standard COVID-19 safety precautions.

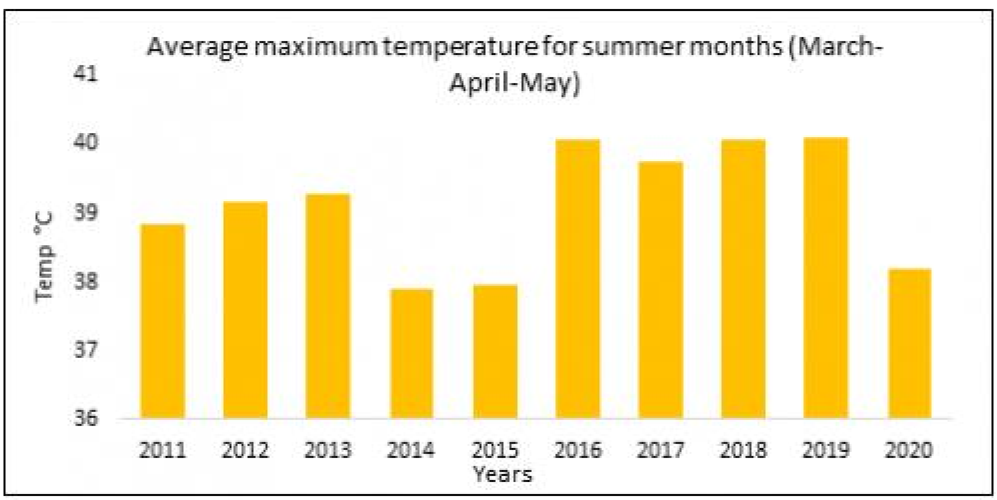
While working outside, men and women use *gamcha* (a big handkerchief) and scarf to cover the face and head to avoid direct heat exposure. These also acted as face masks for people.

Provision of common drinking water facility was avoided at the MGNREGS work sites and workers were encouraged to carry their own water. Everyone preferred having lunch and afternoon rest at home as against the usual practice of having these with co-workers at the work site.

Several households temporarily shifted their residence from village to a temporary hut built near farmland to ensure physical distancing. Restrictions on non-essential outdoor movements, such as going to markets and visiting family, resulted in reduced heat exposure and stress usually experienced while on the road.

Many migrants who had returned to their villages also reported experiencing heat stress. They had to follow a mandatory quarantine, during which they were lodged in village school buildings having tin roofs.

In the absence of fans and with many people confined together, conditions rapidly deteriorated. People reported spending as much time as possible with their children outside under the trees.



There were no electricity cuts during summer as all the industrial activities were shut. With outdoor exposure limited and having cooling facilities inside house, only mild HRS such as sweating, dry mouth, intense thirst and headache were reported.

No incidences of severe HRS (hallucinations, and fainting) occurred. Preparing food inside the house on *chullah* during summers leads to additional heat exposure for women. With considerable time spent cooking, women reported experiencing mild HRS like eye irritation, sweating, headache, intense thirst and fatigue. Most of these symptoms needed no treatment and got cured with time.

The summer of 2021 is still ongoing with heat conditions similar to 2020; rural areas have been spared the extreme heat waves of pre-COVID-19 years while lockdowns returned.

Rural areas in India will be battling the latest COVID-19 wave for some time but with increased vaccination, restrictions will be eased and life may return to near-normal soon. Temperatures, however, will continue to rise for the foreseeable future and outdoor workers and their families will be increasingly exposed to heat stress.

To reduce heat-related vulnerabilities of rural communities, people will need to continue to adjust behaviour, government departments such as the India Meteorological Department should help strengthen preparedness, and local health and line departments need to coordinate and implement appropriate policies to improve healthcare systems to better prevent and respond — all to build and strengthen adaptive capacities.

Managing Heat Stress during the COVID-19 Lockdown in 2020

Neha Bharti, Suruchi Bhadwal, Dhriti Pathak, Santosh Muriki and Christian Siderius

Due to increase in anthropogenic activities, global temperatures have shown a warming trend of 0.85°C during the period 1880–2012 (Qin et al., 2013). Annual surface air temperatures over India also have shown increasing trends of similar magnitude during the period 1901–2014. The Sixth Assessment Report (AR6) of The Intergovernmental Panel on Climate Change (IPCC) released in 2021 has predicted heat waves and heat stress to be more intense and frequent during the 21st century in South Asian region including India. In India, heat wave conditions are usually experienced between March and July, with acute heat waves occurring mostly between April and June.

Long term trend in seasonal heat wave events shows a significant increasing trend in the north-western and northern parts of India. The subdivisions of Uttar Pradesh observed an increase of 0.8 events/year and North Rajasthan with 0.8 events/year and South Rajasthan of 1.4 events/year. Similarly, an increasing trend in Punjab, Haryana, and Uttarakhand region and some regions of Eastern Uttar Pradesh has been noticed (Figure 1). The capital of India, Delhi also shows an increase of 0.80 heat wave events/year.

Time series of frequency of heat waves and their duration over Delhi (IMD's Safdarjung station) are shown in Fig. 2(A) & (B). The frequency of heatwaves over Delhi has shown an increase of 0.30 per decade in the recent 30 years period (1991-2020). The number of heat wave spells over Delhi appearing to be more frequent as compared to past years. The recent 30 years' time series are showing statistically significant (at the 90% confidence level) increasing trends. The long term data (1969-2020) shows heat wave events a slight increasing trend, however, the trends are not statistically significant. Similar patterns can be seen in heatwave days (refer Fig 3). Figure 2(B) shows the duration also has a slight upward trend. Further, the heat wave analysis carried for the COVID-19 pandemic year 2020 shows one heat wave (24-28

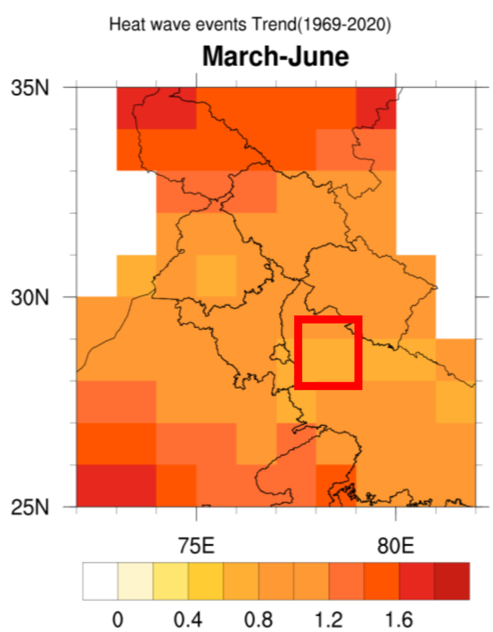
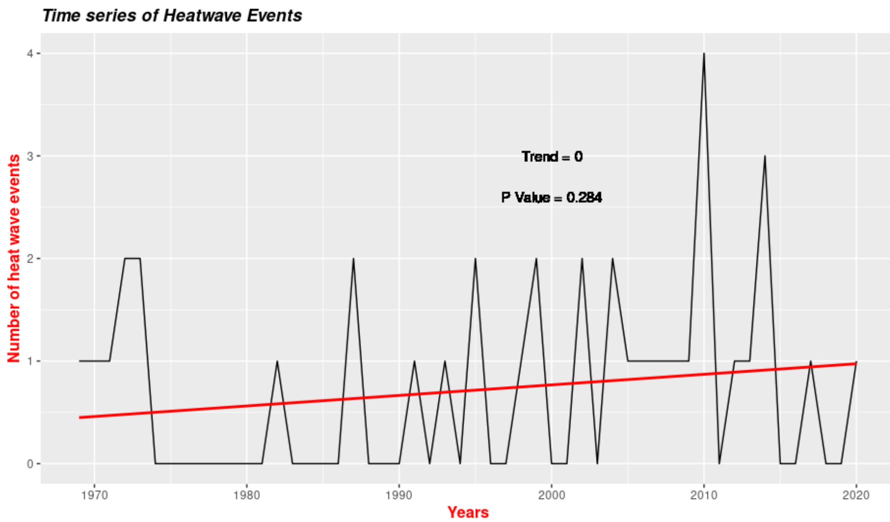
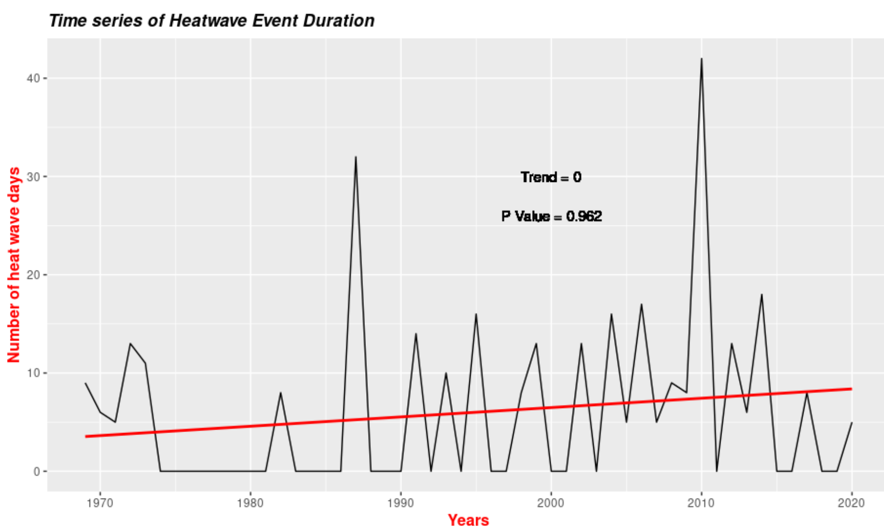


Figure 1 Long term trend in seasonal heat wave events during 1969–2020 (March–June)
Data Source: IMD gridded data

May) formed over Delhi during the summer season.



