



REGIONAL WORKSHOP ON IMPACT-BASED FORECASTING:

IBF for Temperature-related Hazards – Refresher

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09-13 February 2026



Kathmandu, Nepal



Overview (WMO-WHO)

- Heatwave is a period where **local excess heat accumulates over a sequence of unusually hot days and nights.**
- Heatwaves and prolonged excess heat conditions are increasing in frequency, duration, intensity and magnitude due to climate change. **Even low and moderate intensity heat waves can impact the health and well-being of vulnerable populations.**
- Extended periods of high day and nighttime temperature conditions create cumulative stress on the human body, increasing the risk of illness and death from heat exposure.
- **Vulnerability to heat is shaped by both physiological factors, such as age and health status, and exposure factors such as occupation and socio-economic conditions.**
- Heatwaves can acutely impact large populations for short periods of time, often trigger public health emergencies, and result in excess mortality and cascading socioeconomic impacts (**for example, lost work capacity and labour productivity**). They can also cause loss of health service delivery capacity, when power shortages accompany heatwaves and disrupt health facilities, transport and water infrastructure.
- **The number of people exposed to extreme heat is growing exponentially due to climate change in all world regions. Heat-related mortality for people over 65 years of age increased by approximately 85% between 2000–2004 and 2017–2021**

Overview (WMO-WHO)

- **Between 2000–2019 studies show approximately 489 000 heat-related deaths occur each year, with 45% of these in Asia and 36% in Europe.**
- **The negative health impacts of heat are predictable and largely preventable with specific public health and multi-sectoral policies and interventions.**
- **Extended periods of high day and nighttime temperature conditions create cumulative stress on the human body, increasing the risk of illness and death from heat exposure.**
- **Population ageing and the growing prevalence of non-communicable diseases (**respiratory and cardiovascular diseases, diabetes, dementia, renal disease and musculoskeletal disease**) means that populations are becoming more susceptible to negative heat impacts.**
- **Cities are not being designed to minimize the accumulation and generation of urban heat, with a loss of greenspace and inappropriate housing materials (for example, metal roofs) that amplify human exposure to excess heat.**
- **Awareness among health workers and the public remains insufficient of the health risks posed by heat. Health professionals should adjust their guidance, planning and interventions to account for increasing heat exposures, as well as to manage acute increases in admissions associated with heatwaves.**
- **Need to put in place appropriate **Practical, feasible and often low-cost interventions at the individual, community, organizational, governmental and societal levels for saving lives.****
- **Urban and rural poor are often disproportionately exposed to overheating due to low quality housing and lack of access to cooling.**
- **Due to building materials, informal settlements are often hotter than other urban areas in some cities.**
- **Gender can play an important role in determining heat exposure, for example where women are primarily responsible for cooking indoors during hot weather.**

Main Heat Vulnerability Factors

Multiple vulnerabilities compound the health risks of extreme heat

▼ PHYSIOLOGICAL FACTORS



Older and less-abled people



People with certain medical conditions or taking certain medications or drugs



Pregnant people



Infants and children

▼ EXPOSURE FACTORS



Outdoor and manual workers



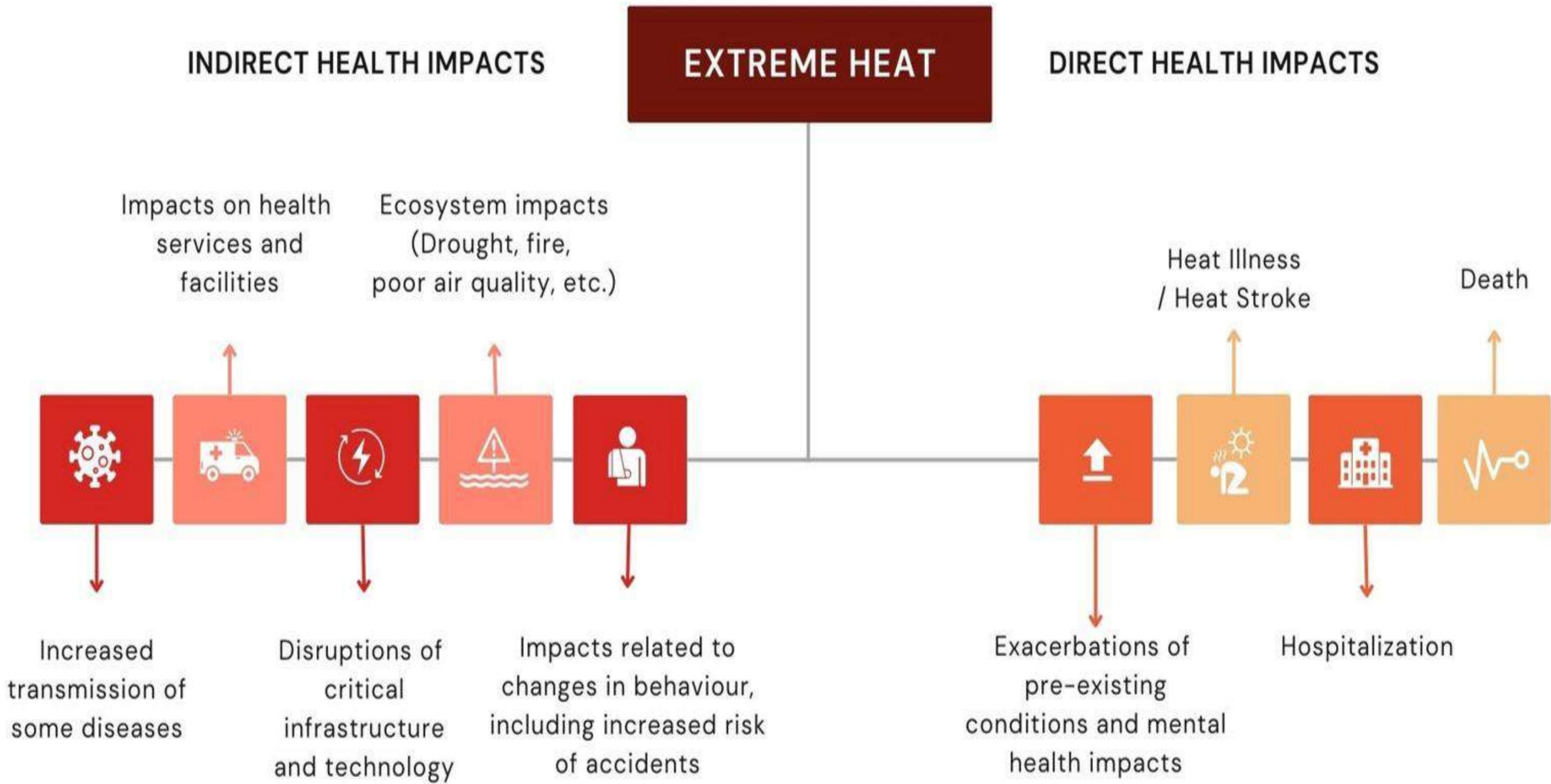
People living in sub-par housing conditions or who lack access to cooling

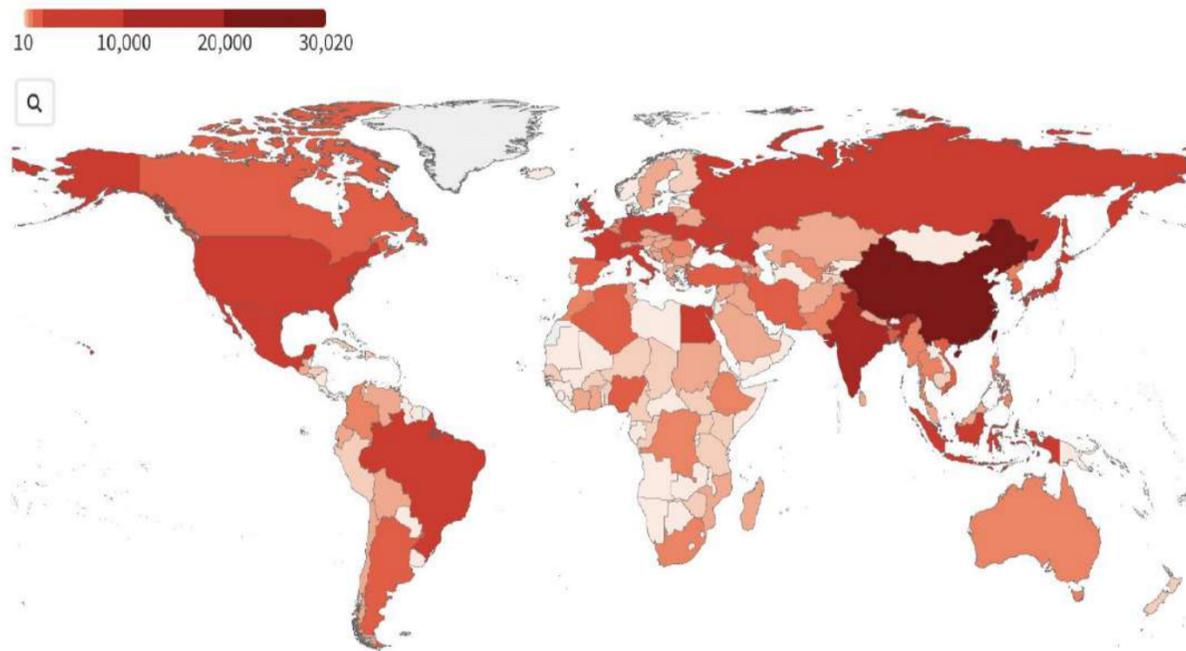


People who are poor, displaced or experiencing homelessness



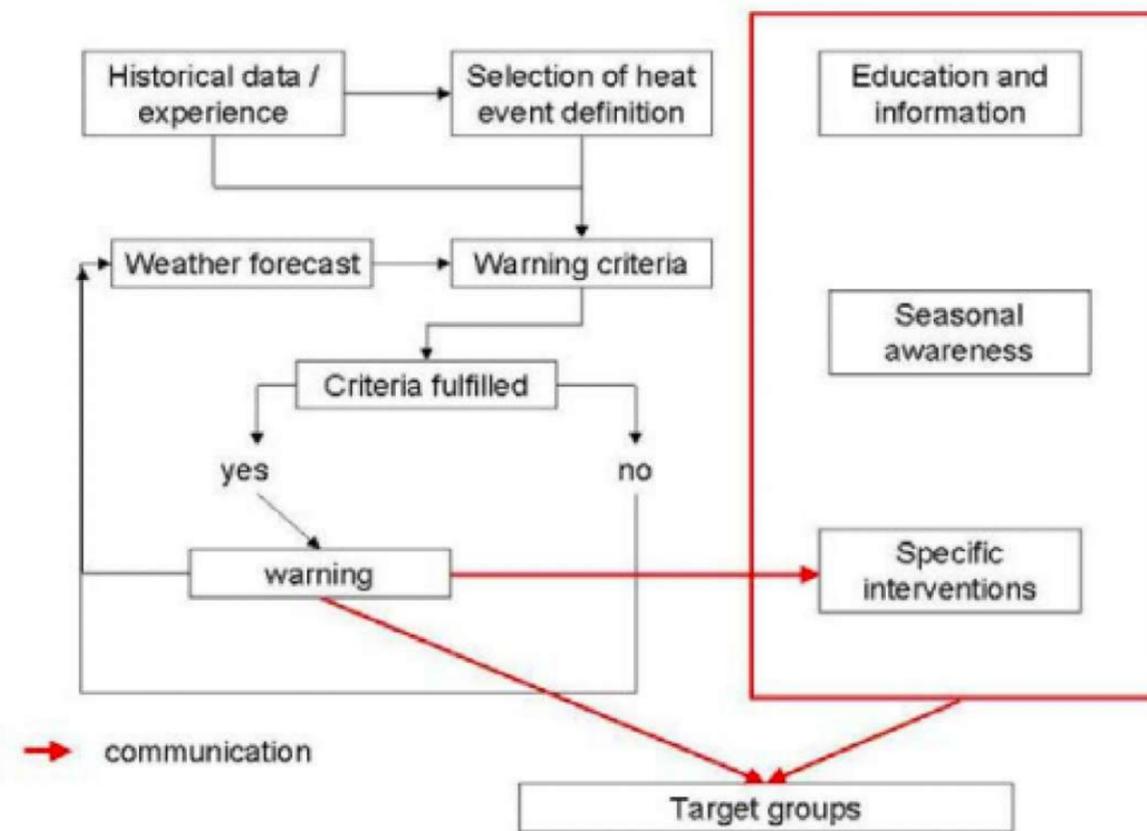
Athletes and attendees of outdoor events





Heat-related mortality for vulnerable people (adults over 65 years age) increased by approximately 68% between 2000-2004 and 2017-2021.

Image Source: Lancet



Flow diagram demonstrating the operation of a typical Heat-Health Warning System within a wider Heat-Health Action Plan

Source: McGregor, Glenn R., et al. *Heatwaves and health: guidance on warning-system development*. WMOP, 2015.

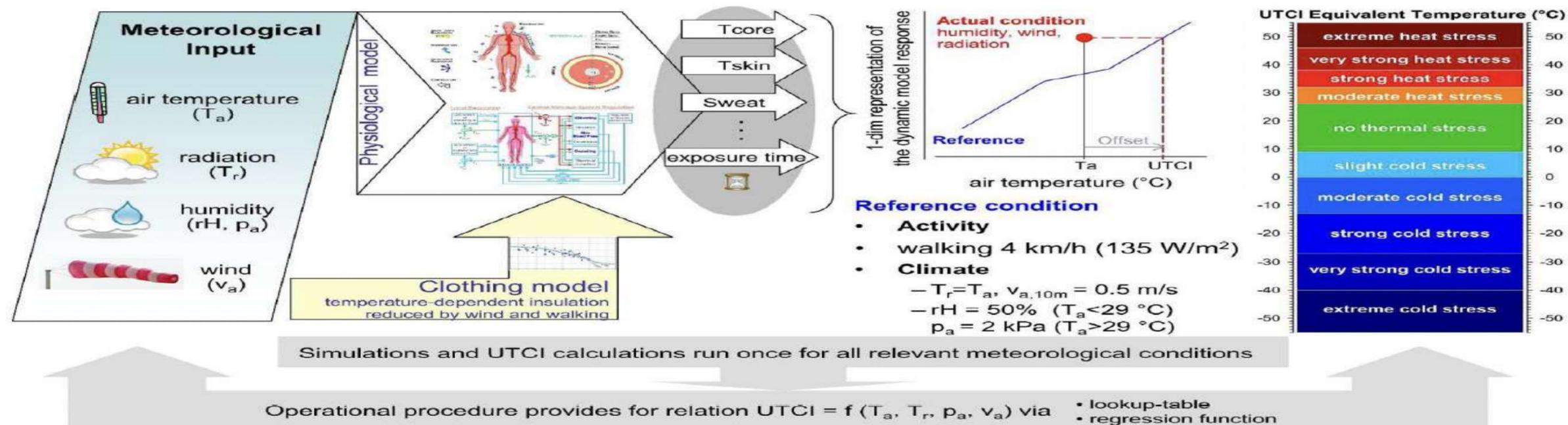
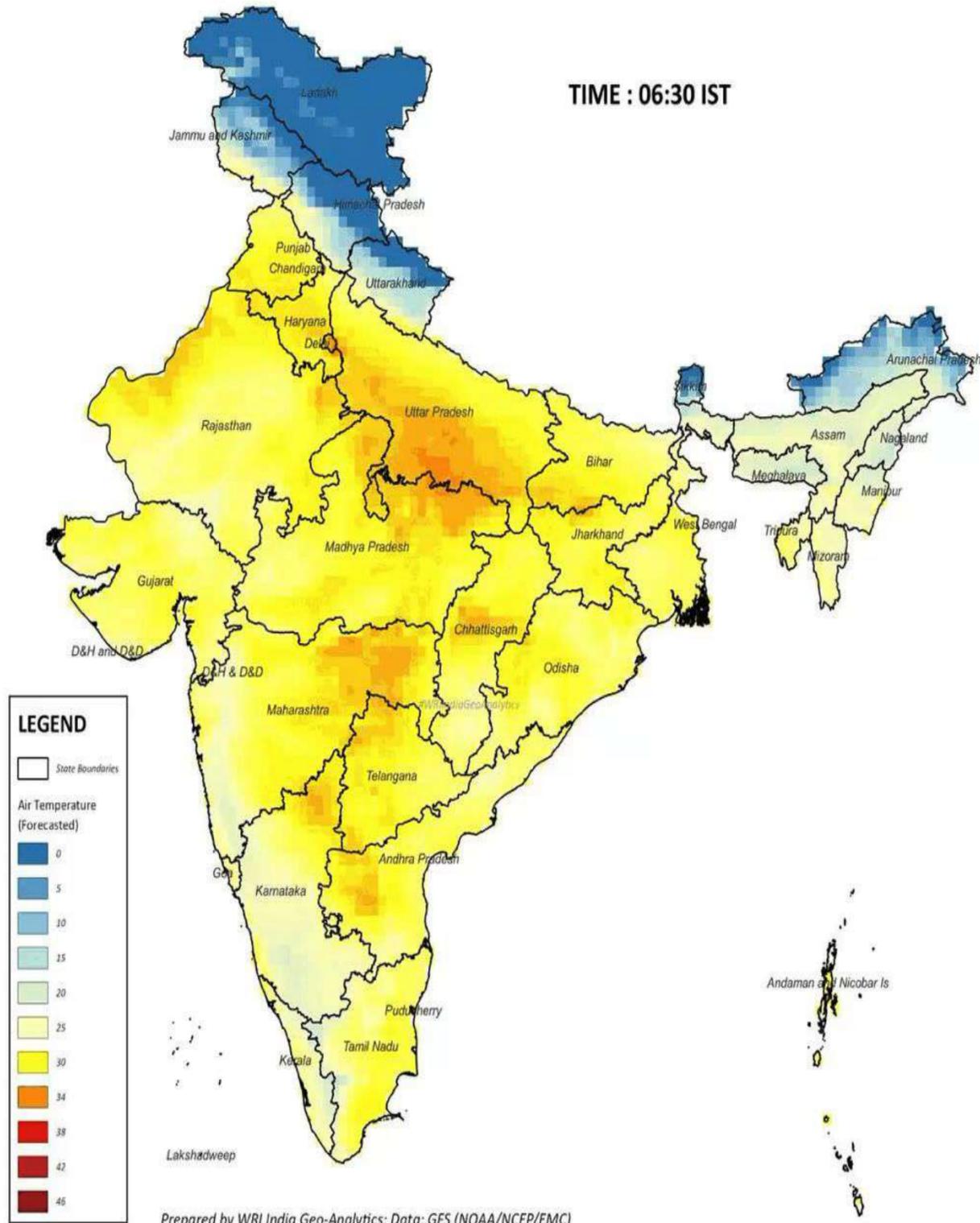


Fig. 1. Elements of the operational procedure and concept of UTCI as categorized equivalent temperature derived from the dynamic response of a thermo-physiological model coupled with a behavioral clothing model.

