COST-EFFECTIVE TRADITIONAL AND MODERN COPING STRATEGIES FOR HEATWAVES PREVALENT IN TRIBAL, RURAL AND URBAN INDIA

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Executive Summary

The global temperature started showing an upward trend between 1971 to 2010 which continued to increase. Recently, the year 2022 recorded extreme temperatures which were greatly unpredictable. Within the tropics, India underwent major heat stress during and before the summer months. Especially the western, central and northwestern parts of India were most affected. India in particular is more vulnerable due to socio-economic inequalities and political context. Various measures taken by the Central and the State Governments are reactive at best, and may not have effective implementation. Thus, it is essential to study the indigenous solutions that communities adopt to tackle the impacts of extreme heat. It is also important the understand the policies around heatwaves and barriers to the medical care so that even the poorest and most marginalized populations can be made resilient to extreme heat. Thus, this study was undertaken to understand the cost- effective indigenous solutions to protect against extreme heat, find the barriers to access medical care. For the study, tribal, rural and urban regions of Siyawa village in Rajasthan, Dhaisariya village in Gorakhpur, Uttar Pradesh and Seema Puri in North East Delhi were chosen, respectively, as the study areas as they have experienced extreme heat even before summer and are home to marginalized communities. The study utilizes a *mixed method approach* with qualitative and quantitative methods of data collection and analysis implemented concurrently. It involves three components i.e. Heat risk mapping, Evidence Gap Map (EGM) and Community Perspectives. The heat risk mapping showed that the selected sites for the study faced moderate to high risk of Extreme Heat owing the high temperatures and the social vulnerabilities. The Evidence Gap Map, which was made to understand gaps in evidence on policy and action interventions for heatwaves, presented a large gaping amount of literature on legislature and policies against extreme heat, especially at village/town and district levels. In terms of education and life skills, literature on awareness drives were mostly covered at personal and community level and medical and technological solutions. From the EGM it is also evident there is a lack of studies dealing with indigenous solutions or traditional coping strategies and cost-effective methods to protect from events of heat wave. Our study helps to fill up these gaps in existing literature effectively. While capturing community perspectives tthrough the interviews and focus group discussions, cost-effective indigenous solutions are brought out. At individual level, home remedies using herbs and plants are utilized, a certain diet is preferred during the summer months, water is stored in earthen pots which keeps it cooler especially in tribal and rural regions, thick cotton clothes are preferred by the people to protect them from the heat. In urban regions ACs and coolers are used and housing structure is changed to protect people. At community level, people in rural areas tend to gather under trees and huts and people in urban areas visit parks and gardens. There are a few initiatives available to the people of Rajasthan, Uttar Pradesh and Delhi launched on behalf of the Central and the State Governments like Heat Action Plans, MNREGA, Anganwadi scheme, PDS scheme, old age pension schemes, Pradhan Mantri Kisan Samman Nidhi scheme, Labour Card Scheme etc. These themes are not designed for dealing with heatwaves, but they can turn out to be a very crucial measure to deal effectively with heatwave events across India, as these schemes provide economic aid, food aid as well as healthcare aid. As per the analysis of findings, in all 3 study areas healthcare gapsneed to be addressed by the government in terms of availability of essential medical supplies and human resources as well as accessibility. This study reflects that the researched communities are not adequately equipped with livelihood opportunities, medical care and awareness to recover easily form the impacts of heatwaves. That they lack the capacity to plan for the next disaster owing to their meagre resources and power. Their adaptation measures are mostly preventive in nature, but for effectively coping with the disaster, they solely depend on the Government to take up essential measures. Thus, the findings show how the level of vulnerability is intensified with the coming of heatwave in the absence of adequate coping strategies. It is evident amongst the residents of Siwaya village, Rajasthan, Dhaisariya village, Uttar

Pradesh and Seema Puri, Delhi that the people are vulnerable as they are mostly engaged in the unorganized sector. The residents are dealing with heatwaves at their individual level using their own traditional measures like natural medical techniques, certain traditional food habits, clothing patterns and housing structures and also take collective measures at the community level for fighting against heatwaves. At the Government level, there is a lack of effective measures for curbing heat wave effects. To make the community resilient in the face of future heatwaves, these vulnerable communities need to be equipped with cost effective coping strategies, with major effort taken at the Government level. Strategies like using local heat resistant material for house construction, social protection schemes like MNREGA with modified timings to avoid exposure to extreme heat, stronger protective laws for unorganized labor and robust public health system at the primary care level with better accessibility are needed to be implemented by Central and State governments to reduce the risks of extreme heat in India.

Abstract

The study brings out the differential impact of extreme heat on the vulnerable populations of rural and urban areas of Siyawa village in Rajasthan, Gorakhpur in Uttar Pradesh and Seema Puri in Northeast Delhi, India and identifies local cost- effective traditional and modern solutions and policy initiatives along with its barriers. In a neoliberal world focusing on macroeconomic stability over social development and exploiting the environment, there is a need to move towards envisioning a resilient society in a holistic manner such that social development occurs while safeguarding vulnerable populations and integrating climate policy with robust health policy frameworks along with ecological preservation and restoration. In order to fulfil this need, the study utilizes a mixed method approach with qualitative and quantitative methods of data collection and analysis. The research study uses Hazard, Risk and Vulnerability Assessment and mapping, Evidence Gap Maps and Sustainable Livelihood Framework, Access model and modified Tanahashi model for analysis. A gap is visible between planning and implementation of policies and schemes especially in terms of heatwave preparedness and healthcare services. Based on the analysis of the study, recommendations are shared which can be utilized to bridge the gaps.

Keywords

Heatwaves, India, cost-effective, traditional/indigenous and modern/urban solutions, Rajasthan, Uttar Pradesh, Delhi

Introduction

Extreme heat event or heatwave is referred to as a span of unusually hot weather conditions which can take place for up to 5 days consecutively and can record a temperature rise of 5°Celsius or above compared to the average temperature. The phenomenon is mostly associated with a system of high pressure which might have shifted into a region. The impact of heatwaves can be less evident at first as compared to other extreme weather events like floods and tropical storms, however thousands of lives are lost because of the abnormally rising heat. As per the Global Climate Risk Index 2020, around 3000 people died in 2018 which was more than the fatalities incurred by tropical storms (Eckstein, 2020).

Heatwaves are becoming a global issue where the major impact is visible in the northern hemisphere. It was between 1971 to 2010 when the decadal rate of global temperature started increasing (WMO, 2013). Over the years the gradual rise in

temperature continued but the year 2020, 2021 and 2022 recorded extreme temperatures. Since the past 45 years, Earth hasn't experienced a cooler year than average (Rebecca Lindsey, 2022). In the year 2022, scorching heat waves struck the globe unpredictably. Tokyo experienced temperatures above 35° Celsius for nine days straights, the United Kingdom broke its records by recording a temperature above 40°Celsius which had never happened before, China underwent consecutive heatwave incidents which affected over 400 cities and certain regions of Germany, France, Greece and Spain faced wildfires triggered by a sudden rise in temperature.

Causes of Heatwaves

Western Europe has been cited as the heatwave hotspot. Compared to the other mid-latitude regions falling in the Northern Hemisphere, extreme temperatures in Western Europe have been increasing at a rate 3-4 times faster since the past 4 decades. This phenomenon was associated with the jet stream flowing eastwards across the North Atlantic Ocean which usually breaks into 2 separate streams when it reaches Europe. As a result, heatwaves developed and persisted. It hasn't been approved yet whether the splitting of the jet stream is induced by climate change but the extreme heatwaves in the month of July, 2022 was directly associated with the double jet stream (Rousi, 2022).

Carbon emission as a result of human activities has nearly doubled the likelihood of heatwaves. At the current rate of increase in global average temperature, it is likely that every year there will be a heatwave or at least twice in every 3 years. The Fifth Assessment Report of IPCC confirms the impact of global warming on jet streams and hence the drastic changes in weather patterns. Further evidence also states that Arctic warming twice as fast compared to the entire planet has majorly affected the stalling of polar jet streams. The heatwaves in the Northern Hemisphere are mostly due to the alteration of polar jet stream which has increased the risk of heatwaves induced by global warming (Eckstein, 2020).

The 2022 heatwaves surpassed the prediction of the researchers in terms of the frequency of heatwaves by arriving sooner than expected. Energy grids were overloaded and as a result supply of electricity was disrupted during the time people needed it the most in order to cool down their homes (Witze, 2022). In a study conducted in the Pacific Northwest, record breaking differences were noticed for the year 2022 compared to the year before which almost seem implausible. The cause of the shocking event was stated to be the atmospheric system of high pressure which resulted in funnelling of hot air. Even Rossby waves were a phenomenon responsible for creating a pattern of stagnant weather at certain locations such as Europe, western North America and China suffering from extreme heatwaves in late July (Kornhuber, 2019). In Southern Asia, heatwaves came very early this year. India and Pakistan experienced extreme temperatures from as early as March till the end of May. In India, temperature was recorded higher than 44° Celsius in many parts of the country by the end of March. Around 90 people died during that period. Most researchers have pointed to climate change as the driving force behind increasing heatwaves in the region (Zachariah, 2022).

Literature Review

Heatwaves: An extreme weather event in India

India, a tropical country geographically bound by the Indian Ocean, Bay of Bengal, Arabian Sea and the highest mountain ranges of the Himalayas, is exposed to major heat stress during and sometimes before the summer months (March to July).

In the year 2018, India experienced one of the longest heatwaves which resulted in hundreds of deaths. As there is a serious lack of national level data and reliable sources for the number of heatwave deaths, fatalities are grossly underreported and underestimated (Azhar, 2019). Some of the major contributing factors to extreme heat in India include rapid temperature rise, irregularities in El Nino in the central Pacific Ocean which is comparatively warmer than the eastern part of the Ocean, tree cover loss and rapid reduction in soil moisture and vegetation shade (Eckstein, 2020). As per the Indian Meteorological Department (IMD) annual Seasonal Outlook, 2022, severe heatwaves were predicted mostly over western, central and north-western India. IMD declares an incident of heatwave when the maximum temperature of a region with low elevation crosses 40° Celsius or the average temperature increases by at least 4.5° Celsius. By the month of March, most parts of western and central India had experienced a scorching rise in temperature touching 40 °Celsius hence heatwave alerts were issued (NRDC, 2022).

Impact of Heatwaves

The health, livelihood, and efficiency of people are adversely affected by extreme heat, so it is referred to as a "silent disaster" (Magotra, Tyagi, Shaw, & Raj, 2021). In India, the effects of heat on health are severe. Apart from that, there is a wide range of other disastrous impacts of heat waves. They are:

Environment: Increased incidents of heat waves can lead to increased events of urban fires, forest fires, and even air pollution which is a direct consequence of the increased level of pollutants due to fires (Mavalankar). High temperatures during heat waves when associated with low humidity and low rainfall- drought conditions provide suitable conditions for inciting wildfire events (Dodla& Satyanarayana, 2021).

Water resources: In many areas, especially in dry and semi-arid ones, a heat wave exacerbates the water issues. Especially in the context of climate change, the event of water shortage, and excessive water use during heat waves can be harmful. (Bal, Prasad, & Singh, 2022)

Crops: The adverse effects of rising temperatures are seen in agricultural productivity. Heat stress causes changes in photosynthesis and rate of respiration, shortens the life cycle of plants, and lowers their yield. (Barnabas, Jager, & Feher, 2008). The disruption of the source-sink connection for photosynthate assimilation is the cause of the decreased crop yield in response to high temperatures (Johkan, Oda, Maruo, & Shinohara, 2011).

Poultry and Livestock: The comfort of broilers is interfered by heat, which also reduces their feed conversion, live weight gain, growth rate, and productivity (Yalcin, Settar, Ozkan, &Cahaner, 1997). Heat stress alters their metabolic, immunological, and behavioural responses. Animal productivity is decreased by heat stress in terms of milk production, body weight, and reproductive efficiency (Bal, Prasad, & Singh, 2022).

Fisheries: Aquaculture and fisheries are impacted by climate change. The distribution of some fish species may change as a result of rising temperatures, with some of them migrating to higher latitudes in search of cooler climates. (Barange& Perry, 2009).

Urban Heat Island (UHI) effect: Due to a combination of more heat-absorbing surfaces (rooftops, buildings, and paved surfaces), the trapping of hot air between buildings, a lack of tree cover, and other heat-trapping and heat-inducing factors like air conditioning and fuel combustion, residents of urban areas are subjected to higher temperatures of around 1-3° Celsius hotter compared to residents of surrounding areas. (Guleria& Gupta, 2018)

Energy consumption: One of the most vulnerable industries as a result of the anticipated increase in surface air temperature is the energy industry. The disproportionately high electricity consumption caused by air conditioning during heat waves causes power interruptions. (Bal, Prasad, & Singh, 2022)

Infrastructure: Infrastructural facilities often suffer huge damage due to increased temperature due to heat waves like melting and buckling of roads, kinking and buckling of railway lines, and bursting of water pipes (Dodla& Satyanarayana, 2021).

Health: The direct impact on health due to heat waves involves– heat syncope, heat cramps, hyperthermia (heat stroke), exhaustion, cardiovascular and respiratory disorders, and even death. It can also worsen pre-existing comorbidities like dehydration, heart, and kidney problems, etc. Increased temperature is connected with heightened interpersonal and societal conflicts and particularly violent crime rates (Hisang, et al., 2015).

Livelihood: Psychological stress caused by heat waves in turn affects performance levels and physical activity. (Dodla& Satyanarayana, 2021) Decrease in working hours and ill health affect the income earning of individuals.

Vulnerabilities

India in particular is more vulnerable due to factors like social and economic inequality and colonial history. As per the official estimates, over 270 million people in India are below the poverty line. The poor people are among the worst affected during any extreme weather event. As a huge number of poor and socially excluded people are engaged in unorganized labour in construction and agriculture, the exposure to heat during summer is maximum for them (Eckstein, 2020). Daily-wage workers, street vendors, construction workers, rickshaw pullers, etc., are particular groups in need of protection from extreme heat. Infrastructure deficiency in Indian cities post migration from nearby villages leads to enhanced exposure to heat. Slums have warm interior temperatures because the roofs are made of plastic or tin sheets,which absorb heat and cause the homes to act like ovens (NIUA, 2016). Residents of slums, squatter settlements, illegal housing complexes, and crowded, poorly ventilated residential areas are also at risk. The elder population segment (people 65 years of age and older) is one of the most susceptible to the dangers of heat. Infants, young children up to 4 years old, those with chronic health conditions, and those with impairments are also susceptible to the impacts of heat waves. People who overexert themselves, are obese, are not adapted to hot weather, have pre-existing medical disorders like diabetes and heart disease, or who use alcohol or drugs are at also high risk. The Indian government has taken various measures to address the growing heatwave situations like formulating heat plans, conducting public awareness programs, medical staff training, altering working and school days and timings, arranging shelters for homeless people and providing them drinkingwater and food. Despite these measures, many are unable to gather the benefits due to various loopholes in implementation and the existing social vulnerabilities based on gender, caste, ethnicity, age, disabilities etc (Azhar, 2019).

Purpose

The current study tries to highlight the differential impact of extreme heat on the vulnerable populations of tribal, rural and urban areas of India and identifies local cost-effective traditional and modern solutions and policy initiatives along with barriers in their implementation. Suggestions and recommendations are also provided, which can be useful in addressing the barriers in access to healthcare and designing participatory approaches to cope with extreme heat.

Aim

The heatwave impacts the most vulnerable populations in India lead to the question - which among indigenous solutions is the most viable and cost effective that can help the vulnerable people of Rajasthan, Uttar Pradesh and Delhi to protect against extreme heat? The measures that can be adopted to cope effectively with future events of extreme heat conditions also need to be focused on.

Research Questions

3.1 Which intervention, including indigenous solutions to protect against extreme heat, is the most viable and has the most return on investment, defined by lives saved for the modest cost? In heatwave prone urban and rural settings in India

3.2 What are the main barriers to accessing cooling options or medical care for extreme heat? What policies could help to address these barriers?

Research Objectives

- To determine the intervention, including indigenous solutions to protect against extreme heat which is the most viable andhas the most return on investment, in heatwave prone urban and rural settings in India.
- To investigate the main barriers to accessing cooling options or medical care for extreme heat.
- To identify the policies that can help to address these barriers.

Study Area

For the study, the Indian states of Rajasthan, Uttar Pradesh and Delhi have been selected. One urban, tribal and rural site has been selected as the study area. Within the state of Rajasthan, Siyawa tribal village has been selected which is one of the 86 villages in Abu Road Tehsil within the district of Sirohi. Within the state of Uttar Pradesh, in Gorakhpur district out of the 7 sub-districts, Khajani sub-district has been chosen under which Dhaisariya rural village has been chosen out of 739 villages. For urban sites, the North East district of Delhi has been selected. In North East Delhi, Seema Puri locality has been selected as the study area.

Rationale for selected site of study

Uttar Pradesh, Rajasthan and Delhi experience extreme heat in summer and are home to several marginalized communities The selected locations also bring out the difference between the vulnerabilities of tribal, rural and urban settings and their coping strategies. Siyawa village in Rajasthan falls under Jodhpur Division and is located in the southern half of Sirohi district which a greater share of rural/tribal area has compared to the urban area i.e. 79.86 %. The village is dominated by people belonging to the Schedule Tribes who constitute 98% of the population and the total literacy rate is only 24%. As a result, the majority of the workforce is employed as an agricultural labourer or construction worker.

The summer of 2022 in India reported its hottest 203 days caused by the heatwaves which was 5 times more than last year. Rajasthan located on the Tropic of Cancer underwent 26 episodes of sweltering heat which was the second highest among the Indian states after Uttarakhand (Mohan, 2022). During the heatwave period, the maximum temperature recorded in Sirohi district was 41° Celsius (OutlookWebDesk, 2022). The minimum temperature on the other hand remained above 30 °Celsius throughout the period (PTI, 2022). Abu Road within the district of Sirohi has witnessed a constantly rising trend in average temperature increase where the major impact was felt since the month of March 2022. The daily temperature increased by 4°Celsius.

As shown in the line graph, the highest temperature in Abu Road was between 95 ° Fahrenheit and 102° Fahrenheit in the month of March i.e. 35° Celsius to 40° Celsius. Even the average minimum temperature was above 26° Celsius (WS, 2022). The temperature was witnessed increasing throughout the month of April till end of May after which a steady fall in temperature was noticed.

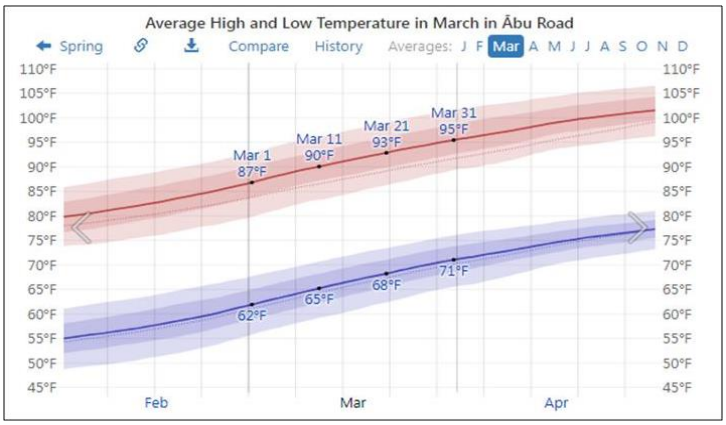


Figure 1: WeatherSpark graphs, Abu Road

Within the state of Uttar Pradesh, Gorakhpur district has been selected for the study. Major heat wave-prone areas in Uttar Pradesh include Allahabad, Varanasi, Gorakhpur, Bareilly, and Lucknow. Additionally, Gorakhpur had historically witnessed significant changes in the pattern of rainfall. Thus, there is an increasing susceptibility of the district to heat waves. (Gupta et al., 2019). Dhaisariya village, Khajni Tehsil in Gorapkhpur district, is a medium-sized rural village of 57.07 hectares in area with a total 46 families residing. The literacy rate of Dhaisariya village is 82.74% and the work profile shows 18.18 % of workers are main workers while 81.82 % are involved in marginal activity (Census, 2011).