(A)



(B)

Figure 2 (A) Time series of heatwave events during 1969–2020 (March–July) and (B) Heat Wave duration during 1969-2020 (March- July)

While mortality rates due to heat waves or heat stress usually are a metric for the severity of the situation, but there are less obvious but equally important metrics such as long term health effects, lower productivity and increased (financial) costs associated with coping with heat. A major category of population affected by heat stress was identified as low income groups (Harlan et al., 2006). This is largely the case in developing countries where the number of people from low income categories is much higher. With reference to coping during heat waves, having access to cooling devices and the financial means to use them is an important aspect for enhancing the adaptive capacity of the population.

During the COVID-19 pandemic people across the country were confined to their homes with schools and office buildings closed. This has shifted the need to cope with heat during the day from the workplace to the home. Their usage of electrical cooling appliances such as air conditioning and coolers (a more basic device, with a fan blowing air over a layer of water to cool it) must is likely to have been more increased compared to previous years as jobs, schools, etc., operated on a work/study from home basis.

India experiences the eighth warmest year in 2020 since 1901, however, during the summer season the temperature was below normal (-0.03°C) and was relatively mild - examined and compiled in a report titled 'Climate of India during 2020' by the Climate Research and Services (CRS) of the India Meteorological Department (IMD)[12]. Similarly, in Delhi an unprecedented combined impact of COVID-19 lockdown and extreme heat waves has fortunately been avoided in the peak of summer of 2020 (on May 19-20) interrupted by the gusty winds and intense showers bringing the temperatures down in the capital. Still, especially people in densely built, low-income neighbourhoods, with no open green spaces, remain unsheltered from heat even at night. Increased use of electricity comes at a cost, at a time many families are cash strapped due to loss of income.

To understand the severity of the heat waves and the impact it had on the different socio-economic groups in society we conducted a small survey among the employees of The Energy Resources Institute (TERI), in Delhi, India having different socio-economic background. We asked people if the lockdown of summer months of 2020 (March to June) impacted household energy consumption and expenses compared to the last summer. We also enquired on access to different cooling devices, income range, and number of work from home days during the lockdown and housing conditions.

As economic conditions of households vary, the ability to afford or run an air conditioning (AC) device, we asked respondents with different income levels about the usage of coolers versus that of ACs with respect to income brackets. The data analysed (Figure 3) for the survey shows that once people cross the lowest income threshold, they tend to shift to the use of AC or shift to more expensive devices for cooling. The use of more simple air coolers, relatively cheaper as compared to ACs decreases with income levels (Figure 3). Families of higher income brackets tend to have higher usage patterns of cooling devices as opposed to people from lower income brackets.

[12] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1686173

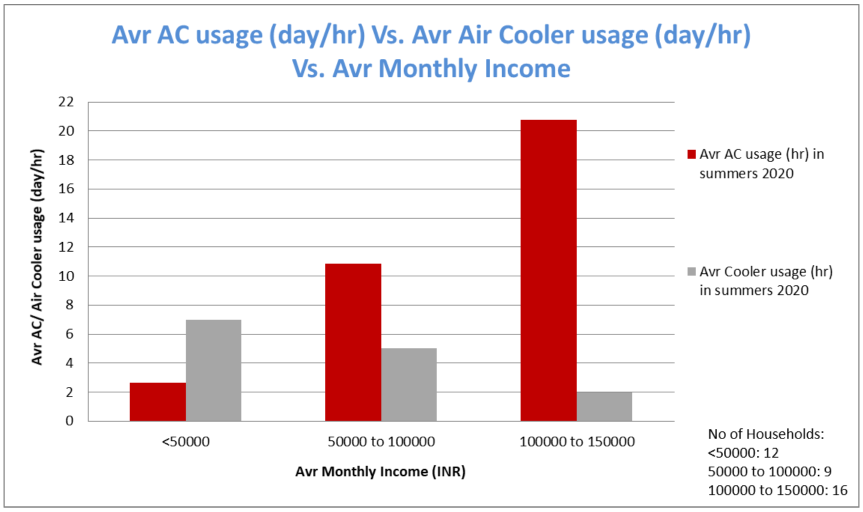


Figure 3 Avg AC usage (hours/day in the summer of 2020) vs Avg air cooler usage (hours/day) vs Avg monthly income

As average income levels rise, the average electricity consumption of the household also increases (Figure 4), establishing a direct relationship between income levels and electricity consumption. It is also seen from the figure that the number of cooling devices in a household also increases with rise in average income levels.

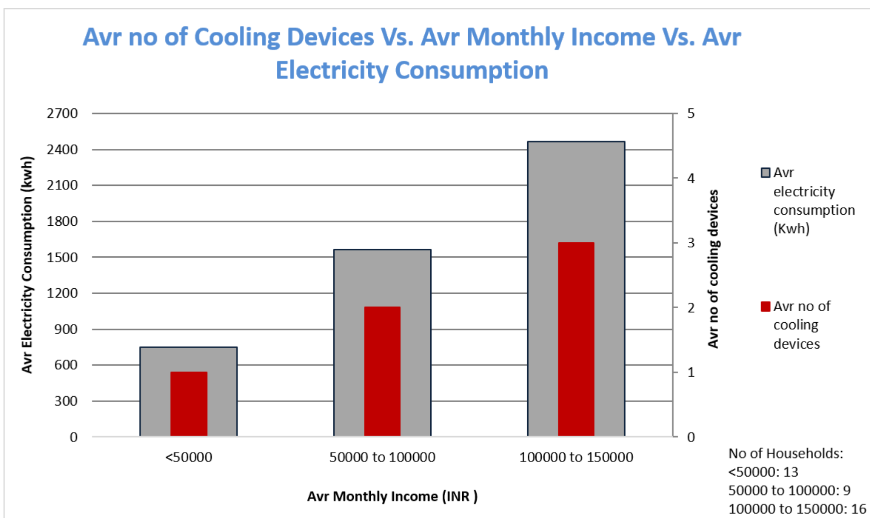


Figure 4 No of Cooling devices vs Average monthly income vs Average electricity consumption

The increase in the number of cooling devices of a household also implies an increase in the consumption of electricity.

A comparative analysis of the summer of 2020 versus that of 2019 shows around 80% of respondents reporting a higher consumption of electricity in 2020. This could be largely related people spending more time at home due to the 'work from home' policy. The respondents also stated to have increased electricity expenditure of the total household expenditure as compared to the previous year which indicates household adaption to increasing summer temperatures.

This analysis has been carried out with a small group of colleagues of TERI and gives suggestive patterns of electricity consumption during the first lockdown. Similar analysis conducted by other agencies indicates how overall energy demand was reduced during the complete lockdown phase during the COVID because of the reduction in demand in commercial and industrial activities. However, the residential electricity consumption, was expected to have increased during the lockdown as people spent more time at home. To sum up, the overall impact on demands is not clear given the official sector-wise data on electricity consumption is still not publicly available. There are varied outputs from different pieces of research that have focussed on the topic. A study conducted by the CSE says household consumption was not affected during the lockdown in Delhi [13]; another study by Prayas (Energy Group) in Uttar Pradesh and Maharashtra found daily average electricity consumption higher in the lockdown period as compared to the pre-lockdown period in the sampled households[14]. However one needs to check what parameters of assessment were considered in these studies and what was the overall focus and goal with which the information was collected.

Access to cooling can be an effective means of managing heat stress – but unfortunately, people with low income classes have dramatically lower access to cooling (as also can be seen from this present study). However, these low income classes are the ones who are more affected during peak summer temperatures and heat wave conditions because of the thermal discomfort in the poorly designed buildings with limited ventilation they reside.

Also, besides the poor, the upper and lower middle class are also stretched to their financial limits given the need for better healthcare services and adapting to heat stress conditions during peak summer times. A growing concern is that India houses a large proportion of its population in the middle income category and the consequences of the biophysical impact on the economics of households presents further challenges for the country as a whole.

A detailed study on understanding the implications of such extremes on the social strata across different settings is needed. The situation may vary from one city to the other given the changes in the tier of the city, overall governance and policy norms and the role of the distributors/ discoms. There is a need to understand the differential vulnerabilities that get created due to the varying underlying conditions for effective adaptation to be promoted.