AIR TEMPERATURE

TIME : 06:30 IST

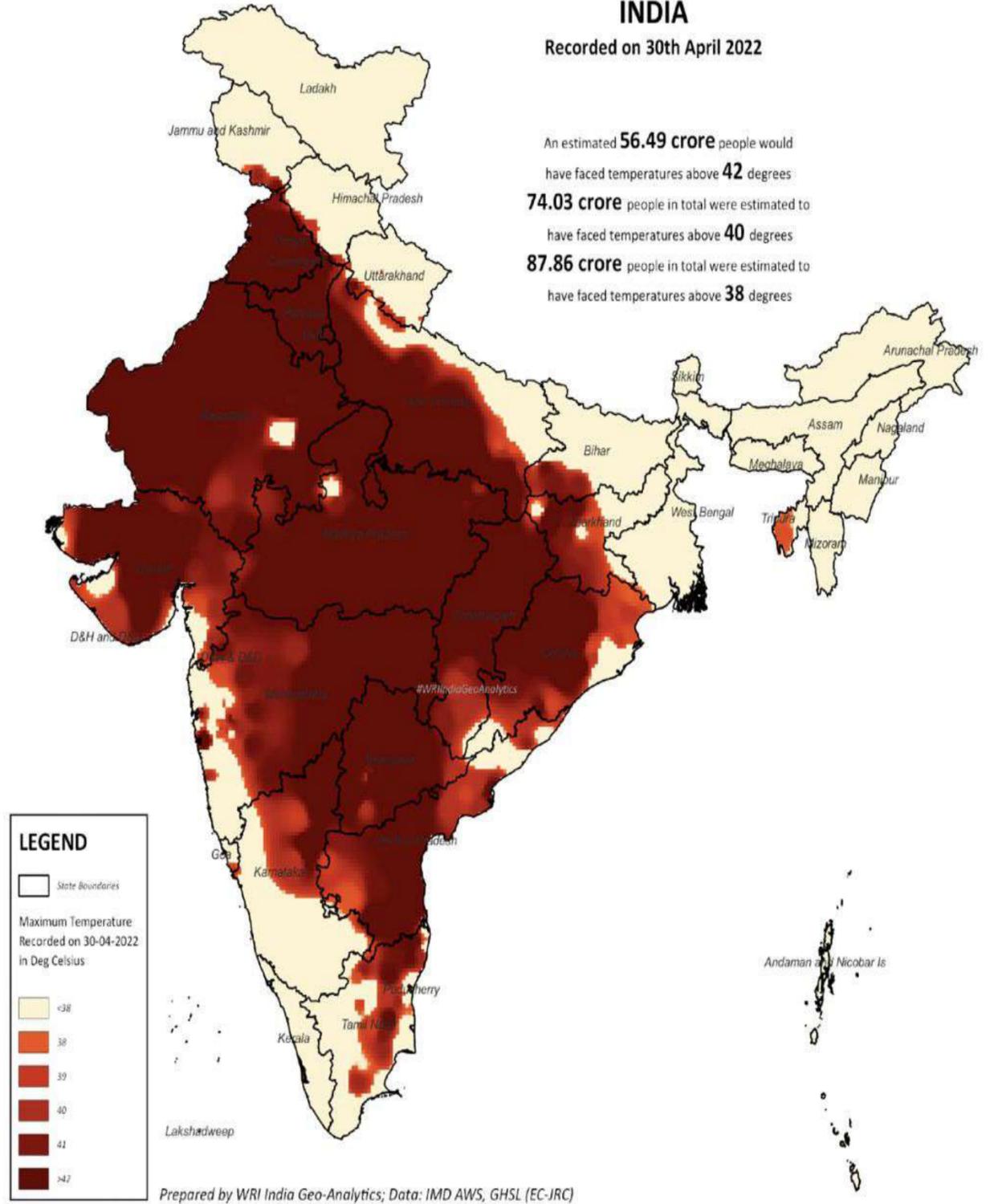


EXPOSURE TO HIGH TEMPERATURES

INDIA

Recorded on 30th April 2022

An estimated **56.49 crore** people would have faced temperatures above **42** degrees
74.03 crore people in total were estimated to have faced temperatures above **40** degrees
87.86 crore people in total were estimated to have faced temperatures above **38** degrees

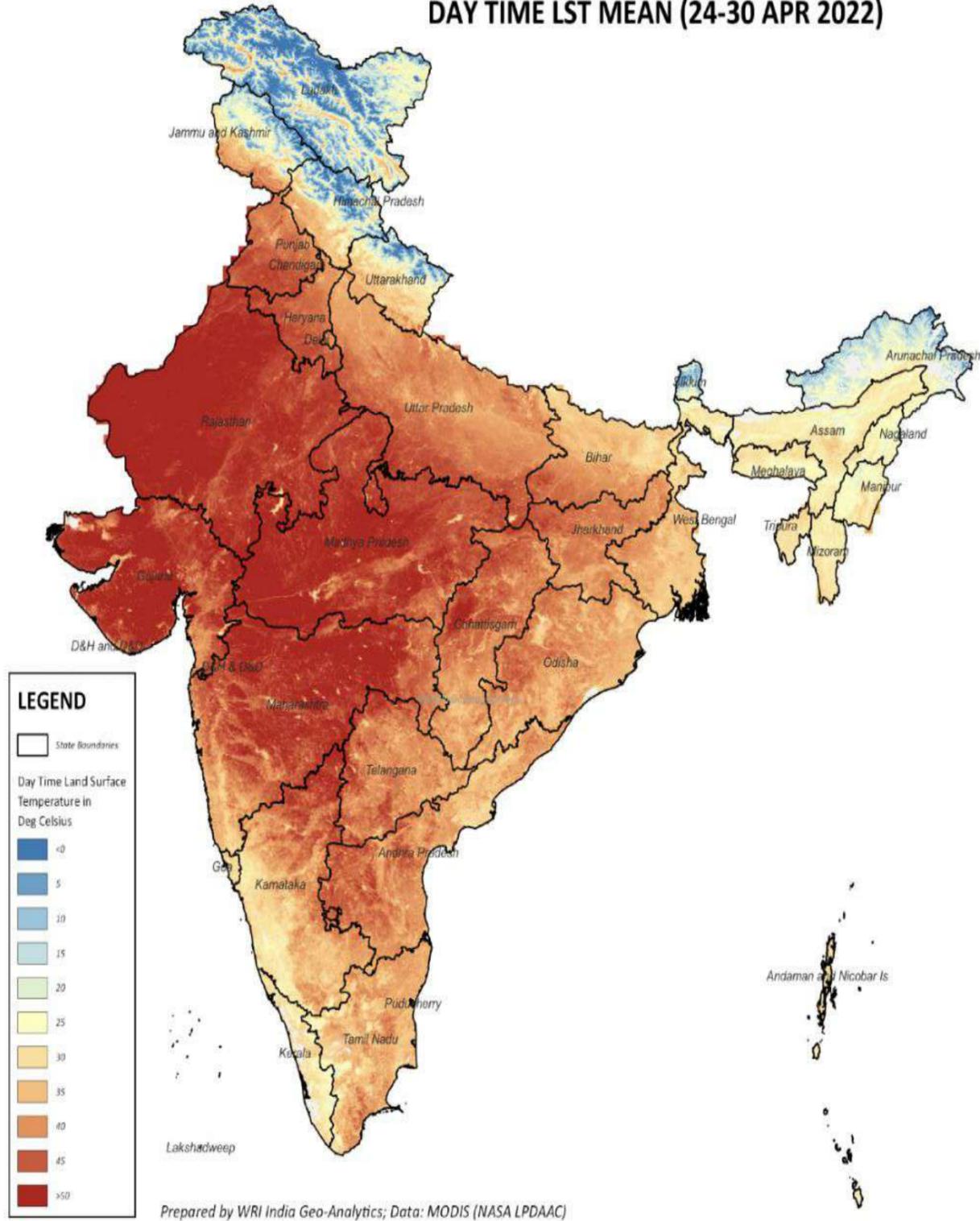


Animation shows the forecasted air temperature for April 30.

Map shows maximum air temperatures in India on April 30.

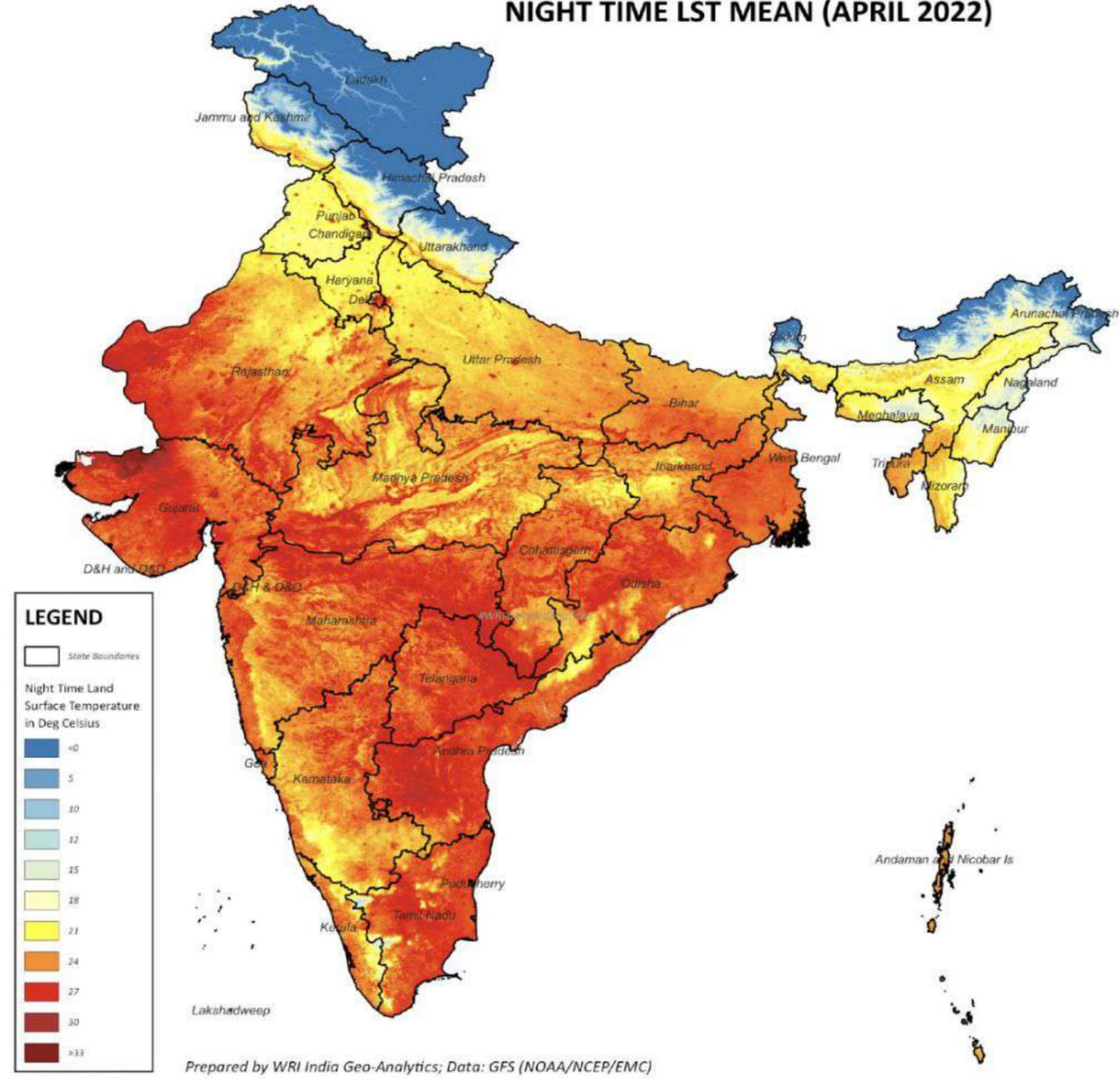
LAND SURFACE TEMPERATURE

DAY TIME LST MEAN (24-30 APR 2022)



LAND SURFACE TEMPERATURE

NIGHT TIME LST MEAN (APRIL 2022)

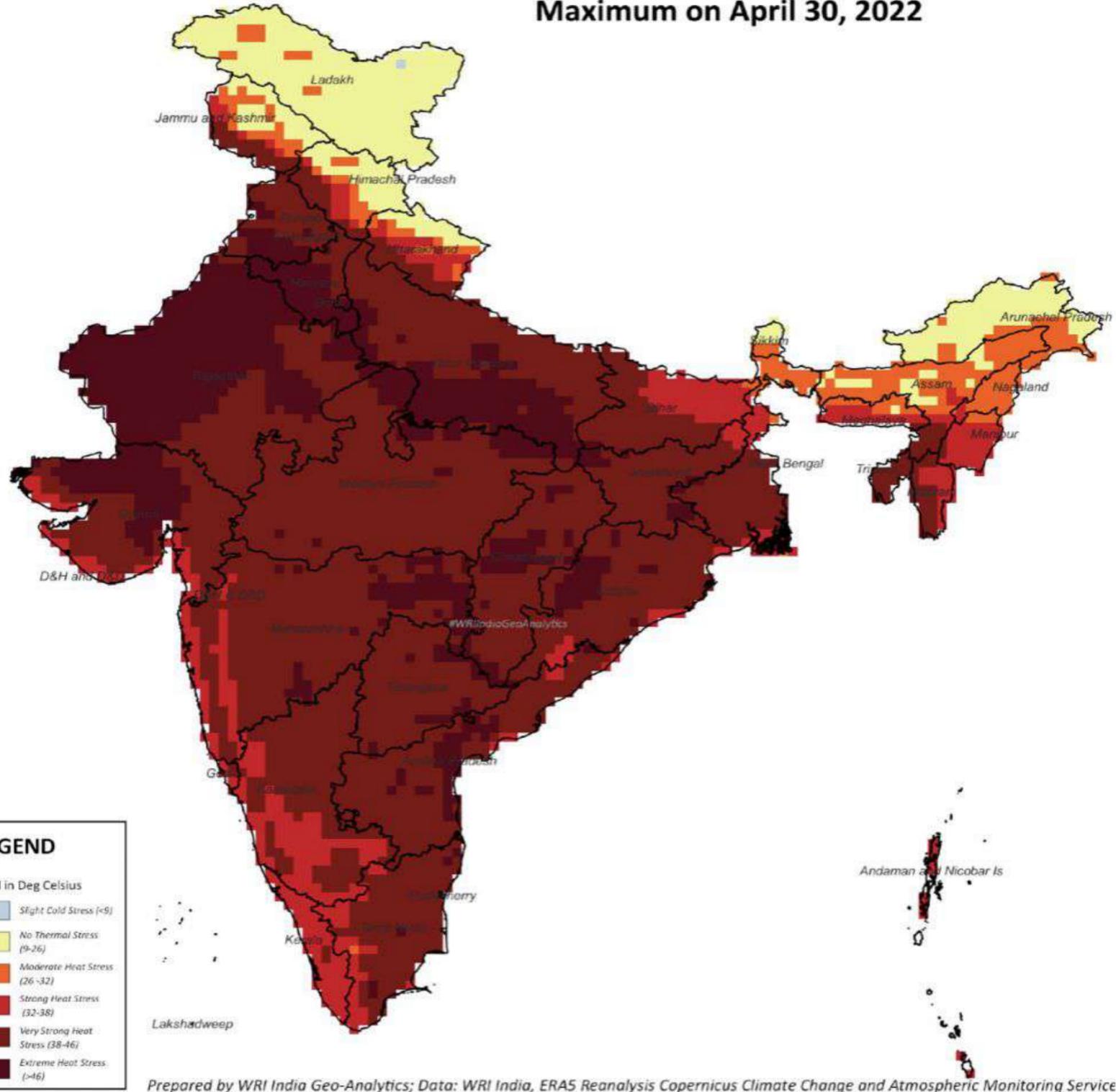


Map shows daytime land surface temperature for the last week of April.

Map shows nighttime land surface temperature for the last week of April.