It can be observed from the line graph that there has been a continuous rise in temperature from the month of March and it continued till the month of June. On the 6th of May, the temperature reached a maximum level rising to 100° F. This reflects a rising trend in temperature, especially in the months of March, April and May.

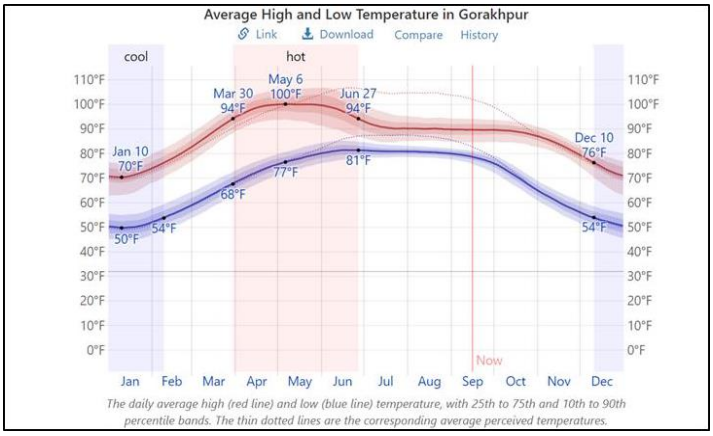


Figure 2: WeatherSpark graphs, Gorakhpur

Uttar Pradesh experienced 11days of heat wave from 11th March to 24th April, 2022 (CSE, 2022). As per 2011 census, among the total number of workers in the Gorakhpur District is 1,351,629, a total of 174,804 people depend on agriculture farming. The agriculture sector has to bear the greatest burden of extreme weather conditions and so does the livelihood of the people associated with this sector.

For Delhi, the North East region has been selected. In Delhi, due to the rise in temperature and relative humidity, it is possible to predict that the frequency of heat waves will grow in the next few years. Under North-East Delhi, a town and tehsil, Seema Puri has been chosen as the study area. According to the 2011 Census, the Seema Puri tehsil has an area of 8 sq.km with a population of 5,39,914 individuals, out of which 286,091 are males while 253,823 are females. 82.39 % of the total population is literate. Schedule Caste constitutes 29.8% while there is no Schedule Tribe population. 92.9% of workersare main workers while 7.1% are involved in marginal activity (Census, 2011). In the North East Delhi district of Delhi, a total of 975 families reside on footpaths or without any form of roof protection as per 2011 census. Also, a large portion of the total population lives in slum areas and is engaged in the informal sector. These segments of the population are more susceptible to heatwaves.

It can be observed from the line graph that there has been a continuous rise in temperature from the month of April and it continued till the month of June. On the 29th of May, the temperature reached a maximum level rising to 103° F.

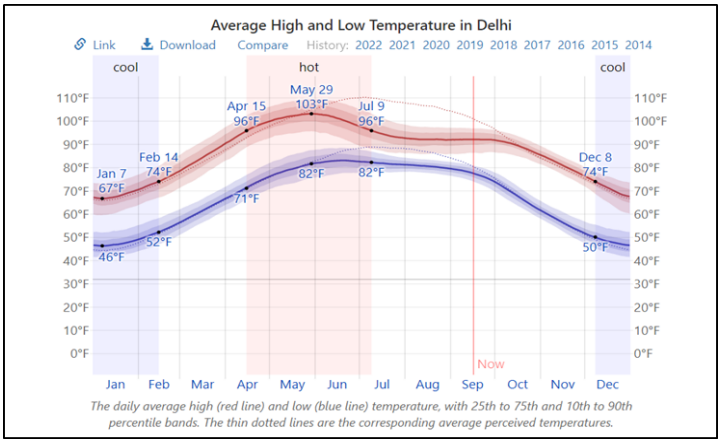


Figure 3: WeatherSpark graphs, Delhi

Owing to these risks experienced by populations in these states, these settings have been selected for the current study. Communities in each of these locations have their own coping mechanisms based on local knowledge. The policies, schemes and state action for healthcare for responding to risks of extreme heat may also be different in each of these locations due to varying geopolitical settings and socio-economic status. Thus these 3 locations present interesting cases forinvestigating the cost-effective solutions and barriers to healthcare to reduce the risk of extreme heat.

Observations for each site

Dhaisariya village, UP

Dhaisariya village, Khajni Tehsil in Gorapkhpur district, is a medium-sized rural village of Uttar Pradesh. It is well populated and the village does not have Scheduled Caste and Scheduled Tribe population. The majority of the people in this

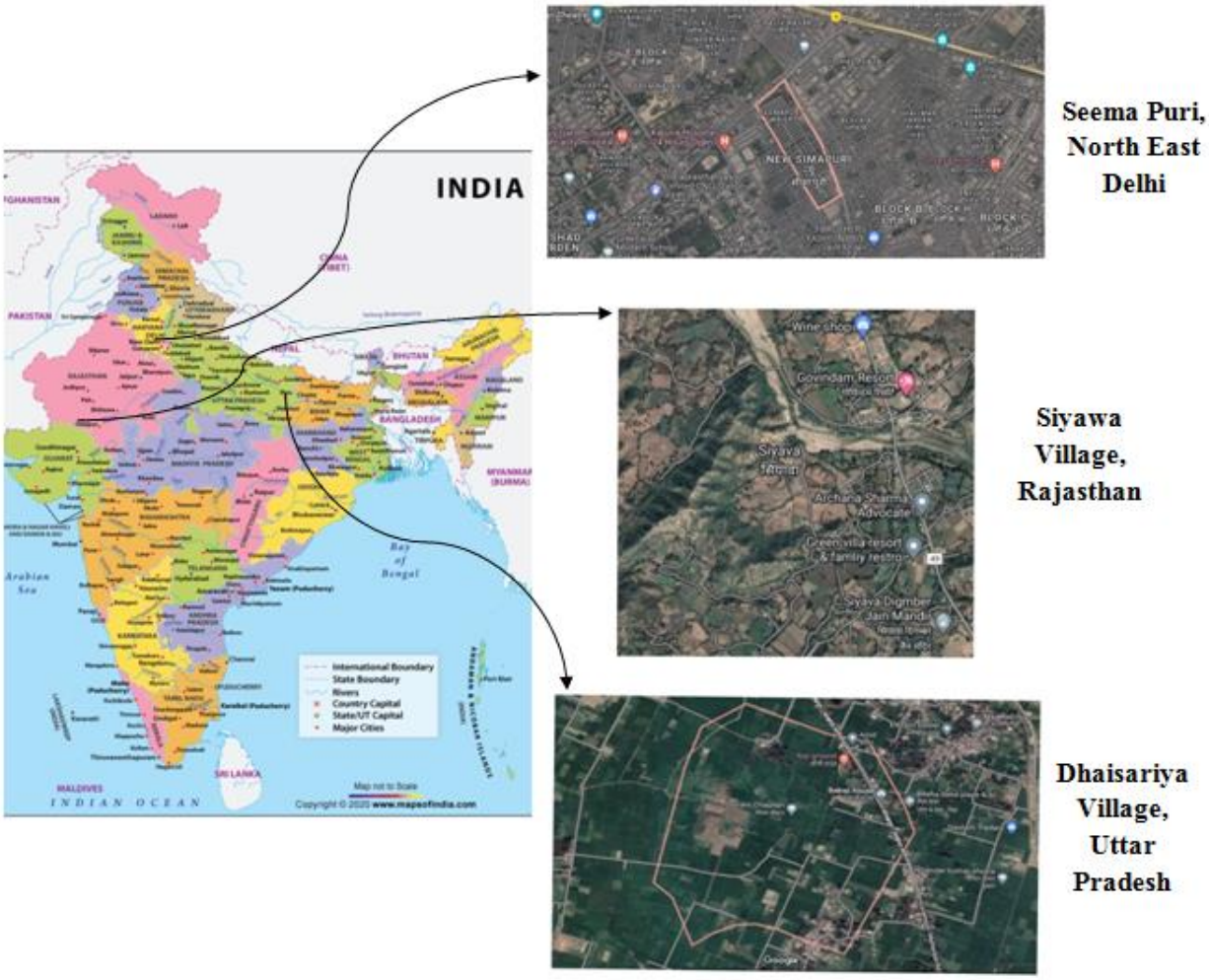
village are engaged in marginal agricultural activity while some are heavily dependent on agriculture farming. They are also engaged in cattle and other livestock rearing. The housing structure in the village involves both Kutcha and pucca houses. There are also traditional indigenous housing structures present. Vegetal cover is present but not adequate. There is no nearby health facility in Dhaisariya village.

Seema Puri, North-East Delhi

Seema Puri tehsil located in North-East Delhi, an urbanized area of Delhi is densely populated. Schedule Caste and Scheduled Tribe population are sparsely present. The people here mostly reside in slums characterized by small congested housing structures. A large section of the people residing in slums is mainly engaged in marginal activity i.e., informal sector. They are engaged as street vendors, rickshaw pullers, factory workers, daily wage laborers etc. there is lack of vegetation in the area, however there is a public park nearby available as green open space. The people of the community have placed water jars in different areas so others could take water from them. In Seema Puri the health facilities are available nearby and are accessible.

Siyawa Village, Rajasthan

Siyawa Village, a part of Abu Road Tehsil under the district of Sirohi, Rajasthan, lies near the Gujarat state border. It is a fairly small village lying at the outskirts of the Abu Road town which is also the financial hub of the district. Out of the total population, the majority of the people belong to the Scheduled Tribe group. The primary economic activity in the village is cultivation followed by agricultural labor. Women participate equally in the economic activities but have a flexible time hence they were mostly available for interviews in comparison to men who were working in the fields away from home. The housing structure in the village consists of maximum kaccha (mud houses) and a few pakka (brick and cement houses). Vegetation cover is sparse in the village but a few traditional techniques have been adopted to increase plant growth. Healthcare Centre is available for the people in the village but the services provided are not sufficient in times of heatwaves.



Models and Frameworks used for analysis

To achieve our objectives, modified Tanahashi model, Sustainable Livelihood Framework and Access Model were used.

Tanahashi Model

The Tanahashi coverage model is one of the models utilized in the study for understanding health service coverage and gaps from both supply and demand side. In 1978, the model was developed by Tanahashi which introduced evaluation and

monitoring of existing health systems. In 2010, Frez and Vega added the interaction of demand and supply at multiple levels and the needs of groups who are greatly vulnerable. The modified framework upheld the influence of social policy and health on the characteristics of the health system and livelihoods, vulnerability, health service needs and empowerment among the people. Hence, the '*Sustainable Livelihood Framework (SLF)'* was also incorporated within the modified Tanahashi model under social policy where vulnerability of an individual or a community was viewed as an outcome of lack of fulfilment of basic needs in life and how they function living within vulnerabilities (McCollum &Taegtmeyer, 2019).

Access Model

The other model which has been chosen for the study is Access Model by Wisner et al. as it provides a useful and dynamic framework to conceptualize social vulnerabilities and provides a scope to analyze the precise interactions between environment and society when the disasters start to unfold. The Access model highlights the trajectory and establishment of vulnerability at a micro-level in addition to its variation among households as well as individuals (Ben Wisner, 2003).

a) b)

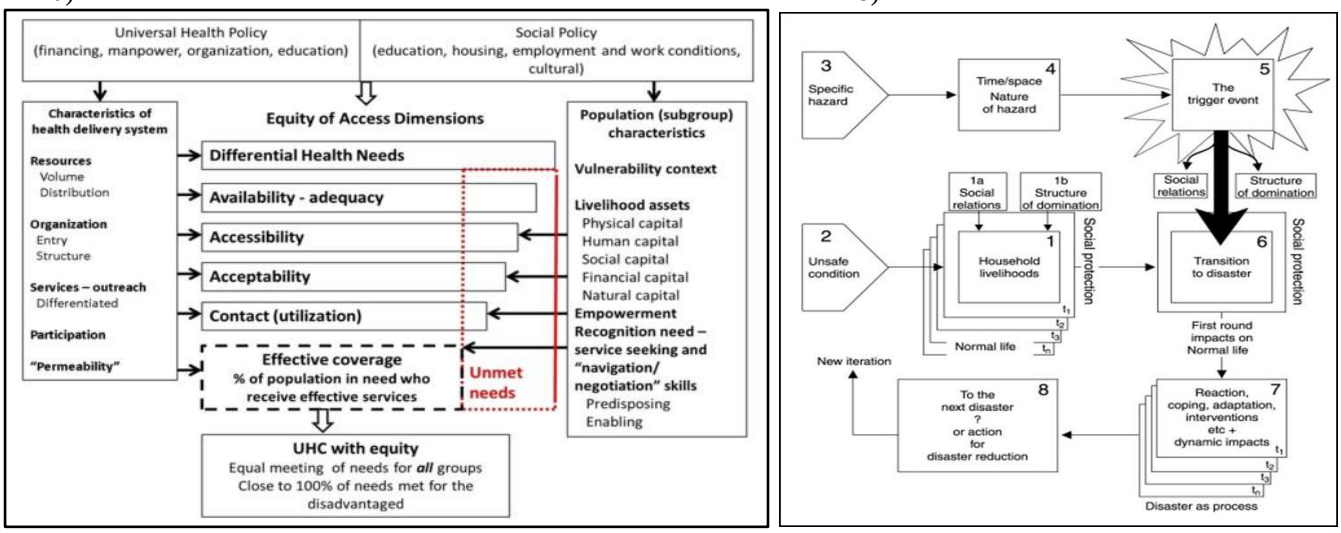


Figure 4a: Tanahashi model for health service coverage [Source: (McCollum &Taegtmeyer, 2019)]

4b: The Access Model [Source: Wisner et al., 2003]

Rationale for the risk frameworks: *This study has used a vulnerability and capacity approach where risk is defined as a combination of hazards, vulnerabilities and capacities. It can be given by a general formula:*

Risk = Hazards x Vulnerability/Capacity

In studying extreme heat from this approach, it is important to understand not just the physical hazards of high temperature and humidity that the people are exposed to, but also their social vulnerabilities owning to an LMIC context, colonial history and current political dynamics, which make them poorly equipped to adapt to the changing climate as well as extreme weather events. Nevertheless, each community as well as individuals have capabilities that can be used to build resilience provided adequate laws, policies and programmes are in place. With this rationale, we have combined the various methods of data collection from the 3 sites using geospatial techniques, social vulnerability calculations to develop the risk maps and then further understand the vulnerabilities, capacities and existing policy frameworks through primary data collection and in-depth literature review. The literature review and mapping techniques provide macro-lens and a static view of the scenario. Hence the primary data is useful to provide a micro-level perspective and capture the dynamics at the community level. The primary

data collection tools have been developed using the following analytical frameworks so as to bring out information relevant to the research objectives.

For the study, Tanahashi model is used to examine the health service coverage, and the Sustainable Livelihood Framework (SLF) integrated with it to understand vulnerabilities where transforming structures and processes along lack of assets form a major barrier to fulfill basic needs, means of income generation and wellbeing. The Access Model is used for conceptualizing social vulnerabilities and analyzing interactions between environment and society. The three models and framework will help answer what are the most cost-effective indigenous solutions to protect against extreme heat, what are the barriers to access medical care during extreme heat and what policies can address these barriers.

Tanahashi Model

The Tanahashi coverage model is utilized in the study for understanding health service coverage and gaps from both supply and demand side. In 1978, the model was developed by Tanahashi which introduced evaluation and monitoring of existing health systems. It comprises 5 stages which are distinct from one another and requires following a sequential order for predicting the quality i.e. proportion of health services with people. The model emphasizes on the availability and requirement of essential medication and services along with human resource i.e. "availability coverage" -the first step in order to attain effective and universal coverage. It is followed by devising strategies for mitigating obstacles to accessibility in health intervention i.e. "accessibility coverage". After accessibility and availability, Tanahashi upheld the importance of addressing other factors like beliefs, values and affordability in order to enhance people's willingness for the utilization of intervention i.e. "acceptability of coverage". By ensuring the fulfillment of these stages, people would undergo continued interaction with essential medical requirements and the ones who are providing the service i.e. "contact coverage", which would further lead to quality coverage or "effectiveness coverage". Tanahashi identified gaps in the health system by finding out the difference between "effectiveness coverage" or proportion of people interacting with the model's 5 states and "nominal coverage" or proportion of people interacting with only the first 3 stages of the model, hence the gap needs to be filled (Ebhohon, 2018). In 2013, O'Connell and Sharkey discussed limitations in the original Tanahashi model when Sustainable Livelihood Framework (SLF) was integrated within the modified Tanahashi model. As per their study, the 5 stages of the model were evaluated using data from the public sector only. This resulted in an important modification in the model which focused on ensuring appropriate measurements in data and proxy indicators for evaluation and monitoring of the 5 stages. Furthermore, the stage of availability coverage was divided into 2 different parts i.e. "availability of essential commodities" and "availability of human resource", in order to improve data management of healthcare services by the ones providing it (Sharkey, 2013).

Sustainable Livelihood Framework

Sustainable Livelihood Framework (SLF) views the vulnerability of an individual or community arising from the lack of fulfillment of basic needs in life and how they function living within vulnerabilities shaping factors like opportunities, seasonal constraints and economic shocks. This framework focuses on the asset pentagon: human, natural, physical, financial and social capitals. It also understands that ownership of capital helps the community or individual recover easily and provide livelihood opportunities in the time of numerous hazardous events. It depicts stakeholders who are functioning in the vulnerability context, in which they can only access certain types of assets. The assets are impacted and influenced by the transforming structures which comprise public and private sectors and processes including institutions, policies, regulation and practice. All these influence the livelihood of marginalized people. It shapes their strategies of livelihood which are available for people to access in order to achieve beneficial livelihood outputs. The livelihood strategies hence comprises combination and range of various

choices and activities which people decide to undertake for achieving livelihood goals. It is a dynamic process where people work with more than one combination of activities for meeting their needs. They also impact the vulnerability context of the poor and their access to assets. The outcome of transforming structures and processes are livelihood strategies consisting of activities and choices, which result in increased income, well-being, reduced vulnerability, improved food security and sustainable use of resources. Usually the aim and the extent need to be clear before proceeding with the chosen activity (DFID, 2000).

Access Model

The Access Model by Wisner et al. provides a dynamic framework to conceptualize social vulnerabilities and scope to analyze the precise interactions between environment and society when the disasters start to unfold. The Access model highlights the trajectory and establishment of vulnerability at a micro-level in addition to its variation among households as well as individuals. It particularly focuses on their coping and adaptation strategies of the individuals before the arrival of the next disaster. Thus it helps to fill up the gap of the SLF model. It makes disasters and its impact an important component along with the people related to it through their agency and role and how they cope and implement strategies for recovery. The model defines a normal life through the context of livelihood having differential access to political, social and material resources. It is represented by assembling 8 boxes consisting of interrelated processes, events and ideas. The arrows in the above diagram depict these interrelations and linkages from its cause to its effect but sometimes effects can also influence the causes. Hazard as a component in this model has specific space and time characteristics which can lead to something called a 'trigger event', which can be an earthquake or a drought or floods etc. In normal times, households earn livelihood and are susceptible to unsafe conditions. The economy, in which they live in, is also heavily influenced by politics and can get shaped by structural domination and social relations. When the trigger event takes place, both the structural domination and social relations get impacted along with the households as well. Next a thick black arrow is shown pointing towards 'transition to disaster' which is also the layer of 'social protection', comprising public, collective and individual aspects. It is followed by a series of human responses and impacts over time which later leads to the question, 'To the next disaster?', and further indicates a condition of preventive actions, social protection and vulnerabilities which gets altered (Wisner, 2003).