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Annex 5: WOTR blog: Experiences from the field - Installing temperature data loggers

Experiences from the field - Installing temperature data loggers: Learning from pre-lockdown
By – Premsagar Tasgaonkar, WOTR

Increasing summer temperatures are likely to impact human health. In India, an increase in severe heatwave days per year has been observed over the past few decades. This is associated with a steady increase in heat related mortality over the decades. India's future climate projections indicate that heat waves will likely be more intense, have longer durations, and occur more often and earlier in the year. At present, to understand the impact of heat stress, most studies have been concentrated in urban areas and few occupational settings. However, there is little evidence of the heat stress experience, impact of heat exposure, and adaptation measures to heat and heatwaves in the rural context. Meteorological data are generally collected outside in non-built-up areas, and indoor heat stress factors are seldomly measured in a systematic way, while these are what people experience in practice.

With the aim to monitor indoor temperature and humidity, the WOTR-Center for Resilience Studies (W-CReS) installed 40 temperature and humidity data loggers inside people’s homes in Jalna. These data loggers are portable measurement instruments used for recording temperature over a defined period. Our key objective was to measure indoor temperature in houses with different types of roofing structures (cement concrete, tin, thatched) in the rural settings of the Jalna district in Maharashtra. The study village was selected based on a combination of social, bio- physical and GIS based indicators. The social indicators included the total number of households working and non-working population, presence of a Primary Health Centre (PHC), and sub-centre. The biophysical indicators consisted of total geographical area, forest area under non-agricultural uses etc.. Average Land Surface Temperature (from 2016 to 2020), average Normalised Difference Vegetation Index (NDVI) (from 2016 to 2020), and average water spread area (in acre) from 2016 to 2020 were also considered. Based on these indicators, we selected the Kouchalwadi village, located in the Ambad block of the district.

Photo 1: Temperature cum humidity data logger

The data loggers were ordered in January 2021, but factory production was stalled, and foreign travel was prohibited due to the COVID-19 pandemic. Initially, we had planned to collect the consignment physically from the manufacture warehouse but internal travel within Pune (where our office is located) was subject to many restrictions at the time. Therefore we had to rely on courier services to deliver it to our office address. Our office was also closed owing to the local administration's lockdown and most of us were working from home (WFH). As a result, we received the data loggers only in mid-April.

On the 20th of April, we decided to travel to the village to install the data loggers and prepare authorisation letters from the appropriate authority. Adequate precautions were taken that included having face masks, sanitisers, medicines and drinking water. We also had to carry extra data logger batteries from Pune as purchasing them in rural locations is a challenge. At 7:00 am, we, along with our field staff started for the Kouchalwadi village. At 8:00 am, we reached the village and met with the village stakeholders (*Sarpanch*, Vice-*sarpanch*, *Anganwadi* workers and with WOTR's *Wasundara Sevak*) briefed them about the study objective and the indoor temperature measurement tool.

Originally, we had planned to have a formal meeting together with all these stakeholders, to explain them the purpose of installing the data loggers and our study objectives. A group discussion with farmers and agriculture labourers was also planned to understand their outdoor heat exposure during the summer months. However, with the restrictions and also to ensure safety of all, we avoided these group interactions and individually visited each household where the data loggers were installed.

Photo 2: Data backup from the loggers

Another challenge was that in most of the village, people feared interaction with outsiders, especially from cities like Pune (as Pune had highest number of COVID patients in the State during that time). Hence, we carried our vaccine certificate while installing the data loggers inside the house. In a few cases, we were not allowed to enter the houses due to fear. Some of these houses had individuals who were more susceptible such as children, elders or pregnant woman and they wanted to have a safe distance from us. We respected their decision in such instances.

We wanted to complete the work as soon as possible as there was an anticipation that the state government would announce inter-district travel restrictions soon. However, the fieldwork was taking time as explaining the study objective to each of the selected households was crucial.

As anticipated, the state government announced a fresh lockdown with immediate effect from midnight. With the help of field investigators and village stakeholders, we managed to install only eight data loggers and decided to return back to Pune, lest we would have been stuck there for a few more days. We started the return journey for Pune at 5 pm (April 21st 2021). During this journey, we crossed three districts (Jalna, Ahmednagar and Pune). At each district entry point, the administration had started barricading roads. As Front Line Worker (FLW) with all the essential required documents (vaccine certificate, travel permission, etc), we were able to return to Pune late at night. Even though we managed to return back to Pune safely, it was essential to complete the pending task of installing the remaining data loggers. So, a demo video was prepared on how to install data loggers, change the batteries, fix an interval in the data loggers, etc. Instructions were also provided regarding the selection of an appropriate place, direction and suitable height for data logger installation. The video was shared with our local field staff. With some initial hiccups, the field team managed to install all the remaining data loggers.

After the training, the field personnel now sends us a regular data backup, which is critical for understanding the rural people' indoor heat exposure and vulnerabilities.

In hindsight, we are happy and proud that we achieved these results. We had considered on one hand the expenses for the equipment and the limited window for collecting data in the summer period of 2021, as was agreed in a contract, and on the other hand the risks of getting ill, making others ill, or ending up far from home under travel restrictions. Then we took a calculated risk and kept on improvising to finally acquire the precious data that we needed. Of course this was also made possible by the cooperation of the local staff and the households that admitted us in their homes. We thought it would be interesting to share this account of research in practice, to show it is not always easy but that with persistence and a little help from friends a researcher can achieve his or her goals.

Annex 6: A rural heat stress warning and advisory service – summary

This is a summary of a 40 page report on the tested heat advisory service to a rural population. The report will be delivered separately.

Christian Siderius, Dipak Zade, Premsagar Tasgaonkar and Komal Modhave

With rising temperatures, heat waves have become a worldwide concern. Developing countries are particularly vulnerable, due to their location in the low latitudes and changing landscapes with rapid urbanization. Major heat wave events in Pakistan and India in recent years have highlighted the disastrous impact of heat stress even in regions where high temperatures are a regular feature of climate. In rural areas, heat exposure is believed to be compounded by what is popularly perceived as a 'drying' of the landscape outside of the major irrigated areas. Those working in the fields have limited options to shield themselves from the sun.

Generally, little has been done to develop specific warnings for particularly vulnerable groups, such as the elderly, obese or very young, or people with specific occupations putting them more at risk. Although information brochures and messages mention that these individuals are more susceptible to heat problems, systems are often designed for the population at large.

India's first Heat Action Plan (HAP) specifically tailored for a city was prepared by Ahmedabad in 2013. The plan includes early-warning systems, color-coded temperature alerts, community outreach programs, and staggered or reduced timings for schools and factories . A review of this plan and other literature highlighted three key issues- i) most of these efforts and plans are targeted towards urban populations and are city centric, with relatively less focus on rural areas, ii) the advisories are disseminated at a community level with certain advisories being occupation focused and iii) the weather parameters used for setting thresholds and providing forecast are based on IMD's meteorological stations, which cover relative larger geographic area thus missing locale- specific conditions.

The heat health advisory system piloted under our study has attempted to address the above three issues. It is rural and livelihood specific and relies on weather parameters obtained from local AWS[15] installed in the project villages. Further, rather than being aimed at community level, they were disseminated through mobile text messages to individual farmers.

We started sending the advisories from summer month of May up to monsoon month of October. A total of 297312 messages were sent out of which 297030 messages were delivered to the farmers.

A rapid feedback survey was on heat-health advisories was conducted in September 2021. The results of the feedback survey are presented in Annex 7.

[15] AWS: Automatic Weather Stations

Annex 7: Results from the rapid feedback survey on heat and health advisories

A rapid feedback survey on heat-health advisories was conducted in September 2021. The team had to visit the study village to check upon the installed data loggers and its overall functioning. During the same visit, we took the opportunity to also conduct the rapid assessment of the heat-health advisories. Due to COVID-19 restriction, the feedback survey was conducted in only 60 households (the same households where we had conducted the baseline survey). Majority of the households (80%) reported receiving these advisories from WOTR. About 20 per cent of households said that they had not received the advisory (Figure 1). The key reasons for not receiving the advisories was change in mobile number, weak network coverage etc.