Universal Thermal Climate Index

Maximum on April 30, 2022

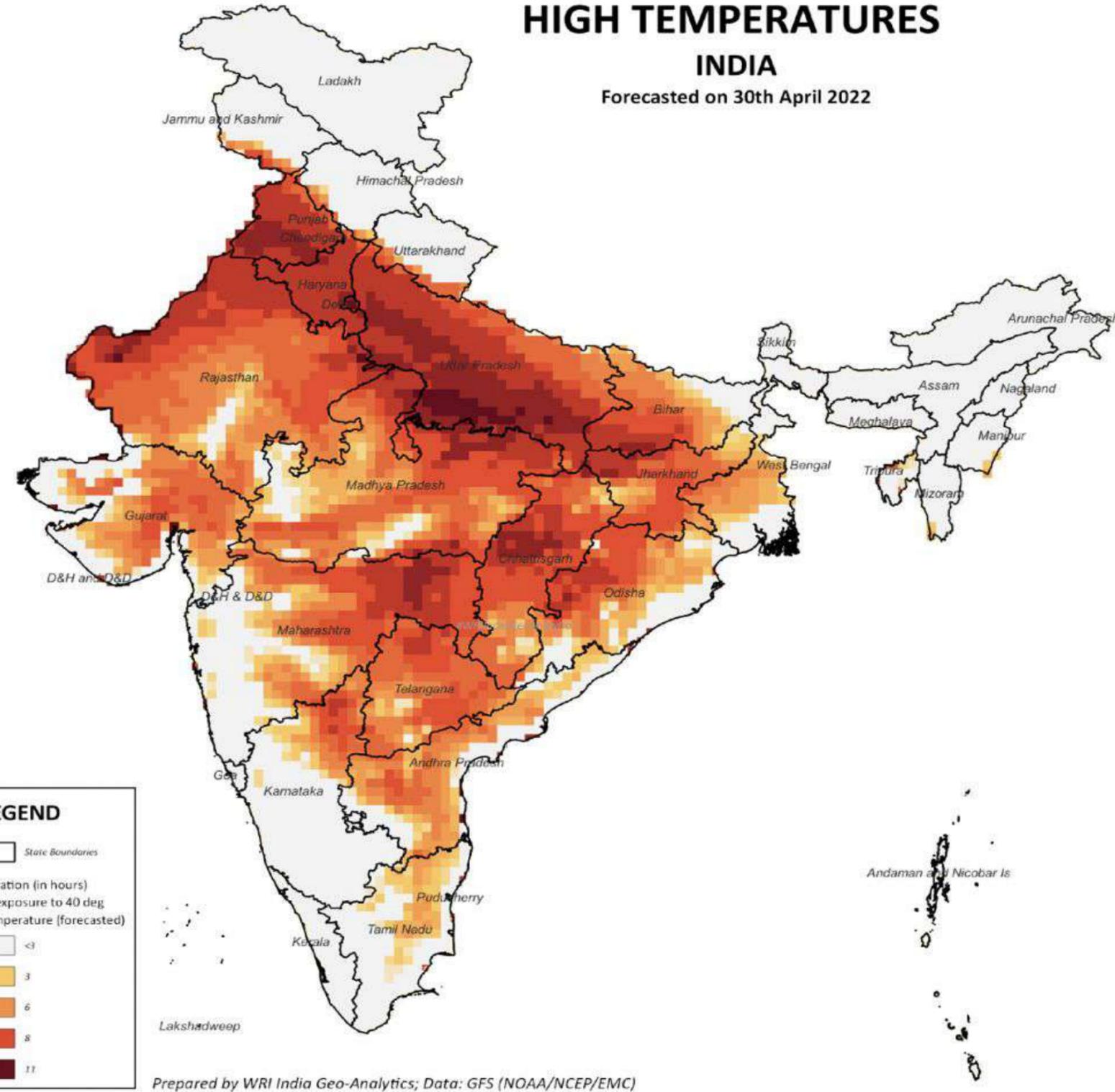


Map shows maximum recorded Universal Thermal Climate Index for 30 April

DURATION OF EXPOSURE TO HIGH TEMPERATURES

INDIA

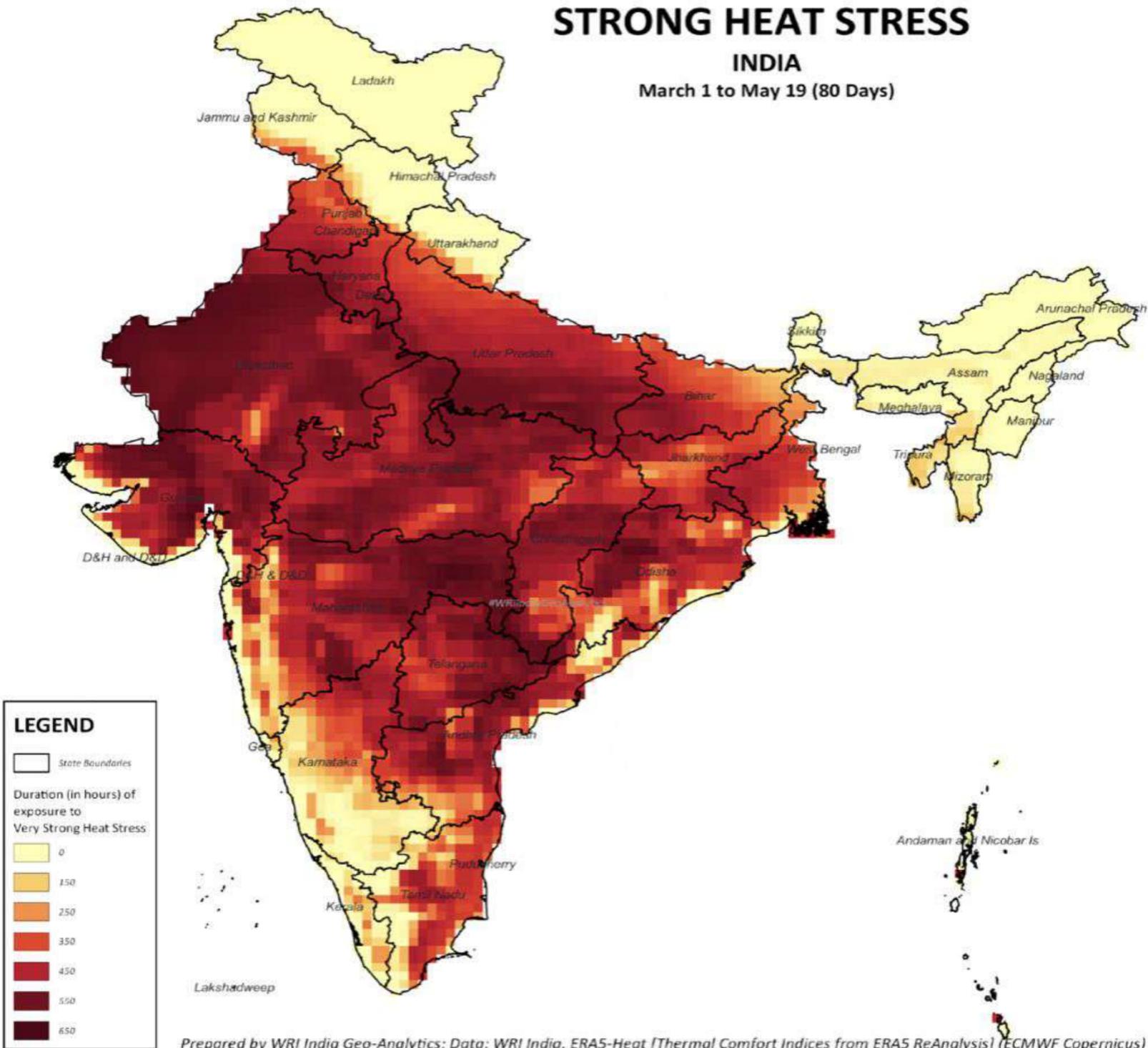
Forecasted on 30th April 2022



Map shows duration of exposure to high temperatures for 30 April

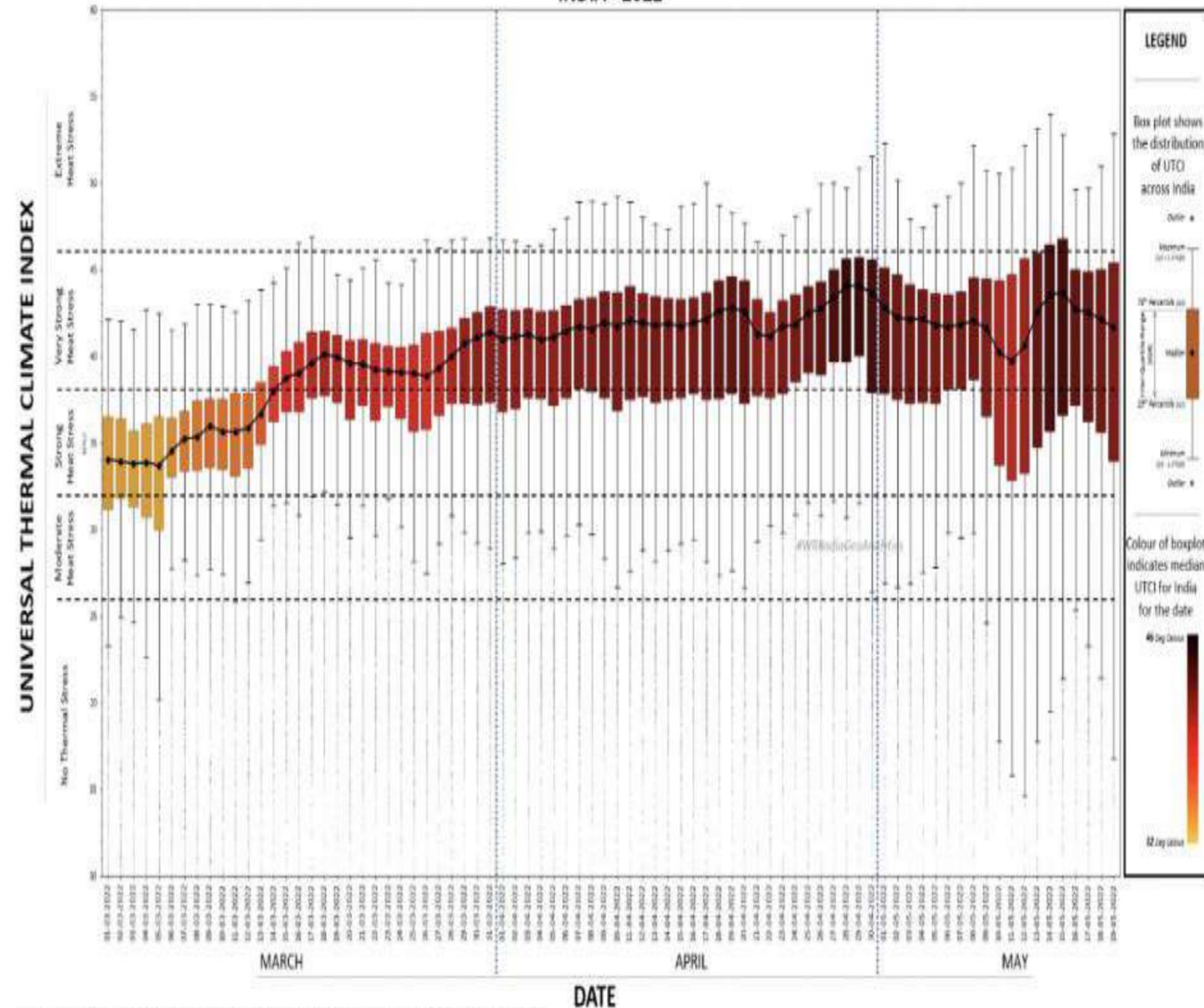
DURATION OF EXPOSURE TO VERY STRONG HEAT STRESS

INDIA
March 1 to May 19 (80 Days)



EXPOSURE TO HEAT STRESS

INDIA - 2022



Map shows duration of exposure to very strong heat stress (UTCI based) over a period of 80 days.

Chart shows the UTCI distribution for 80 days.

Changes in high temperatures and projections for the South Asian Region

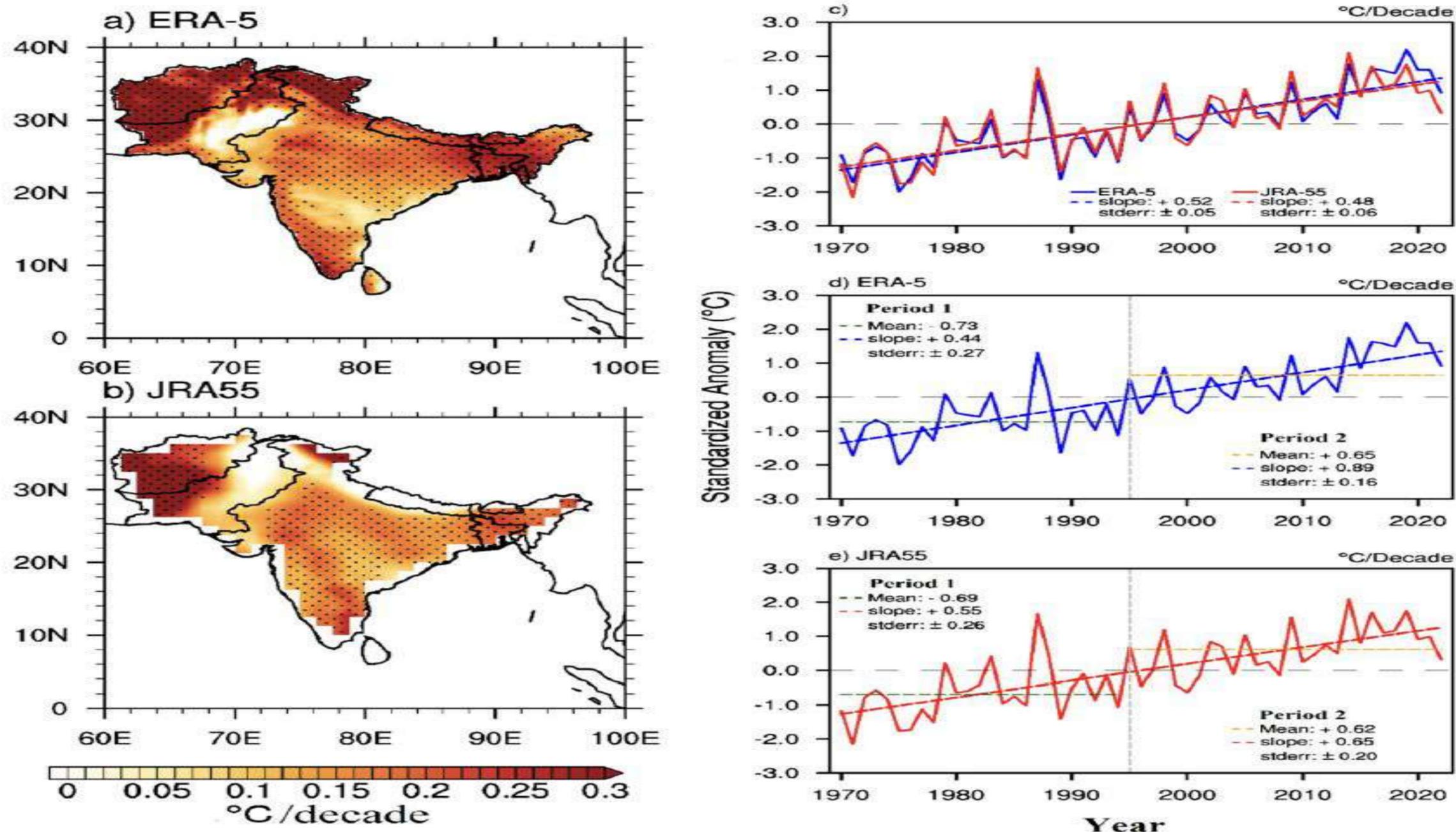


Fig. 1. Spatial distribution of JJAS 2 m temperature (t2m) trends for the period 1970–2022 for (a) ERA-5 and (b) JRA55 reanalysis, and year-to-year standardized anomaly (solid line) and linear trends (broken line) of JJAS 2 m temperature (t2m) over South Asia for (c) ERA-5 and JRA55, (d) ERA-5 only, and (e) JRA55 only with associated statistics. Stippling in (a, b) indicates grid points where trends are statistically significant at the 95% confidence level. The standardized anomaly in (c,d,e) is computed relative to the reference mean of 1970–2022. The grey vertical line indicates the change point of 1995, and the horizontal green and orange dashed lines represent the t2m average anomaly values for the anomalous cooler (1970–1994) and anomalous warmer (1995–2022) periods, respectively.

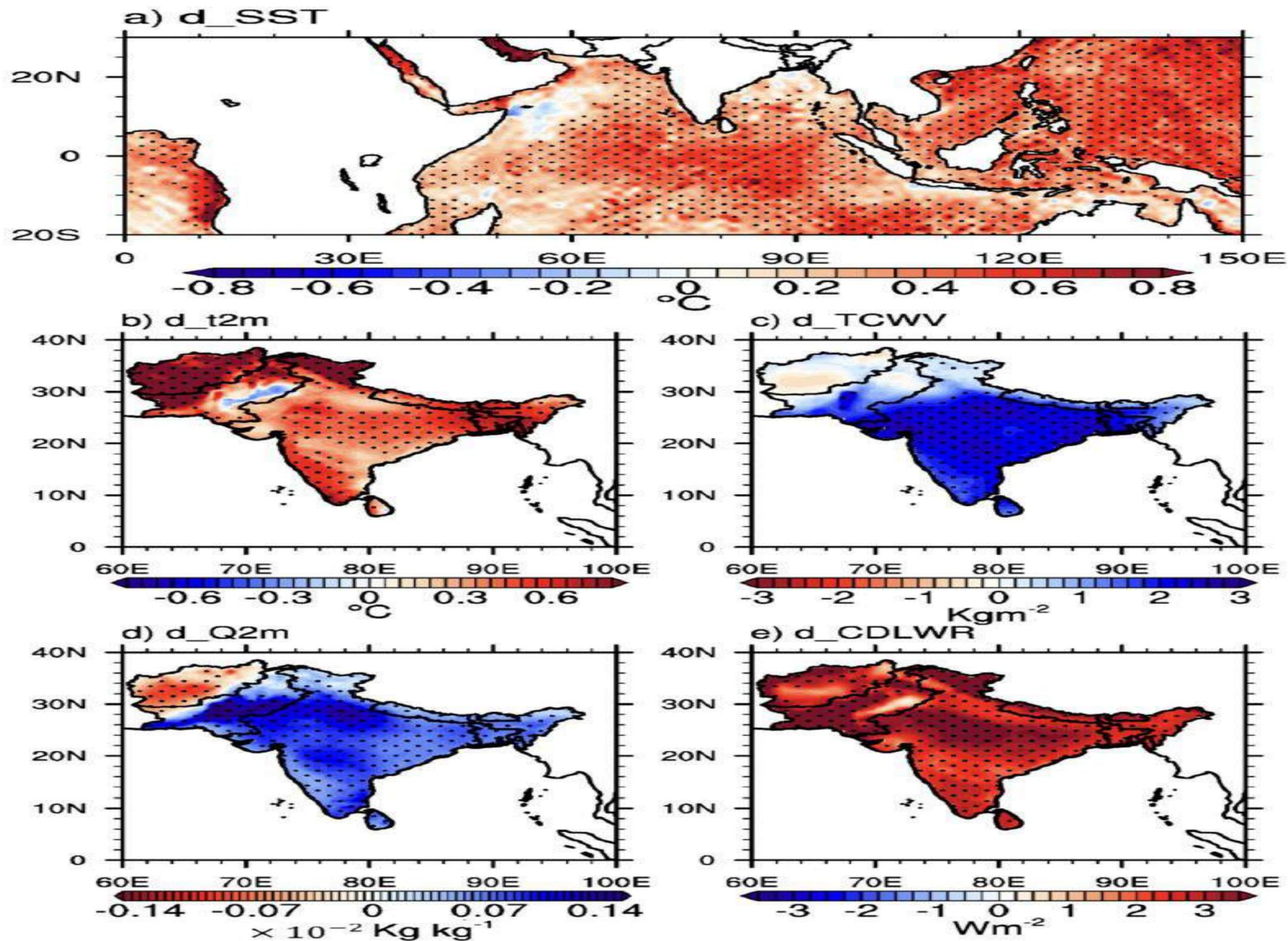
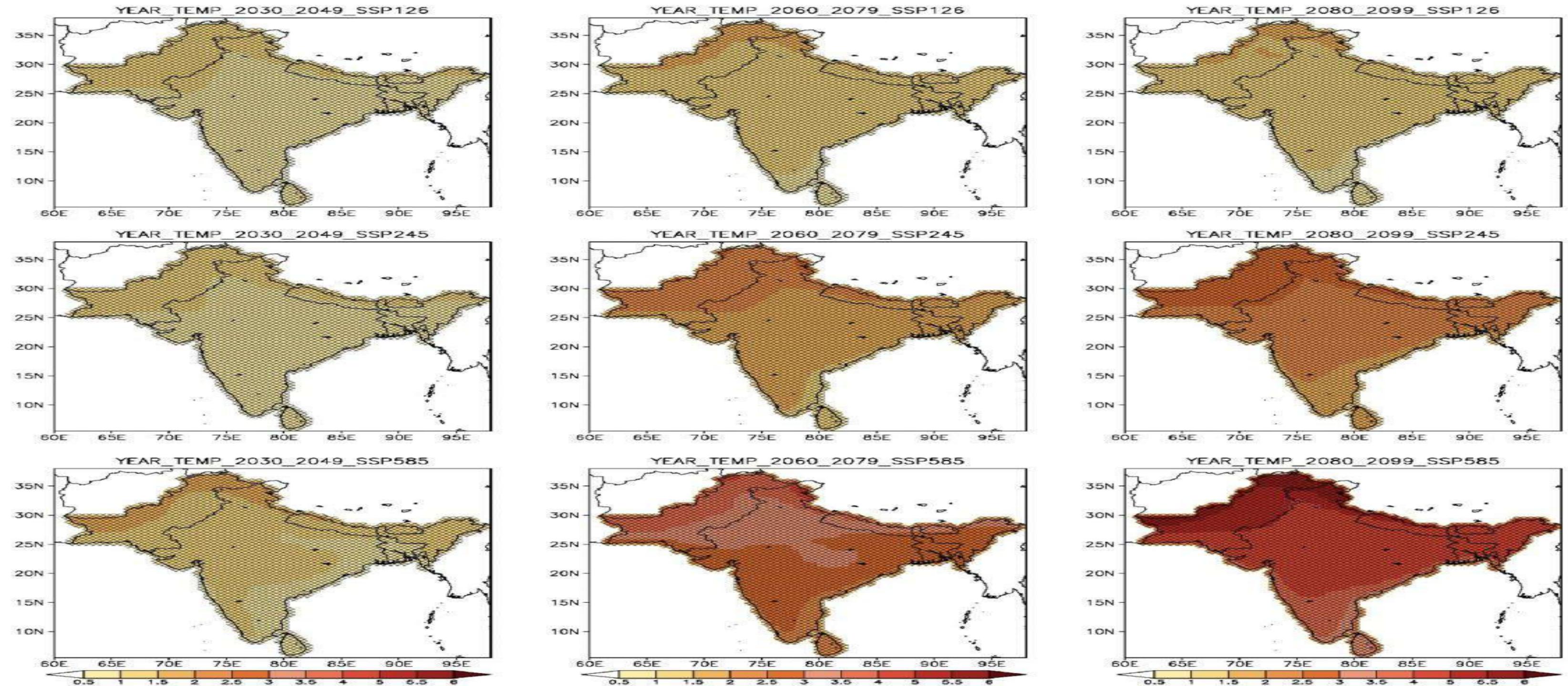


Fig. 3. Difference in the ERA-5 JJAS (a) sea surface temperature, (b) 2 m temperature, (c) total column water vapor, (d) 2 m specific humidity, and (e) clear-sky downward longwave radiation between the two periods (1995–2022 minus 1970–1994). The stippling in (a–e) indicates grid points where the differences are significant at the 95% confidence level using the Student's t -test.

Projections of Precipitation and Temperature over the South Asian Countries in CMIP6(Earth Systems and Environment; 2020)

M. Almazroui et al.



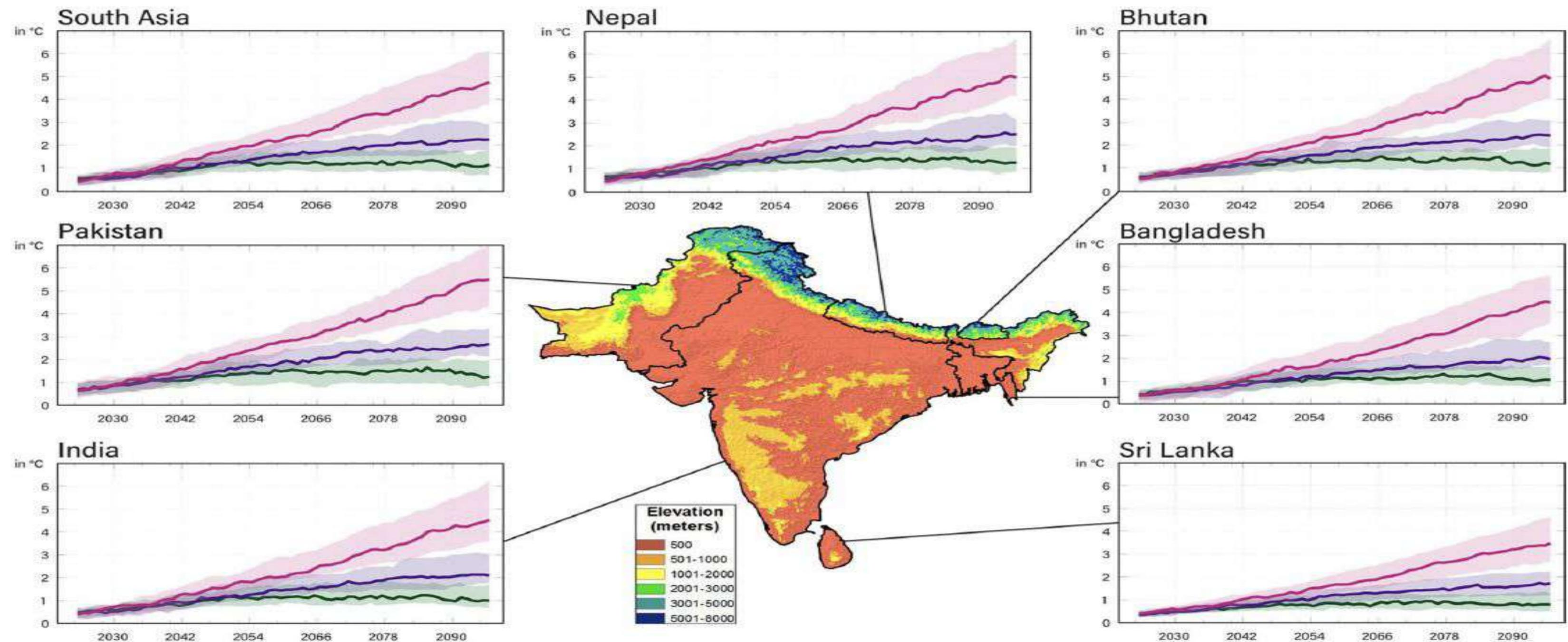


Fig. 3 The evolution of future changes in temperature for the six South Asian countries as well as for entire South Asia during the twenty-first century. The green, purple, and pink curves represent the result for median values for SSP1-2.6, SSP2-4.5, and SSP5-8.5, respectively, and the shaded areas around each curve represent the

likely range (66% of the projected changes). The curves are obtained by taking the difference of each future year with respect to the average from the historical period (1995–2014), and then taking the 7-year running average afterward