Methodology

Research approach and methods

The study has utilized a *mixed method approach* with qualitative and quantitative methods of data collection and analysis implemented concurrently. The method involves 3 components: Heatwave risk mapping, Evidence Gap Map (EGM) and Community perspectives on extreme heat.

Extreme Heat Risk Mapping

Using the Geographic Information System (GIS) approach, the risk of heatwaves in the specific study regions of were determined. Rainfall, humidity, and temperature variation during the heatwave season (mid-April-mid July) have ben specific quantitative indicators of hazard, risk mapping. The shapefiles for the risk maps were obtained from the reports of *Socioeconomic Data and Application Center (SEDAC).* To create the heatwave risk maps the following risk framework developed by Crichton David (1999) and Tomlinson et al., 2011 was used (Buscail et al., 2012). The risk maps were generated in ArcGIS tool where the Social Vulnerability indicators were integrated with Hazard indicators using weighted overlay method. The Land Surface Temperature (LST) was calculated using raster data of MODIS 8-day observation composite output of daily day/night land surface temperature at 1km global resolution (*MOD11A1 Terra Product*). The MODIS LST

emissivity data consists of atmospheric temperature, atmospheric water vapor and land use type. The effective calibration formula for the "LST" Scientific Data Set (SDS) is LST = the SDS data in unit 16 * 0.02, giving a value in the range of 150-1310.7K (in Kelvin unit) which was converted to ℃ by subtracting 273.15 [T(K)= 273.15+T(℃)]. The LST Maps were prepared using Google Earth Engine. The Social Vulnerability Index was calculated using Census 2011 for each village and town/ward in Gorakhpur, Sirohi districts and North East Delhi division. The specific variables used for the calculation were: Total population in the village, Male female ratio, Female illiteracy ratio, Occupation and Caste or tribal status. The main social vulnerabilities identified in each location, as per Indian context were: belonging to an SC or ST category, being landless labourer or marginal worker, or unemployed and high female illiteracy. Based on this context, appropriate weightages were assigned to the variables corresponding to these vulnerabilities. The vulnerability scores were then normalized and standardized and an aggregate SVI score was calculated. The SVI scores were calculated in the range of 0-10 as a non-integer data type. The final calculated SVI scores were allocated for different sub-districts respectively using the shapefile (Shp files) followed by raster conversion. The raster layers of LST maps and SVI maps were reclassified using ArcMap 10.3 version application of ArcGIS system. The reclassified maps were further assigned weightage and overlaid using Weighted Overlay tool in ArcMap 10.3 application. The layers of LST and SVI were assigned 50:50 weightage before overlay and the final heat wave risk maps layout were prepared.

Evidence Gap Map

A systematic review of the existing literature on policies, programs, interventions, and indigenous solutions to address heatwaves in the selected locations was done. Research papers, journals, and academic articles were referred to for collecting secondary data and a visual Evidence Gap Map was prepared as shown in Appendix 1.· The keywords used in the search for academic articles were defined by research question 3.1. Google scholar service was used for searching articles. Articles retrieved using keyword search were further filtered based on the date of publishing between 2018 to 2022. From these only the review articles were selected. Further paid articles were excluded and the remaining articles were used for abstract screening. After filtering them according to research question requirements, the remaining articles were used for full-text screening based on the various categories of interventions and outcomes for extreme heat. The codes were provided to each and every article and marked accordingly in the EGM template. A total of 6 keywords were used to completely cover the scope of the research question. The exact protocol of refining the search and the articles used for preparing the EGM is described in Appendix 2.

Community perspectives on extreme heat

In order to validate the findings from the heat risk map and EGM and to understand the existing policies and solutions for extreme heat from grassroots communities' perspective, primary data collection using *key informant interviews (KIIs), in-depth interviews (IDIs) of vulnerable individuals from the community, focus group discussions (FGDs)* and *health system survey tools was performed.* Integrated *Tanahashi model,* and *Access Model of Vulnerability* were used for data collection and analysis. This arm of the study focused on the barriers to cooling options and healthcare service to protect from extreme heat, gaps in the existing policies, their implementation, and issues of equity. FGDs were conducted based on the guidelines prepared by the research team, for collecting generic information, perspectives and thoughts of the community on extreme heat. A few individuals from the focus group were selected for IDIs to gain a detailed and specific insight into the impacts and solutions to heatwaves. *KIIs* were conducted to gather in-depth information from key officials and representatives in the locality. Separate guidelines for *IDIs and KIIs* were prepared**.** The interviews were *semi-structured interviews* prepared in advance. The questions were kept *open-ended* that would provide new insights which may be unexpected and more detailed answers while conducting the interviews which would help in-depth understanding. All guidelines for KIIs, IDIs and FGDs

were translated to local languages for the ease of collecting information from the local population. Criterion sampling followed by the snowball sampling technique was applied to select the KII participants. The selection criteria for key informants included- being an official from Health, Disaster Management official, or Water management departments, primary health care center or a self-help group involved in providing health and welfare services to the local communities in the selected sites. The local partner organizations from each location enabled this data collection, storage, transcription and translation. From Siyawa, Rajasthan, 3 FGDs and 2 IDIs were conducted. From Dhaisariya, Uttar Pradesh, 3 FGDs, 6 were KII and 3 IDIs were conducted. In Seema Puri, Delhi,4 FGDs and 6 IDIs, 5 KIIs were done. Additionally, data on the situation of healthcare services in each of the study sites was obtained with the help of a Health Facility Assessment Survey tool designed by the research team. The interviews were recorded in the local language/dialect of each location, which were then translated and transcribed in English and the field observations were written down. The transcripts were coded with help of MS Word. The codes were combined to form categories and then the themes were formed. These themes were analyzed based on modified Tanahashi and Access models. All survey tools are provided in Appendix 3.

Table- FGD and interview details

Study Areas	***Number of FGDs***	***Interviewee***	***Number of IDI***	***Interviewee***	***Number of KII***	***Interviewee***	***Health Facility Survey***
Siyawa village	*3*	*Adult Women and teenage girls*	-	-	*2*	*Anganwadi workers and Ward Panch*	*1*
Dhaisariya village	*3*	*Adult men and women*	*3*	*BMC, BPM and Pradhan*	*6*	*Asha worker, CHC doctor, Helper*	*1*
Seema Puri	*4*	*Adult men and women*	*6*	*Community members*	*5*	*Anganwadi worker, Councillor, Teacher, Worker of Jansandesh and Worker of RWA*	*1*

Ethical Considerations

Before conducting the interview, the participants were given complete information regarding the study and they were provided with the Informed Consent Form (Appendix 4) stating the purpose of the study. They were informed that their participation in this study is voluntary and they might withdraw from the study at any time. They were also informed in advance that the interview session would be recorded. Only after the participants gave their consent, the interview was conducted. Their consent was taken and it was ensured that whatever information they have given will be kept anonymous and their names will not be enclosed to any other entity. After completing the preliminary analysis, the findings were shared with the grassroot level leaders from Rajasthan, Uttar Pradesh and Delhi, who had helped in the entire process of data collection from these three locations. Along with them, all the members of the Research team, the Research mentors aswell as the external advisor were present. The findings were validated by these leaders in the online meeting. Further, these community leaders and all other members provided feedback based on the findings and analysis. The suggestions made by each of the members present were taken into consideration and were incorporated in the final report.

Findings and analysis

Heat Risk maps

The Sirohi district in Rajasthan underwent massive heat stress during the months of March, April and May this year. As per the Heatwave risk map showing the variation in heatwave risks across the Sirohi district, highest risk is observed in Sirohi sub-district probably owing to the population density in the urban and peri-urban areas. In comparison to Sirohi sub-district, Abu Road is seen to be the lowest heat wave risk area. One of the chosen area of study i.e. Siyawa village is situated at the southern tip of the district of Sirohi hence falling within the low heatwave risk zone of Abu Road. However, it is worth noting that frequent and rigorous temperature monitoring of urban areas and more developed regions in a state may mislead researchers into believing that an urbanized area is more at risk, whereas the underserviced areas like the tribal hamlets in remote villages might be overlooked for study and monitoring. These areas specifically are under-resourced and vulnerable to health impacts of heatwaves due to poor access to healthcare services, employment in the informal sector of the economy and social exclusion. Based on these, we selected a less studied area of Siyawa tribal village in Abu Road tehsil.

The Gorakhpur district in Uttar Pradesh underwent massive heat stress during the months of March, April, and May and it continued until June this year. As per the Heatwave risk map showing the variation in heatwave risks across the Gorakhpur district, the highest risk is observed in Gorakhpur sub-district. In comparison to Gorakhpur sub-district, Gola is seen to be the lowest heat wave risk area. Other sub-district like Campierganj, Sahjanwa, Chauri Chaura, Khajni and Bansgaon fall in the high to moderate heat wave risk zone. A major part of the district shows high heat wave risk according to the final maps. One of the chosen areas of study, Dhaisariya village is located in Khajani sub-district, which is situated in the South Western part of the Gorakhpur district hence falling within the high heatwave risk zone.

North East Delhi, a district of Delhi underwent massive heat stress during the months of March, April, and May and it continued until June this year. As per the Heatwave risk map showing the variation in heatwave risks across North East Delhi, the highest risk is observed in Seema Puri sub-district. In comparison to the Seema Puri sub-district, Saleem Pur is seen to be the lowest heat wave risk area. Shadara falls in the moderate heat wave risk zone. A major part of the district shows low heat wave risk according to the final maps. One of the chosen areas of study i.e., Seema Puri, is situated in the South Eastern part of the North East Delhi district hence falling within the high heatwave risk zone.

All the selected study sites faced the extreme summers this year signified by hot winds or '*loo*'. It affected their livelihood, especially livestock and agricultural activities, education of children, health, social life, and overall daily life of the people. The informal sector workers who had to go out for work in spite of the scorching heat were the worst sufferers along with children and elderly people.

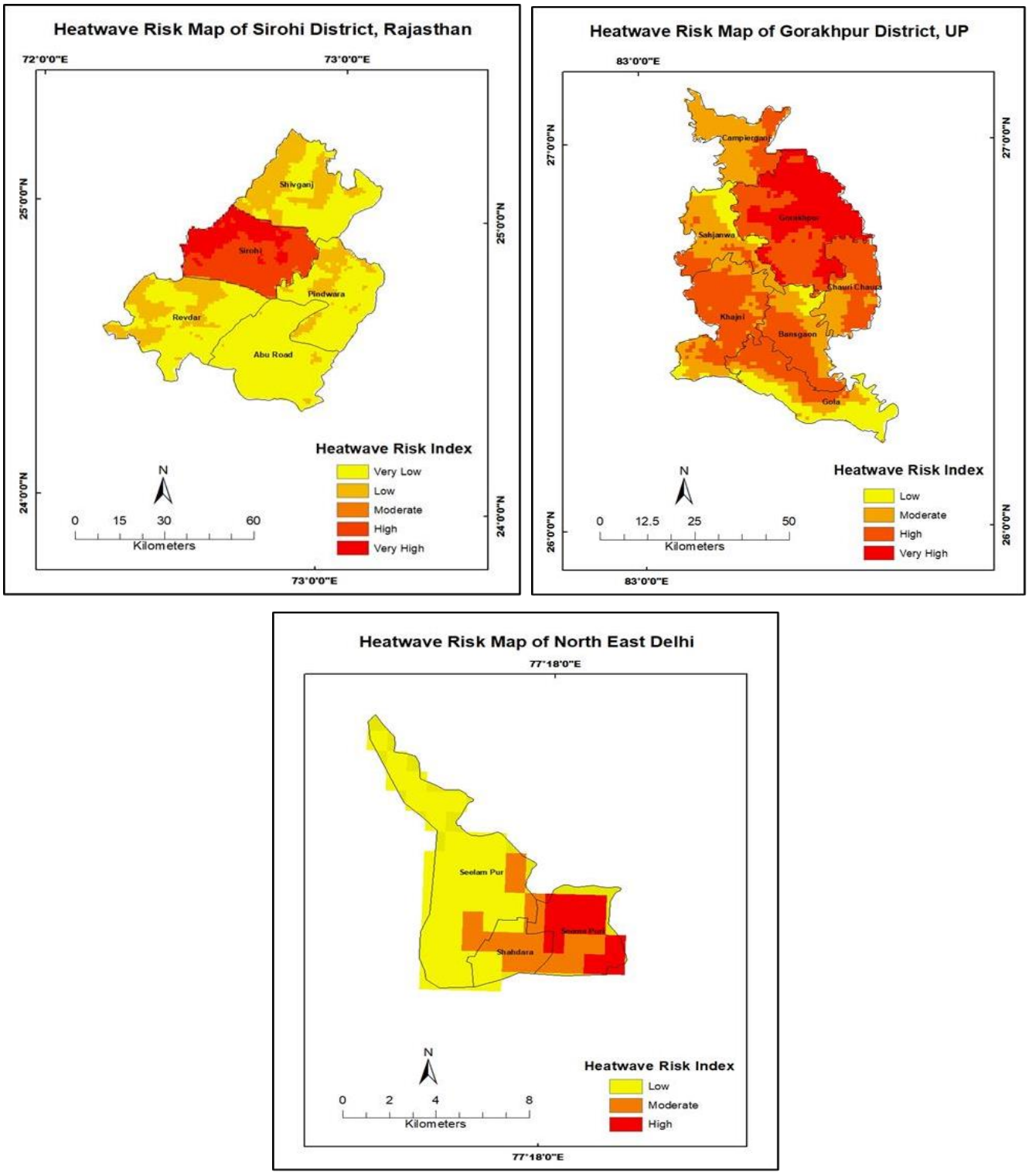


Figure 5: Heatwave Risk Maps for Sirohi district, Gorakhpur district and North East Delhi

EGM

An Evidence Gap Map (EGM) of the existing literature was created on policies, programs, interventions and indigenous solutions, to address heatwaves in the selected locations and analyze policy for understanding existing government strategies and gaps in the existing system. The EGM map given in Appendix 1 was prepared manually using codes for the scholarly articles used in preparing the map. The following are the major themes based on which the EGM has been analyzed in order to find out the existing studies conducted on heatwaves and gaps which have not been addressed.

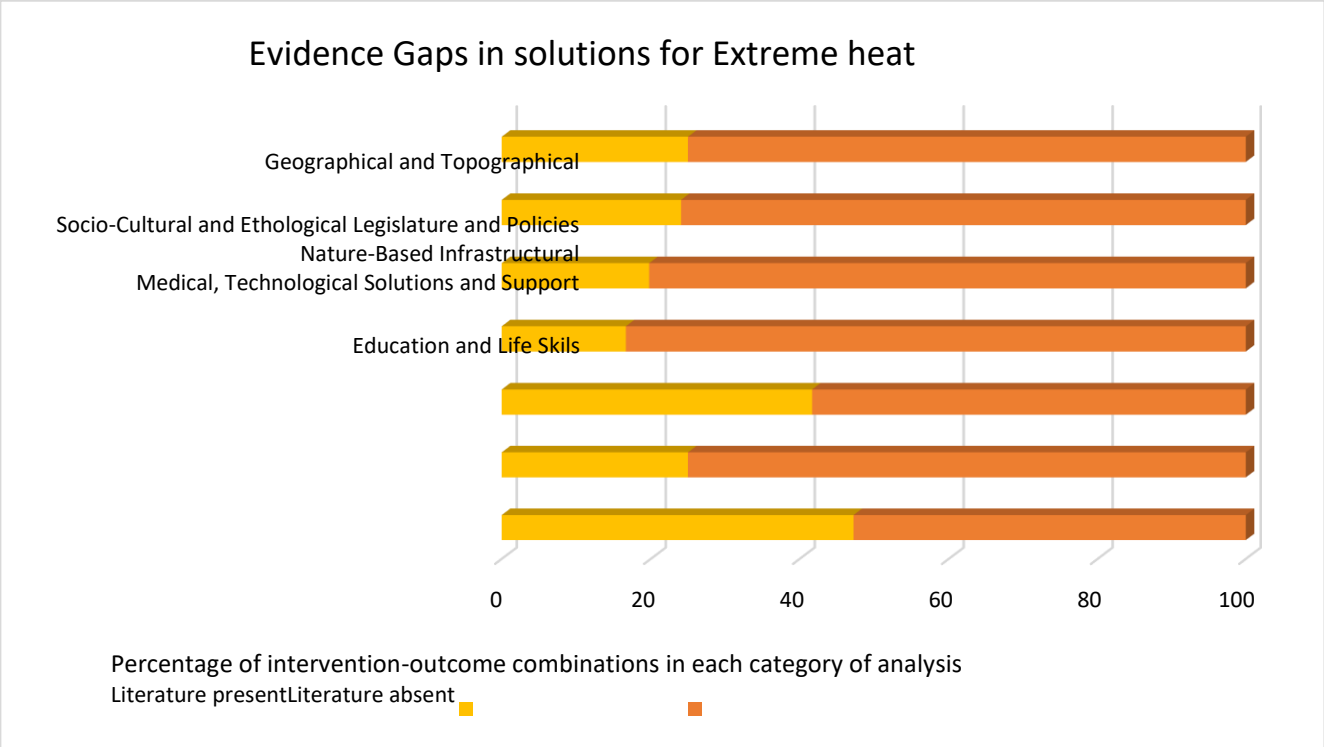


Figure 6 Evidence gaps in solutions for Extreme Heat in India. Prepared based on EGM in Appendix 1

Nature-based Solutions: Among all the themes or variables, nature-based solutions for heatwaves are most neglected. Traditional solutions like planting trees, ensuring presence of water bodies and altering working hours are incorporated most in the studies where it highlights a requirement for community level policies, programs for housing and cost-effective solutions. Modern solutions like parks, urban green belts and new water bodies focus on informing policies and programs at community level. The importance of these traditional and modern solutions for individual and government level policies are not covered in the articles referred for the EGM literature. The role of traditional solutions for economic, social, and health outcomes in terms of poverty and food security, employment and labour force, and finally in terms of morbidity and comorbidity are yet to be researched. Contemporary solutions like drinks, food and clothing which would prevent people from the scorching heat are also not part of the literature.