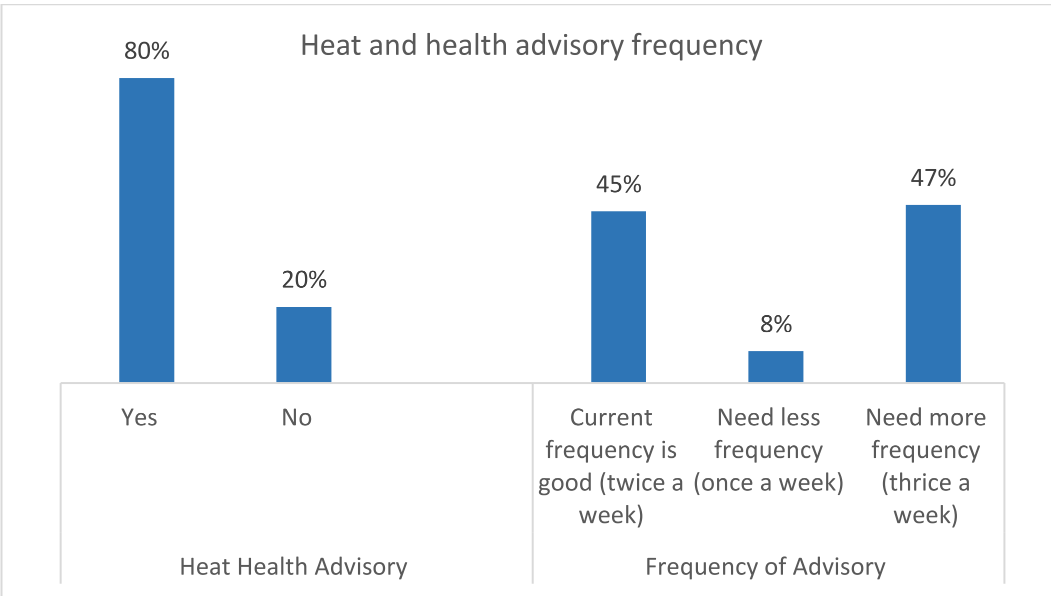

Figure 5: heat & health advisory and frequency

When enquired about the frequency of receiving the advisories, nearly 47 per cent of households reported a need for higher frequency (thrice a week), especially during peak heat month. About 45 percent of households was satisfied with the current frequency of twice a week (Figure 1). Around 83 percent of households reported that the heat and health advisory warning matches with their experience of actual weather conditions.

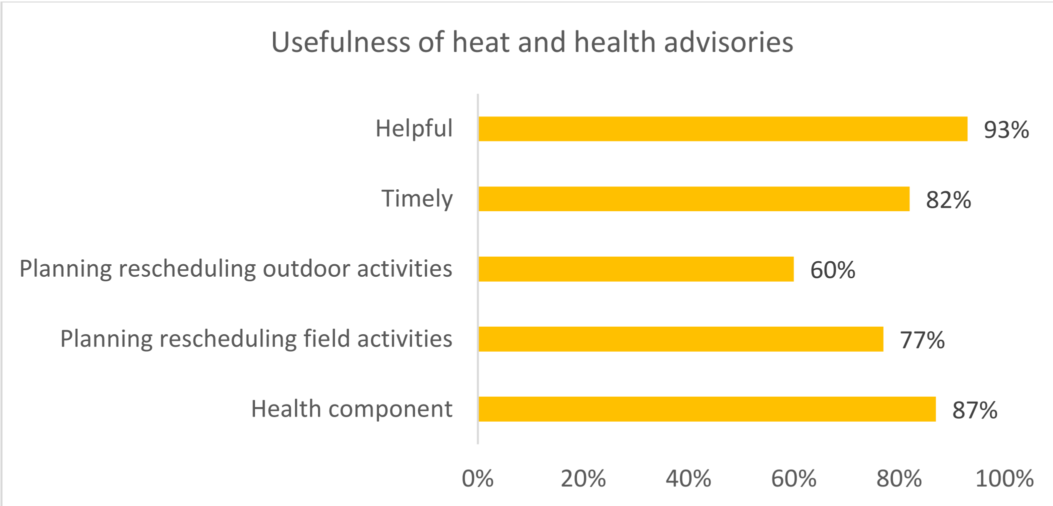

Figure 6: usefulness of heat and health advisories

The respondents were also enquired about the usefulness of these advisories. Figure 2 indicates that 93% of households reported that the advisories were useful, while 82 per cent of households reported that the advisories were timely. Regarding the usefulness of the advisories, 60 per cent of households said that these advisories helped them in rescheduling the outdoor activities, 77 per cent reported that it helped in rescheduling the field activities and 87 per cent of households reported that it was useful from the health perspective. Most men in the age group of 22 to 50 years, which is the main working population, reported that it was helpful in planning their work schedule and taking adequate precaution.

Many households (40%) felt that the heat conditions during the summer 2021 was normal, 38 per cent felt it was extreme, while for 22 percent households, there was a usual summer in 2021.

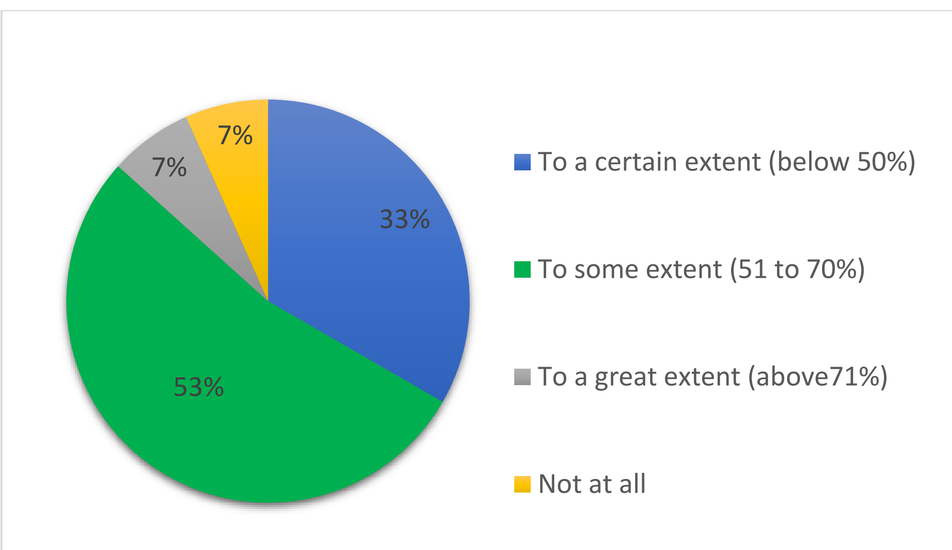

Figure 3: Overall usefulness of heat and health advisory

When asked to rate the overall usefulness of the heat and health advisories, 53 percent households felt that they were useful to some extent while seven percent felt that they were useful to a great extent (Figure 3).

Annex 8: Baseline questionnaire rural areas

Confidential (for research purpose only)

Reducing Health Risks of Rising Temperatures In South Asia

Household Questionnaire

(To be administered to the head of the household in the présence of other responsible adult male and female members.

IDENTIFICATION PARTICULARS

Before Starting Interview

Name of District ____

Name of Taluka ____

Name of the village: ____

Serial number of Household: ____

Name of Household Head: ____

Address: ____

Time of starting Interview (HH.MM): _____ . _____ AM/PM

Time of ending interview (HH.MM): _____ . _____ AM/PM

Name of Respondents 1: ____

2: ____

Contact Number: ____

Date of Interview (DD/MM/YY): _____/_____/______

Name of Interviewer: __________________________________ Code: _____________

Name of Supervisor: ___________________________________Code: _____________

INFORMED CONSENT

Namaskar! My name is _________ and I am working with Watershed Organisation Trust (WOTR). Since 1993, WOTR has been working for rural development though watershed development program. So far WOTR has supported and carried out developmental work in over 3500 villages across 7 states of India.

Extreme heat is an important public health issue in India and it is expected to worsen over the coming years, impacting people in various ways. In this regard, WOTR has initiated a study to understand the impact of heat stress on the semi arid rural communities in Maharashtra. Presently, we are conducting a survey to collect and analyse data on heat related vulnerabilities, perceptions and knowledge. The information provided by you will be strictly used for research purpose only.

The survey will take about 20 minutes to complete. The information provided by you will be strictly kept confidential and will not be shared with others except the concerned project persons. Your names and other information provided will be kept anonymous and the finding will not relate with names of the informants.

Participation in the survey is voluntary and you may choose to withdraw at any time and you are free not to answer any specific question. There are no direct benefits of the study as an individual. However, collecting this data is important for us to understand the impacts of heat stress on health and vulnerabilities of rural community. This will help us plan relevant interventions and provide better information in the future. Without this data we will not be able to do so properly.

We would like to invite you for the survey and appreciate your participation. Do you have any questions regarding the survey?

(***Answer the questions and clear concerns of respondent, if any***)

Can we begin the interview now?