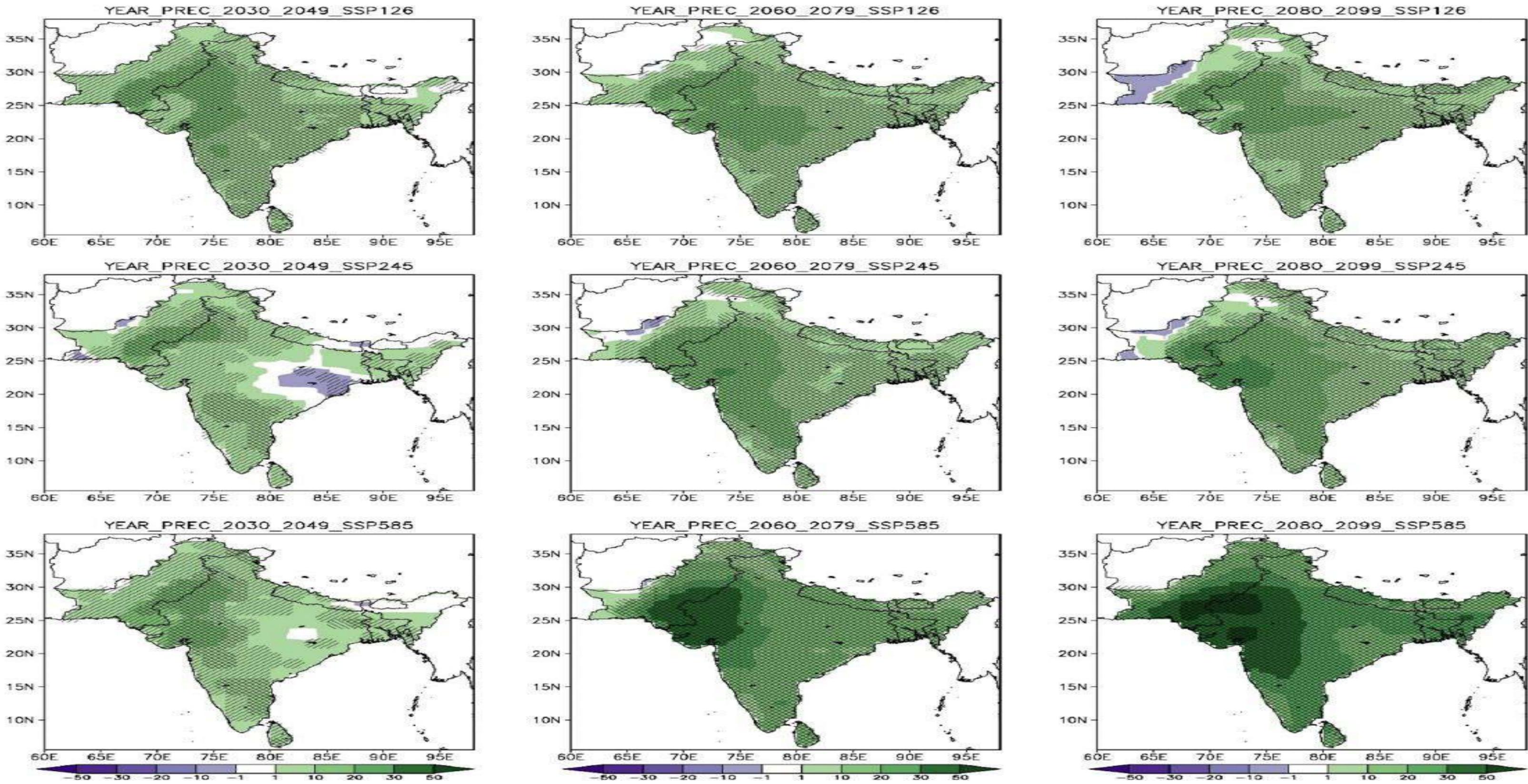


Fig. 4 Same as Fig. 2, except showing the annual mean precipitation change, expressed as a percentage

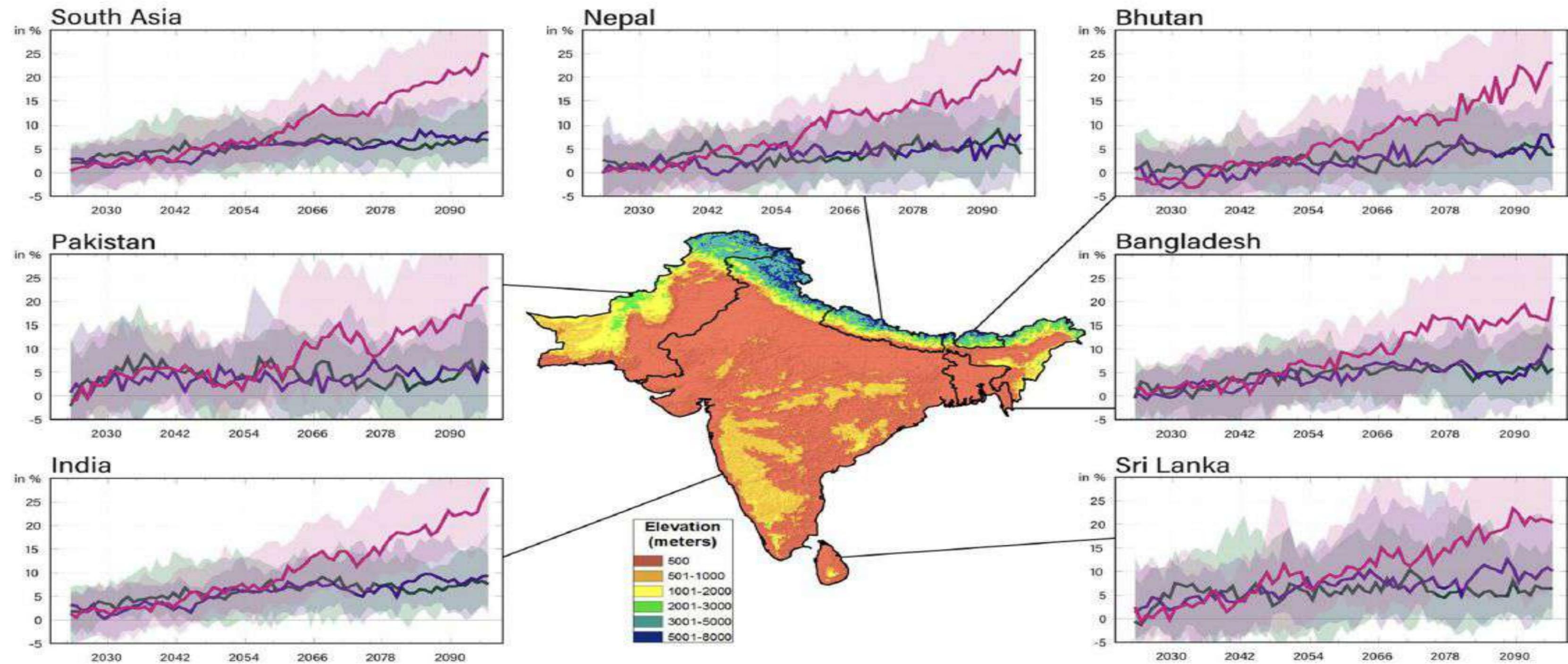


Fig. 5 Same as Fig. 3, except showing future changes in precipitation for the six countries as well as over the whole of South Asia. The green, purple, and pink curves represent the results for median values for SSP1-2.6, SSP2-4.5, and SSP5-8.5, respectively, and the shaded

areas around each curve represent the likely range (66% of the projected changes). The curves are obtained by taking the difference of each future year with respect to the average from the historical period (1995–2014), and then taking the 7-year running average afterward

Table 2 Changes in temperature (°C) and precipitation (%) in six South Asian countries and entire South Asia under three SSP scenarios for the near (2030–2049), mid (2060–2079), and far (2080–2099) future periods with respect to the base period 1995–2014

Variable	Scenario	BAN			BHU			IND			NEP			PAK			SRI			South Asia		
		Near	Mid	Far	Near	Mid	Far															
Temperature	SSP1-2.6	0.9	1.1	1.1	1.1	1.4	1.3	0.8	1.1	1.0	1.0	1.3	1.3	1.1	1.5	1.4	0.6	0.8	0.8	0.9	1.2	1.2
	SSP2-4.5	0.8	1.5	2.0	1.1	2.0	2.3	0.8	1.7	2.1	1.1	2.1	2.3	1.2	2.1	2.6	0.7	1.4	1.7	0.9	1.8	2.1
	SSP5-8.5	1.0	2.6	4.0	1.3	3.0	4.5	1.2	2.7	4.2	1.3	3.1	4.5	1.5	3.3	4.9	0.9	2.2	3.2	1.2	2.9	4.3
Precipitation	SSP1-2.6	4.4	6.8	5.5	1.6	3.2	4.9	9.3	12.0	9.7	3.6	5.7	5.8	9.3	9.1	11.5	6.6	6.4	4.8	7.4	11.4	8.7
	SSP2-4.5	2.8	7.1	8.0	-0.3	2.3	5.4	4.8	11.1	14.4	1.2	5.2	7.0	6.2	10.0	9.1	4.3	8.8	11.2	4.7	9.4	11.6
	SSP5-8.5	2.8	12.8	17.1	1.1	10.7	18.9	7.7	17.0	27.3	2.6	13.0	19.5	10.8	12.9	26.4	5.8	13.2	21.2	7.1	17.3	25.1

Table 3 Trends in temperature (°C decade⁻¹) and precipitation (% decade⁻¹) in six South Asian countries and for entire South Asia under three SSP scenarios for the period 2030–2099

	Scenario	BAN	BHU	IND	NEP	PAK	SRI	South Asia
Temperature	SSP1-2.6	0.07	0.06	0.06	0.08	0.08	0.05	0.07
	SSP2-4.5	0.23	0.26	0.25	0.28	0.29	0.19	0.26
	SSP5-8.5	0.59	0.63	0.59	0.64	0.70	0.45	0.61
Precipitation	SSP1-2.6	0.62	0.67	0.55	0.63	-0.23*	0.09	0.41
	SSP2-4.5	0.88	1.12	1.06	0.76	0.28	1.01	0.91
	SSP5-8.5	2.79	3.48	3.44	3.08	2.39	2.95	3.24

All trends are significant at 99% confidence level. The only insignificant trend in precipitation over Pakistan under SSP1-2.6 is shown by the asterisk (*)

Figure ES1 Extreme heat disproportionately affects vulnerable groups

By age/health



- Elderly
- Young children
- Pregnant women
- Individuals with chronic conditions

By social context

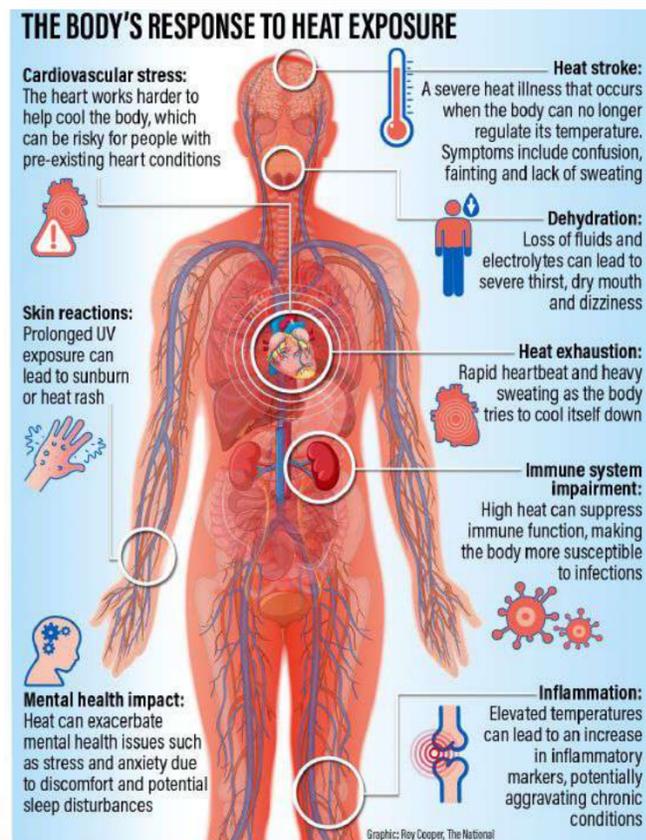


- Marginalised communities*
- Slum dwellers

By occupation



- Gig workers / Delivery riders
- Police personnel
- Agricultural labourers
- Construction workers



Source: Hassan, Marwa. "Feeling the Heat? It Might Be Making You More Prone to Illness." *The National*, March 19, 2024.

Extreme heat is a slow-onset hazard with uneven impacts across different population groups. Building resilience requires granular, local insights on the interplay of rising heat hazards, exposure levels, and inherent vulnerabilities. To strengthen decision-making, we have developed a district-level heat risk index (HRI) that offers a comprehensive view of heat risks, enabling targeted resilience-building strategies.

Twelve hazard indices were used to quantify heat from IMDAA data, capturing relative humidity, rainfall, frequency, intensity, and duration of day and night heat extremes.

Indicator	Calculation	Rationale	Weightage (%)	Relation to heat risk
Increase in frequency of very hot days	Number of days exceeding the 95th percentile of maximum temperature (Tmax) for the 1982–2011 baseline.	A higher frequency of very hot days is a direct indicator of increasing heatwaves, leading to heightened heat stress, particularly for outdoor workers.	17	Direct
Increase in frequency of very warm nights	Number of nights exceeding the 95th percentile of minimum temperature (Tmin) for the 1982–2011 baseline.	Warmer nights exacerbate chronic health conditions and reduce overall resilience to heat, as they prevent the human body from cooling down after daytime heat exposure.	15	Direct
Increase in relative humidity	Percentage change in daily average relative humidity compared to the 1982–2011 baseline.	High humidity impairs the body's ability to cool through sweating, amplifying heat stress. Even at moderate temperatures, high relative humidity significantly increases heat-related impact.	12	Direct
Increase in duration of hot spells	The average length of spells when the number of consecutive days where both Tmax and Tmin exceed the 90th percentile threshold of the 1982–2011 baseline.	Prolonged hot spells—even at lower intensity—create cumulative stress on the human body, increasing the risk of heat-related illnesses over time.	10	Direct
Decrease in diurnal temperature range	Change in the difference between Tmax and Tmin for the summer season compared to the 1982–2011 baseline.	Reduced diurnal range correlates with higher heat stress and lower cooling potential during the night.	6	Direct

Code	Indicator	Calculation	Rationale	Weightage (%)	Relation to heat risk
H6	Peak daytime temperature	Historically highest one-day Tmax is during the summer season.	Extreme daytime and nighttime temperatures increase the risk of heatstroke and heat-related illnesses. These indicators also help identify historically hottest regions and maximum temperature extremes that a district may experience.	4	Direct
H7	Peak nighttime temperature	Historically highest one-night Tmin is during the summer season.		5	
H8	Increase in the average of 10 hottest days	Change in the average Tmax of the 10 hottest days each summer.	An increase in the average of the 10 hottest days and nights reflects intensifying heat hazards, capturing both shifts in heat intensity and duration.	7	Direct
H9	Increase in the average of 10 hottest nights	Change in the average Tmin of the 10 hottest nights each summer.		7	
H10	Early onset of heat season	Date of first occurrence of Tmean exceeding the 95th percentile threshold for the month of March.	Earlier heat season onset can strain resources and increase risks for those unprepared for prolonged exposure to high temperatures.	7	Direct
H11	Delay in withdrawal of heat season	Date of last occurrence of Tmean exceeding the 95th percentile threshold for the month of June.	Delayed heat season withdrawal extends the number of days people are exposed to high temperatures, increasing cumulative heat stress well into June and beyond.	6	Direct
H12	Decrease in total summer rainfall	Change in total rainfall during the summer season compared to the baseline of 1982–2011.	Reduced rainfall heightens heat stress risks—particularly due to delayed monsoon onset and water shortages—compounding the impact of extreme heat.	4	Direct

How Extreme Heat is Impacting India - Assessing District-level Heat Risk
 Shravan Prabhu, Keerthana Anthikat Suresh, Srishti Mandal, Divyanshu Sharma, and Vishwas Chitale
 May 2025 | CEEW Report

Table 4 Three indices were used to map heat exposure

Code	Indicator	Calculation and source	Rationale	Weightage (%)	Relation to heat risk
E1	Population density	Population divided by the total area of the district based on Census 2011 projections.	Higher population density increases heat exposure, as more people are concentrated within a smaller area, amplifying heat-related risks.	46	Direct
E2	Building density	Number of buildings per 500 sq.m. calculated from 2024 Google building footprint data at 30-metre spatial resolution.	Higher building density is interpreted as a proxy for increased population concentration due to residential and commercial developments. It also strongly correlates with urban heat stress, since dense built environments limit natural cooling mechanisms such as ventilation and green spaces.	36	Direct
E3	District gross domestic product (DGDP)	Actual value of DGDP at constant rates from the State Handbook of Districts 2013–2022.	High economic activity indicates greater potential financial losses from extreme heat events, affecting productivity, infrastructure, and overall economic resilience.	18	Direct

Adaptive capacity (vulnerability)

Code	Indicator	Calculation and source	Data source and year	Rationale	Weightage (%)	Relation
AC1	Literacy rate	Percentage of literate individuals to the total population.	Census 2011	Lower literacy rates may hinder awareness and understanding of heat-stress risks and prevention measures, leading to increased vulnerability.	10	Inverse
AC2	Population with electricity access	Percentage of households with electricity to the total number of households.	NFHS-5, 2019–2021	Limited electricity restricts the use of cooling appliances, increasing heat-stress risks during high-temperature periods.	9	Inverse
AC3	Improved drinking-water access	Percentage of households with improved sources of drinking water located in the premises as per NFHS-5 and NSSO. ¹	NFHS-5 and NSSO data for 2019–2021	Safe drinking water is crucial for hydration during heat waves; a lower percentage indicates a higher risk of heat-related illnesses.	15	Inverse
AC4	Green spaces	Percentage of geographical area under green cover calculated by NDVI at a 30-metre resolution.	Landsat 8 data, 2024	Higher NDVI values indicate more green spaces, which reduce urban heat islands and mitigate heat stress in surrounding populations.	19	Inverse
AC5	Water resources	Percentage of geographical area under water bodies calculated by MNDWI at a 30-metre resolution.	Landsat 8 data, 2024	Higher MNDWI values reflect greater water availability essential for cooling and hydration; areas with insufficient water resources are more vulnerable.	8	Inverse
AC6	Healthcare centres	Number of healthcare centres per 1,000 people.	CEEW 2024 compilation based on PMGSY ² rural dataset, India's open government data platform, PMJAY ³ website, National Medical Commission, and Railway Authority of India.	Increased access to healthcare centres is essential for addressing heat-related illnesses; fewer facilities increase morbidity risks during heat events.	19	Inverse
AC7	Workers under MGNREGA ⁴	The total number of workers enrolled under MGNREGA in 2024 summer.	MGNREGA, 2024	The availability of guaranteed employment under MGNREGA helps workers adapt to livelihood disruptions caused by environmental or economic shocks. Providing income stability and local work opportunities enhances their ability to cope with stressors, thereby reducing their overall vulnerability.	9	Inverse
AC8	Health insurance	Number of people enrolled under PMJAY for 2024.	PMJAY National Health Authority dashboard, 2024	Enrolling for PMJAY ensures access to affordable healthcare for vulnerable populations to enhance their resilience to health-related shocks.	11	Inverse

Table 5 Twenty indicators were used to map vulnerability—12 for sensitivity and 8 for adaptive capacity.