Legislature and Policies: Among the existing studies on heatwaves, major gap in literature has been on legislative changes and new policy interventions. As represented in the EGM, most of the articles concentrated within this variable are studies at National level. Few articles concentrate on local community level dynamics. Studies conducted at a national level are mostly focused on formulating heat action plans and climate change policies followed by labour laws, welfare schemes and meteorological forecasting. From the existing referred literature, at institutional level the evidence addresses a few measures on awareness drives and NGO interventions. Topics of insurance, economic aid and support have not been covered. Studies on the local level have been limited to on labour and wage hour management. There is a lack of much literature on law and order and resource mobilization. For labour and wages hour management, studies are limited to cost - effectiveness in economic activities and do not address the health, mental health, and food security concerns. At the institutional level, there isa dearth of policies and action that address health concerns for heatwaves. In the case of state level, studies have not been conducted to show the effect of interventions on the economic, social and health outcomes. Therole of extreme heat policies, labor laws leading to individual and government policy level changes, health, mental health, and medical, social/community level program outcomes have not been studied at the state level. Interventions like community resource mobilization, what is their impact at individual and Government level changes, health, mental health, and medical, economic and agricultural activities, social/community level and legislative program level outcomes have also not been studied. There is a lack of studies of advisories, action plans' outcomes at individual and Government level, health, mental health, and medical, housing and landscaping, social/community level, legislative programs. Studies on medical, water, and safe shelter supply programs, economic, social and health outcomes and policy level changes except forpolicies at community level are not covered. Similarly, there is a lack of studies on the role of welfare schemes related programs, economic, social and health outcomes and policy level changes except for policies at individual level. Finally at the Union/National level, studies of directives and advisories leading to policy level changes, development of economic andagricultural activities, housing and landscaping, social/community level programs and improvement in employment and labor force, cost-effectiveness, morbidity and comorbidity levels are missing from literature in this EGM. Meteorological forecasting causing outcomes related to individual and community level policies, housing and landscaping programs and economic, social and health aspects, studies are absent. National heat action plans, climate change policies, jurisdiction relating to individual and community level policies, social/community level and cost-effectiveness, morbidity and comorbidity outcomes have not been studied. Finally, Labor laws and welfare schemes for outdoor workers causing economic and agricultural activities, social/community level and legislative programs and economic, social and health aspects are yet to be studied.

Heat Action Plan for 3 states: Seventeen states in India that are vulnerable to heat waves have created "Heat Wave Action Plans" (HAP) in the last five years. Additionally, more than 120 districts and cities across fourteen states have created independent district level Action Plans. Through coordinated work with numerous agencies, these plans assist the state governments in developing measures and policies for "heat wave assessment, forecast, preparedness, and mitigation" (NDMA, n.d.)

HAP in Uttar Pradesh: To define a district-by-district standard action and operating mechanism for disaster management, the Uttar Pradesh Heat Action Plan was created in 2018.It provides a thorough summary of the "Financial Provisions" for the management of heat waves. The "Heatwave" has been declared a "State Specific Disaster" by the Uttar Pradesh's State Government. As a result, the "State Disaster Relief Fund" is now able to provide aid for heatwaves. Additionally, the HAP

places a strong emphasis on “Dealing with Heat-Related Illnesses”. It describes the signs, symptoms, causes, and treatments for illnesses brought on by excessive heat, as well as precautions to take in response to those conditions (Magotra, Tyagi, Shaw, & Raj, 2021). The District Disaster Management Authority (DDMA), Gorakhpur developed the Heat action plan which was created in 2019 which specified strategies and initiatives to reduce the impact of heat waves in the area with technical assistance and advice from UNICEF, Uttar Pradesh. The primary objective and function of the HAP, Gorakhpur is development of a dynamic early warning dissemination network, entrusting stakeholders with responsibilities for enabling communities to combat heat waves in Gorakhpur, catalyzed preparedness of the schools & community level responders, promoting adaptive & economic measures to combat heat waves in Gorakhpur, formulation of a system for public outreach for the dissemination of forecasts (Magotra, Tyagi, Shaw, & Raj, 2021)

HAP in Delhi: Delhi has experienced 24 heatwaves since March of this year, with the most intense, in terms of maximum temperature, occurring from May 12 to 22, 2022. Despite this, the city lacks a “heat action plan” to prevent deaths from extreme heat.

HAP in Rajasthan: Under the direction of the Disaster Management and Relief Department (DMRD) and Rajasthan State Pollution Control Board, the Government of Rajasthan, the Indian Institute of Public Health at Gandhinagar, and the Disaster Risk Reduction (DRR) section of UNICEF, Rajasthan, developed and implemented the Heat Action Plan (HAP) in2019. This HAP has the distinction of being India’s First Climate Resilience Heat Action Plan for rural settings. The HAP lays out a 3-phase implementation strategy with clearly defined roles and responsibilities for various departments and authorities. Importance is given to improving the HAP by assessing the impact after implementation of HAP (Magotra, Tyagi, Shaw, & Raj, 2021). HAP for Sirohi district, Rajasthan has not been developed

Socio-cultural and Ethological aspect: Under socio-cultural and ethological aspects, adaptation and sustainability have been the major focus areas for both indigenous and modern solutions. Most of the outcomes deliberate upon newer policies at community level and developing awareness programs on economic and agricultural activities. Community practices are also studied for indigenous solutions. Traditional solutions on working hours alteration, housing, lifestyle, clothing and modern solutions on housing, urban planning, food habits and cooling techniques have also been studied. In the case of both traditional and urban solutions, the improvements in economic, social and health outcomes have been less investigated. However, there are a few studies examining the role of adaptation, sustainability and community practices in poverty and food security outcomes.

Medical and Technological solutions: Medical and technological solutions for heatwaves have been studied at community level with focus on poverty and food security. However, there are no studies on individual and government level policies. In case of indigenous technologies hand fans have been discussed. Within modern solutions, building techniques, air conditioning and technological solutions have been studied where technological solutions are encouraging new policies at an individual level. However, they are absent from outcomes leading to improvements in economic, social and health status. Heat resistant paints, green roofs, chemical prophylaxis and processed food are also addressed in the studies under modern solutions with outcomes pointing at community level policies, programs on health and economic activities and cost-effective solutions. Chemical prophylaxis and processed food interventions have not been studied with respect to

economic, social and health outcomes. Within indigenous knowledge, the topic on herbal prophylaxis and food choices to withstand heatwaves are yet to be studied.

Infrastructure: The relationship between infrastructure and increasing temperature have been studied extensively. Most of the articles focus on creating safe habitats during heatwaves especially with the help of heat resistant housing and cooling solutions followed by ensuring a safe environment by making existence safe. The outcome of these articles is directed towards new policies at an individual level and community level, initiation of awareness programs on economic and agricultural activities, housing and legislation at a social and community level and improvement in poverty and food security. Government policies have not explored interventions like heat-resistant houses and cooling solutions. There is alsoa dearth of studies of these interventions for food security, employment and health.

Education and Life Skills: It is one of the variables which have been studied most extensively. The studies are conducted both at personal and community level where most of the studies discuss awareness campaigns. The focus on the awareness campaigns are on policy changes at a community level, development of health, medical, economic, housing and legislative programs at social and community level and improvement in the situation of poverty, food security, employment, labor force, morbidity and comorbidity. However, the outcomes in individual and community level and as the economic aspect interms of cost effectiveness is not specified in any of the researched articles. It is followed by studies on health awareness programs and media campaigns which also deliberates upon new policies at community and government level and economic, social and legislative programs. But the role of the variable at individual level, programmes and housing and landscaping and the economic, social and health impacts are completely missing. The least studied aspect are community mobilization programmes for educating people about heat waves and building life skills. The limited studies highlight the requirement of health and legislative programs for ensuring awareness among communities.

Geographical aspect: Heatwaves have been studied extensively mostly at a global level. Compared to India, there are multiple studies which have been conducted globally especially in European countries, US, Australia, Mediterranean regions and some Southeast Asian countries. Studies at a global level deliberated on policies at community and government level, awareness programs for heath, mental health, economic and agricultural activities, housing. poverty, food security, employment and labor force. From the existing articles in the EGM, only 11 out of 44 studies are based in India. The Indian studies mostly discusses modern solutions for agriculture, traditional methods like clothing, alternate working hours etc., community drives for awareness, infrastructural development for safe environment, legislative actions at state and district level, sustainability, climate change mitigation, formulation of heat policy and labor law, heat actions plans, technological solutions for building techniques and heat resistance, traditional solutions like planting trees and modern green belt solutions, resource mobilization and forecasting. All these studies suggest new community level policies, programs for heath and legislation and improvement in the situation of poverty and food security at national, state and district level. Studies on heatwaves at community, village, block and town level have not been conducted. At district level the policy level outcomes, economic, social and health impacts and health, mental health, and medical, economic and agricultural activities, housing and landscaping, social/community level programs are not reviewed. Even at state level there are lack of studies on governmental policies, programs/awareness measures. At national level studies on various level policies focusing on economic and agricultural activities, housing and landscaping, employment and labor force, health and morbidity are yetto be researched.

Community perspectives on Heatwaves and coping strategies

Causes of heatwave

The FGDs conducted with the people of Siyawa, Rajasthan brought out the concern regarding the rising temperature over the years, over and above the hot desert climate. The respondents were concerned about the increasing temperatures experienced during summer in 2022 and they believed that the current year has been the hottest experienced so far. They attributed air pollution to increase of factories, private vehicles, use of air conditioners, change in land use patterns such as increase in concretization of roads, as causes of heatwave.

"For rising temperature rich people are mainly responsible, the amount of electricity they use by means of TV, fridge, coolers and motor cars, they are adding more harmful effects in our lives as, AC can cool our rooms but they are causing heat in the atmosphere."

Interviewee 1 from Dhaisariya

The people from Dhaisariya and Seema Puri are generally aware that huge energy consumption through use of cooling appliances is in some ways responsible for rise in temperature. According to a recent Economic Forum, 2021 research for the city of Delhi, about 43% of dwelling units have one air conditioner, the majority of which were just purchased in the preceding 2-3 years, and 11% of households have all three cooling systems (Magotra et al., 2020). The release of hot air from the cooling appliances is contributing towards urban health island effects. An "urban heat island effect" is produced when physical infrastructure absorbs ambient heat and slowly releases it back into the environment, increasing ambient temperatures (Rai & Verma, 2022).The residents of Seema Puri also believed that burning of garbage could induce heat waves. In addition to it, changing land use was also observed by the people where reduction of trees for construction of *'pakka'* or cemented houses created maximum impact. A group of teenage girls from Siyawa during their FGD spoke about overheating of ground as a result of changing land use. In Western India, land-use and land-cover changes have majorly contributed to an increase of 0.06°Celsius per decade (Mandal, 2012).

Figure 7: FGDs conducted with the women in Siyawa village, Rajasthan and Dhaisariya, Uttar Pradesh

In Dhaisariya Village, the people state that the number of trees in the area are less as cutting down of trees has increased over the years. The condition of soil is observed to be drier than usual, hence adding to the setting in of heat waves across many regions. Deforestation raises temperatures and alters the quantity and distribution of rainfall, often leading to a drier environment (Lawrence, 2014).

"*As concrete forests are being built, these heatwaves are happening. For the last fifty years, human beings have cut down the forests, increased urbanization, made bridges, stopped the water of rivers, due to which this pollution and this climate change is happening."*

Interview 1 from Seema Puri

In Seema Puri, people state that there has been a rise in population over the years which has led to increase of construction work and this has led to cutting down of trees with least focus on planting trees. Thus, the process of urbanization is responsible for the rise in temperature. Change in landuse pattern causes overheating of the ground and has increased the intensity of heatwaves in these areas.

Heatwave impacts

The direct impact on health due to heat waves involves heat syncope, heat cramps, hyperthermia or heat stroke, exhaustion, cardiovascular and respiratory disorders, and even death (Dodla& Satyanarayana, 2021). The health impacts faced by the people in Siyawa, Rajasthan were fever, dizziness, weakness, diarrhea and vomiting as stated by an interviewee, "*Afterwork when someone comes back home and says they have fever or feeling week along with vomiting, we understanding thatthe person is affected by 'loo' (heatwave)*".

The health impacts in Dhaisariya Village are mostly visible among the children. During summer children suffer from diarrhea, dehydration and vomiting. The residents of Seema Puri also stated that kids and old people are more at a disadvantage during heat waves. The World Health Organisation states that a heatwave increases the risk of complications and death for elderly persons, children, and those with chronic conditions who take daily medications. The people of Khajani discussed that other health impacts involve itching eyes and sleeplessness at night.

"Due to excess heat in summer, water level in the body becomes very low and everyone gets ill quickly. There is loss of appetite in summers. There is sign and symptom of anaemia due to not eating food."

An ASHA worker from Khajani.

The health impacts faced by the people of Seema Puri involve vomiting, indigestion, stomach upset, typhoid, diarrhea, tuberculosis, fever, sneezing, dizziness and breathing issues. The extreme heat also leads to the problem of sunburn, reddening of face, coarse rashes/pimples on skin or acne, itches and boils on the body, allergy, heat rashes, infection and nosebleeds. During summer there is also a rise in mosquito borne diseases like dengue and chikungunya. The Centers for Disease Control, which keeps track of vector-borne diseases, predicts that as the planet heats, disease-carrying insects will proliferate and spread illness faster (Gibbens, 2019). Hence, heat waves are accompanied by detrimental health impacts particularly among elder and child populations.

Being a dry and arid region lying on the Tropic of Cancer, Rajasthan faces excessive water shortage. As stated by an interviewee during FGD, "*The river is dry during summers, even small dams cannot help when water is not available, we have to walk a lot for water*". In Siyawa, in spite of a river flowing over its terrain, the availability of water isn't enough especially during summer months. Women living in the village shared their experiences of traveling a long way to collect water. The people of Dhaisariya also face the problem of water supply in summer. The pipes are not properly cleaned, which affects the supply of water. The drainage system is weak along with lack of cleanliness. In many areas, especially in dry and semi-arid ones, a heat wave exacerbates water issues (Bal et al., 2022). During heat waves when they require water to cool themselves, water shortage becomes a common phenomenon across Rajasthan and Uttar Pradesh. Because of water shortage, livelihood also gets affected where the prevalence of heatwaves make the situation even worse in Siyawa. As most people in the village are engaged in agriculture, people are unable to work in their own fields in the afternoon because of heat. As a consequence, people earn less and their families suffer. Similarly, in DhaisariyaVillage people are mostly engaged in farming activities, during the period of intense heatwaves, they are unable to go to work in the field. Often they fall sick due to high temperatures and hence their livelihood is affected which impacts their incomes. The agricultural industry is expected to account for around 60% of the global decrease in working hours due to heat stress estimated to occurin 2030 (ILO, 2019). Due to water shortage, the crops dry up and get damaged and so productivity suffers both in Rajasthanas well as Uttar Pradesh. Hence, adverse effects of rising temperatures are seen in agricultural productivity (Barnabas et al.,2008).

Cattle in Siyawa and Dhaisariya are one of people's most valued assets. These domestic animals are generally cows, buffaloes, goats etc. They are used in agriculture for ploughing and the animal products like milk, curd, butter etc. are utilized extensively by the people in their daily life. Due to the heatwaves this year, the fodder for animals had also dried upwhich led to the animal starving leading to death of livestock. In Dhaisariya and Siyawa this year, the cattle even starved for 3-4 days and had to be taken to doctors and given medication. Animal productivity is decreased by heat stress in termsof milk production, body weight, and reproductive efficiency (Bal et al., 2022).

The informal workers of Seema Puri also suffer due to heatwaves. Due to high temperatures the street vendors, fruits and vegetable sellers are unable to work throughout the day and hence there is loss in working hours and their items also perish in the heat. There are even fewer customers during high temperatures in the day. The detrimental health impacts due to heatwave on these people force them to remain absent from work, which ultimately leads to loss of income(NIUA, 2016). Those who work in factories face great difficulty in working with the machines as it is very hot inside the factories. However, if they are unable to continue for the required working hours or fall sick, their wages are deducted. Extreme heat exposure can increase the risk of injury and cause work-related diseases and productivity losses (ILO, 2019).

Absence of proper physical infrastructure, as pointed out by the residents of Dhaisariya and Seema Puri, is a major factor for their suffering during the heatwave. In Seema Puri, the people who live in slums are characterized by small congested housing structures that make the summers unbearable. According to a specialist at the "National Workshop on Preparedness, Mitigation and Management of Heatwave", slums in Indian cities are the most susceptible to the effects of heat waves in the summer (The_Hindu, 2018). There is a problem of frequent power cuts in summers. Due to the early start of summer, India has experienced its worst electricity shortfall in more than six years, and demand has reached record highs. (TOI, 2022) According to a report by the UN-backed organization Sustainable Energy for All (SE4ALL), in India, about 323 million people are at high danger from extreme heat and a lack of cooling devices like fans and refrigerators. Lack of access to proper physical infrastructure among the poor intensifies the effect of heatwave on them.

Heatwave also has a detrimental impact on the education of children. The people of Dhaisariya village and Seema Puri stated that due to excess heat and warm weather the children don't feel like going to school as usual because there is no proper facility for fans in the schools. Often, they faint in the prayer lines. In some tropical regions, early exposure to extremes in temperature or precipitation is linked to later childhood school attendance that is shorter (Randell, 2019). Even the people of Dhaisariya mentioned that on their way to school the children are faced with excess heat. Also due to dust storms there is congestion in the eyes, nose and ears of children, so there is high risk of infection amongst them. The people of Seema Puri mentioned that as their income earning is less during summers, they stop sending their children for tuition classes.

The people of Seema Puri stated that there is an event of out migration of people from North East Delhi during summer season as they think they would move to their villages and would earn less through farming but will at least get cool breezes instead of sitting here idle without work in the cities. And it is mostly prevalent amongst the people of lower strata such as rickshaw pullers. When looking at population movements associated with heat in the past, it can be shown that efforts to reduce the health consequences of heat during hot weather have frequently been associated with urban to rural amenity migration (Chazalnoël et al., 2017). Hence heatwaves play a major role in dictating migration of both human beings and birds.

Cost-effective indigenous and modern solutions undertaken at individual and community level

Individual level

In Indian villages, almost every individual uses natural resources mindfully. Conservation and sustainability is practiced religiously where the natural resources are utilized to the fullest with minimum wastage (Practically, 2020). Siyawa being one of the villages in Rajasthan also witnesses effective utilization of natural resources which are both sustainable and cost-effective. Along with traditional measures the people of Gorakhpur and North East Delhi have also adopted certain modern solutions to deal effectively with heat waves.

Remedies using herbs, plants and coolant paste: People in the village of Siyawa, Rajasthan, extensively use various herbs and plants for reducing the impact of heat, either by consuming it or applying it on their body. They make a paste by blending raw mangos, tamarind and '*palash flower*' (*Butea monosperma*) and apply it on their body or drink it after diluting it with water. People take a bath with water containing '*palash flower*' extracts. Neem leaves are also used by boiling them in water for a few minutes, after which, people take a bath with the neem water. The water helps in reducing fever after exposure to heat or cooling the body in general. In North East Delhi people apply coolant paste made of *'multanimitti'* (bentonite clay) on their bodies to get relief from heatwaves. It helps to reduce acne or pimples on their skin caused by excessive heat. The people mentioned it as a traditional method, still prevalent amongst the people as a natural remedy for heat rashes, without any side effects.

Food choices: Onions are a staple within the diet of people living in Rajasthan. The state records the hottest summer almost every year hence people have developed a certain food habit which helps them bear the heat by keeping them cool (Sharma, 2019). The use of onion is also prevalent amongst the people of Dhaisariya. The people stated that they mash red onion and apply it on their head or hands and feet as it helps the body to cool down. The workers of Seema Puri, eat onions with bread as they go out for work in the afternoon. In addition to onions, lemonade, buttermilk and other sour vegetables and fruits

like tamarind, raw mangos etc. are consumed extensively in Rajasthan to tackle the rising temperature as well as ensure hydration. Many people in the village are unable to domesticate animals due to lack of financial capital. In spite of these challenges, drinking buttermilk is considered essential to survive the heat. The ones who cannot make buttermilk at home either buy it from a local shop owner or borrow some from the affluent farmers. In order to keep the body hydrated during summers, the people of Dhaisariya take a wide variety of juices or drinks made from natural fruits and leaves. In India, Uttar Pradesh is the second largest producer of mango having at least 4 lakh hectares of land under mango production (Shukla, 2022). So, mango water is very common among the people which they even rub on their head which helps to get relief. Having green mango drink (panna) is also common amongst the people of Seema Puri. People also believe, drinking mango juice helps to reduce heat stroke. People in Dhaisariya and Seema Puri mostly take *'pudina drink'* (mint juice), *shikanji'* (lemon based drink) and lemon water or lemonade when they come from outside and lemonade is especially beneficial after vomiting. Other juices like amrud (guava) juice, cool drinks made from sattu (roasted lentils and cereals), saffron, sugar, etc. are also popular drinks during summer. The farmers while going to the farm carry drinking water along with them for keeping their body hydrated while working under the sun. Even the workers of North East Delhi carry cool water with them as they go out for work. They also intake beverages like ORS (Oral Rehydration Solution) and Glucon-D (Glucose solution) at times of excessive sweating to replenish their osmolyte balance. The people follow a healthy diet and eat light food with less chillies and spices during excessive heat, like dal (lentil curry) and rice, coarse grains, curd, *'dalia'* (broken wheat), *'sabu dana'* (sago), etc. They prefer consuming more seasonal fruits and green leafy vegetables like melon,banana, cucumber. Even the children take lemon to school. They prefer taking lassi or cold water instead of drinking tea. However, intaking beverages and fruits leads to a rise in food expenses during summers. The people of Seema Puri also drink neem juice and eat jaggery as it helps them to deal with itching and boils caused by excessive heat. These eating habits act as a natural shield of the body to protect from heatwave.