____

Name of Person Obtaining consent

____

Signature of Person Obtaining consent

____

Date

A: Demographic Information

Q.1 Respondent's name

Q.2 Age

Q.3 Gender

a) Male
b) Female

Q.4 Marital status

a) Unmarried
b) Married
c) Widow/Widower
d) Separated

Q.5 Education

a) Too young
b) Illiterate
c) Primary education
d) Secondary education
e) Higher secondary
f) Graduation
g) Post-graduation
h) Above post-graduation
i) Diploma
j) ITI
k) Other (specify)

Q.6 No. of HHs Members:

1) 0-6
2) 7- 18
3) 19- 60
4) 61 +

Q.7 Primary occupation of the family:

00. None,
01. Farming
02. Agriculture labour
03. Non-agriculture labour
04. Salaried
05. Artisan/craftsman/household industry
06. Contractor/broker
07. Petty business/trade
08. Livestock rearing

09. NREGA/MREGS work)
10. Other (specify).

B: Knowledge on Increasing Temperatures

Q.11 In the last five years, has the normal/everyday temperature during summer months in your area increased?

a) Yes
b) No
c) Don't know
d) If other specify it___________

Q.12 in the last five years, how common have heat wave events/extreme heat days in your area been?

a) More common
b) Less common
c) No change
d) Don't know

Q.13 Do heat waves/high temperatures cause serious health problems in your area?

a) Yes
b) No
c) Don't know

Q. 14 Have you heard about heat stress?

a) Yes
b) No

Q.15 What contributes to heat stress?

a) Temperature
b) Direct sun
c) Air pressure
d) Humidity
e) Lack of a breeze/wind
f) Other (specify) ________________
g) Don't know

Q.16 What is the most serious form of heat stress?

a) Heat exhaustion
b) Heat stroke
c) Other (specify)_______________
d) Don't know

Q.17 Have you ever heard of heat exhaustion?

1) Yes
2) No
3) Don't know

Q.18 what are the common symptoms of heat exhaustion?

a) Heavy sweating
b) Extreme weakness or vomiting
c) Dizziness, confusion
d) Nausea
e) Other (specify)
f) Don't know

Q.19 what is the best form of first aid from someone suffering from heat exhaustion?

a) Move the person to cooler or shaded area
b) Lie down near a fan or cooler
c) place a wet towel or a wet-cloth dipped in cold water over the person
d) Spray with water
e) Other (specify) ______________________
f) Don't know

C: Practice/Behaviour

Q.20 how do you protect yourself from heat on days that are excessively hot?

a) Stay Indoors
b) Drink Plenty of Water
c) Seek Shade
d) Wear Light Clothing, loose fitting clothing (Cotton)
e) Wear a Cap/Cover Head
f) Take a Bath
g) Use protective equipment like sun coat/cap
h) Change Work Schedule or Take Break In Afternoon
i) Reduce Activity
j) Avoid Outdoor Activity
k) Change in Food Pattern
l) Do Nothing Different

Q.21 if you did not do anything different, what was the reason?

a) I did not know heat stress conditions would be so severe
b) Inconvenience
c) Unnecessary
d) Unprotectable
e) Unsuitable
f) Insufficient

g) Other (specify) ________________

D: Heat stress perceptions

Q.22 heat stress perceptions

No	Statements	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	I think I am not at risk of having heat stress					
2	If I feel tired when working in the heat, it is a serious problem					
3	It is necessary to use personal protective equipment when I am working in the heat					
4	I cannot prevent myself from suffering from heat stress by taking precautionary measures					
5	Having heat stress seriously impacts my health					
6	I am healthy and don't need to protect myself from the sun					
7	My physiological characteristics are not relevant to the risk of heat stress					

Q.23 who do you think is the most vulnerable group to heat stress?

a) Pregnant women

b) Babies

c) Children

d) Medically-ill people

e) Elderly

f) Socially isolated people

g) Social problems

h) Extreme physical effort

I) Obese people

j) Youths

k) Working men

L) Working women

m) Don't know

Q. 24 Related to heat impacts on health, are you worried about anyone at home getting sick? If yes, who?

a) Yes
b) No
c) Relation to the respondent (specify) __________________

Q.25. How dangerous do you think is heat for you?

a) Very dangerous
b) Somewhat dangerous
c) Slightly dangerous
d) Not dangerous at all

E. Information on Heat and Health

Q.8 Are you informed about heat stress conditions and about the health problems related to heat? If yes, from where?

a) Radio
b) TV
c) Internet
d) Newspaper
e) Community Newsletter
f) Medical Professional
g) Family Member
h) School Teachers
i) Friends
j) Neighbors
k) Religious Leader

Q9. How regularly do you receive this information?

a) Seasonal forecast
b) Warned before extreme heat events
c) Follow weather bulletins

Q.10 Do you think it is necessary to have weather information specifically related to heat?

a) Yes
b) No

Q.11 Have you been informed of actions to prevent heat stress and heat stroke? If yes, from whom?

a) Doctor
b) Pharmacy
c) Family Member
d) School Teacher
e) Friends
f) Neighbors

g) Other (Specify)__________________

Didn't Get Information

Annex 9: Feedback questionnaire rural areas

Final Copy

Uptake of Climate Change Adaption Research Results in South Asia

(Reducing Health Risks of Rising Temperatures In South Asia)

SHORT FEEDBACK SURVEY ON HEAT AND HEALTH ADVISORY SYSTEM

(To be administered to the household member receiving the heat and health advisories)

IDENTIFICATION PARTICULARS

Before Starting Interview

Name of District ______________________________

Name of Taluka ______________________________

Name of the village: ______________________________

Serial number of Household: ______________________________

Name of Respondent: ______________________________

Contact Number: ______________________________

Date of Interview (DD/MM/YY): _____/_____/______

Name of Interviewer: ______________________________

INFORMED CONSENT

Namaskar! My name is _________ and I am working with Watershed Organisation Trust (WOTR). Since 1993, WOTR has been working for rural development through watershed development program. So far, WOTR has supported and carried out developmental work in over 3500 villages across 8 states of India.

This short survey is part of our ongoing heat and health advisory system through which you are receiving advisories twice a week. This survey will help us to further fine-tune our system so that it helps to reduce the vulnerabilities of the rural communities. This survey is part of our study funded under the ***"Uptake of Climate Change Adaption Research Results in South Asia" (****Reducing Health Risks of Rising Temperatures in South Asia – (RRR)*.

This feedback questionnaire will take maximum of 10 min. The data that obtained from this short survey will be used only for the research reports, journal papers, conference and publication purposes only. No any individual identity (such as name, contact number and location) will be display anywhere or will not share with anyone.

However, collecting this data is important for us to understand your views and option on our heat and health advisory system disseminated through SMS. This will help us to plan relevant interventions in the future. Without this data, we will not be able to understand these issues.

We would like to invite you for the short feedback survey and appreciate your participation. Do you have any questions regarding the survey?

(Answer the questions and clear concerns of respondent, if any)

Can we begin the interview now?

____

Name of Person Obtaining consent

____

Signature of Person Obtaining consent

____

Date

QN	QUESTIONS AND FILTERS	CODING CATEGORIES
1	Are you receiving the heat & health advisories through SMS?	YES..............................1 NO...............................2
2	What is your opinion about the frequency of the advisories?	CURRENT FREQUENCY IS GOOD (TWICE A WEEK).......................1 NEED MORE FREQUENTLY(THRICE A WEEK)..2 NEED LESS FREQUENTLY(ONCE A WEEK).3
3	Did the warning match/correspond with your experience of weather conditions	YES..............................1 NO...............................2
4	How would you rate heat conditions during the 2021 summer?	MODERATE/COOL.....................1 NORMAL.............................2 EXTREME............................3
5	What is your opinion about the following components of the advisories?	**YES-1, NO-2** Useful in planning indoor/home activities.. 1 2 Useful in planning/rescheduling 1 2 field activities............. 1 2 Useful in planning/rescheduling Outdoor activities........... 1 2 Easy to understand.......... 1 2 Good lenghth............... 1 2 Timely............
6	Rate the overall usefulness of the advisories?	TO A CERTAIN EXTENT (BELOW 50%).......1 TO SOME EXTENT(51% TO 70%)..........2 TO A GREAT EXTENT (ABOVE 71%).......3 NOT AT ALL.......................4
7	Are these heat health advisories essential during summer months?	YES..............................1 NO...............................2
8	Would you like to continue receiving these advisories in the future?	YES..............................1 NO...............................2
9	Any other comments, suggestions for improvements	____________________ ____________________ ____________________