Sensitivity (vulnerability)					
Code	Indicator	Calculation and source	Rationale	Weightage (%)	Relation
S1	Labour population	Percentage of total number of agricultural workers and main cultivators to the total working population as defined in Census 2011.	As outdoor labourers, agricultural workers and main cultivators experience prolonged exposure to extreme heat, increasing their susceptibility to heat-related illnesses, dehydration, and productivity losses.	7	Direct
S2	Total number of disastrous heatwave days	Total number of heatwave days (as per IMD criteria) that have led to at least one human death as per IMD's <i>Hazard and Vulnerability Atlas 2022</i> .	Developed by the IMD, this indicator is based on the occurrence of at least one heatwave-related human fatality. It serves as a proxy for heat-related mortality, providing insights into the sensitivity of districts by identifying areas with a history of heatwaves resulting in human deaths.	8	Direct
S3	Change in land use and land cover	Based on Landsat 8 satellite imagery data from 2005 and 2023, we used the increase in built-up area and the decrease in vegetation cover as indicators.	Increased built-up areas and reduced vegetation or water bodies amplify heat risks by intensifying the urban heat island effect, reducing natural cooling through evapotranspiration and exposing more people to extreme temperatures.	10	Direct
S4	Young population (below 5 years)	Percentage of young population to the total population as defined by Census 2011 projections.	A higher percentage of young children indicates a demographic that may be more vulnerable to heat stress.	12	Direct
S5	Old population (above 65 years)	Percentage of old population to the total population as defined by Census 2011 projections.	Older adults are more susceptible to heat-related illnesses; a higher percentage of elderly individuals suggests an increased risk of heat stress in the population.	11	Direct
S6	Scheduled Caste	Percentage of SC population to the total population as per Census 2011.	People belonging to SCs often face socio-economic disadvantages, limiting their access to resources and protective measures against heat stress which increases their vulnerability.	7	Direct
S7	Sex ratio	Sex ratio calculated as per Census 2011.	A low sex ratio increases heat vulnerability since women—especially pregnant and elderly women—face higher health risks from extreme heat due to physiological sensitivity, limited access to healthcare, and socio-economic constraints.	8	Direct
S8	Scheduled Tribe	Percentage of ST population to total population as per Census 2011.	People belonging to STs may face higher exposure to heat stress due to geographical, economic, and social disadvantages, including inadequate healthcare access.	8	Direct
S9	Household members with pre-existing non-communicable illnesses (all in %)	As per NFHS-5 data (2019–2021), we used Anaemia, blood pressure (Hypertension), and blood sugar levels (Diabetes) as indicators.	Individuals with pre-existing non-communicable illnesses are particularly vulnerable to climate and environmental stressors since their health conditions can worsen under extreme heat, making them less resilient.	12	Direct
S10	Persons with disability	Percentage of persons with disability to the total population as defined by Census 2011.	Individuals with disabilities may have reduced mobility and higher vulnerability to heat stress, especially without access to cooling resources.	5	Direct
S11	Marginal workers	Number of marginal workers to the total working population as defined by Census 2011.	A high number of marginal workers indicates economic instability and limited access to health resources, increasing the impact of heat stress.	5	Direct
S12	Temporary and semi-permanent houses	Number of temporary and semi-permanent houses in proportion to the total number of houses as per Census 2011.	A higher number of temporary or semi-permanent houses has been interpreted as a proxy for slum households, i.e., inadequate housing conditions. This increases the risk of heat-related health issues in informal settlements.	7	Direct

About 57 per cent of Indian districts, home to 76 per cent of India's total population, are currently at high to very high heat risk. We found that 417 out of 734 Indian districts fell in the high and very high risk categories (151 under high risk and 266 under very high risk), as seen in Figure ES3. Moreover, 201 districts fell in the moderate category, and 116 fell in either the low or very low categories. This does not indicate that these districts are free of heat risk, but that it is relatively lesser than that of other districts.

Aggregating these risks at the state level, we found that the ten states and UTs with the highest heat risk are Delhi, Maharashtra, Goa, Kerala, Gujarat, Rajasthan, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, and Uttar Pradesh.

Figure ES3 More than 57% of districts are at high to very high heat risk in India

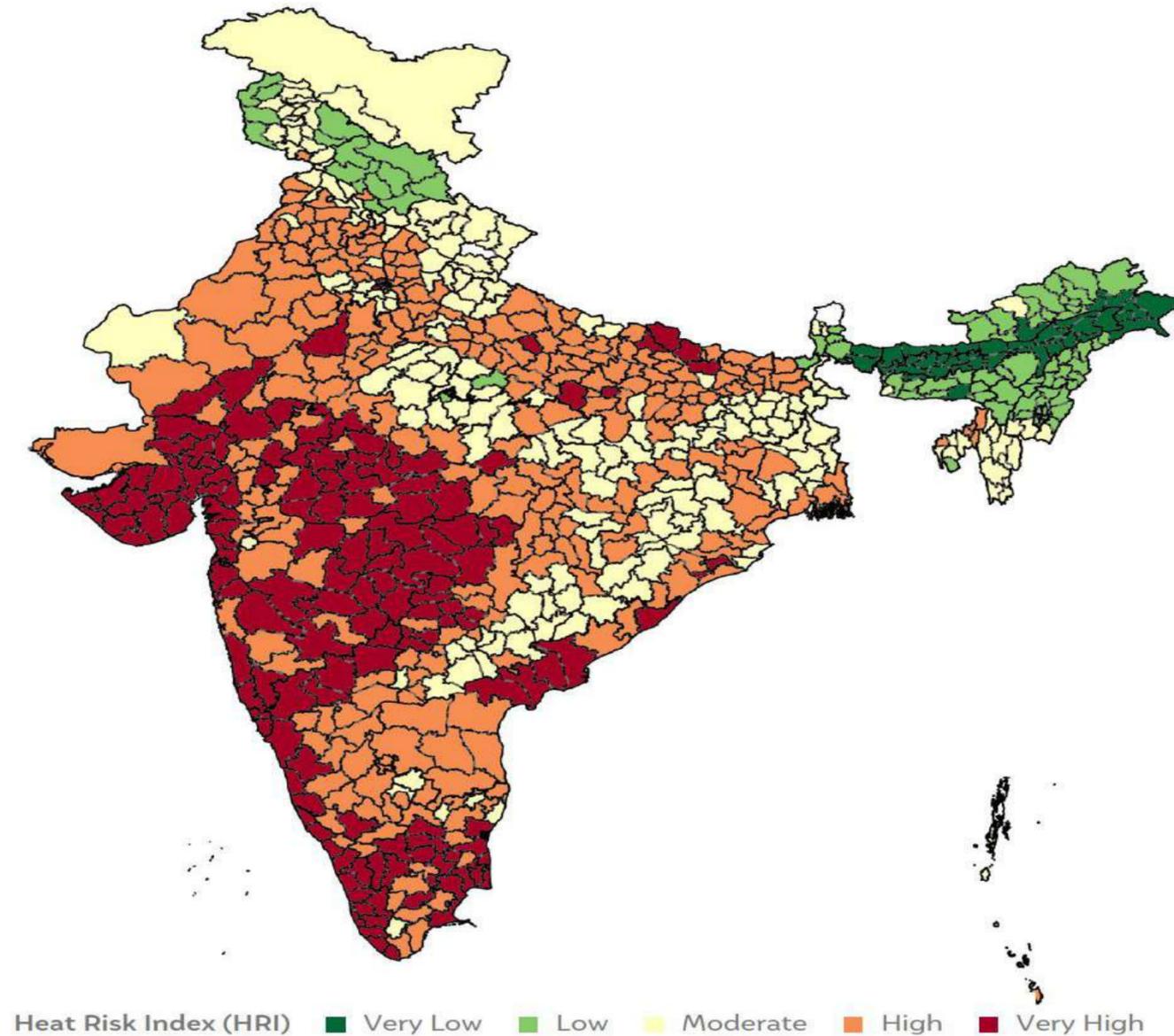
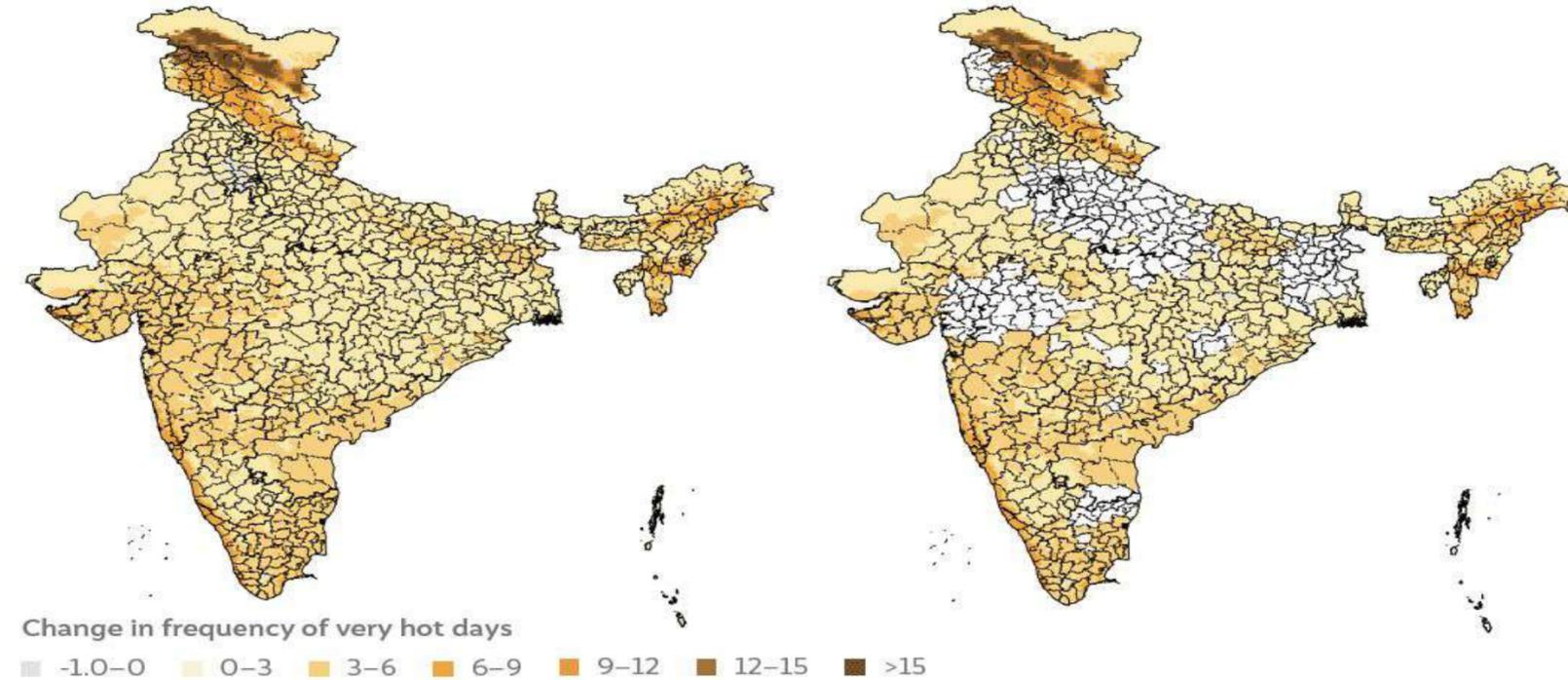


Figure ES4 During 2012–2022, ~70% of Indian districts experienced five more very warm nights per summer than the climate baseline of 1982–2011

a) Changes in the frequency of very hot days in the last decade (2012–2022) compared to the climatic baseline (1982–2011)

b) Statistically significant trends in very hot days over a 40-year continuous time series at a 95% confidence level



c) Changes in the frequency of very warm nights in the last decade (2012–2022) compared to the climatic baseline (1982–2011)

d) Statistically significant trends in very warm nights over a 40-year continuous time series at a 95% confidence level

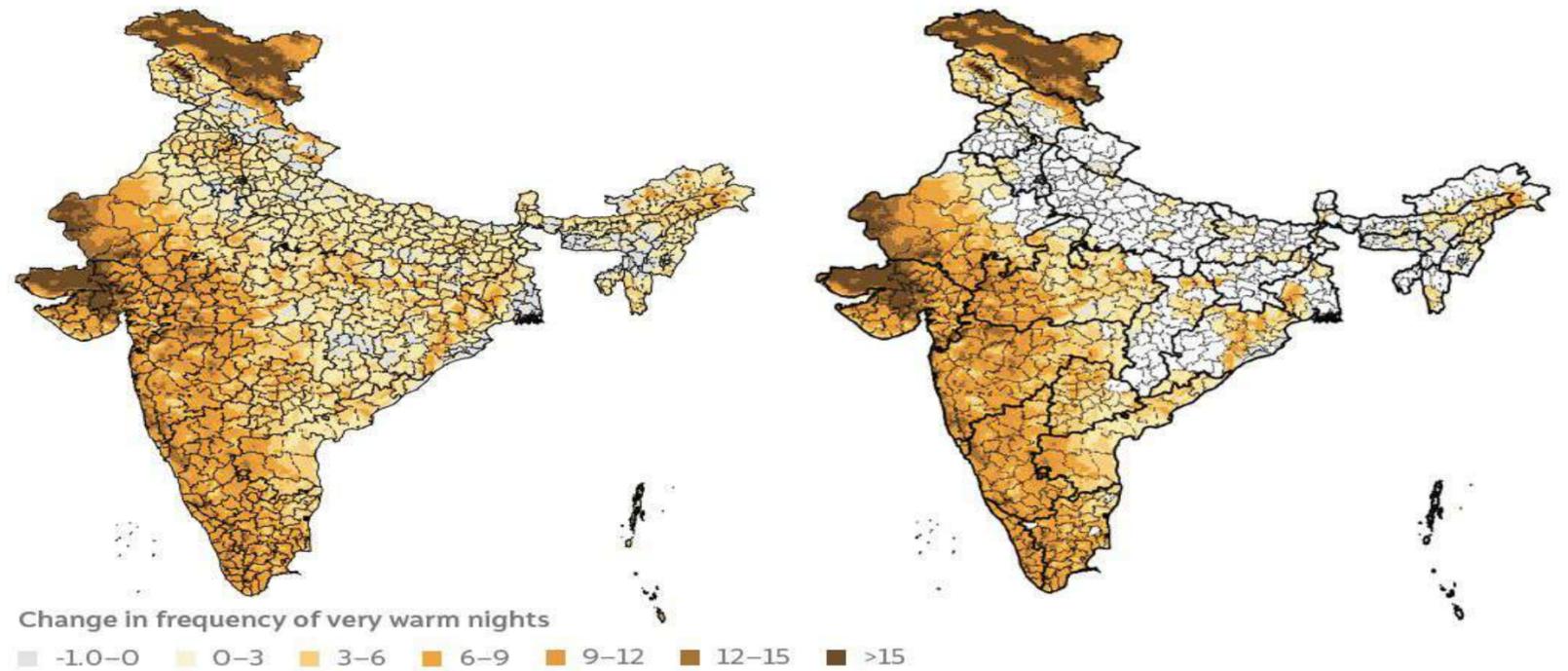
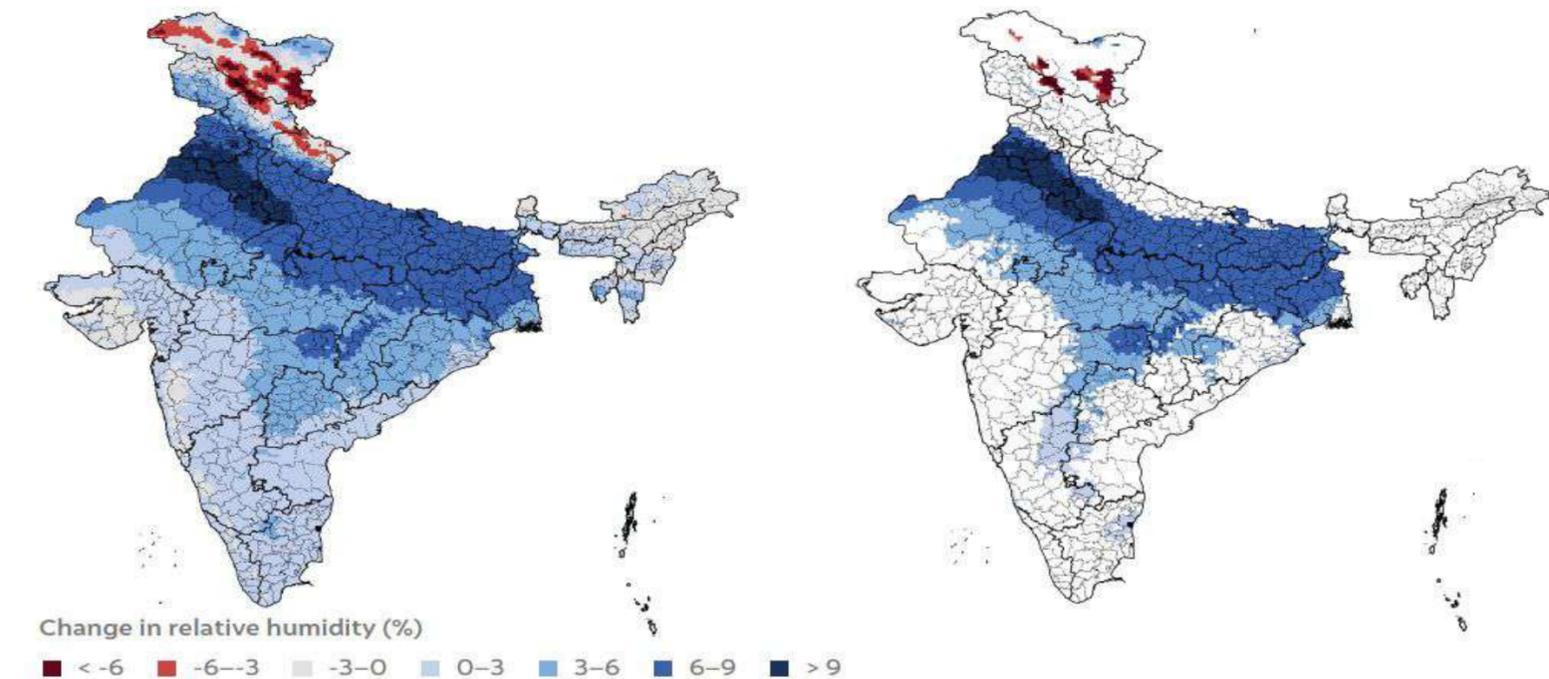


Figure ES5 Between 2012–22, during the summer months (March to June), relative humidity rose by up to 10% in North India

a) Changes in summer relative humidity (%) in the last decade (2012–2022) compared to the climatic baseline (1982–2011) b) Statistically significant trends in summer relative humidity (%) over a 40-year continuous time series at a 95% confidence level



To further examine the rising trend in very warm nights, we analysed the diurnal temperature range (DTR)—the difference between the daytime maximum and nighttime minimum temperature. Typically, peak daily temperatures occur in the afternoon as the atmosphere continues to absorb heat beyond noon, while minimum temperatures are recorded around dawn following the sustained loss of heat through the night. DTR is a key indicator of climatic change and serves as a critical thermal metric for assessing the impact on agriculture and human health.