Drinking water from earthen pots: Storing water in earthen pots is known for having many therapeutic and health benefits. The tiny pores on its clay surface helps in quick evaporation of water which keeps the water inside the pot cool naturally. It also keeps the nutrients and minerals intact in water and hence its daily consumption can prevent a person from sunstroke (Gupta, 2021). People in Siyawa store their drinking water in earthen pots throughout the year. Similarly, the people of Dhaisariya keep the drinking water in clay pots. It keeps the water cool and is a pleasure to drink after a long day of work in the heat. In order to keep the water cooler, they wrap a wet piece of cloth on the pot. Use of earthen pots is also an age-old traditional practice followed by the people in Rajasthan and Uttar Pradesh.

Clothing pattern and coverings to protect from heat: Excessive heat also means excessive perspiration. Cotton as a clothing material is very useful during summers as it absorbs excess perspiration from the body and helps prevent bacteria and fungus accumulation. People in Siyawa, Rajasthan, prefer wearing only cotton clothes as it is easily accessible, absorbs sweat and are comfortable to wear in the heat. Only thick cotton clothes are worn in order to protect skin from getting damaged. People of Dhaisariya Village and Seema Puri, also prefer wearing cotton clothes mostly white color and loose clothes as they are comfortable. They even carry umbrellas while going out in the summer. The people of Seema Puri also mentioned carrying wet handkerchiefs or putting clothes on their heads during the day. Even they wear elbow length cotton gloves, sunglasses, and wear masks to protect themselves from sunburn.

Cooling appliances: There is an increase in use of cooling appliances like fans, coolers or AC during the summer season. At temperatures above 30°C, cities like Delhi have seen an increase in energy demand by 30% or more (Magotra et al.,

2020). In Dhaisariya, these appliances are used in those areas of the village where electricity is available. This is mostly prevalent amongst the affluent members of Dhaisariya Village.

Housing structure: The amount of heat that enters a house can be managed by a number of design elements (such as landscaping, orientation, external shading and eaves) and building components (such as coating and color of roof, insulation, windows and type of glass) (Miller, 2017). The housing structure in Dhaisariya has shaded areas in their house where less heat and dust will occur and the place will become cold. This place helps to provide natural relief during the summer season. They also put curtains on their windows and doors which helps to prevent the penetration of direct sunlight. There are even traditional housing structures in the village where they built houses made of cloth and bamboo. These materials act as natural insulators that block the heat from entering and help to keep the house cold from within. They plant more and more trees near their houses which act as natural coolant in summers. Along with it, some people also mentioned that they cover their porch and windows with a wet *'chaddar'* (long piece of cloth) in mornings and afternoons. This prevents the heat from directly entering their houses and keeps the house cool and moist from inside. While in Delhi there are no such traditional housing structures as the people mostly live in congested slums. However, during power cuts atnight, they sleep by laying their beds outside of their house. They even take cold water and sprinkle it on the top of the roof to get some relief.

Making a coolant paste: A traditional way of keeping the house cool in Siyawa village, Rajasthan, is by making a paste consisting of a mixture of soil, water and cow dung. The mixture is then applied on the walls of houses which are '*kaccha'* or made of mud and straw. The paste acts as a natural insulator for the house which blocks heat to a certain extent. It is mostly applied right before or during summer.

Community level

Collective action along with individual measures can be very effective in addressing climate change and its resultant threats (Jagoo, 2022). People of Siyawa and Seema Puri take measures together for the welfare of the community. But this social bonding was not observed in Dhaisariya village and there is absence of adequate community level measures for fighting against heatwaves.

*Gathering under the shade and visiting gardens in villages and moving to parks in cities:*People in Siyawa do not have the privilege of dense vegetation surrounding their land unlike other parts of India. Presence of big, dense and fast growing trees is considered to be a privilege hence they have designated certain trees like neem and banyan trees as their resting and gathering locations. Trees are also planted in agricultural fields which shade the crops and help the soil retain moisture. In certain locations where the trees are sparse, people have built '*jhopri*' or open huts under which they gather during a hot afternoon. Tree shade or a shade made with leaves and grasses directly benefit people by reducing the convection and storage of land surface heat which leads to lowering of overall surface temperature of the area where trees are planted (Yu, 2020). Even in Dhaisariya Village, there are frequent events of power cuts or low electricity supply especially during summer and so their fans don't work. Everyone prefers going to the garden and no one is at home at that time. People like to sit under the trees, mostly neem or other trees that have big canopies that help to provide natural shade. Trees provide natural air conditioning as their surface moisture partially absorbs heat from hot air moving over and beneath leaf surfaces. As a result of this process, the air temperature surrounding the trees can lower up to 9°Fahrenheit. (Grzebik, 2010) There is a park in Seema Puri, where people prefer moving in the evening for walking or sitting under the shade of the trees. According to the people, sitting under the trees is cooler compared to sitting inside the house.

*Growing trees faster:*In Siyawa, people collect '*nimboli*' or neem seeds when they are ripe and mix it with animal excreta, soil and water. The thick paste is then shaped in the form of a ball and left to dry after which they are scattered all over empty fields and deserted lands. The nutrients in the paste help seed germination and induce growth of trees faster than usual. More trees would mean more shade for the people to rest and gather during rising temperatures.

A wide range of measures are taken at the community level of Seema Puri sub district of North East Delhi for dealing with rising temperature, environmental problems and problems of water supply. "Strong social networks" are said to promote both individual and group efforts to adapt and build resilience. (Wolf et al., 2010)

Placing water jars and distribution of fruits, water and tree plantation: The people mentioned that, members of the community irrespective of their religious identity place water jars in different areas so others could take water from them. Even they take up measures like distributing *'sharbat'* and water, water packets or bottles, distribution of fruits like melons and watermelons to the common people who are out on the streets under the scorching rays of the sun can get some relief. The people of the community take up initiatives like planting trees that can provide shade to the people and protection from the heat rays of the street.

Protecting birds: Not only the people of Seema Puri take up measures for the welfare of the community at the time of need, they take measures for birds as well. They mentioned placing water containers at different places for birds to help them deal with the extreme heat. This simple measure can help the birds survive the killer heatwaves.

Performing street plays, and taking part in rallies and meetings: These are other effective methods on the part of the community to create awareness, among the many being street plays. Street plays have been used in explaining how water is important for the body and what one should eat so that the body can absorb water and the kids won't suffer from diarrhea. People even take part in rallies spreading awareness regarding saving water and sharing water. While doing so they also distribute water. There are meetings held amongst the women of the community to discuss and spread awareness. However, there is absence of this social cohesion amongst the people of Dhaisariya. There is an absence of willingness amongst the people of the community to work together for the welfare of society.

Role of NGO: In North East Delhi, various NGOs are involved in the process of dealing with heatwaves such as RWA (Residential Welfare Association), Action India etc. The people of Seema Puri mentioned that there are dispensaries and NGOs from where one can get ORS. There are medicines provided by them that help individuals to protect themselves from hot winds. Even medical camps are held by NGOs. RWA has started a program of tree plantation inside the park in Seema Puri and in the surrounding areas. The NGOs also have constructed some resting rooms where people can take rest and get relief from the discomforting environment outside. They also create awareness by doing door-to-door campaigns. In Dhaisariya as well, the people mentioned that NGOs play an important role at times.

Existing Policies and Measures at the Government level

There is a lack of Government actions particularly for curbing heat wave impacts. In spite of the gaps, some alterations and provisions were ensured by the government in some of its schemes and additional measures.

Government schemes: The social protection schemes available to the people of Rajasthan, Uttar Pradesh and Delhi launched on behalf of the Central and the State Governments provide a wide range of facilities in the form of economic aid,

food aid as well as health aid. These schemes are not designed for dealing with heatwaves, but they can turn out to be crucial measures to deal effectively with changing weather conditions across India.

MNREGA or '*Mahatma Gandhi National Rural Employment Guarantee Act',* 2005, is an Indian social security measure as well as labor law which protects the 'right to work' for Indian citizens. It focuses on enhancing security of livelihood in rural areas by providing minimum 100 days of manual unskilled work with wage within a financial year to at least one adult member from rural households. For women, one-third reservation is done in MGNREGA (MoRD, 2006). Earlier, the working hours were not flexible but with the increasing temperature and simultaneously increasing heat threat, people in Siyawa confirmed a change in working hours to 6am - 1pm during days recording extreme heat in summers. In addition to it, some of the workers were given ORS packets and were recommended to drink cold water and lemonade frequently by the in-charge on site.

Anganwadis are child care centers providing basic health care services like nutrition supplements, counseling, preschool activities, awareness etc to children in rural locations of India as a part of the Integrated Child Development Services programme (IGI Global, 2022). In Siyawa village, people praised the services provided by the Anganwadi, especially the nutritional benefits given to the children. Even though the Anganwadi workers didn't carry out a heatwave awareness campaign for quite some time, women in FGDs assured their presence and involvement in the center. When people used to get sick, they would visit the Anganwadi center where they used to get ORS packets and were also made aware of the problems heatwaves can cause. They were told to stay indoors as much as possible and eat nutritious food which can be a natural coolant. In Anganwadi of North-East Delhi, the Anganwadi school children were given ORS solution mixed with water when they had diarrhea. The Anganwadi workers of Dhaisariya are also provided training so that they can create awareness among people and provide them with a preliminary health facility.

The '*Public Distribution System (PDS)'* was developed and launched in 1992 as a method of managing shortages through the rationed distribution of foodgrains. PDS has grown in importance as a component of the government's strategy for managing the nation's food economy (NFSA, 2013.) The ration cards issued by the Indian government grant the card holders the right to a stipulated amount of food at heavily subsidized costs (wheat, rice, and sugar). The people of both Dhaisariya and Seema Puri can avail the facility of ration as some of them have Below Poverty Line (BPL) ration cards. PDS can serve as an important measure to provide poor people with food security in case there is a hike in food prices and loss of income due to changing weather conditions.

Indian government launched the '*Pradhan Mantri Kisan Samman Nidhi'* initiative in 2018, providing farmers with a basic income support of up to 6,000 rupees annually. The scheme can be availed by the farmers of Dhaisariya, however, the process is slow. The way the heat wave is having detrimental impact on the livelihood of the farmers, through extensive damage done to crops by rising temperature conditions, resulting in loss of their incomes, these schemes can provide some financial aid at the time of need.

Labour Card Scheme: Labor card is an identity card which helps the poor people engaged in construction and farm labor avail of a few specific services by the government. The Government of Delhiimplemented a new method for creating labor cards mainly in the context of COVID-19, under which they can do so by calling from home. Women workers are given preference in the Labor Card Scheme. Labor cards offer rations and cash assistance to the poorest people (*Labour Card Scheme in Delhi 2022*, n.d.) Although done in the context of COVID-19, this can also affect the poor people of North East Delhi, at the time of heat wave when people are unable to move out of home and go for work.

For the benefit of the state's senior citizens, the Delhi government has started an *old age pension program*. The primary goal of this program is to offer state-eligible senior citizens financial help in the form of monthly pensions. A pension of five hundred rupees is given to the eligible persons and the people of Seema Puri receive it. The UP Widow Pension Scheme 2022 is being run by *Samajik Kalyan Vibhag* of the Uttar Pradesh government for widowed women. All widow women, regardless of age, whose names appear on the final BPL list for the entire country are eligible to receive Rs. 1000 under the '*Vidhwa Pension Yojana'*. (Chhabra, 2022) The people of Dhaisariya can avail these schemes. These measures can also help the people to meet their additional expenses especially during summers.

Meetings in Gram sabha: In Dhaisariya, in general there are two meetings of gram sangathan held in a year. In the meeting 10-25 women come, they discuss various pressing issues and provide the people with various important information. Along with it ORS is also distributed. Hence, it acts as an important platform for discussion and distribution of basic medicines to deal with the problem of dehydration.

Disaster Management Authority: The people of Seema Puri mentioned that Disaster Management authority takes help from the Water Board to provide people with water via water tankers. They also take up measures to create awareness amongst the community members on planting more trees. Even free saplings are provided from the nursery so that people can plant trees. These are very effective measures that can help people to fight against rising temperatures.

Shelter homes: The Delhi Government has set up shelter homes and they provide relief during excessive heat. People can relax and take rest in shelter homes/ small hospices that have fans and coolers provided by the government. At noon they can relax in shelter homes and at night when it's cooler they can pull rickshaws or do other work.

Tree plantation and park construction: The Government takes measures to plant trees in the Khajani sub-district where the people mentioned the vegetation cover is sparse. The Government/ Forest department gives plants to the people of Dhaisariya village for plantation like drumstick, mango, amla (gooseberry), guava etc. The people mentioned that around 50 trees were planted which produced vegetables but they are not good in taste. Similarly measures for planting of trees likegooseberry tree, vine stone plant etc. are carried out by the Government of Delhi. Government has even taken up measures to construct a park in Seema Puri. However, people mention that there is a lack of maintenance. *'Chabutra'* i.e., a platform has been built around a tree where people can sit under the shade of the tree. These are important steps on part of the Government, though not directly linked to putting a check on heatwave but this measure can help to counter rising temperatures especially in cities and provide some relief by cooling the temperature of surroundings.

Water supply: In Dhaisariya, cold water spots are made in various locations in the village by the local government too provide purified water supply. However, there is a lack of awareness among the village people to use it. In Seema Puri, the Government sends water tankers in different localities to spray water on roads in the early morning. From the hot surface of the roads, the water evaporates rapidly there and takes the heat away from the roads. Thus, the roads and the surroundings cool down. Government tankers also supply water in the localities where there is water shortage or rise in water problem. Drinking booths/water kiosks have been installed by the Government at different intervals in the area. There are also measures like distributing water packets and ORS packets to the people. These measures are extremely useful for dealing with heat waves. These measures will help to protect people on the streets from dehydration in the summer.

Discussion

Existing health facilities and its barriers

In order to find out the healthcare services and its gaps provided in Siyawa, Dhaisariya and Seema Puri, modified Tanahashi model has been utilized. The very first step of the model is "availability coverage" which emphasizes the availability and requirement of essential healthcare commodities. In Siyawa, a government primary health center (PHC) is present which is equipped with 2 beds, 20 Out patient departments (OPDs) and most of the essential medical supplies but there are no special provisions made during summer related to heatwave. When people visit the healthcare center ailing because of heatwaves, they are given ORS packets. In Khajani sub-district, Uttar Pradesh, there are 2 community health centers (CHC), 2 PHC, 16 community health officers (CHOs), a women's clinic and a veterinary hospital for animals. During heatwaves, they usually provide ORS packets and Zinc supplements to children. In Northeast Delhi, a wide range oftreatment facilities are available in private as well as public hospitals along with local clinics in Seema Puri. This year, noneof the healthcare centers reported a case related to heatwaves. "Availability coverage" also includes the availability of human resources. In Siyawa, there aren't many health staff available. They are mostly equipped with handling cases of malaria and skin disease and not heatwaves. Other than the staff there are 2 Auxiliary Nurse Midwives (ANMs) and 5 female Accredited Social Health Activists (ASHA) workers helping in the healthcare center. According to the interviewees,most of the services aren't available in the healthcare center. The ASHA and Anganwadi works also don't go door to door togenerate awareness but when people visit the centers, they distribute ORS packets and suggest remedies like staying indoors, drinking lemonade etc. In Seema Puri, there are 225 OPDs, 5 ANMs and 25 female ASHA workers. The staff is trained and more doctors are appointed in local clinics during the summers. Here, the ASHA workers have conducted outreach activities by visiting people and distributing ORS packets. The second step is "accessibility coverage" which talks about physical access to services. In Siyawa, the government healthcare center is accessible in terms of distance but according to the health survey, roughly 6 men and 14 women visit the center daily for reasons other than heatwaves. In Khajani, the PHC is around 10 km away from Dhaisariya village and after 3 kms from the village, there is no transport available to take people to the PHC. The health facilities provided by the staff are also not easily accessible hence ASHA workers try to bridge the gap by visiting households personally. In Seema Puri, the health facilities are accessible but crowdmanagement isn't done well. People stand in long queues for 2-3 hours for treatment and medicines and the medicines provided to them aren't effective. Sometimes the clinics are closed as well. As there isn't much facility to handle cases undergoing heat stress, people don't prefer going to the healthcare center. Thus, there is low "acceptability coverage". The fourth step is "initial utilization" which highlights people's willingness for the utilization of intervention. In Siyawa, due to the lack of proper healthcare facilities, an availability issue has been prevailing because of which people have almost stopped visiting the healthcare center for heatwaves. Instead, they have been using various traditional strategies (listed in analysis) for precaution and cure at an individual level and community level. In Dhaisariya, even though health facilities areavailable, they are not accessible hence they depend on ASHA workers for suggestions and remedies. In Seema Puri, long waiting time and lack of proper medicines have caused both availability and accessibility issues, hence people depend on private clinics more. The fifth step is "continuous coverage" which states a continuation of interaction between patients andhealthcare centers and the sixth and last step is "effective coverage" which describes the quality of service provided. For all the 3 areas of study, the people haven't experienced the final 2 steps. Tanahashi had also coined a term called "nominal coverage" which describes people who have only covered the first 4 steps hence requiring major

filling of gaps. In all 3regions, healthcare gaps need to be addressed by the government either in terms of availability of essential medical suppliesand human resources or accessibility or both. The healthcare centers also need to come up with a preparedness plan before incidence of heatwaves in order to address it effectively.