***** END *****

Annex 10: Telephonic interview guide Heat & COVID 19 rural areas

Heat & COVID 19 - Final Tool

About the Respondent	Background information: Name of the respondent, village/block, Age, Gender, landholding, primary occupation, house type (roof), total members in family etc
COVID-19 (1 time info from respondent)	o About the village, population, household, health care facilities etc. Number of person who came back to village? Volunteers to participate in COVID 19 activities? o COVID situation in the village, number of patient identify, number of HHs or families quarantine during lockdown situation. COVID-19 care committee in the village? Role and responsibilities? o Is the committee made any arrangement for accommodation and other essential services for the migrants? Services at such place (sufficient drinking water, fan, proper ventilation during summer months) o Food security, shortage and livelihood activities, migration pattern during COVID-19 and difficulties during lockdown - food grains availability, PDS functioning and services, how many hungry people/household in the village o Did you had to spend more time indoors as compared to outdoors due to the lockdown? o If yes, what are the indoor heat exposure experiences? Do you feel hotter inside as compared to outside due to your home structure? (roof, wall material etc) o How do you cope with hot temperatures inside, when going out is not permitted? (changing sleep time, cooking time, use fan/cooler etc) o What about the other members of your family (women, children and elderly) and their activities. o Schedule of your family members, teenager, youths and elderly – indoor and outdoor exposure.
Livelihood	o Are you working right now outdoors for livelihood? (In own farm/ as wage laborer (farm or non-farm), MGNREGS work etc? nature of work or specific activities? / Types of livelihood activities have you been engaged in during the lockdown? o How are your work conditions different from normal times? (Physical distancing, use of safety precautions- hand masks, sanitizers, etc). What are your work times and duration? o Did you have to alter your work schedule due to the high temperatures in the afternoon? (take frequent breaks, change work timings, rest under shade etc) o Do you have adequate water for drinking, maintaining hygiene (hand washing, cleaning work equipment etc)? Access to public drinking water resources and COVID-19 and heat? o Are you using personal protective equipment for safety? Are they of any hindrance in the current hot season? o Average time of exposure to sun during peak heat hours (11 am- 3 pm) o Caution of workers to avoid direct sunlight and COVID care? Adequate facility for washing hands with water and soap at the worksite?
Heat and health	o As a result of indoor or outdoor heat stress, did you experience heat related symptoms (list of common symptoms)? What are they? (also ask about family members who work outside) o How did you treat them? Home or health care facility? Were you able to access the health care facility due to the lockdown restrictions? o Will they action they will take change the schedule or not in change in schedule due to certain reason. o Is it safe to use outdoor public spaces for cooling? Such as community/public hall, school or temple? During COVID-19 situation? o Quarantine places (community hall or school) have proper cooling devices? Is the quarantine places have proper drinking water facilities? o Access to private or public health care services (PHC etc) and information on heat

	stress, early warning system and COVID 19 issue? o Is the public health system able to rapidly detect a cases of COVID 19 during this summer pick months? o Local risk perceptions, myths, and concerns about heat waves and COVID-19. o Communication systems to ensure COVID-19 situation and heat stress/communication channels (newspapers, radio, television, whatapp group etc) or IEC material? To maximize the reach of messaging on heat-waves while maintaining physical distancing measures for COVID-19. o Information on the heat stress and preventing the on heat stress? o Any online training on COVID 19 and heat stress?
Expectation	o What does the village expect from the government? Heat stress and COVID 19?/ What does the villages expect from the government to face this COVID 19 crisis and heat stress? o What services should be mobilized to deal with combined exposure to excessive heat and COVID-19 in your village? o Is the village grampanchyat is able to absorb an extra people (return migrant) and provide medical care? And cooling places in the village

Annex 11: Questionnaire Delhi heat bulletins

Survey Questionnaire Reducing Health Risks of Rising Temperatures in South Asia - RRR Study- Delhi

Section A: Basic Details			
1	**Name of the Respondent**		
2	**Age**		
3	**Sex**	Male	
		Female	
		Others	
4	**District/ Zone**		
5	**Ward**		
6	**GPS location**		
7	**Surroundings**	Open area	
		Dense/congested	
		Green area	
8	**Education**	Illiterate	
		Primary	
		Secondary	
		Higher Secondary	
		Graduate	
		Post Graduate & above	
9	**Occupation**	Daily wage labour	
		Salaried	
		Business/Self-employed	
10	**Household monthly income (range)**	Less than 5000	
		5000-20,000	
		20,000-50,000	
		50,000-2,00,000	
		2,00,000 and above	
11	**(a) No. of family members (male)**	**Total no. of members:**	
		Male members with age	
	(b) No. of family members (female)	**Female members with age**	
12	**Structure of house**	Grass/thatch/mud	

		Tin/shack	
		Single brick	
		Well-made structure	
13	**Type of house**	Independent single-storied	
		Independent multi-storied	
		Apartments	Top floor
			Lower floor
		High rise	Top floor
			Lower floor
		Slum areas	
		Informal settlements	
14	**No. of rooms**		
15	**Asset ownership** (in nos.)		
	Ceiling fan/fans		
	Refrigerator		
	Cooler		
	Air Conditioners		
	Other cooling devices		
	Vehicle ownership	2 wheeler	4 wheeler
	Geysers		

Section B: Awareness on Heat wave advisories			
1	**Do you feel there has been a change in the climate of Delhi in the last 10 to 15 years?**	Yes	No
2	**If yes, what do you feel the major changes have been? (multiple answers possible)**	Higher daytime temperatures	
		Warmer nights	
		Higher humidity	
		Longer heat waves	
		Change in precipitation contributing to heat	
		Others (please specify)	
3	**How concerned are you about the effect of heat waves?**	Extremely concerned	
		Highly concerned	
		Moderately concerned	
		Somewhat concerned	
		Not at all	
4	**If concerned, what concerns you the most during a heat wave? (multiple answers possible)**	Getting adequate rest & thermal comfort	
		Power cuts & load shedding	
		Water stress/shortage	
		Health & well-being of family members	

		Health of pets	
		Others	
5	**Are you aware of the health implications of rising temperature?**	Yes	No
6	**If yes, what health impacts have you experienced/heard of in your location or in other areas?**	Heat stroke	
		Dehydration	
		Severe headache	
		Fatigue/restlessness/discomfort	
		Cardiac arrest	
		No impact/feel the same	
		Other health issues (please specify)	
7	**What are the measures that can be taken to cope with heat stress?**	**Tick suitable options**	
		Government	
		Alerts	
		Public water sources enhanced	
		Shaded shelters	
		Assigned timings for outdoor activities	
		Ramping up public health infrastructure	
		Increasing green spaces	
		Community	
		Changing outdoor activity time	
		Community drinking water sources	
		Individuals	
		Increasing water intake	
		Using cooling devices – gunny bags, ACs, coolers, fans, ventilation	
		Staying indoors	
		Appropriate clothing	
8	**Are you aware of advisories issued to address exposure to heat stress? (If no, skip to Q16)**	Yes	No
9	**a) If yes, are you aware of the format in which heat alerts & advisories are issued? (If no, skip to Q13)**	Yes	No
	b) If yes, are you aware of the colours and their associated meanings?	Yes	No
10	**What do each of the colours in heat wave advisory denote?**	**Colours**	**Meaning (select only response for each colour)**

		Green	**No action required**(Normal day)	**Be updated** (Heat Alert Day)	**Be prepared** (Severe Heat Alert for the day)	**Take action** (Extreme Heat Alert for the day)
		Yellow	**No action required**(Normal Day)	**Be updated** (Heat Alert Day)	**Be prepared** (Severe Heat Alert for the day)	**Take action** (Extreme Heat Alert for the day)
		Orange	**No action required**(Normal Day)	**Be updated** (Heat Alert Day)	**Be prepared** (Severe Heat Alert for the day)	**Take action** (Extreme Heat Alert for the day)
		Red	**No action required**(Normal Day)	**Be updated** (Heat Alert Day)	**Be prepared** (Severe Heat Alert for the day)	**Take action** (Extreme Heat Alert for the day)
11	**How did you learn about these advisories? (multiple answers possible)**	Peer group learning/family & friends				
		Television				
		Radio				
		Internet (including social media & apps)				
		Text messages				
		Newspapers				
		Doctors				
		Other local healthcare workers				
		Local leaders/MLAs				
		NGOs				
		Others (please, specify)				
12	**How closely do you follow news/updates about heat waves?**	Very closely				
		Somewhat closely				

		Not at all	
13	**What information was provided in the bulletin? (multiple answers possible)**	Dates/days for heat waves	
		Areas affected	
		Expected temperature range	
		Suggested coping measures	
		Helpline nos.	
		Others (please, specify)	
14	**Did you use the information as provided in the advisory? (multiple answers possible)**	Did not find the advisory useful or follow it	
		Followed the advisory	
		Shared the advisory with family & friends	
		Read more about heat waves and coping mechanisms	
		Kept emergency contacts and medicines handy	
15	**What other information should be included in the advisory? (multiple answers possible)**	Signs for detecting heat stress	
		Helpline nos. (Hospitals, clinics, ASHA, ANM etc.)	
		Specific advisories for vulnerable groups (elderly, pregnant	

		women, children, outdoor workers and homeless people)	
		Nearby locations where health assistance can be sought	
		Suggestions for rescheduling outdoor work and other activities carefully	
		Other means	
16	**What could be the reason for not being aware of advisories for exposure to heat stress? (only for those who are not aware of heat wave advisories)**	Not aware of heat waves	
		Don't have resources (eg. access to internet, TV, radio etc.)	
		Others (please specify)	
17	**What could be alternate sources of information?**	Communication channels such as voice messages, social media, text or Whatsapp messages etc.	
		Dashboards-graphics/imagery for better understanding	
		Others (please specify)	
18	**According to you, what is the likelihood of occurrence of heat waves in future?**	Extremely likely	
		Very Likely	
		Somewhat likely	
		Less likely	
		Not at all	
19	**Any other suggestions or concerns related to heat waves?**		

Draft Journal Paper in Development (to be added)

Annex 12: Questionnaire TERI heat and COVID survey

H0: Lockdown has increased demand in residential areas with cooling requirements owing to the high temperatures and heat wave conditions created this Summer in the Delhi/ NCR region

RQ: has the lockdown impacted household energy expenses this summer compared to the last?