Figure 14 The diurnal temperature range has reduced in almost 86% of Indian districts, especially in the last decade (2012–2011) compared to the climatic baseline (1982–2011)

a) Changes in DTR in the last decade (2012–2022) compared to the climatic baseline (1982–2011) b) Statistically significant trends in DTR on 40 years' continuous time-series at a 95% confidence level

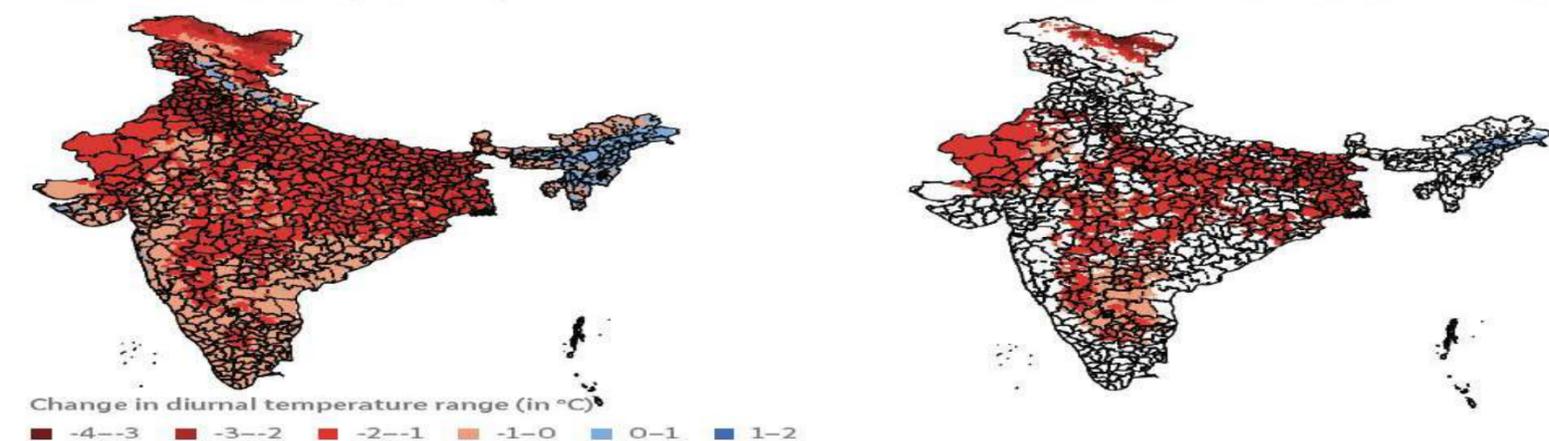
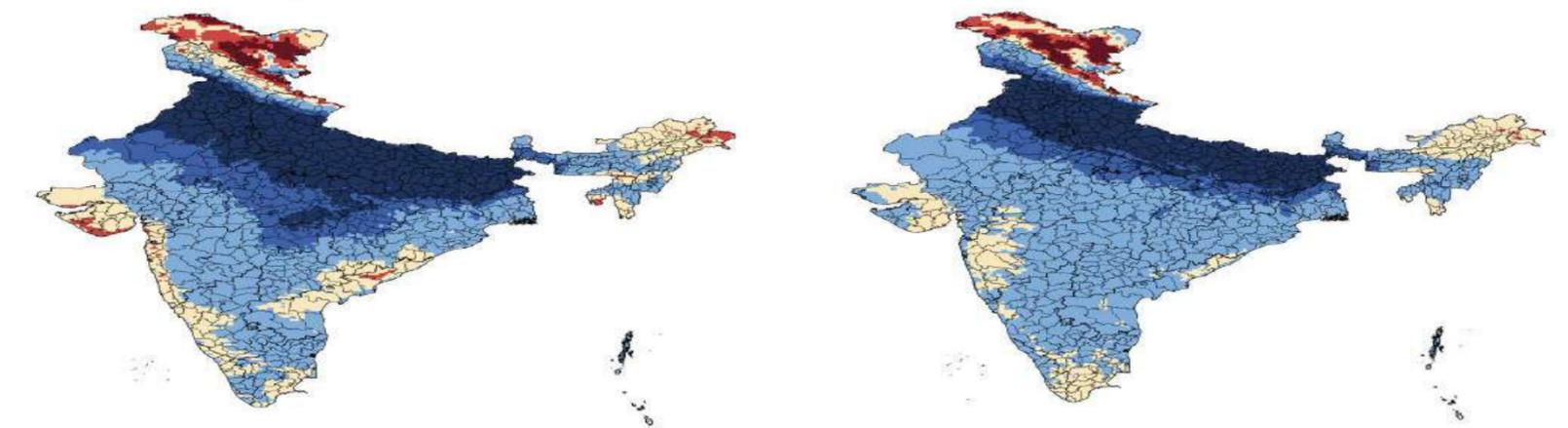
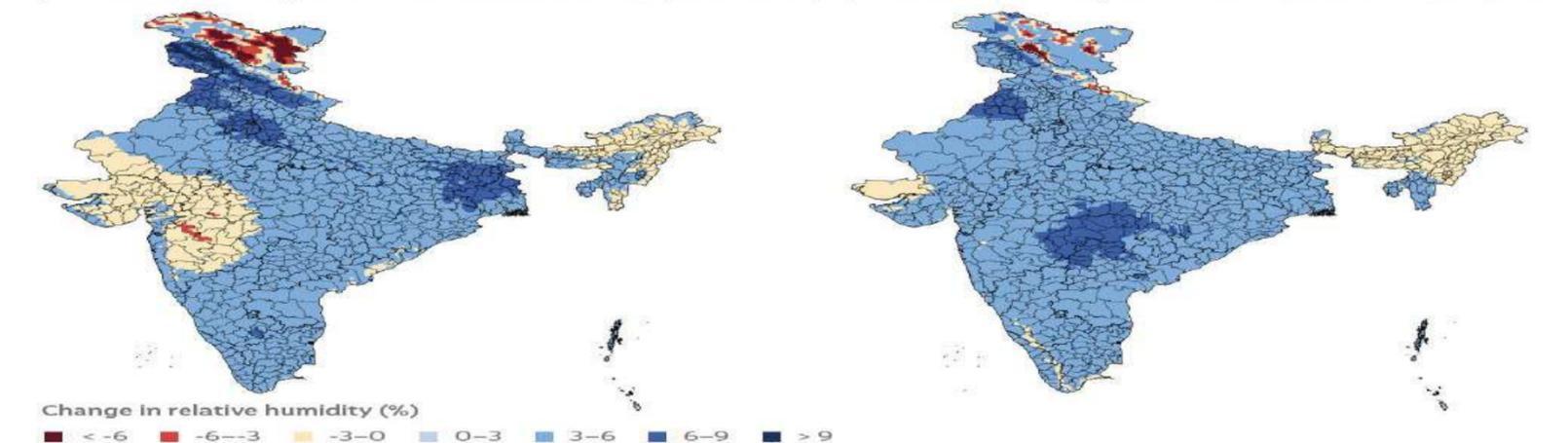


Figure 15 Majority of India has seen an increase in relative humidity across summer months (March to June)

a) Changes in relative humidity in March in the last decade (2012–2022) as compared to the climatic baseline (1982–2011) b) Changes in relative humidity in April in the last decade (2012–2022) as compared to the climatic baseline (1982–2011)



c) Changes in relative humidity in May in the last decade (2012–2022) as compared to the climatic baseline (1982–2011) d) Changes in relative humidity in June in the last decade (2012–2022) as compared to the climatic baseline (1982–2011)



Box 2 India's heat action plans and their gaps

In 2016, the NDMA issued guidelines for creating HAPs to improve the preparedness and response capabilities of health systems and disaster management authorities. These guidelines prioritised allocating scarce healthcare, financial, informational, and infrastructure resources to safeguard the populations most at risk from excessive heat in certain jurisdictions.

The guidelines were updated in 2017 and 2019 to combine short-, medium-, and long-term heat risk mitigation techniques. The updated framework includes an eight-point checklist to build inter-agency and stakeholder coordination, develop a stakeholder responsibility matrix, map vulnerable and at-risk populations, set localised heat thresholds for early warnings, and outline strategies for monitoring, evaluation, and plan updating (NDMA n.d.).

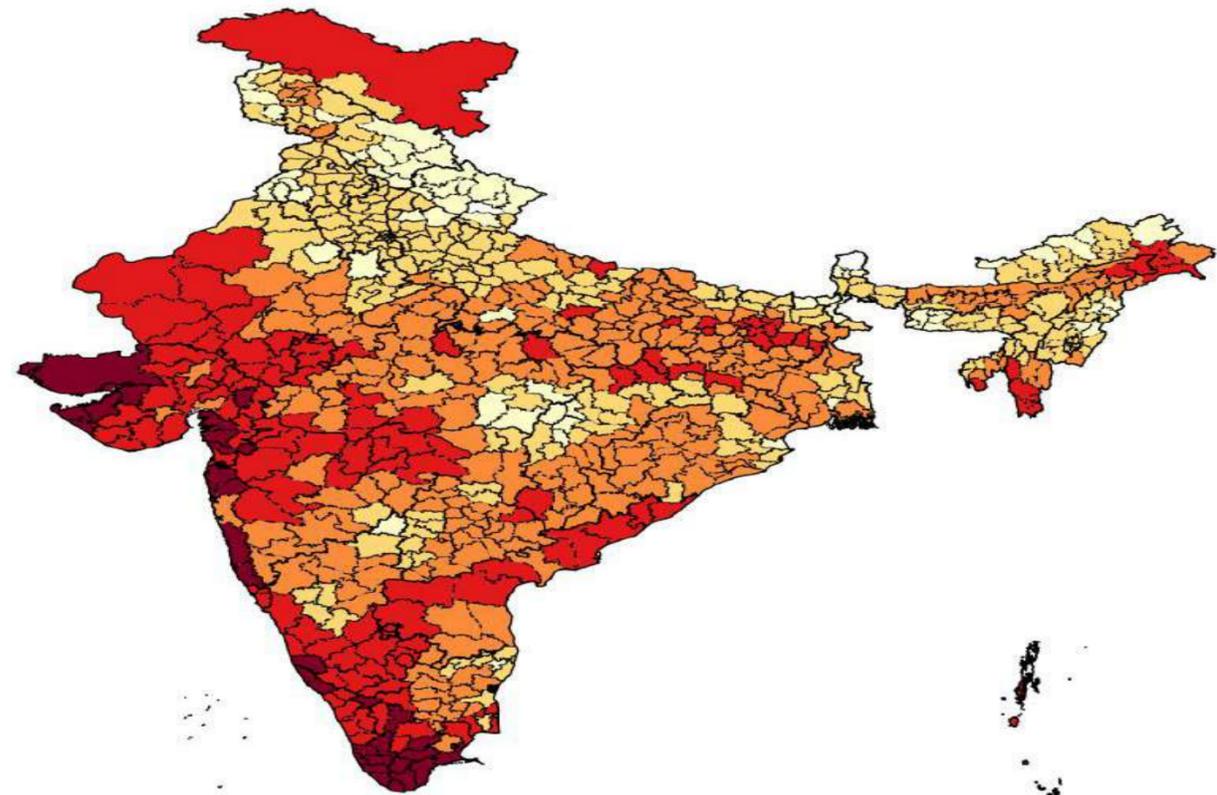
According to publicly available data, more than 100 HAPs exist in India. However, even though NDMA's HAP guidelines are robust and require HAPs to include sections on risk quantification, a recent review of 37 plans revealed critical gaps (Figure 5). One significant gap is that nearly 95 per cent of the reviewed HAPs lack risk and vulnerability assessments (Pillai and Dalal 2023). This shortfall highlights an important area for further research, which we explore in this study.

Lack of localised heat hazard mapping	Lack of heat risk and vulnerability assessments	Lack of funding sources	Lack of strong legal foundations for implementation	Lack of monitoring, evaluation and implementation transparency
67% of HAPs only consider ambient temperature day-time extremes in definition; humidity and warm nights not considered Locally defined heat thresholds not considered	95% of HAPs lack vulnerability assessments List of solutions do not focus on identified vulnerable groups	Only 30% of reviewed HAPs discuss funding sources Majority ask implementing departments to self-allocate resources	No linkage with the legal structure for disaster management and environmental governance	Lack of repositories for access to general public Non-clarity in updation period and evaluation data

Source: Valiathan Pillai, Aditya, and Tamanna Dalal. *How Is India Adapting to Heatwaves? An Assessment of Heat Action Plans with Insights for Transformative Climate Action*. New Delhi: Centre for Policy Research, 2023.

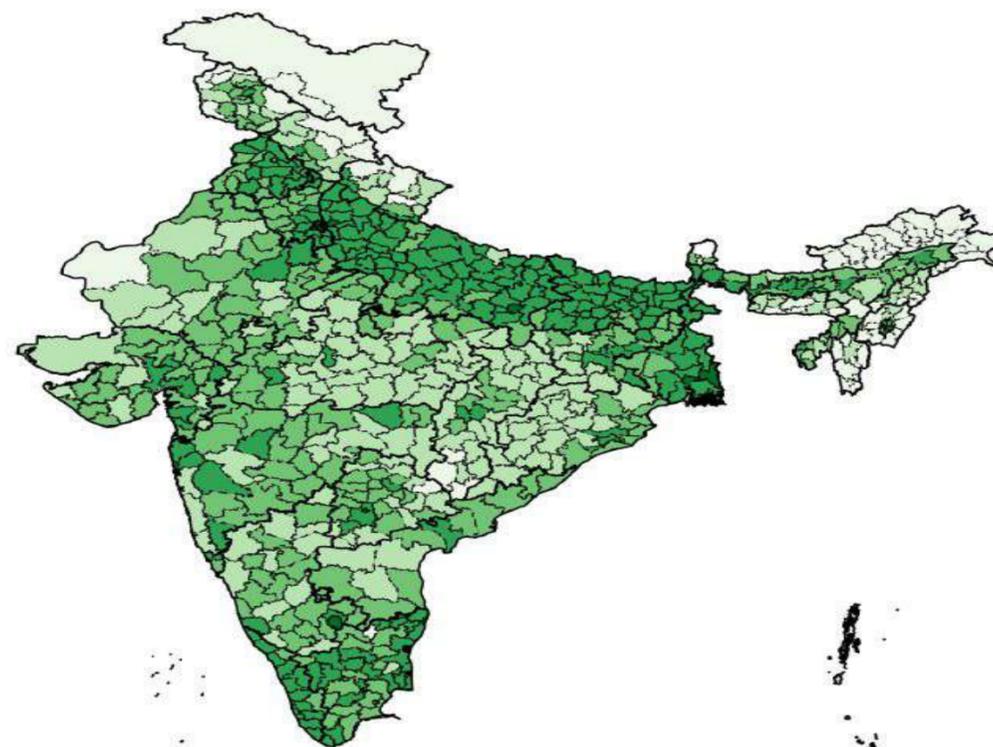
We reviewed 15 publicly available state and UT-level heat action plans (as of November 2024) and found that only 2 had undertaken heat risk and vulnerability assessments. These assessments are crucial for prioritising vulnerable areas within a city, district, or state for effective resource allocation.

Figure 17 Heat hazard levels are the highest in districts of the western coast, Central Maharashtra, Rajasthan, Gujarat, and Peninsular India



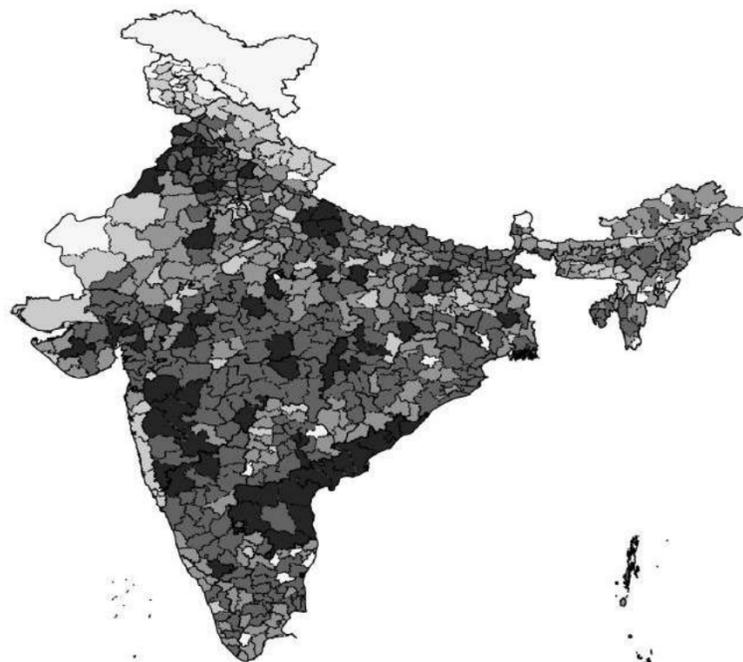
Hazard Index Very Low Low Moderate High Very High

Figure 18 Exposure levels are highest in densely populated urban areas like Mumbai and Delhi, and in populous states such as Uttar Pradesh and Bihar



Exposure Index Very Low Low Moderate High Very High

Figure 19 Vulnerability levels are the highest in districts across Andhra Pradesh, Central Maharashtra, Vidarbha, Chhattisgarh, and the Indo-Gangetic Plains



Vulnerability Index Very Low Low Moderate High Very High

Our study found that 57 per cent of Indian districts, home to 76 per cent of India's total population, are currently at high to very high heat risk. All government authorities—at the state, district, and city levels—must plan for extreme heat risk mitigation, preparedness, response, and relief. As recommended by the *NDMA Guidelines*, this issue is primarily addressed through HAPs in India.

This study provides actionable insights to inform heat risk—based decision-making across key sectors including:

- **Water**—to assess and manage water scarcity risks;
- **Agriculture**—to map risks to outdoor workers and crop productivity;
- **Health**—to understand the direct impact on public health;
- **Power**—to estimate cooling and electricity demand.

This study's key objective is to support agencies such as SDMAs as well as district- and city-level authorities in developing more effective, data-driven HAPs. Insights from our study can help agencies recognise key risk drivers and prioritise financial resources accordingly. To facilitate this, we have developed state- and UT-specific handbooks (Annexure 1), which include heat risk trend analyses, maps, and data visualisations. Agencies can directly leverage these resources to inform HAP development and other policy documents.

Based on our study's findings, we present some key recommendations for national, state, district, and city authorities. Most of our recommendations focus on using existing funding mechanisms more efficiently.

A. Move beyond a daytime temperature—based approach and incorporate warm nights, humidity, demographics, and health vulnerabilities into the second generation of HAPs

We reviewed the open-access HAPs of 15 states (as of November 2024) and found that only two states—Bihar and Andhra Pradesh—had conducted heat vulnerability mapping. To address this gap, we have developed free-to-use handbooks for every state and UT in India (Annexure 1). These feature district-specific heat risk maps and identify key risk drivers to strengthen decision-making and targeted resource allocation.

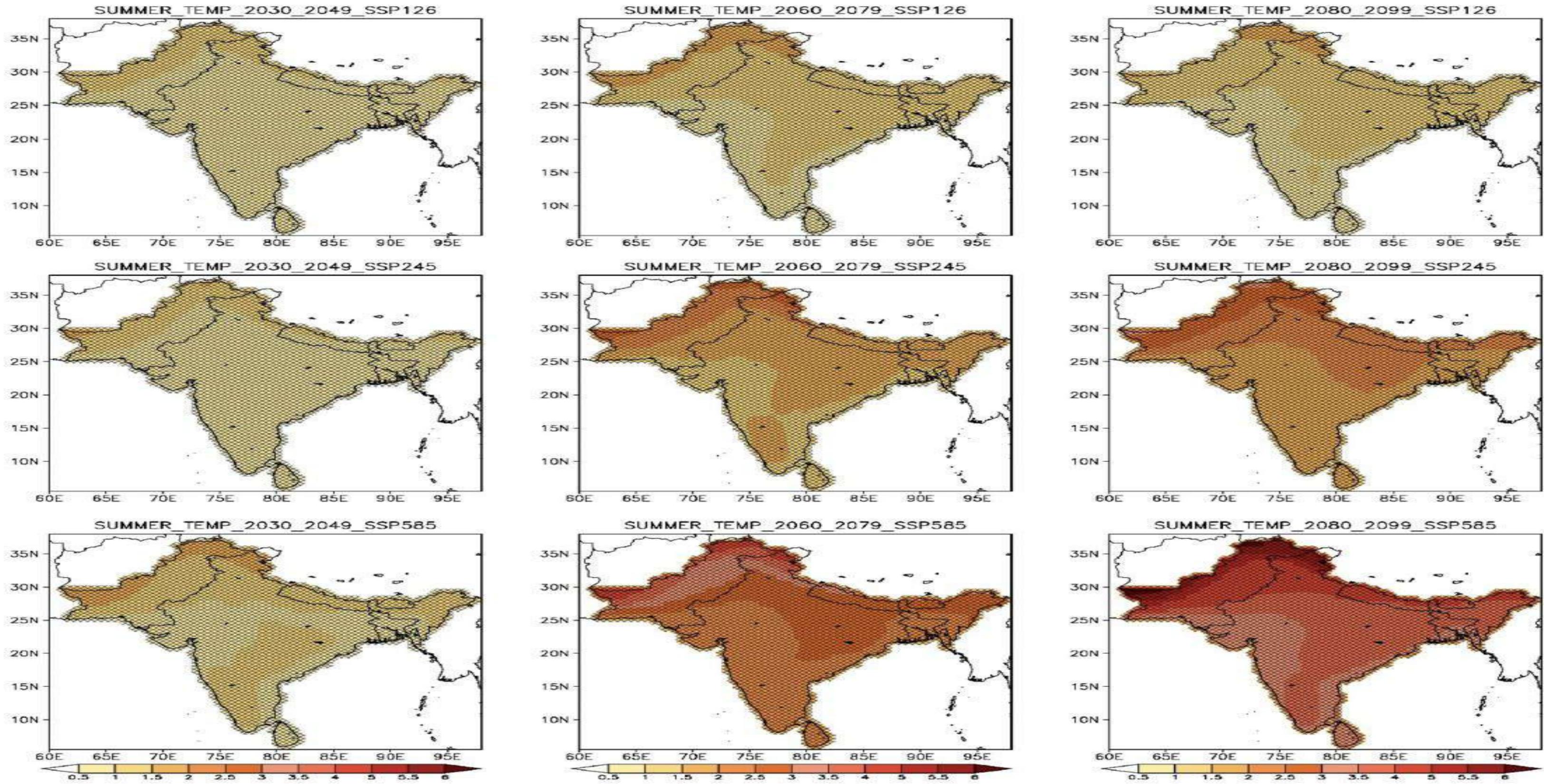


Fig. 6 Same as Fig. 2, except showing projected changes in mean temperature for the summer season