Sustainability of the existing policies and the indigenous solutions in the face of future disasters

"Sustainable Livelihood Framework" (SLF) integrated within the modified "Tanahashi model", views the "vulnerability" of an individual or community arising from the lack of fulfillment of basic needs in life and how they function living within vulnerabilities shaping factors like opportunities, seasonal constraints and economic shocks. Although all people around the globe will be affected due to changing weather conditions, it is the marginalized population particularly engaged in the informal sector that will be most affected. People engaged in the agricultural sector are most affected, as seen in case Siyawa village, Rajasthan and Dhaisariya village, Uttar Pradesh. The seasonality of the crop damage is on a high along with reduced yield of milk from livestocks. Even for others like those of street vendors, rickshaw pullers, construction workers all are affected, since they are unable to work under the heat leading to loss of working hours and so does their income. The "human asset" indicating people's ability to work due to illness is prominently discussed. However, they possess rich traditional knowledge that helps them to fight heatwave cost effectively. "Natural asset" is particularly applicable in the case of agricultural workers, whose lands are their natural capital. Marginal and small farmers are selling off their land as there is a lack of adequate production. This shows that the decline in agricultural production is caused by lack of adequate government policy to support them at the time of distress which aggravates poverty under the influence of extreme heat conditions. "Physical assets" are inadequate amongst the people as it has been seen in Rajasthan, Uttar Pradesh and Delhi, their lack of cooling appliances and proper water supply that is utmost essential at the time of heatwave. Even in Seema Puri, they live in slums which are characterized by congested settlement and lack of proper ventilation. "Financial assets" are almost absent as they are mostly daily wage workers. Their income is almost spent to meet their daily expenses. Finally the "social asset" is the network and bonding and the society which is very strong in Seema Puri where people set up water pots in the locality for other people on the road to use, water containers for birds and so on. Even in Siwaya, people sit under the tree shade in summer and exchange words, however, the bond is poor in Dhaisariya. Thus it can be understood that the ownership of all the 5 capitals is not adequate which would help the community or individual recover easily and provide livelihood opportunities in the time of heatwave. The assets are impacted and influenced by the transforming structures and processes. The "transforming structures" operate in these centers like Government bodies, Disaster Management Authority, private and public health centers, Anganwadi centers and some private NGOs. The "transforming processes" are the policies and programmes such as Heat Action Plans for Rajasthan, Gorakhpur and UP, MNREGA, Anganwadi scheme, PDS scheme, old age pension schemes, Pradhan Mantri Kisan Samman Nidhi scheme, Labour Card Scheme, water supplies, public infrastructural facility programmes etc. These structures and schemes exert some influence on the financial and health capitals. However since these are not directed to particularly deal with heatwaves and their accessibility and implementation process is slow . Thus the assets don't gain much value and weight with the help of an already existing organizational, institutional and social environment which is shaped by institutions, policies and processes. All these influence the livelihood of these marginalized people shaping their strategies of livelihood. Often these people try to find alternative means of livelihood, such as the informal workers in North East Delhi moving to villages to earn some living by working in fields, trying out more traditional measures and stopping the education of their children, using less electric appliances to reduce household expenses and so on. However, these measures don't lead to much increase in income, well being and improved food security. Thus, their level of vulnerability is heightened in the face of heatwave, as the livelihood strategies they adopt are not sustainable.

As already stated in literature, the other model, "Access Model", highlights how the variation in access to resources between households engaged in particular means of livelihood, plays an important role in determining the potential loss and rate of recovery. The model determines the causes and symptoms of vulnerability. The "specific hazard" here is the extreme rise in temperature due to climate change. The time of high temperature in this year was March to May 2022, almost extended upto June, when the temperature was extremely high across India. The "trigger event" was when this rising temperature ultimately transformed into a heatwave. The "household livelihood" is the livelihood of the poor and marginal informal workers of Siwaya, Dhaisariya and Seema Puri, engaged mostly in unorganized sectors or agricultural sector. In normal times, the households earn livelihood and are susceptible to "unsafe conditions". However due to change in weather conditions as most of them have to work under extreme heat consition . The "unsafe condition" is posed by lack of access to proper physical infrastructure, financial sources, proper health conditions and even natural resources. The economy, in which they live in, is also heavily influenced by politics and can get shaped by "structural domination" and "social relations". The members of the community of Siwaya and Seema Puri share a strong bond. The "structure of domination" comprises the head of the family and men in the family being the breadwinners at a household level, the Government at the State level, followed by the Central Government along with some private NGOs. These structures of domination exert immense influence on the livelihood of the individual households through their decisions. Thus due to the heat wave, normal life is affected and their life enters the phase of "transition to disaster". Their health, their livelihood, the health of livestock, the education of their children, migration patterns and most importantly their social life is impacted which is also a result of their decision-making with the arrival of disaster. When "the trigger event" takes place, both the "structural domination" and "social relations" get impacted along with the households as well. Their "social relations" help at the time of disaster with each other such as in Seema Puri people set up water pots in the locality for other people on the road to use, water containers for birds, and so on. Even in Siwaya, people sit under the tree shade in summer and exchange words and discuss local issues. However the bond among the people in Dhaisariya is not the same as the social discriminating factors play a major role. The government is already running a number of schemes, like MNREGA, Anganwadi scheme, PDS scheme, old age pension schemes, Pradhan Mantri Kisan Samman Nidhi scheme, Labour Card Scheme, water supplies, public infrastructural facility etc. in Rajasthan, Uttar Pradesh and Delhi, and seen particularly in Delhi water tankers for cooling roads, distribution of water and ORS, etc. However, these are temporary solutions and they don't provide any effective solution to the complex problem they face. In the absence of any effective measures, they "cope" with the situation and are "adapting" to the situation using measures at individual level and community level, like using traditional techniques in terms of food, clothing, housing, planting trees, trying to create awareness, etc. They are poor and marginalized people and so they lack the capacity to plan for "the next disaster". Moreover, the "adaptation" measures are preventive in nature, but for effectively coping with the disaster, they solely depend on the Government to take up essential measures before the new iteration i.e., possible heatwave (more extreme) in the future years. Thus, the model demonstrates the increase in vulnerability with the coming of heatwave in the absence of adequate coping strategies.

As already stated in literature, the Access Model highlights how the variation in access to resources between households engaged in particular means of livelihood, plays an important role in determining the potential loss and rate of recovery. The model determines the causes and symptoms of vulnerability. The specific hazard here is the extreme rise in temperature due to climate change. The time of high temperature in this year was March to May 2022, almost extended upto June, when the temperature was extremely high across India. The trigger event when this rising temperature ultimately transformed into a heatwave. The household livelihood is the livelihood of the poor and marginal informal workers of Siwaya, Dhaisariya and Seema Puri, engaged mostly in unorganized sectors or agricultural sector. In normal times, the households earn livelihood and are susceptible to unsafe conditions. due to change in weather conditions as most of them have to work under heat of the sun. The unsafe condition is posed by lack of access to proper physical infrastructure, financial sources, proper health conditions and even natural resources. The economy, in which they live in, is also heavily influenced by politics and can get shaped by structural domination and social relations. The members of the community of Siwaya and Seema Puri share a strong bond. One of the structures of domination is patriarchy which dictates that the men are the primary breadwinners and head of the family. The decisions of the state government, followed by the central government and some private NGOs, exert immense influence on the livelihoods of individual households. Thus, due to the heat wave, normal life is affected and their life enters the phase of transition to disaster. Their health, their livelihood, the health of livestock, the education of their children, migration patterns and most importantly their social life is impacted which is also a result of their decision-making with the arrival of disaster. When the trigger event takes place, both the structural domination and social relations get impacted along with the households as well. Their social relations help at the time of disaster such as in Seema Puri people set up water pots in the locality for other people on the road to use, water containers for birds, and so on. Even in Siwaya, people sit under the tree shade in summer and exchange words and deliberate on each other's issues, however, the bond is poor in Dhaisariya. The reactive measures taken by the governments are temporary solutions and they don't provide any effective solution to the complex problems they face during heatwaves. In the absence of any effective measures, they cope with the situation and are adapting to the situation using measures at individual level and community level, like using traditional techniques in terms of food, clothing, housing, planting trees, trying to create awareness, etc. They are poor and marginalized people and so they lack the capacity to plan for the next disaster. Moreover,the adaptation measures are preventive in nature, but for effectively coping with the disaster, they solely depend on the Government to take up essential measures before the new iteration i.e., possible heatwave (more extreme) in the future years. Thus, the model shows how the level of vulnerability is intensified with the coming of the heatwave in the absence ofadequate coping strategies. However, it is worth noting that communities and neighbors are the first responders in times of crises and people across religions and castes may unite in order to cope with the disaster. This presents a window of opportunity to enhance community-based disaster preparedness and risk reduction strategies and also driving socio-cultural change for a more equitable society. Strong social and cultural bonds will make the communities more resilient to heatwaveand other disasters.

Cost-effectiveness of the indigenous solutions

Cost-effectiveness: *A procedure is cost-effective when the maximum benefit is obtained for the lowest possible price. The concept is widely used while selecting from a wide range of investment options in order to create the highest possible return for the invested amount. (Cost-Effective Definition, 2022)*

Indigenous solutions: *Indigenous solutions are derived from indigenous knowledge which is referred to as the practices and methods which have been developed by a group of people over numerous generations based on the understanding of their local environment. They usually originate within the community, disseminated non-formally, owned collectively, have adapted over generations and are embedded within their way of life hence considered as a solution in times of environmental crisis (ISDR, 2008).*

In the world, there are around 370 million indigenous people approx. who represent thousands of cultures and languages. They inhabit only 20% of the total land but have contained 80% of the world's existing biodiversity, hence proving that they are the much needed leaders and knowledge bearers we need today. In comparison to the capitalist practices of development, privatization and ownership which resulted in biodiversity loss, land degradation, pollution, climate change and have intensified and increased the number of disasters, indigenous solutions to such damages have been sustainable over centuries. They possess unique knowledge systems developed over generations which ensures management of natural resources in the most sustainable and cost-effective manner (Recio & Hestad, 2022). The Indigenous or traditional solutions mostly consist of natural products found around them or grown by them hence incurs no additional cost. Using a mixture of cow dung, soil and water to keep houses cool in the villages of Rajasthan gathering raw mangoes and its consumption to keep their body cool in the villages of Uttar Pradesh and applying multani mitti (Fullers Earth or Bentonite clay powder) on their body to keep it cool in Delhi are some of the examples which are discussed in the study in details.

One of the risks of requiring measurable outcomes is that it forces us to focus on what can be assessed rather than what is important. Excessive focus on assigning a number to a "measured" outcome is that it gives people the illusion that they can prove they've accomplished something while disguising the common reality that they have no idea how to accurately measure their success. Measured learning outcomes can be useful if there is a specific, performance-based goal in one's mind (Segar, 2014). Quantifying every measure or solution often does not give the true picture of the ground reality. As the people of Siwaya, Dhaisariya and Seema Puri mentioned that the use of coolant devices raises electricity costs at the time of heat wave in summer so their household expenses increase. But as the indigenous solutions that already exist with the people of Dhaisariya, Gorakhpur like applying water on the rooftop or putting up wet clothes in the verandah and windows also creates a cooling effect and provide natural relief whereas they do not have to incur any additional cost for it. Even the people of Siwaya and Dhaisariya prefer sitting under the shade of a tree and people of Seema Puri prefer visiting the park as they believe it provides them with a natural cooling effect and relief more than artificial cooling by appliances at home. These indigenous measures are not measurable in monetary terms but these measures help them to get some relief during extreme heat conditions in summer without incurring any additional costs. Therefore even without quantifying these measures in terms of monetary values it can be stated that the measures used by the people of Siwaya, Dhaisariya and Seema Puri are cost effective in nature although cost-effectiveness is measured in economic terms.

Addressing barriers in a cost-effective manner

Based on the analysis derived from the FGDs and interviews along with the suggestions given by the community, the following are some recommendations which can be carried forward for further deliberation and action.

- In Siyawa village, Rajasthan, '*kaccha*' houses or houses made with mud and straw are gradually reducing and getting replaced by houses made with cement. The cement/concrete houses are neither sustainable nor effective to withstand the rising temperature with every passing year as per the interviewees. In social welfare programmes like Pradhan Mantri Awas Yojana for affordable housing for urban poor and Pradhan Mantri Gramin Awas Yojana for affordable housing for rural poor, construction of '*pakka*' houses or houses made with bricks and cements were promotedin urban areas and to a certain extent in rural areas well in order to upgrade the housing of the people. Rapid construction ofhouses took place as subsidies were also extended but it resulted in reduction of houses made with available local material. There are some researches which talk about incorporation of indigenous technologies for housing which have proved to be sustainable and resilient in nature. Currently, these studies are restricted to their respective locations and have not been replicated in some other location. Hence, there is a need to research more on sustainable and cost-effective housing which can be a blend of traditional as well as modern improvements. These types of housing should be incorporated in social welfare schemes and policies in India.
- In addition to housing, utilization of natural resources found locally should also be incorporated within available healthcare facilities for heatwaves. As the measures used by people are mostly locally found or are a part of their diet, they are cost-effective and simple to make and use. It comprises both precaution and cure and can be utilized by everyone.
- Participatory approach needs to be promoted through initiatives like Self Help Groups (SHGs) and cooperatives where people in the community can form informal associations of solidarity to create awareness and bring about an improvement in their communities. Such groups need to be established for heatwaves as well which can work simultaneously with the government to inform the policies based on the needs of the communities.
- From the interviews it was understood that people were not very aware about the alarming situation of heatwaves and even if they understood the difference, they lacked awareness hence every year before summer, awareness drives should be initiated by the government by actively incorporating Anganwadi and ASHA workers who are already well involved with the communities studied. These awareness initiatives should also take place in schools as children are one of the vulnerable groups during heatwaves.
- Even though most of the Primary Health Centers (PHCs) are equipped with required medical supplies and equipment, when the time of need comes, the number of staff aren't enough or aren't trained well to tackle the situation. This points out the lack of preparedness in healthcare facilities which needs to be bridged. Before heatwaves take place, all the PHCs should be prepared to tackle the stress caused by it. Ensuring the PHCs are able to provide saline in case a person falls sick, at least to that extent the PHCs needs to be equipped. Proper training needs to be ensured for the staff along with their availability. Even ASHA and Anganwadi workers should be included during preparedness and an alternative should be devised for big cities like Delhi as the workers cannot go door to door for awareness. Also, the Government should take up measures at the earliest to construct nearby health facilities as well as improve accessibility in the villages.
- As mentioned in the literature review, there are Heat Action Plans for some states in the country. A Heat Action Plan should be made for every state in the country and also at district, village and local level. Not only should the action

plan be implemented by all, active monitoring should also be carried out along with evaluation and improvement using a participatory approach.

- National Institute for Transforming India (NITI) Ayog and National Urban Transport Policy have shared a pathway for change towards sustainable transport where they highlighted the importance of using public transport instead of private vehicles. In spite of it, the implementation of it is still missing in the country. The concept of sustainable transport should be promoted beyond urban locations and should be implemented and monitored well.
- Traditional ways of living should be promoted like drinking water from earthen pots, applying multanimitti to keep the skin cool etc.
- Laws for the safety and health of factory workers need to be implemented strongly. Components of heatwave solutions need to be added to the existing labor laws that will help to provide a legal solution for the suffering of the factory workers during extreme heat.
- Rainwater harvesting is already being done on the rooftop of Government schools in Delhi. It needs to be implemented across Rajasthan and Uttar Pradesh as well, that can help to lower the problem of water scarcity during summers. The Government can make it compulsory that every new house made under Pradhan Mantri Awas Yojana, is equipped with the infrastructure for rain water harvesting.
- Conversion of the marriage hall, community halls, Anganwadi centers or nearby schools into relief centers i.e., well equipped with cooling devices having the ability to provide primary health treatment in case individuals fall sick.
- The number of natural water sources is reducing so the animals and birds on the streets are facing shortage of water availability and often losing lives due to extreme heat. Artificial water tankers can be placed in different parts of the locality for them as well as the Government can provide fodder facilities for those who are having livestock.
- The Government should take up initiatives to plant more trees, construct more huts in rural areas and make more parks in urban areas along with the communities which would ensure more places of shade for the people during hot summer days. It is important to check the sustenance of the plants in the long run so that they do not die off. The plantation drives must not be reduced to tokenism.
- The homeless people especially in urban areas need to be provided with adequately cooled housing facilities.

Conclusion

Heatwaves are an emerging threat to vulnerable communities in India whose intensity, duration, and prevalence are increasing due to the combination of warming climate and anthropogenic activities. The impact of extreme weather eventsis mostly faced by the vulnerable population as India in particular is more vulnerable due to various factors like prevalent social inequality, low per capita income and dependence on the agricultural sector (Eckstein, 2020). This is evident amongst the residents of Siwaya village, Rajasthan, Dhaisariya village, Uttar Pradesh and Seema Puri, Delhi. The people are vulnerable as they are mostly engaged in the unorganized sector. Particularly in cases of Dhaisariya and Siwaya villages, their living and livelihood has received a severe blow from the rising temperatures as the majority of these people are engaged in the agricultural sector. There is also a detrimental impact on their health, education of children, migration patterns and social life of the people. However, as they are a vulnerable section of the society, they do not possess adequate physical, human, social, financial or natural capital, that can ensure the sustainability of their livelihood in the long run that are efficient in the face of deadly heatwaves in India.

The residents are dealing at their individual level using their own traditional measures like natural home remedies, certain traditional food habits, clothing patterns and housing structures. Along with traditional measures the people of Dhaisariya and Seema Puri have also adopted certain modern solutions to deal effectively with heat waves. Siwaya and Seema Puri, also take collective measures at the community level to fight against heatwaves. However, at Dhaisariya, there is an absence of adequate community-level measures. At the Government level, there is a lack of effective measures for curbing heat wave effects, but some provisions have been ensured by the government in some of its schemes and additional measures. There is a gap between planning and implementation as people face difficulty in accessing the scheme benefits due lack of monitoring at the ground level.

In all three areas, health facilities are available but they are not easily accessible. There is a gap in terms of availability of essential medical supplies and human resources, preparedness plan before heatwave and accessibility. Thus, the level of vulnerability of both poor people and animals/birds is intensified with the coming of heatwave in the absence of adequate coping strategies. These healthcare gaps cannot be filled up by community measures, they are required to be addressed by the government. The healthcare department has to come up with cost-effective solutions particularly focusing on the inaccessible areas for providing treatment to poor people.

To make the community resilient in the face of future heatwaves, these vulnerable communities need to be equipped with cost effective coping strategies, with major effort taken at the government level. Also, the government and the community have to come together to ensure the safety of street animals and birds during extreme heatwave effects. Traditional cost-effective measures adopted by the people need to be blended with modern scientific solutions to develop effective solutions which can help people to adapt to changing climatic conditions and to make their application more effective and sustainable. The government has to incorporate the component of changing weather conditions, in the existing schemes or policies, which in turn will help people fight against deadly heatwaves. A “one size fits all"’ approach won’t be effective. Certain problems can be addressed effectively only by taking up location-centric measures. Along with it, heatwaves actionplans need to be developed at city and village level as well.

Gaps addressed: This particular study involves villages and sub-district as from the EGM it is deduced that no studies on heatwaves at community, village, block and town level have been conducted in India. From the EGM it is also evident there is a lack of studies dealing with indigenous solutions or traditional coping strategies and cost-effective methods to protect from events of heat wave. Indigenous or traditional medical solutions utilizing herbs, food choices, and clothing are missing from the existing studies conducted on heatwaves, especially in India, as highlighted by the EGM. Our study helps to fill up these gaps in existing literature effectively.

Limitations and challenges in the study

The field engagement consisting of FGDs and interviews conducted in Siyawa, Rajasthan, Dhaisariya village in Uttar Pradesh and Seema Puri in Delhi, facilitated constructive discussions regarding heatwaves, its causes, impact and various remedies and measures undertaken at individual, community and government level. Recommendations were also shared by the locals reflecting their immediate as well as long-term needs for a common good. The field visits proved to be fruitful forthe study but there were some limitations faced by the grassroot partners.

Knowledge gap among younger generation: In Siyawa village, Rajasthan, an FGD was conducted with young girls who were mostly teenagers and young adults. Compared to their elders, they were almost completely unfamiliar with the traditional techniques used by their parents and grandparents to tackle the rising temperature. The reason for this knowledgegap is reduced interaction and engagement with their elders over the course of time.

Prevailing rain: When the FGDs and interviews were conducted in Siyawa, Rajasthan, as well as in Gorakhpur, UP, heatwaves were already a past phenomenon which would again take place next year according to the people. It was raining during some of the field visits hence people were not able to grasp the seriousness of heatwaves which can leave massive impacts in the near future.