General information of Respondent:

HH1	Name	
HH2	Age	
HH3	Sex (F/M)	
HH4	City (Residence)	
HH5	Locality (Area)	
HH6	Ward no/District	
HH7	Mobile No.	
HH8	Educational Level	Primary School/Middle School/High School/ Higher Secondary/Graduation/Post Graduation and above
HH9	Occupation	Salaried/Daily Wage/Business
HH10	Total No of household members	
HH11	Type of Family	Nuclear/Joint
HH12	No of days Working from Home (March)	
HH13	No of days Working from Home (Aprl)	
HH14	No of days Working from Home (May)	
HH15	No of days Working from Home (June)	

Type of House of Respondent:

HH16	Type of House	Independent/Multi-storeyed/Slum/ other (specify)
		If multi storeyed, No of floors:
		If apartment what floor: bottom/ middle/ top
HH17	If Independent: No. of floors	
HH17	Multi-storeyed: What floor	
HH18	Ownership status (of house)	Rented/Owned
HH19	No of rooms	
HH20	Type of walls in the house	Tin walls Brick walls Thicker walls with cement
HH21	Type of roofs in the house	Tin roofs

		Asbestos sheet roofs Cemented roof Insulated roof (Tiled/ Painted)

Household Income Details:

HH22	**Household Annual Income (INR)**	
	<5000	
	5001-15000	
	15001-30000	
	30001-60000	
	60001-100000	
	100001-150000	
	>150001	

Access of Household to electricity supply and cooling systems:

HH23	Do you have electricity supply?	Yes
		No
HH24	Do you face any load shedding issues?	Yes/No
HH25	How many hours in a Week?	
	Cooling devices used?	Yes
HH26		No
HH27	Do you use AC in your household?	Yes/No
HH28	No. of ACs used in the household?	
HH29	Cooling capacity of AC No.1	
HH30	No. of hours (avg.) air conditioning No. 1 is used per day (2020 summers) ?	
HH31	Cooling capacity of AC No.2	
HH32	No. of hours (avg.) air conditioning No. 2 is used per day (2020 summers) ?	
HH33	Cooling capacity of AC No.3	
HH34	No. of hours (avg.) air conditioning No. 3 is used per day (2020 summers) ?	
HH35	Cooling capacity of AC No.4	
HH36	No. of hours (avg.) air conditioning No. 4 is used per day (2020 summers) ?	
HH37	Cooling capacity of AC No.5	

HH38	No. of hours (avg.) air conditioning No. 5 is used per day (2020 summers) ?	
HH25	Fans in the household	

Electricity consumption of Household:

HH26	Are all ACs used	Yes/ No
HH27	Number of ACs used in total	
HH28	No of hours (avr.) each air conditioning is used/day (2020 summers)	
HH29	Are all Air Coolers used	Yes/ No
HH30	No of hours (avr.) each air cooler is used/day (2020 summers)	
HH31	Electricity consumption (2020)	March:
		April:
		May:
		June:
HH32	Was the electricity consumption in 2019 higher/ lower/ almost the same compared to 2020?	
HH33	Electricity bill of 2020 (INR)	March:
		April:
		May:
		June:
HH34	Was the electricity bill in 2019 higher/ lower/ almost the same compared to 2020?	
HH35	What has been your specific experience during the lockdown for energy use? Has it increased or remained the same or decreased and Why?	

Annex 13: Summary data analysis from indoor temperature loggers in Jalna villages

A scientific article was submitted on temperature measurements in Jalna. This is based on ASSAR- OSF, HI-AWARE and RRR studies funded by IDRC. Below a summary of the results.

Between 2016 and 2021, 40 temperature data loggers were installed in people's homes in several villages in the Jalna District in India. The aim was to gain scientific knowledge on heat stress among the rural population of India and to know the difference between outside and inside temperatures. The first 10 data loggers were installed for the Hi-Aware project, as part of the CARIAA programme, running from 2012-2019. The RRR project, running from 2020-2021, continued to collect temperature and humidity data inside people's homes. An additional number of 30 data loggers was installed for the RRR project. The temperature data were collected by WOTR in May and June from each year.

An article on the data of the temperature loggers is forthcoming. Here we present a summary of a first primary level analysis for four reference periods: 2016, 2017, 2018 and 2021. This analysis is based on the specific time period from the 10th of May to the 15th of June for each year.

Figure 1: Indoor temperature variation in RCC, tin, tile, wood and thatch roof houses for the mentioned period and study site classfied by day, evening and night time.

Note: For this analysis three classifications were made such as i) Day (from 11 AM to 5 PM), ii) evening (6 PM to 12 PM) and night (1 AM to 6 AM)

The results show that the indoor temperature not only depends on the outside temperature, but also on the construction of the roofs. The graphs in Figure 1 compare the results for tin roofs, Reinforced Cement Concrete (RCC) roofs, tile roofs, thatched roofs and wood roofs.

In 2016, the indoor temperature in tin roof houses was high throughout the mentioned period (10th May to 15th June 2016) but the indoor temperature decreased in the night. The average maximum temperature in tin roof houses was recoded for 42°C during day time. In tile roof houses the indoor temperature was high during day time (11 AM to 5PM) but the evening and night temperature was low as compared with RCC and tin roof houses.

During 2017, the indoor temperature in tile roof houses was low during evening and night times as compared with RCC and tin roof houses. In RCC roof houses, the indoor temperature in the night was high as compared with tile. In tin roof houses, the indoor temperature was high throughout the mentioned period. The highest indoor temperature was recorded in the tin roof houses (40°C) in the daytime.

In the 2018 study period, the indoor temperature in tin roof houses was high (39°C) in the daytime and the indoor temperature in the RCC houses was 37°C. During evening and night time, the indoor temperatures in the RCC house were high at 37°C and 34°C accordingly. The temperature trend line of tin roof houses shows that in the evening and night time the indoor temperature decreased. Throughout the period the indoor temperature in thatch roof houses was lower compared with RCC roof houses and tin roof houses.

In 2021, there were some interesting findings. In tin roof houses the indoor temperature was high during daytime (36℃) while in the evening time it decreased to 32℃ and during night time it was 30℃, showing a decreasing trend line. In RCC houses the indoor temperatures during the day and evening time were high compared to wood roof houses and even a little higher than tin roof houses.

Concluding, tin sheets as a roof have a higher mean temperature compared to concrete in all the months. Thatch, wood and tiles seem to reduce the indoor effect from summer heat. The effect is evident but it needs more analysis due to variable sample size and statistically insignificant values. With this knowledge, the RRR project wanted to explore people’s adaptive capacity and develop tools to improve people’s response to extreme heat events.

Annex 14: Heat advisory messages translated

Heat Advisory in English	Heat Advisory in Marathi	Character count (with spaces)
WBGT messages		
Weekday: Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday	सोमवारी, मंगळवारी, बुधवारी, गुरुवारी, शुक्रवारी, शनिवारी, रविवारी	
WBGT class: Mild, Moderate, High, Extreme	सौम्य, मध्यम, तीव्र, अति तीव्र	
Similar High heat stress on both other days	दोन्ही दिवशी उष्णतेचा अतिताण राहील	34
Conditions on both other days are High	इतर दोन्ही दिवशी उष्णतेच्या ताण जास्त राहील	43
Conditions on both other days are also High to Extreme	इतर दोन्ही दिवशी उष्णतेचा ताण तीव्र ते अती तीव्र स्वरुपाचा राहील	64
Conditions on all three days are Extreme	पुढील तिन्ही दिवस उष्णतेची स्थिती ही अती तीव्र स्वरुपाची राहील	62
"On " <<weekday>> " , heat stress is expected to be " ” <<WBGT class>>	<<मंगळवारी>> उष्णतेचा << तीव्र >> ताण अपेक्षित आहे	50
On " <<weekday>> " and " <<weekday>>" , heat stress is expected to be ", ” <<WBGT class>>	<<सोमवारी>> आणि <<मंगळवारी>> उष्णतेचा << मध्यम >> ताण अपेक्षित आहे	67
"On " <<weekday>> ", heat stress is expected to be ", ” <<WBGT class>>, " and on " <<weekday>> " ",WBGTother)	उष्णतेचा ताण << सोमवारी >> << तीव्र >> आणि << मंगळवारी >> <<अति तीव्र >> राहील	80
"On " <<weekday>> ", heat stress is expected to be " <<WBGT class>> " with " <<here the explanations, combined>> “.” <<WBGT on other days>>	<< सोमवारी >> उष्णतेचा << तीव्र >> ताण अपेक्षित आहे. तसेच << here the explanations, combined >> << WBGT on other days >>	
Explanation of major meteorological contributing factors		
expected temperature higher than normal	सामान्य तापमानापेक्षा अपेक्षित तापमान जास्त असेल	48
extreme maximum temperature expected	कमाल तापमानात तीव्रवाढ अपेक्षित आहे	35