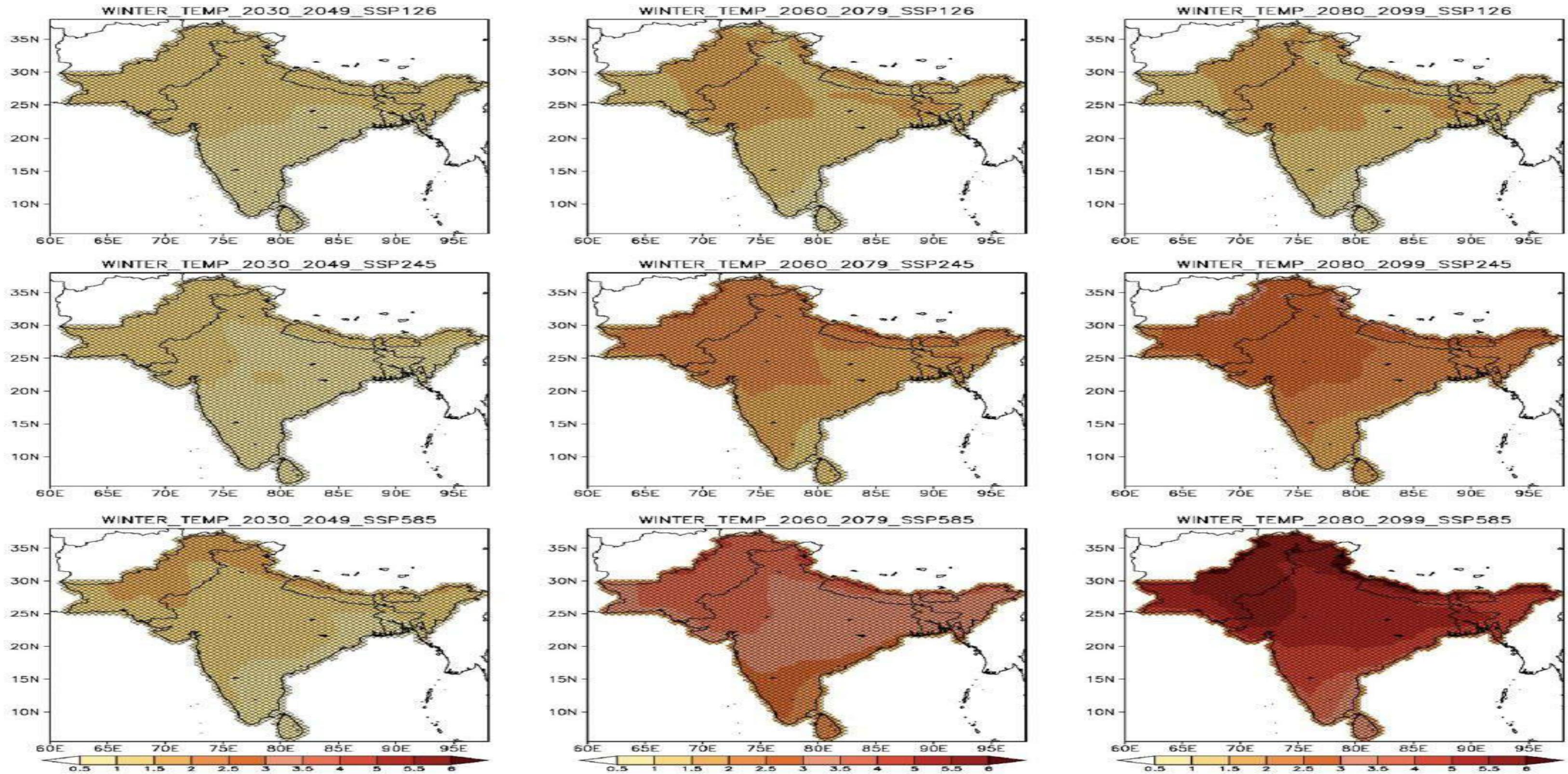


Fig. 7 Same as Fig. 2, except showing projected changes in mean temperature for the winter season

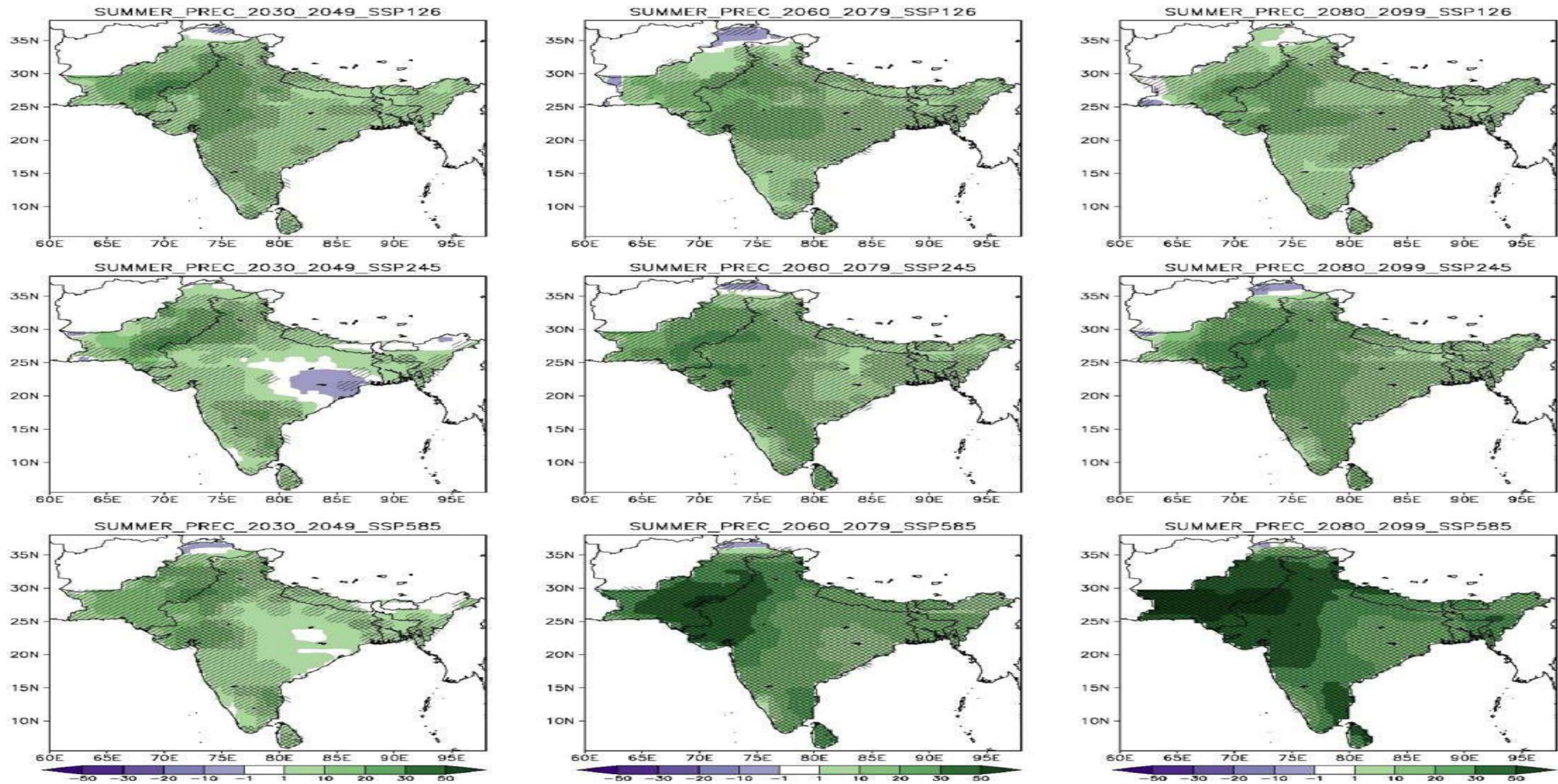


Fig. 8 Same as Fig. 4, except showing the summer mean precipitation change, expressed as a percentage

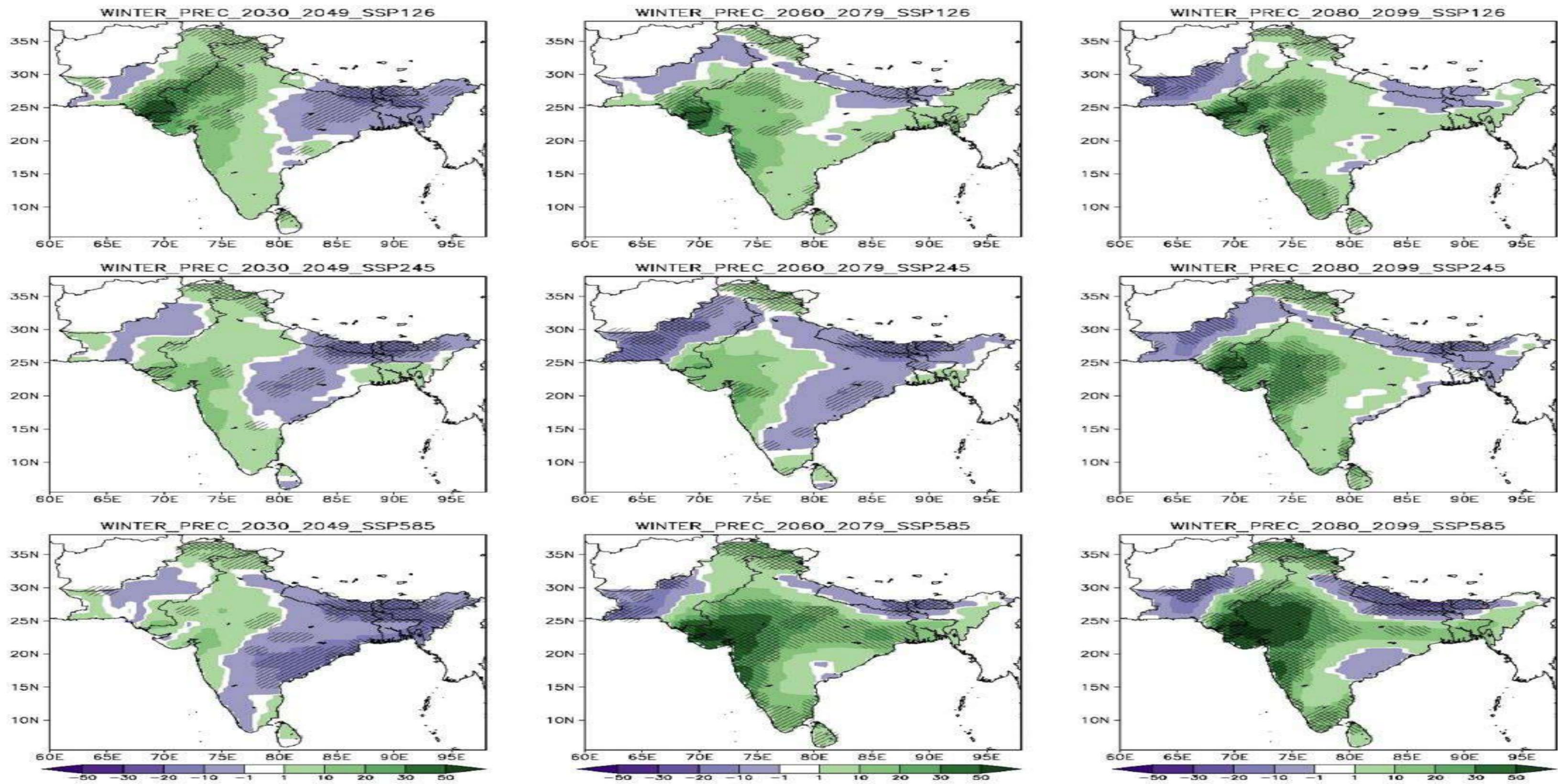


Fig. 9 Same as Fig. 6, except showing the winter mean precipitation change, expressed as a percentage

Table 4 Projected changes in the seasonal mean temperature and precipitation over South Asia and its constituent countries for near-future (2030–2049), mid-future (2060–2079), and far-future (2080–2099) periods with respect to the reference period (1995–2014)

Variable	Scenario	BAN			BHU			IND			NEP			PAK			SRI			South Asia		
		Near	MID	Far	Near	MID	Far	Near	MID	Far	Near	MID	Far	Near	MID	Far	Near	MID	Far	Near	MID	Far
Temperature (Summer)	SSP1-2.6	0.7	0.9	1.0	0.9	1.2	1.1	0.7	1.0	0.9	0.9	1.2	1.1	1.0	1.4	1.3	0.6	0.9	0.8	0.8	1.0	1.0
	SSP2-4.5	0.8	1.5	1.7	1.0	1.7	2.1	0.8	1.4	1.9	1.0	1.7	2.2	1.1	2.0	2.6	0.7	1.4	1.5	0.9	1.5	2.1
	SSP5-5.8	1.0	2.3	3.4	1.1	2.7	4.0	1.0	2.3	3.6	1.2	2.7	3.9	1.4	3.1	4.6	0.9	2.1	3.2	1.1	2.5	3.8
Temperature (Winter)	SSP1-2.6	1.0	1.3	1.3	1.2	1.6	1.4	1.0	1.4	1.2	1.3	1.5	1.6	1.2	1.5	1.4	0.6	0.8	0.8	1.1	1.4	1.3
	SSP2-4.5	0.9	1.8	2.1	1.2	2.3	2.7	0.9	1.9	2.2	1.1	2.3	2.7	1.2	2.3	2.7	0.7	1.3	1.6	1.0	2.0	2.4
	SSP5-5.8	1.1	3.0	4.4	1.5	3.5	5.3	1.2	3.0	4.7	1.4	3.6	5.3	1.6	3.5	5.4	0.8	2.2	3.2	1.3	3.1	4.8
Precipitation (Summer)	SSP1-2.6	4.5	6.2	3.9	4.1	4.8	5.5	11.3	12.5	12.7	4.4	7.0	8.5	12.2	13.5	16.1	7.1	7.8	10.5	12.2	12.3	12.8
	SSP2-4.5	2.4	7.1	8.1	-0.2	5.5	8.5	6.0	13.5	13.7	4.4	7.4	9.9	15.9	23.0	23.7	7.3	13.9	15.9	7.8	17.4	15.2
	SSP5-5.8	4.1	13.7	16.5	2.5	14.1	20.9	9.6	18.4	27.9	4.9	14.7	27.8	16.9	36.1	53.7	9.3	22.3	32.0	9.4	23.8	36.1
Precipitation (Winter)	SSP1-2.6	-7.1	4.7	-0.8	-9.1	-4.0	-3.8	11.4	10.8	7.7	-7.0	-3.7	-5.4	11.2	4.5	0.9	6.8	5.7	4.7	9.8	8.1	4.1
	SSP2-4.5	-0.7	0.7	-7.8	-12.8	-14.0	-8.0	0.4	-4.8	10.2	-10.0	-15.6	-8.4	3.1	0.4	7.1	3.0	1.6	14.4	0.9	-4.8	9.1
	SSP5-5.8	-8.5	-1.1	3.1	-11.5	-7.5	-10.1	0.1	7.2	15.2	-9.0	-1.3	-20.5	8.1	1.8	11.5	3.9	8.6	7.1	1.0	11.3	10.1

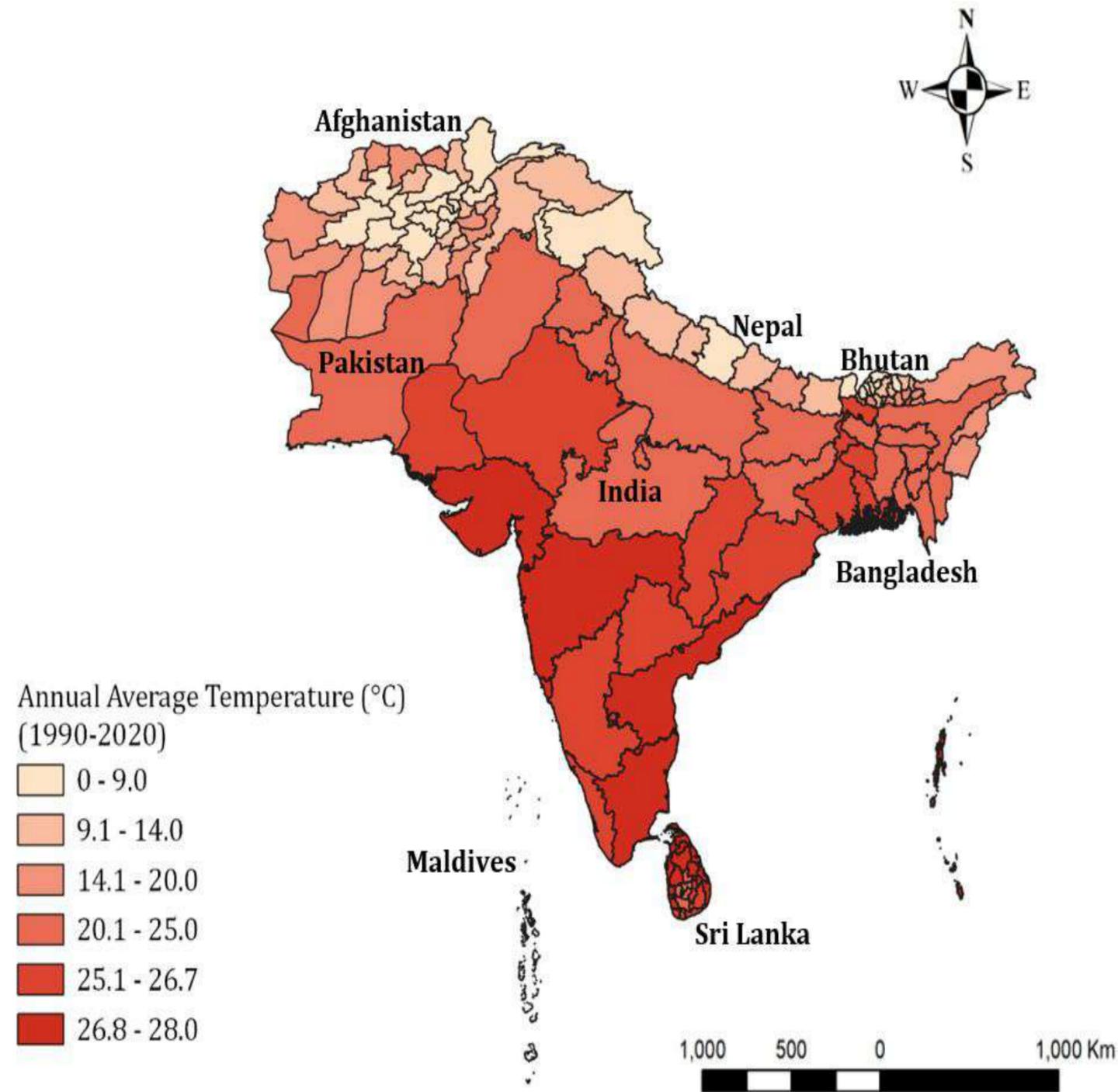


Figure 1. Map showing global South Asian countries with annual average temperature (°C) from 1990 to 2020 (source of data: World Bank Group)

Table 1. Average temperature trends in South Asian countries.