Migration: In Siyawa, Rajasthan, some people had migrated to different states like Gujarat and Madhya Pradesh for better job opportunities in the informal sector. Some of the people who were present in the village were migrants from different places hence didn't have much knowledge about the traditional practices prevailing in the region. In addition, many people weren't present in their homes.

Unable to talk against the Government: The people interviewed didn't prefer talking against the existing government. As a result, most of them weren't responding regarding the interventions carried out by the government or preferred to cite only the positive roles played by the government avoiding the drawbacks.

*Difficulty in assembling people:*Most of the people involved in the interview process were daily wage workers, involving in the interview meant losing their work time. Therefore, it was difficult to bring the people together to conduct the FGDs at a particular time which was suitable for all and carry on with the process of data collection.

References

Azhar, G.S. (2019). Indian Summer. *Pardee Rand Graduate School*.

Bal, K.S., Prasad, J., & Singh, V. K. (2022). Heat wave 2022 Causes, Impacts and Way Forward for Indian Agriculture.

Barange, M., & Perry, R. I. (2009). Physical and ecological impacts of climate change relevant to marine and inland capture fisheries and aquaculture. *In: Climate change implications for fisheries and aquaculture overview of current scientific Knowledge*, 7-107.

Barnabas, B., Jager, K., & Feher, A. (2008). The effect of drought and heat stress on reproductive processes in cereals. *Plant Cell Environ*, 11 - 38.

Ben Wisner, P.B. (2003). At Risk: Second edition, natural hazards, people's vulnerability and disasters.

Buscail, C., Upegui, E., &Viel, J. F. (2012). Mapping heatwave health risk at the community level for public health action. *International Journal of Health Geographics*. https://doi.org/10.1186/1476-072x-11-38

Census. (2011). *Dhaisariya Population - Gorakhpur, Uttar Pradesh*. www.census2011.co.in. https://www.census2011.co.in/data/village/186921-dhaisariya-uttar-pradesh.html

Census. (2011). *Seema Puri Tehsil Population, Caste, Religion Data - North East district, Delhi*. www.censusindia.co.in. https://www.censusindia.co.in/subdistrict/seema-puri-tehsil-north-east-delhi-438

Chazalnoël, M. T., Mach, E., & Ionesco, D. (2017). Extreme Heat and Migration. 1-14.

Chhabra, K. (2022, September 19). *SSPY UP Vidhwa Pension List 2022-23, Status: Widows Apply Online*. sarkariyojana.com. https://sarkariyojana.com/up-widow-pension-scheme/

Crichton, D. (1999). The Risk triangle. *Natural disaster management*.

CSE. (2022). *Heat Waves in India*. www.cseindia.org: https://www.cseindia.org/heat-waves-in-india-a-cse-media-briefing-note-11241
Cost-Effective Definition. (2022, May 6). www.accountingtools.com. https://www.accountingtools.com/articles/cost-effective
DFID. (2000). DFID's Sustainable Livelihood Approach and its Framework. GLOPP.
Ebhohon, E. (2018). Utilization of the Modified Tanahashi Model for Assessing Universal Effective Health Coverage. University of North Carolina, Chapel Hill.
Dodla, V., & Satyanarayana, G. (2021). Heat Waves Over India. 30-47.
Eckstein, D. (2020). Global Climate Risk Index. *GERMANWATCH*.
Gibbens, S. (2019, July 29). *Summertime means disease-carrying insects. Here's what you should know.* www.nationalgeographic.com. https://www.nationalgeographic.com/environment/article/what-you-should-know-about-disease-carrying-ticks-mosquitoes-this-summer
Grzebik, J. (2010, November 1). *Trees can function like a natural air conditioner*. www.staradvertiser.com. https://www.staradvertiser.com/2010/11/01/features/the-urban-gardener/trees-can-function-like-a-natural-air-conditioner/
Guleria, S., & Gupta, A. K. (2018). Heat Wave in India: Documentation of State of Telangana and Odisha (2016). 1-69.
Gupta, A. (2021, May 19). *6 health benefits of drinking water from an earthen pot*. healthshots. https://www.healthshots.com/healthy-eating/nutrition/6-health-benefits-of-drinking-water-from-an-earthen-pot/
Gupta, A., Gupta, G., & Khan, S. (2019). Heat Action Plan. *Standard Operating Procedure for Heat Wave in Gorakhpur*, 1-45.
ISDR. (2008). Indigenous Knowledge for Disaster Risk Reduction: Good Practices and Lessons Learned from Experiences in the Asia-Pacifi c Region. International Strategy for Disaster Reduction.Heat Related Illness. (n.d.). *Picture of America Report*, 1-7.
Hisang, Solomon, Burke, Marshall, Miguel, & Edward. (2015). *Climate and Conflict. Annual Review of Economics*, 577-617.
IGI Global. (2022). *What is Anganwadi*. IGI Global. https://www.igi-global.com/dictionary/kudumbashree/87278
ILO. (2019). Working on a warmer planet: The impact of heat stress on labour productivity and decent work. 1-97.
Indian Village Directory. (2022). villageinfo.in. https://villageinfo.in/delhi/north-east-delhi/seema-puri.html
Jagoo, K. (2022, March 23). *Collective Action Could Relieve Climate Anxiety*. verywellmind. https://www.verywellmind.com/collective-action-could-relieve-climate-anxiety-5222062
Johkan, M., Oda, M., Maruo, T., & Shinohara, Y. (2011). Crop production and global warming. *Casalegno S (ed) Global warming impacts: case studies on the economy, human health, and on urban and natural environments*, 139-152.
Kornhuber, K. (2019). Amplified Rossby waves enhance risk of concurrent heatwaves in major breadbasket regions. *Nature Climate Change*.
Labour Card Scheme in Delhi 2022. (n.d.). pmjandhanyojana.co.in. https://pmjandhanyojana.co.in/labour-card-scheme-delhi-kaise-banaye-online-apply/
Lawrence, D. (2014, December 18). Nature Climate Change. *Effects of Tropical Deforestation on Climate and Agriculture*, 1-9.
Magotra, R., Tyagi, A., Shaw, M., & Raj, V. (2020). *Review of Heat Action Plan*, 1-58.
Mandal, N. (2012). Impact of land-use and land-cover changes on temperature trends over Western India. *Current Science*.
Mavalankar, D. (n.d.). Impact of Heatwaves on public health and Health sector Heat Action. 1-40.
Miller, W. (2017, February 13). *We need a comprehensive housing approach to deal with heatwaves*. Theconversation.com. https://theconversation.com/we-need-a-comprehensive-housing-approach-to-deal-with-heatwaves-72800
Mohan, V. (2022). Total heatwave days in 2022 over 5 times more than last year's. *Times of India*.
MoRD. (2006). *Mahatma Gandhi NREGA- Ministry of Rural Development*. NREGA. https://nrega.nic.in/Nregahome/MGNREGA_new/Nrega_home.aspx
NDMA. (n.d.). *Beating The Heat : How India Successfully Reduced Mortality Due To Heat Waves*. ndma.gov.in. https://ndma.gov.in/sites/default/files/IEC/Booklets/HeatWave%20A5%20BOOK%20Final.pdf
NFSA. (n.d.). *Public Distribution System (PDS)*. nfsa.gov.in. https://nfsa.gov.in/portal/PDS_page#:~:text=The%20Public%20Distribution%20System%20(PDS,food%20economy%20in%20the%20country.
NIUA. (2016). India-Urban Climate Change Fact Sheets: Heat Waves. 1-4.
NRDC. (2022). Expanding Heat Resilience Across India: Heat Action Plan Highlights 2022. *NRDC*.
Onefivenine. (2021). *One Fice Nine. com*. http://www.onefivenine.com/india/villages/Sirohi/Abu-Road/Siyawa
OutlookWebDesk. (2022). Heatwave Grips Parts of Rajasthan. *Outlook*.

Practically. (2020). *Management of Natural Resources*. Practically. https://www.practically.com/studymaterial/blog/docs/class-10th/biology/management-of-natural-resources-2/
PTI. (2022). Heatwave revives in Rajasthan. *The Print*.
Recio, E., & Hestad, D. D. (2022, April 22). Indigenous Peoples: Defending an Environment for All. International Institute for Sustainable Development (IISD).
Segar, A. (2014, January 6). Why measurable outcomes aren't always a good thing. www.conferencesthatwork.com. https://www.conferencesthatwork.com/index.php/facilitating-change/2014/01/why-measurable-outcomes-arent-always-a-good-thing/
Sharkey, T. O. (2013). Universal Health Coverage through District Health System Strengthening: Using a modified Tanahashi model sub-nationally to attain equitable and effective coverage. New York: United Nations Children's Fund (UNICEF).
Wisner, B. (2003). At Risk: Second edition, natural hazards, people's vulnerability and disasters.

Rai, S., & Verma, A. (2022, June 22). *The roots of sustainability: 5 reasons why cities need trees*. www.weforum.org. https://www.weforum.org/agenda/2022/06/cities-urban-trees-climate-change/
Randell, H. (2019, May 7). *Climate Change May Weaken Children's Education in the Tropics*. www.newsecuritybeat.org. https://www.newsecuritybeat.org/2019/05/climate-change-weaken-childrens-education-tropics/
Rebecca Lindsey, L. D. (2022). Climate Change: Global Temperature. *NOAA*.
Rousi, E. (2022). Accelerated western European heatwave trends linked to more-persistent double jets over Eurasia. *Nature*.
Sharma, R. (2019, June 15). *How people keep thier cool during summer in Churu, India's hottest place*. Business Standard. https://www.business-standard.com/article/beyond-business/how-people-keep-their-cool-during-summer-in-churu-india-s-hottest-place-119061401444_1.html
Shukla, N. (2022, May 30). *Uttar Pradesh: Heatwave ruins 80% crop in Malihabad mango belt*. timesofindia.indiatimes.com. https://timesofindia.indiatimes.com/city/lucknow/uttar-pradesh-heatwave-ruins-80-crop-in-malihabad-mango-belt/articleshow/91897350.cms
The_Hindu. (2018, February). *'Slums in Indian cities most vulnerable to heat wave'*. www.thehindu.com. https://www.thehindu.com/news/cities/Vijayawada/slums-in-indian-cities-most-vulnerable-to-heat-wave/article22822096.ece
TOI. (2022, April 30). *Explained: Why India is facing longest power cuts in 6 years*. timesofindia.indiatimes.com. https://timesofindia.indiatimes.com/india/explained-why-india-is-facing-longest-power-cuts-in-6-years/articleshow/91198487.cms
Tomlinson, C. J., Chapman, L., Thornes, J. E., & Baker, C. J. (2011). International Journal of Health. *Including the urban heat island in spatial heat health risk assessment strategies: a case study for Birmingham, UK*. https://doi.org/10.1186/1476-072x-10-42
Witze, A. (2022). Extreme heatwaves: surprising lessons from the record warmth. *Nature*.
WMO. (2013). The Global Climate 2001-2010. *World Meteorological Organization*.
Wolf, J., Adger, W. N., Lorenzoni, I., & Abrahamson, V. (2010, February). *Social Capital, Individual Responses to Heat Waves and Climate Change Adaptation: An Empirical Study of Two UK Cities*, 44-52.
WS. (2022). *WeatherSpark*. https://weatherspark.com/m/107358/5/Average-Weather-in-May-in-%C4%80bu-Road-India#Figures-Temperature
Yalcin, S., Settar, P., Ozkan, S., &Cahaner, A. (1997). Comparative evaluation of three commercial broiler stocks in hot versus temperate climates. 921-929.
Yu, Q. (2020). A preliminary exploration of the cooling effect of tree shade in urban landscapes. *ScienceDirect, 92*.
Zachariah, M. (2022). Climate Change made devastating early heat in India and Pakistan 30 times more likely. *World Weather Attribution*.

Appendix 1

EVIDENCE GAP MAP

					OUTCOMES											
					Policies			Programs/awareness					Economic, social, and health			
	S. No.	VARIABLES	CATEGORIES	SUBCATEGORIES	Individual	Community	Government	Health, mental health, and medical	Economic and agricultural activities	Housing and landscaping	Community level	Legislative	Poverty and food security	Employment and labour force	Cost-effectiveness	Morbidity and comorbidity
INTERVENTIONS	1	Education and Life skills	Personal and community level	Awareness drives				6A,6D,6E, 6P, 2I	6A,6B	6D	6B, 6C,6D,2F	6Q	6A,6D,6J	6A,6D		6A,6D,6E,6J
	2			Community mobilization programs				6P				6Q				
	3			Health awareness programs and media campaigns		6D,6L,2C	6L,2J	6P	2E,		6L	2P				
	4	Medical, Technological solutions, and support	Indigenous knowledge	Herbal prophylaxis, food choices												
	5			Housing trends, Cooling technique, Clothing		6B, 5B		2L	2H	6B	5B		6B,2H,2L		2H, 5B, 5AA	
	6			Other Indigenous knowledge, hand fans		6B										
	7		Modern Approach	Building techniques, air-conditioning					2C,2H	6B,2C,2L	6L,2C	2P				
	8			Heat-resistant paint, green roofs, shading		5M				6D					6D	
	9			Chemical prophylaxis, processed food,				6A,	6A,6O							
	10			Technological solutions	5N				6O, 5O, 5P	6D,2L		2P				
	11	Infrastructural	Safe Environment	Making existing safe	6D	6D,6E , 5B, 5R			6B,2G,2I	6B	6A,6C,2H, 5B		6A,2L			6A,6J
	12			Creating safe	6D				6O,2F		6C,6L		2J			
	13		Safe habitats	Heat resistant houses	5D, 5J, 5M, 5V	5H			6O						5D, 5H, 5J, 5M	
	14			Cooling solutions	5M, 5V, 5W	5H			6B,6O	2H					5H, 5M, 5W	
	15	Nature-based	Traditional	Tree plantations, water bodies, alteration in working hours		5G, 5L				6D,2H					5G	
	16		Modern	parks, urban green belts, new water bodies		5G				6D					5G	
	17			Drinks, food, and clothing to prevent heat.												
	18	Legislature and policies	Local	Law and order, resource mobilization								6L, 5X				
	19			Economic policies				2Q				6L, 5X				
	20			Labour and wages hour management					2F,2G,2I			6L			5AA	
	21			The media campaign, medical resource management.				6P								
	22		Institutional	NGOs and other institutional Interventions								2F				
	23			Insurance, economic aid, support.												
	24			Awareness Drives and campaigns.								2F				
	25		State	Extreme heat policies, labour laws.		2C			2F	6D		2O				
	26			Community resource mobilization		2C, 5U				6D						
	27			Advisories, action plans		5X		2Q, 5T				2F				
	28			Medical, water, and safe shelter supply		2C										
	29			Welfare schemes	5AA											
	30		Union/National	Directives and advisories				6E				2J	2P			
	31			Meteorological forecasting			5I	6J	2I		6L	2J				
	32			National heat action plans, climate change policies, jurisdiction			6B, 5I	6Q	6O,2G	6B,2H		2O	2J	2D		
	33			Labour laws and welfare schemes for outdoor workers.			6B,6Q		2I	2H						
	34	Socio-cultural and ethological	Indigenous/ traditional	Food habits, cooling techniques							6C					

35			Working hours alteration /migration		2C,			2S		6L					
36			Clothing, housing, way of life, culture		2C	6B				6L					
37			Adaptation, sustainability		6D, 5X, 5Z	6B	6E	2G,2S		6C,6E,6L		2J			
38			Community practices		6D,6E,2C, 5E	6B						2L, 5E			
39		Modern/ urban	Housing and urban planning working hours			6B				6L					
40			Adaptation, sustainability		6D, 5F, 5S	6B	6E, 5F			6C,6E, 5F			5F		
41			Food habits and cooling techniques		5S					6L					
42			Parks, air conditioning, and water parks							6L					
43	Geographical and topographical	Within India	Community level/village /block/town level												
44			District level								2F,2O				
45			Province or State level		2C							2L			
46			National level (INDIA)				5T					2J			
47		Outside India	Global level		5S, 5Y	6B, 5B	6A 6D, 6E, 6O, 6Q, 2F, 2I, 5T	6A,6O,2G,2S, 5P, 5Y	6C,2H	6E,6L, 5B		6E, 5S, 5AB	2D,2H	5T	6J

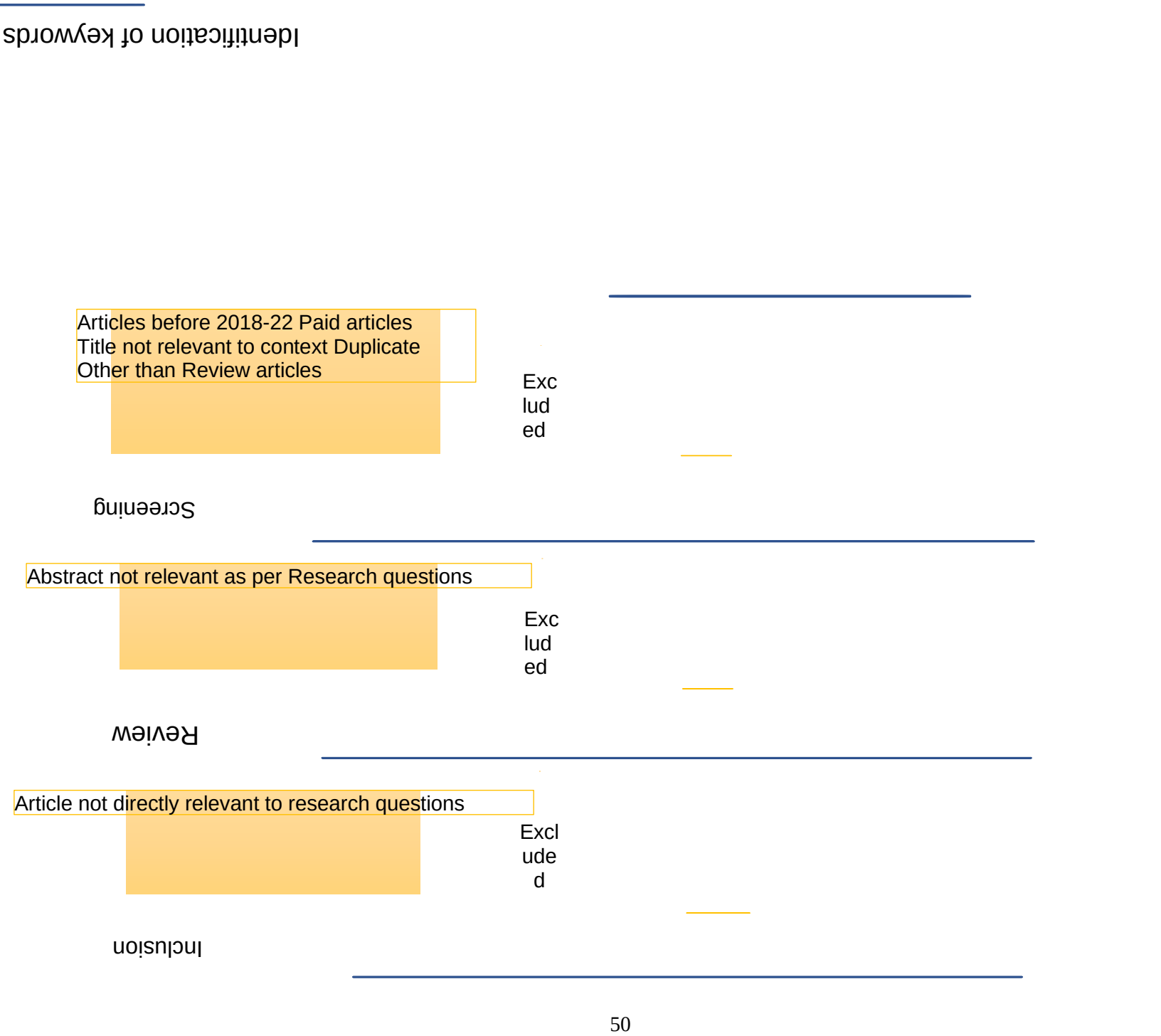
The above EGM map was prepared manually using codes for the articles reviewed. Please follow below code table for article codes mentioned in the EGM.