higher daytime humidity than normal expected	दिवसाची आर्द्रता सरासरी आर्द्रतेपेक्षा जास्त अपेक्षित आहे	57
low wind speed conditions expected	वाऱ्याची गती कमी राहणे अपेक्षित आहे	35
preceding night will remain warm	आजच्या रात्रीचे तापमान जास्त राहील	34
timely rain might lower heat stress conditions	वेळेवर पाऊस पडल्यास उष्णतेचा ताण कमी होऊ शकेल	45
heat stress conditions for more than 4 hours likely	उष्णतेच्या ताणाची स्थिती ४ तासांपेक्षा जास्त काळ राहू शकेल	59
WBGT>=30 & WBGT < 32 (HIGH)		
Drink sufficient water and as often as possible.	शक्य असेल तितक्या वेळा पुरेसे पाणी प्या	39
Begin work in the early morning	सकाळी लवकर काम सुरू करा	23
Take a 3 hour break at noon	दुपारी १२ ते ३ या कालावधी मध्ये विश्रांती घ्या	46
Take rest every hour in the shade	थेट उन्हात काम करायचे असल्यास प्रत्येक तासानंतर थोडा वेळ सावलीमध्ये विश्रांती घ्या	82
Cover your head and face with a cloth, hat or cap, even while travelling on a motorbike	काम करतांना किंवा गाडीवरून प्रवास करताना आपले डोके आणि चेहरा हे कापडाने, गमछाने किंवा टोपीने झाकून घ्या	103
	Total	**293**
WBGT >= 32 & WBGT < 33 (EXTREME)		
Drink sufficient water and as often as possible.	शक्य असेल तितक्या वेळापुरेसे पाणी प्या	38
Begin work in the early morning	सकाळी लवकर कामे सुरू करा	24
Take a 3 hour break at noon	दुपारी १२ ते ३ या कालावधी मध्ये कामातून विश्रांती घ्या	54
Take a long rest every hour in the shade	दर तासाने सावलीमध्ये पुरेशी विश्रांती घ्या	42

Create temporary shelters in treeless work areas	झाडे कमी असलेल्या भागात काम करताना तात्पुरता सावलीसाठी आडोसा तयार करा	69
Cover your head and face with a cloth, hat or cap, even while travelling on a motorbike	काम करतांना किंवा गाडीवरून प्रवास करताना आपले डोके आणि चेहरा हे कापडाने, गमछाने किंवा टोपीने झाकून घ्या	103
Recognize the signs of heat stroke, heat rash or heat cramps.	उष्माघात, उष्णतेचे पुरळ आणि पेटके येणाची लक्षणे ओळखा	52
Pregnant workers and workers with a medical condition should be given additional attention	गर्भवती महिला आणि आधीपासून काही आजार असलेल्या कामगारांवर जास्तीचे लक्ष द्यावे	77
	Total	**459**
WBGT >= 33 (EXTREME, and likely during most of the day)		
Heat stress conditions throughout the day. Reschedule activities to other days	दिवसभर उष्णतेच्या-ताणाची स्थिती राहील. तरी आजची कामे पुढील दिवसांसाठी नियोजित करा	81
Drink sufficient water and as often as possible.	शक्य असेल तितक्या वेळापुरेसे पाणी प्या	38
Cover your head and face with a hat, cap or an umbrella and also use a damp cloth on your head, neck, face and limbs	डोके आणि चेहरा हे टोपी, कापड किंवा छत्रीने झाकून घ्या, डोके, मान, चेहरा आणि हात-पायांवर ओलसर कापडाचा वापर करा	109
Recognize the signs of heat stroke, heat rash or heat cramps.	उष्माघात, उष्णतेचे पुरळ आणि पेटके येणाची लक्षणे ओळखा	52
Take care of pregnant workers and workers with a medical condition	गर्भवती महिला आणि आधीपासून काही आजार असलेल्या कामगारांवर जास्तीचे लक्ष द्यावे	77
If you feel faint or ill, see a doctor immediately	चक्कर येत असल्यास किंवा आजारी वाटत असेल तर ताबडतोब डॉक्टरांना भेटा	66
	Total	**423**
General messages to be sent once at beginning		

To maintain the water level in the body, add a pinch of salt and a teaspoon of sugar in a glass of water and drink it.	शरिरातील पाण्याची पातळी नियंत्रित ठेवण्यासाठी एक ग्लास पाण्यात चिमूटभर मीठ आणि एक चमचा साखर घालून ते प्यावे	107
Fluids such as lime water, buttermilk, coconut water, and aam panna can also help. Avoid alcohol, tea, coffee and sugary soft drinks, which dehydrates the body.	उन्हाळयात लिंबूपाणी, ताक, नारळपाणी आणि आम पन्हे या सारखे पेय घ्या. चहा, कॉफी घेणे व मद्यपान करणे टाळा त्यामुळे शरीरातील पाणी लवकर कमी होते	138
Heat stroke symptom: When the heat-stress progresses, the pulse and breathing can become faster and weaker. The affected person may pass very little urine. It may be dark in colour. In some cases headache, nausea and vomiting might also occur. Slowly, the person becomes lethargic and drowsy, and starts talking incoherently. He/she may refuse to drink water even if given. Skin may become dry and pale. There might be no sweating and the person can run a very high fever.	उष्माघाताची लक्षणे: जेव्हा उष्माघाताचा त्रास होत असेल तेव्हा नाडीचे ठोके मंदावतात, श्वासाची गती जलद होते आणि लघवी कमी प्रमाणात आणि गडद रंगाची होते. काही लोकांना डोकेदुखी, मळमळ आणि उलट्या होऊ शकतात. हळू-हळू ती व्यक्ती थकलेली व सुस्तावलेली होईल, कदाचित पाणी पीऊ शकणार नाही. घाम न येता त्वचा कोरडी होऊ शकते तसेच स्पर्श केला तर त्वचा गरम लागू शकते व जास्त ताप येऊ शकतो	365
Wear loose and light coloured clothes made from light fabrics like cotton and cover your head and face with a cloth or cap, even while travelling on a motorbike.	फिकट रंगाचे, सैल कॉटनचे कपडे घाला, आपण काम करतांना किंवा गाडीवरून प्रवास करताना आपले डोके आणि चेहरा हे कापडाने, गमछाने किंवा टोपीने झाकून घ्या	142
During noon time the indoor temperature in tin roof is high, so prefer to take a rest in courtyard shade/in a community hall/ in a village temple	दुपारच्या वेळेस पत्र्याच्या घरतील तापमान हे जास्त असते अशा वेळेस घरा बाहेर सावलीत, सामूहिक हॉल किवा मंदिरामध्ये विश्रांती घ्या	126

Elderly, small children's, pregnant and breastfeeding mothers, particularly if they are working outdoor or even in kitchen needs a special care.	वृद्ध, लहान मुले, गर्भवती आणि स्तनपान करणाऱ्या माता जे घराबाहेर किवा स्वयंपाकघरात जास्त वेळ काम करतात यांची विशेष काळजी घ्या	124
	Total	**1002**
Introductory message on WBGT and our warnings:		
"The WBGT is a measure of the heat stress in direct sunlight, which takes into account temperature, humidity, wind speed and cloud cover/radiation. Based on IMD forecast we calculate the WBGT for the next three days and provide you a warning in four categories: Mild, Moderate, High and Extreme. Heat stress is a risk in any of these categories, but certainly in the High and Extreme category one should adjust behavior: start work early and rest at noon, take breaks frequently, drink fluids often and avoid exposure to the sun as much as possible. If you have any questions or would not like to receive these warnings, please call Mr. Premsagar on 9284716291	डब्ल्यू.बी.जी.टी हे थेट सूर्यप्रकाशात उष्णतेच्या ताण मोजण्याचे एक साधन आहे जे वातावरणाचे तापमान, आर्द्रता, वारयाचा वेग आणि ढगांची स्थिती यांचावर आधारित आहे. हवामान विभागाच्या अंदाजानुसार आम्ही पुढील तीन दिवसांचा डब्ल्यू.बी.जी.टी ची गणना करतो आणि याच आधारावर चार श्रेणींमध्ये उष्णतेचीमध्ये चेतावणी देण्यात येते जसे की सौम्य, मध्यम, तीव्र आणि अति तीव्र. उष्णतेचा ताण हा कोणत्याही श्रेणीत धोकादायक असतो परंतु तीव्र आणि अती तीव्र श्रेणीमध्ये प्रत्येकाने योग्य खबरदारी घ्यावी. जेसे की दिवसा लवकर काम सुरू करा आणि दुपारी विश्रांती घ्या. तसेच दिवसभराच्या कामामध्ये थोडी थोडी विश्रांती घ्या. नियमित पाणी/ अन्य पेयांचे सेवन करा. शक्यतो थेट सूर्यप्रकाशात जाणे/ काम करणे टाळा. आपल्याला काही प्रश्न असल्यास किंवा आपल्याला या चेतावणी नको नसल्यास कृपया प्रेमसागर यांना 9284716291 वर कॉल करा	**777**