Codes	Keyword	Title of the study	Method	Reason for Exclusion
2A	"Traditional" "coping strategies" for "heatwave" in "India"	A Literature Review of the Impacts of Heat Stress on Human Health across Africa	Full Text reading and screening	Not related to RQ and RO
2B	"Traditional" "coping strategies" for "heatwave" in "India"	Climate change, urban futures, and the gendering of cities in South Asia	Full Text reading and screening	Not related to RQ
2C	"Traditional" "coping strategies" for "heatwave" in "India"	Community-level assessment of heatwaves in Odisha State, India Effects, resilience and implications.	Full Text reading and screening	
2D	"Traditional" "coping strategies" for "heatwave" in "India"	Courting emissions climate adjudication and South Africa's youth.	Full Text reading and screening	
2E	"Traditional" "coping strategies" for "heatwave" in "India"	Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa.	Full Text reading and screening	
2F	"Traditional" "coping strategies" for "heatwave" in "India"	Disaster, displacement and rehabilitation a case study of Kosi floods in North Bihar.	Full Text reading and screening	
2G	"Traditional" "coping strategies" for "heatwave" in "India"	Egyptian Agriculture in Transition Farmer Perceptions of Risks and Adaptation Opportunities in a Changing Climate.	Full Text reading and screening	
2H	"Traditional" "coping strategies" for "heatwave" in "India"	Global Climate Risk Index 2020_13.	Full Text reading and screening	
2I	"Traditional" "coping strategies" for "heatwave" in "India"	Heat exposure and adaptation strategies of outdoor informal sector workers in urban Bulawayo-Zimbabwe.	Full Text reading and screening	
2J	"Traditional" "coping strategies" for "heatwave" in "India"	Indian summer.	Full Text reading and screening	
2K	"Traditional" "coping strategies" for "heatwave" in "India"	Local urban risk assessment of dry and hot hazards for planning mitigation measures	Full Text reading and screening	Not related to RQ
2L	"Traditional" "coping strategies" for "heatwave" in "India"	Low-income residents' strategies to cope with urban heat.	Full Text reading and screening	
2M	"Traditional" "coping strategies" for "heatwave" in "India"	On the linkage between urban heat island and urban pollution island Three-decade literature review towards a conceptual framework	Full Text reading and screening	Not Related to RQ
2N	"Traditional" "coping strategies" for "heatwave" in "India"	Ruminant Productivity Among Smallholders in a Changing Climate Adaptation Strategies	Full Text reading and screening	Not related to RQ
2O	"Traditional" "coping strategies" for "heatwave" in "India"	Saving-lives-and-livelihoods_the-benefits-of-investments-in-climate-change-adaptation-and-resilience.	Full Text reading and screening	
2P	"Traditional" "coping strategies" for "heatwave" in "India"	The international conference on climate services 6 Advancing the knowledge and practice of climate services for climate resilience.	Full Text reading and screening	
2Q	"Traditional" "coping strategies" for "heatwave" in "India"	Understanding and Expanding the Role of Personal and Household Behaviour in Climate Change Adaptation.	Full Text reading and screening	
2R	"Traditional" "coping strategies" for "heatwave" in "India"	Use and communication of climate information to support uptake of adaptation actions in semi-arid regions in Africa and Asia	Full Text reading and screening	Not related to RQ
2S	"Traditional" "coping strategies" for "heatwave" in "India"	Vulnerabilities of rural women to climate extremes A case of semi-arid districts in Pakistan.	Full Text reading and screening	

NEXT KEYWORD				
6A	Indigenous solution of "heatwave" in "India"	6A A review of the global climate change impacts, adaptation, and sustainable mitigation measures	Full Text reading and screening	
6B	Indigenous solution of "heatwave" in "India"	6B Climate_change_adaptation_to_extreme_heat_A_global	Full Text reading and screening	
6C	Indigenous solution of "heatwave" in "India"	6C Climate change and interconnected risks to sustainable development in the Mediterranean	Full Text reading and screening	
6D	Indigenous solution of "heatwave" in "India"	6D Climate_Solutions_Double_as_Health_Interventions	Full Text reading and screening	
6E	Indigenous solution of "heatwave" in "India"	6E Creating the healthiest nation Climate change and environmental health impacts in Nigeria A narrative review	Full Text reading and screening	
6F	Indigenous solution of "heatwave" in "India"	6.6 Creating the healthiest nation Climate change and environmental health impacts in Nigeria A narrative review	Full Text reading and screening	Not related to RQ and RO
6G	Indigenous solution of "heatwave" in "India"	6.7 Current Research in Environmental Sustainability	Full Text reading and screening	Not related to RQ and RO
6H	Indigenous solution of "heatwave" in "India"	6.8 Energy_Poverty_and_Health_in_Climate_Change_A_Comp	Full Text reading and screening	Not related to RQ and RO
6I	Indigenous solution of "heatwave" in "India"	6.9 Genomic_Approaches_for_Conservation_Management_in_	Full Text reading and screening	Not related to RQ and RO
6J	Indigenous solution of "heatwave" in "India"	6J Impact of heat on mortality and morbidity in low and middle-income countries A review of the epidemiological evidence and considerations for future research - ScienceDirect	Full Text reading and screening	
6K	Indigenous solution of "heatwave" in "India"	7.1 Impact of recent and future climate change on	Full Text reading and screening	Not related to RQ and RO
6L	Indigenous solution of "heatwave" in "India"	6L Impacts_of_Climate_Change_and_Heat_Stress_on_Farmw	Full Text reading and screening	
6M	Indigenous solution of "heatwave" in "India"	7.3 Plant Tolerance to Drought Stress in the Presence of Supporting Bacteria and Fungi An Efficient Strategy in Horticulture	Full Text reading and screening	Not related to RQ and RO
6N	Indigenous solution of "heatwave" in "India"	7.4 Risk Management and Adaptation for Extremes and Abrupt Changes in Climate and Oceans Current Knowledge Gaps	Full-Text reading and screening	Not related to RQ and RO
6O	Indigenous solution of "heatwave" in "India"	6O The Impact of Anthropogenic Climate Change on Egyptian	Full Text reading and screening	
6P	Indigenous solution of "heatwave" in "India"	6P The impact of climate change on mental health and emotional wellbeing current evidence and implications for policy and practice	Full Text reading and screening	
6Q	Indigenous solution of "heatwave" in "India"	6Q Vulnerability to heatwaves and implications for public health interventions–A scoping review	Full Text reading and screening	

		Next Keyword		
5A	“Cost Effective” Method to prevent “Heat Wave” in “India”	5A Climate Change: what we know and what is to be done	Full Text reading and screening	Not Related to RQ and RO
5B	“Cost Effective” Method to prevent “Heat Wave” in “India”	5B Hydro-meteorological risk assessment methods and management by nature-based solutions	Full Text reading and screening	
5C	“Cost Effective” Method to prevent “Heat Wave” in “India”	5C Fast action on short-lived climate pollutants and nature-based solutions to help countries meet carbon neutrality goals	Full Text reading and screening	Not Related to RQ and RO
5D	“Cost Effective” Method to prevent “Heat Wave” in “India”	5D Comparative analysis of building insulation material properties and performance	Full Text reading and screening	
5E	“Cost Effective” Method to prevent “Heat Wave” in “India”	5E The costs of climate change in India : a review of the climate-related risks facing India, and their economic and social costs	Full Text reading and screening	
5F	“Cost Effective” Method to prevent “Heat Wave” in “India”	5F Establishing intensifying chronic exposure to extreme heat as a slow onset event with implications for health, wellbeing, productivity, society and economy	Full Text reading and screening	
5G	“Cost Effective” Method to prevent “Heat Wave” in “India”	5G Nature-based solutions efficiency evaluation against natural hazards: Modelling methods, advantages and limitations	Full Text reading and screening	
5H	“Cost Effective” Method to prevent “Heat Wave” in “India”	5H Incorporation of phase change materials into building envelope for thermal comfort and energy saving: A comprehensive analysis	Full Text reading and screening	
5I	“Cost Effective” Method to prevent “Heat Wave” in “India”	5I Progress in extreme heat management and warning systems: A systematic review of heat-health action plans (1995-2020)	Full Text reading and screening	
5J	“Cost Effective” Method to prevent “Heat Wave” in “India”	5J Phase change material incorporation techniques in building envelopes for enhancing the building thermal Comfort-A review	Full Text reading and screening	
5K	“Cost Effective” Method to prevent “Heat Wave” in “India”	5K Association between ambient temperature and heat waves with mortality in South Asia: Systematic review and meta-analysis	Full Text reading and screening	Not Related to RQ and RO
5L	“Cost Effective” Method to prevent “Heat Wave” in “India”	5L An overview of monitoring methods for assessing the performance of nature-based solutions against natural hazards	Full Text reading and screening	
5M	“Cost Effective” Method to prevent “Heat Wave” in “India”	5M Resilient cooling strategies – A critical review and qualitative assessment	Full Text reading and screening	
5N	“Cost Effective” Method to prevent “Heat Wave” in “India”	5N A process-driven and need-oriented framework for review of technological contributions to disaster management	Full Text reading and screening	
5O	“Cost Effective” Method to prevent “Heat Wave” in “India”	5O A comprehensive review of remote sensing platforms, sensors, and applications in nut crops	Full Text reading and screening	
5P	“Cost Effective” Method to prevent “Heat Wave” in “India”	5P Global Warming, Impacts and Mitigation Measures: An Overview	Full Text reading and screening	
5Q	“Cost Effective” Method to prevent “Heat Wave” in “India”	5Q Global Prospects and challenges of latent heat thermal energy storage: A review	Full Text reading and screening	Not Related to RQ and RO
5R	“Cost Effective” Method to prevent “Heat Wave” in “India”	5R Combating Urban Heat Island Effect—A Review of Reflective Pavements and Tree Shading Strategies	Full Text reading and screening	
5S	“Cost Effective” Method to prevent “Heat Wave” in “India”	5S Integrated Assessment of Urban Overheating Impacts on Human Life	Full Text reading and screening	
5T	“Cost Effective” Method to prevent “Heat Wave” in “India”	5T Building sustainable and resilient surgical systems: A narrative review of opportunities to integrate climate change into national surgical planning in the Western Pacific region	Full Text reading and screening	
5U	“Cost Effective” Method to prevent “Heat Wave” in “India”	5U A framework for complex climate change risk assessment	Full Text reading and screening	
5V	“Cost Effective” Method to prevent “Heat Wave” in “India”	5V Review of carbon dioxide (CO2) based heating and cooling technologies: Past, present, and future outlook	Full Text reading and screening	
5W	“Cost Effective” Method to prevent “Heat Wave” in “India”	5W Resilient cooling strategies – A critical review and qualitative assessment	Full Text reading and screening	
5X	“Cost Effective” Method to prevent “Heat Wave” in “India”	5X Sustainable City Development is Possible? A Review of Challenges and Key Practices towards Urban Development in Developing Countries	Full Text reading and screening	
5Y	“Cost Effective” Method to prevent “Heat Wave” in “India”	5Y Climate Change Impact, Adaptation, and Mitigation in Temperate Grazing Systems: A Review	Full Text reading and screening	
5Z	“Cost Effective” Method to prevent “Heat Wave” in “India”	5Z Environmental sustainability: challenges and viable solutions	Full Text reading and screening	
5AA	“Cost Effective” Method to prevent “Heat Wave” in “India”	5AA Occupational Heat Stress Assessment and protective strategies in the context of climate change	Full Text reading and screening	
5AB	“Cost Effective” Method to prevent “Heat Wave” in “India”	5AB Role of Vegetation as a Mitigating Factor in the Urban Context	Full Text reading and screening	

Appendix 2


Identification of keywords
Articles before 2018-22 Paid articles Title not relevant to context Duplicate Other than Review articles
Excluded
Screening
Abstract not relevant as per Research questions
Excluded
Review
Article not directly relevant to research questions
Excluded
Inclusion

Appendix 3

Instructions for field investigators for the Extreme Heat Project

1. Please make sure that you have collected information about the village/ward by doing a transect walk and ground observations before starting the discussions and interviews.
2. Please fill the community checklist before starting the discussions.
3. Conduct FGDs first, followed by personal interviews and then the key informant interviews
4. Select participants for the FGD based on their gender and age. Conduct at least 3 FGDs – one with men, one with women and one with youth/adolescents
5. Select participants for the personal interviews from among the FGD participants who show interest in sharing more information about their households or may need a separate interview because of any particular health/livelihood condition
6. Build a rapport with the participants by telling them about yourself and the details of the research study. You may need to meet/speak to the key participants multiple times to gain their trust.
7. Make sure that all participants have understood the contents of the informed consent forms and participant information sheet and have agreed for sharing the information.
8. Do not promise any immediate benefits/gifts/results of the study. You may say that this study is important to bring out their voices and inform the policy for disaster/climate change management
9. Those who do not want to be named or quoted should be assured that their identities will not be revealed.
10. If any of the participants do not want to answer a question or want to stop the interview midway, they should not be pushed or forced to participate. That particular question(s) should be skipped or the interview should be stopped if they are very uncomfortable.
11. Your questions may not be answered in the order given in this form. Do not interrupt the participant when they are speaking. Notice which questions are being answered during their conversation, maintain the flow of the conversation and ask the unanswered ones at the end.
12. Make sure that any photos/audio/videos recorded have been done after taking permission from the participants.
13. **Possible key informants** – Gram Panchayat head (Sarpanch)/ward officer, ANM, Anganwadi Teacher, ASHA worker, Health service provider at the nearest health facility, Corporator, MNREGA officials, Block Development officer or any relevant person in a position of responsibility for heatwaves/ disasters/ climate/ environment/ employment/ health.

Observation checklist for transect walk

Any warning signs about heatwave/flood/rains etc in the village/ward

Any functional Anganwadi and PHC/Sub centre

Private health facilities or outreach units/mobile vans coming to the village/ward

Any PDS shop in the village/ward

Gram panchayat

FGD guidelines

1. What is heatwave impact on your community?
2. Discuss the impact on health and livelihoods.
3. What are the health facilities and health care mechanisms available here?
4. What individual and collective measures are taken by the community to deal with heatwave?
5. Discuss the cooling option taken by the community?
6. What measures, and awareness activities are done by the government?
7. Which measures do you think are most cost-effective?
8. What are the social protection schemes, safety nets available in the community?
9. What are your suggestions and recommendations to reduce risk of heat wave?

Personal Interview Guide

3. How were you impacted by the heatwave this year in March-April 2022?
4. Was this the first time your village has been affected; can you give more details on previous heatwave events?
5. What measures do you take for someone impacted by the heatwave? Whom do you consult?
6. Do these measures differ for children and the elderly? How?
7. Do you seek medical help or employ household remedies?
8. Which health facility do you refer to for heat-related issues?
9. What precautions do you take to avoid sunstroke when you go outside? (food/water/clothing/medication)
10. What measures do you normally take to protect yourself from heat stress at your home? (food/clothing/medication/infrastructure/appliances)
11. What cooling option is available in the community? (Water points/resting areas/tree
12. Which measures do you think are most cost-effective?
13. What are the traditional practices in your locality to protect from heat stress?
14. Does your livelihood get affected by extreme heat? If yes how?
15. What are your coping measures for the lost income? Or What other income options do you have when you are unable to work due to a heat wave?
16. Do people migrate due to the heatwave to other places for work?
17. Have you come across awareness activities for the heatwave and how has it been helpful for your community?
18. What measures are provided by the government for safety from heatwaves? (Heatwave warning/Modifying working hours/Infrastructure/Water points/medical help/wetlands/fountains/green spaces)
19. What more could be provided by the government for safety during the heatwave?
20. Has there been any changes in weather/climate patterns in the past 2 to 3 decades or more in general?
21. How have these changes impacted you? Your livelihood and health?
22. Are there any diseases affecting your family in general? Do they aggravate during summers?
23. What do you suggest should be done to cope with these changes better?
24. Do we need new forms of adaptation/coping strategies for the changing climate? What could they be?
25. What is the status of forests in your area? has deforestation increased?
26. Are there mining activities done in the village or nearby areas? Has there been an increase in these?
27. How have these activities impacted the water table/ moisture content and overall environment/ecology of your village?

Appendix 4

Key Informant Interview Guide

1. How was this region impacted due to the heatwave this year in March-May 2022?
2. What precaution measures do community take for the heatwave?
3. What health facilities are available in the region for dealing with impact of heatwave? When people use these facilities?
4. What cooling option is available in the community?
5. What kind of information is provided to the community for protection against heatwave?
6. What awareness measures are taken by the government to warn and prepare communities for the heatwave?
7. What are the traditional practices in your locality to protect from heat stress?
8. How are the livelihoods of people (especially those working outdoors) impacted by extreme heat?
9. What measures are taken by the community to protect income loss from heat waves?
10. Do people migrate due to the heatwave to other places for work?
11. What measures are provided by the government for safety from heatwaves? (Heatwave warning/ Modifying working hours/ Infrastructure/ Water points/medical help/wetlands/fountains/greening)
12. What more could be provided by the government for safety during the heatwave? (Heatwave warning/ Modifying working hours/ Infrastructure/ Water points/medical help/wetlands/fountains/greening)
13. Which measures – individual, community, or policy do you consider Cost-effective for a heat wave?
14. How does the livelihood situation or social reality affect the adaptation to heatwave?
15. What changes are needed in the socio-economic situation for better resilience to heatwave or any other form of climate change?
16. Is the Disaster Management Authority working at the community level? If yes, then mention the activities being conducted at the community level?
17. Were there similar heatwave events in this region previously? Can you mention few such events?
18. Are extreme weather events impacting this region?
19. Do we need new forms of adaptation/coping strategies for the changing climate? What could they be?

Informed Consent Form

Dear Sir/ Madam

In this study, we want to explore the impact of heatwaves on the health of this community and the cost-effective solutions to address this. We understand that some of the solutions can be implemented as the household and community level, whereas some solutions will have to be a part of policy. There may be some indigenous practices and knowledge of the community to deal with the heat in this region. We believe that the problems prevalent in the community and solutions and strategies required by this community must be voiced by the people and they must get an opportunity to co-produce the public policies addressing the issue of extreme heat, health and livelihoods.

Nature of Participation: We would like to request your consent to participate in the study. If you agree to participate, you will be asked to participate in a group discussion and/or a personal interview. We would like your permission to take some pictures, recordings and video recordings if needed during the conversation.

Confidentiality: To make sure that no one learns about any information shared by you in this study, your name will not appear on any document or other materials associated with the project. The audio recordings and any hard copy documents will be accessible only by the authorized persons of the research study. The identity of the interviewee will always remain confidential. Your name will be removed from all records.

Compensation: There will be no monetary compensation for your participation in the study.

Right to refuse or withdraw: Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time.

If you have questions about the research: The project staff is willing to answer any questions you may have concerning the procedures described.

Participants' consent: I have read and understood this entire consent form and any questions I have, have been answered to my satisfaction. I agree to participate in the study and to respond to the questions. I understand the purpose, nature, and length of my involvement in the study. I understand that I may choose not to participate at the beginning of the project or at any time during the project without penalty.