Countries	Annual Average Temperature Range (1990–2010)	Historic Trend (per Decade) (1990–2010)	Increased Trend (1950–2010)
Afghanistan	5 to 15 °C	0.27 °C	2.5 °C to 3.0 °C
Pakistan	15 to 20 °C	0.17 °C	2.5 °C to 3.0 °C
Nepal	–5 to 15 °C	0.14 °C	1.0 °C to 1.5 °C
Bhutan	–5 to 15 °C	0.15 °C	N/A
India	20 to 30 °C	0.11 °C	1.0 °C to 1.5 °C
Bangladesh	25 to 30 °C	0.09 °C	1.0 °C to 3.0 °C
Sri Lanka	25 to 30 °C	0.17 °C	1.0 °C to 3.0 °C
Maldives	25 to 30 °C	0.07 °C	0.8 °C

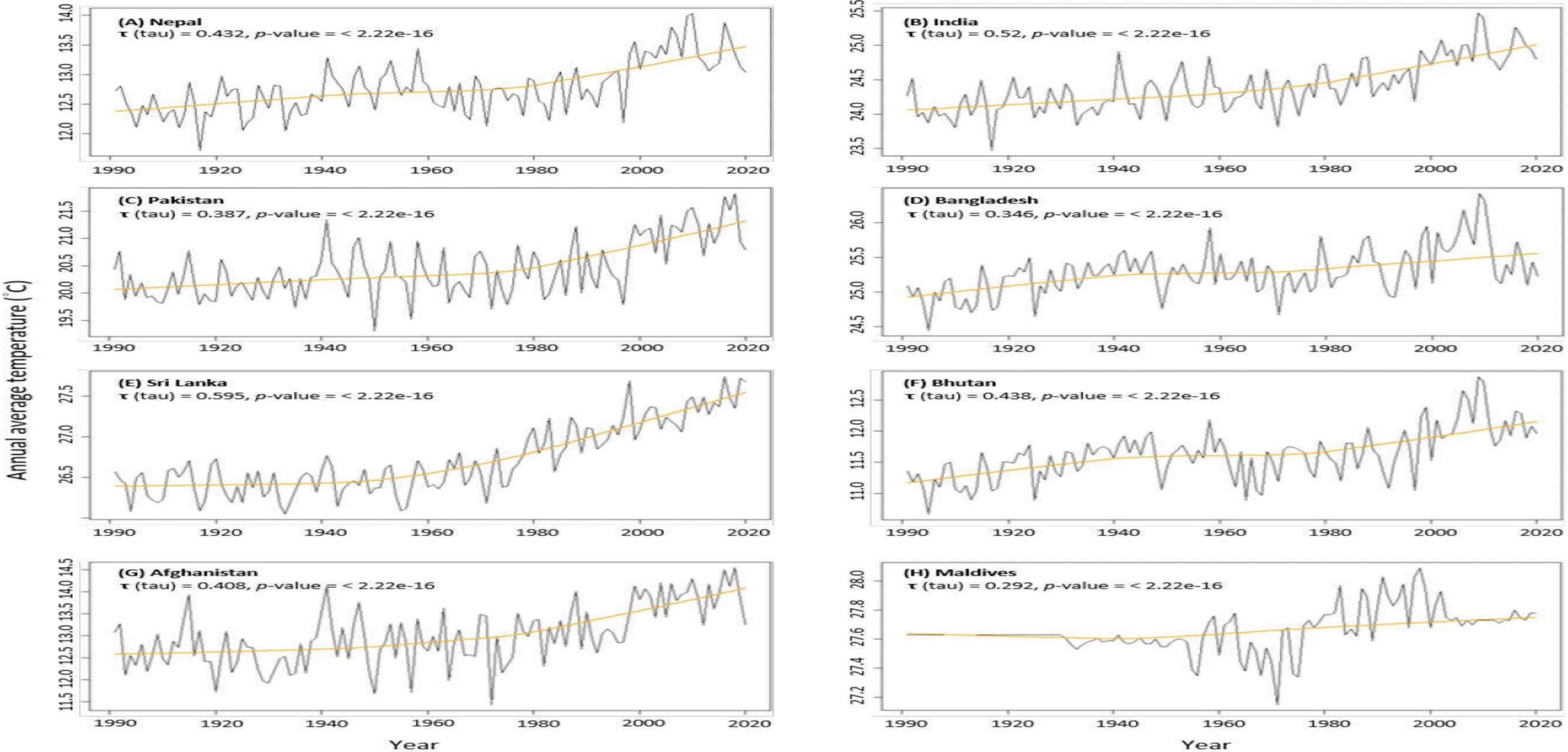
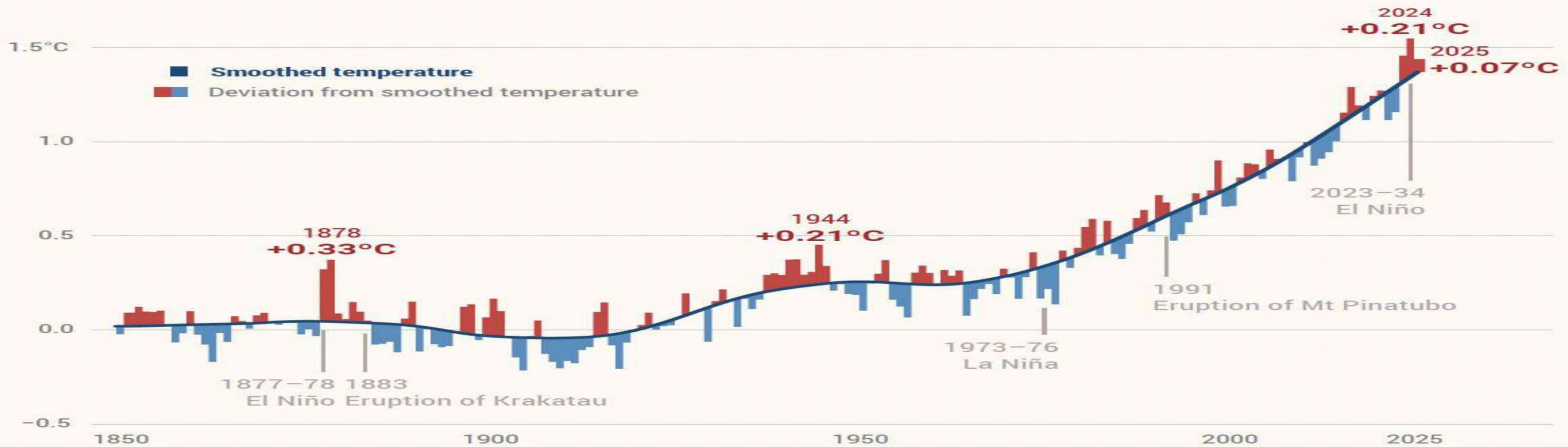


Figure 2. Historical temperature trends analysis using Mann–Kendall’s test across South Asian countries from 1900 to 2020. (A) Nepal (B) India (C) Pakistan (D) Bangladesh (E) Sri Lanka (F) Bhutan (G) Afghanistan and (H) Maldives.

By how much do annual global temperatures deviate from evolving climatological averages?



Only a sample of some of the most important natural events are highlighted.

Data: average of Berkeley Earth, ERA5, GISTEMPV4, HadCRUT5, JRA-3Q, NOAAAGlobalTempv6 - Reference period: pre-industrial (1850-1900) - Credit: C3S/ECMWF

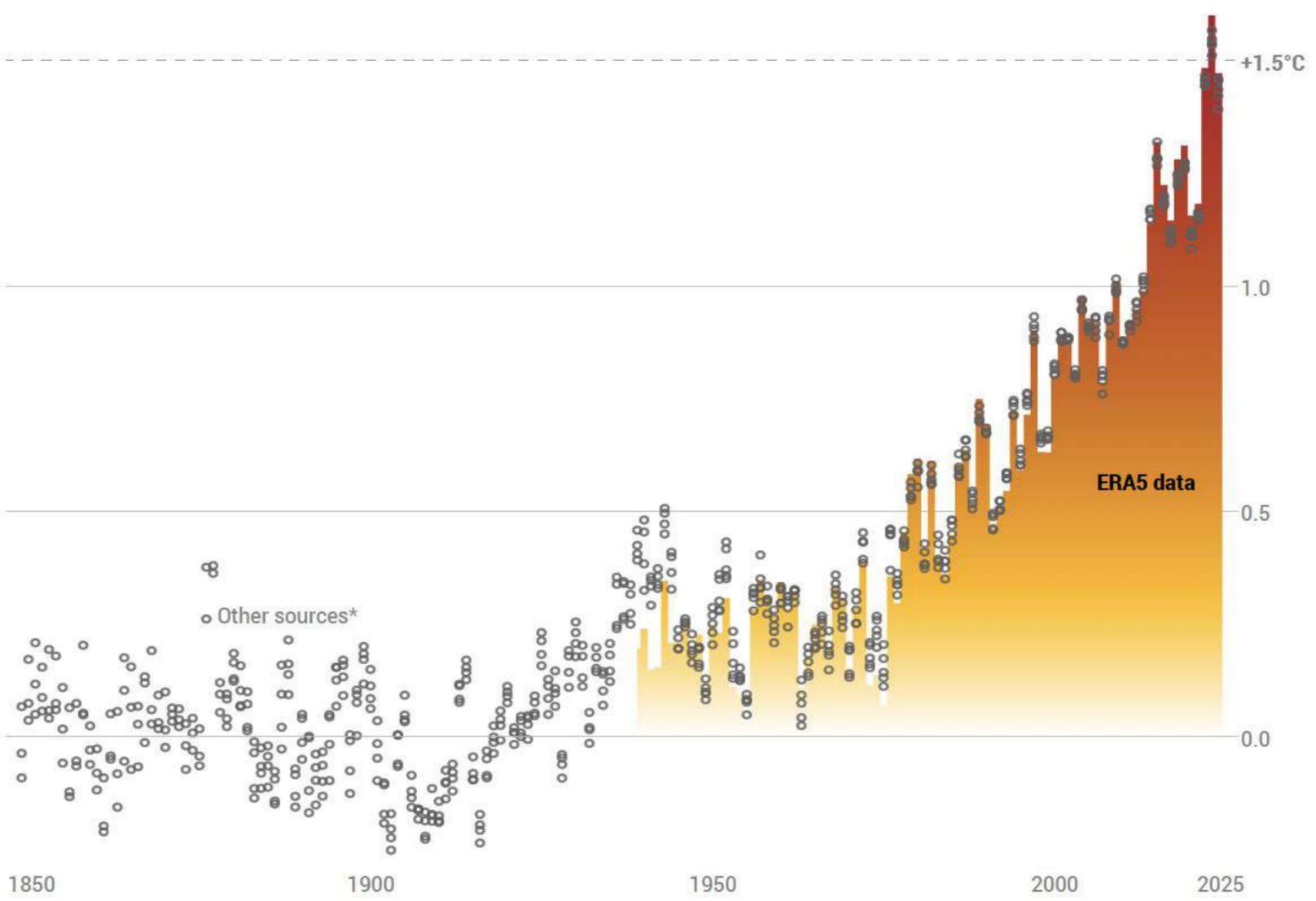
Figure 9.

Difference in global-average temperature ($^{\circ}\text{C}$) from the designated pre-industrial (1850–1900) level, based on the averages of monthly values from up to six datasets: Berkeley Earth, HadCRUT5 and NOAAAGlobalTemp (from 1850), GISTEMP (from 1880), ERA5 (from 1940) and JRA-3Q (from September 1947). Datasets are normalised to have the same averages for 1991–2020 and an average offset of 0.88°C is used to relate 1991–2020 and 1850–1900 averages. The black curve shows an estimate of the long-term climatological variation of temperature (see [About the data and methods](#)). The red and blue bars show the deviations of annual-average temperatures from this estimate. *This figure was updated on 28 January 2026 to reflect full availability of global datasets for 2025.

Credit: C3S/ECMWF.

2025 was the third-warmest year on record according to ERA5

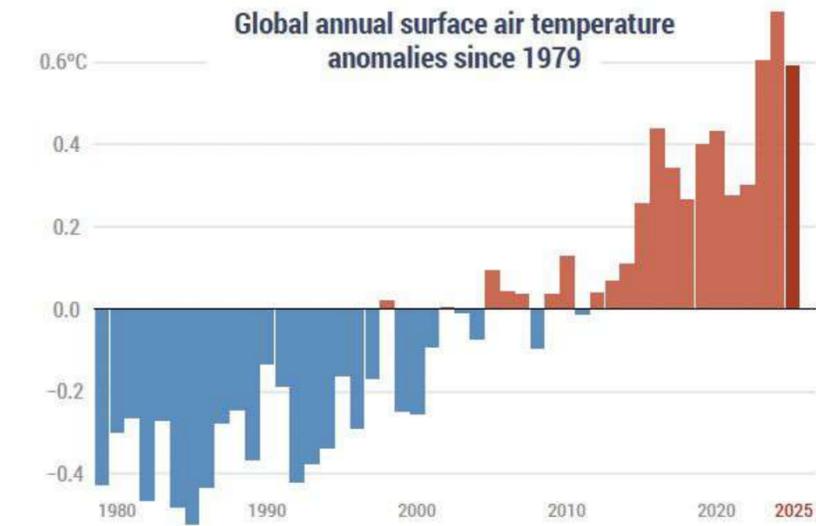
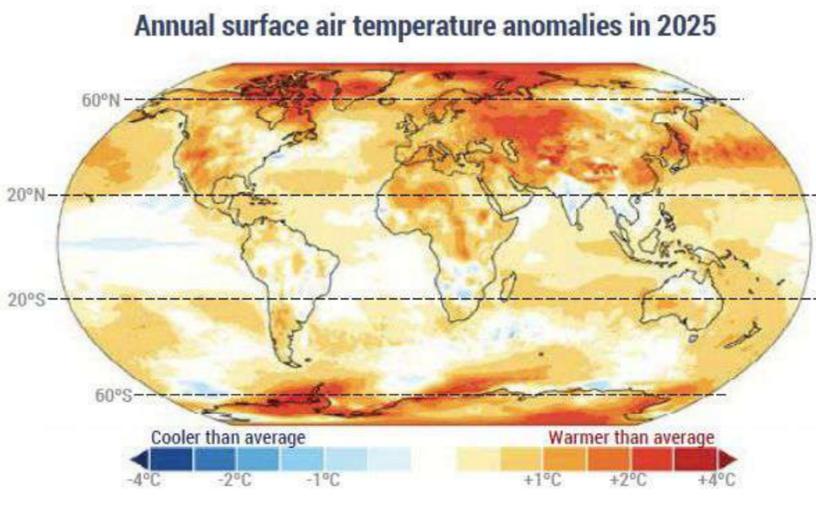
Global annual surface air temperature increase above pre-industrial level since 1850



*Other sources comprise JRA-3Q, GISTEMPV4, NOAA GlobalTempv6, Berkeley Earth, HadCRUT5. Reference period: pre-industrial (1850-1900) • Credit: C3S/ECMWF

Figure 3. Global surface air temperature increase (°C) above the average for the 1850–1900 designated pre-industrial reference period, based on several global temperature datasets. *This figure was updated on 28 January 2026 to reflect full availability of global datasets for 2025.
Credit: C3S/ECMWF.

2025 saw higher temperatures in the polar regions



Data: ERA5 • Reference period: 1991-2020 • Credit: C3S/ECMWF

Figure 6. (Top left) Map of annual surface air temperature anomalies in 2025. (Bottom left) Time series of global annual temperature anomalies from 1979 to 2025. (Right) Time series of annual temperature anomalies averaged over five latitude bands from 1979 to 2025. All anomalies are calculated relative to the average for the 1991–2020 reference period.
Data source: ERA5. Credit: C3S/ECMWF.

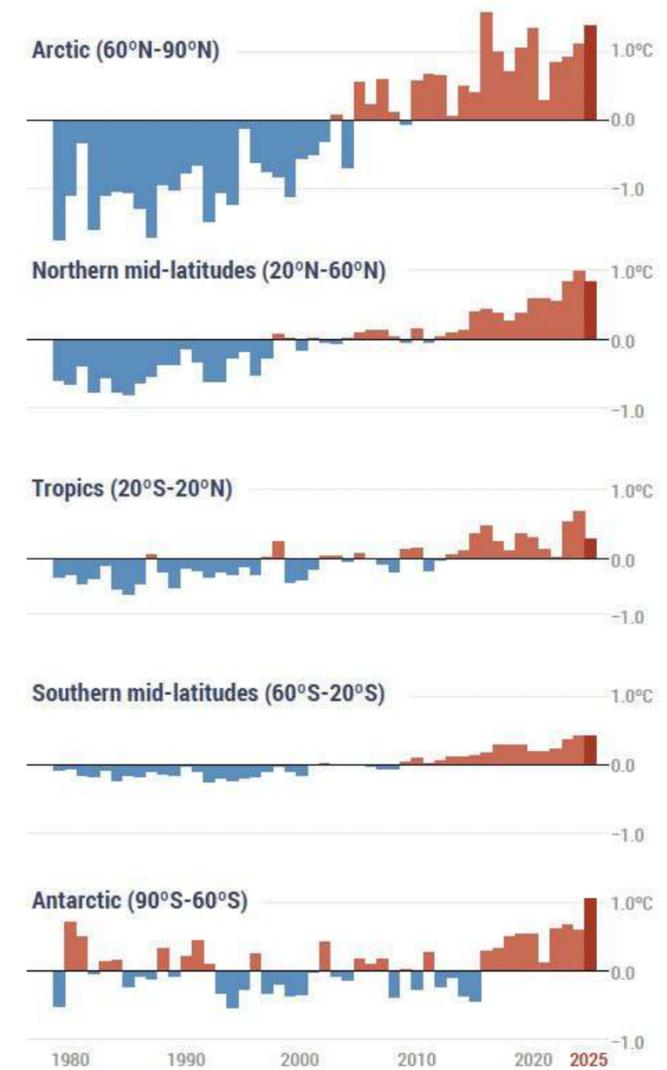


Table 2. Different definitions of heatwaves across South Asian countries.

Country	Threshold	Duration	Heatwave Definition
Afghanistan	90th percentile	3 consecutive days	Heatwaves are defined as in a year with at least three consecutive days above the threshold for the reference period 1981–2010. The threshold is calculated as the 90th percentile of daily maxima, centered on a 31-day window.
Pakistan	>40 °C and 45 °C	5 or 7 consecutive days	Temperature >40 °C and 45 °C for five and seven consecutive days.
Pakistan	45 °C or above	5 consecutive days	45 °C or above temperature for five consecutive days is considered a heatwave.
Pakistan	90th, 95th, and 99th percentile	-	The maximum temperature above different percentiles, namely, 90th, 95th, and 99th, is a heatwave.
Pakistan	>45 °C and >40 °C	-	Heatwave will be considered when the maximum temperature for the understudy meteorological station is >45 °C for plains and >40 °C for hilly areas.
Pakistan	42 °C, then a noted rise of 5 °C to 6 °C	8 consecutive days	When the average maximum temperature of the understudy station is equal to 42 °C, then a noted rise of 5 °C to 6 °C for 8 days or more is considered as a heatwave.
Pakistan	>45 °C	8 consecutive days	When the maximum temperature for a station is >45 °C for >8 days, it is considered a heatwave irrespective of the normal temperature trend.
Nepal	-	-	“Heatwave” is defined as a period of abnormally and uncomfortably hot and humid weather.
Bhutan, Maldives	95th percentile	≥3 days	A heatwave is defined as a period of three or more days where the daily temperature is above the long-term 95th percentile of the daily mean temperature.
India	44.5–46.8 °C	-	Qualified as a “heatwave” with daily maximum temperatures varying between 44.5–46.8 °C.
India	85th and 90th percentile	3 or 5 consecutive days	The number of three or five consecutive days with maximum temperature above the 90th percentile.
India	90th percentile	-	90th percentile of daily maximum (daytime) temperatures.
India	≥97th percentile	≥2 days	Heatwaves were defined as ≥2 days with local temperature ≥97th percentile.
Bangladesh	95th percentile	3 consecutive days	Daily minimum and maximum temperatures over the 95th percentile for three consecutive days are qualified as heatwaves.
Sri Lanka	95th percentile	≥3 days	A heatwave is defined as a period of three or more days where the daily temperature is above the long-term 95th percentile of the daily mean temperature.

Table 3. Health impact of heatwaves across South Asian countries.

Location	Study Period	Impacts of Heatwaves
Pakistan	2015 heatwaves	The 2015 heatwaves in Pakistan resulted in the death toll of 1233 due to hyperthermia. Around 65,000 people were treated for heatstroke.
Pakistan	2000–2019	All-cause mortality increased by 27% with a temperature range between 35–40 °C, while by 11% with a temperature range between 30–35 °C.
Karachi, Pakistan	2015 heatwaves	Heat-related causes of death during June 2015 heatwaves were 18% higher than the reference period of June 2014 [95% CI: 13.87–22.53].
Nepal	2009–2014	Hospitalization/death increased by 2.1% to 7.3% per 1 °C rise in temperature. All-cause deaths rose by 0.9% to 8.2% per 1 °C change in temperature below or above 20 °C.
Bhutan	1961–1990	Heat-related deaths in people above 65 years could increase to 49 deaths per 100,000 by the 2080s.
Ahmedabad, India	May 2010 heatwave	Around 4462 all-cause deaths occurred, comprising 1344 excess all-cause deaths, an estimated 43.1% increase compared to 2009 and 2011 (3118 deaths).
India	2000–2012	Across communities, total mortality increased by 18.1% during heatwave days compared to non-heatwave days [95% CI: –5.3, 47.3].
India	1992–2016	Across India, in the 24 years between 1992 and 2016, 25,716 heat-related deaths were reported, with 1111 and 2040 deaths reported in 2015 and 2016, respectively.
India	1972, 1988, 1998, and 2003	During the 1972, 1988, 1998, and 2003 heatwaves, with over ten heatwave days on average across India, heat-related mass mortality ranged between 650 and 1500 people.
Bangladesh	1989–2011	Mortality increased by 22% during heatwave days [95% CI: 8–38].
Bangladesh	2003–2007	Heat effects increased the all-cause mortality by 1–3%.
Sri Lanka	2019	The outbreak of diseases caused by heatwaves was identified as a serious concern.
Maldives	2015–2016	Severe heat stress resulted in high coral mortality on Maldivian Reefs following the 2015–2016 El Niño event.

Summary

Temperature trends across South Asian countries indicate a consistent and statistically significant warming pattern, though the intensity and specific effects vary by sub-region

Regional Warming Trends

- **Decadal Rise:** Since 1970, South Asia has seen a temperature increase of approximately **0.5°C per decade**.
- **Critical Transition:** A major shift occurred around **1995**, marking a move from a period of anomalous cooling to one of accelerated warming.
- **Country-Specific Variations:**
 - **Afghanistan and Pakistan:** These countries exhibit the steepest rise, with increases ranging from **0.13°C to 0.36°C per decade** in recent decades.
 - **India:** Average warming is approximately **0.51°C** above the 30-year climatological normal, with notable "hotspots" in the Thar Desert and Indo-Gangetic Plain.
 - **Sri Lanka and Maldives:** Warming is slightly lower than in the northern landmasses, though **Sri Lanka** has recorded a **2°C increase** in its central highlands over the last century.

Future Projections

- **Projected Rise:** Under high-emission scenarios, annual mean temperatures in South Asia are projected to rise by **3°C to 5°C** by the end of the 21st century.
- **Economic Impact:** Without global action, the collective economy of countries like **Bangladesh, India, and Sri Lanka** could shrink by up to **8.8% by 2100** due to climate changes.
- **Agricultural Risk:** Rising temperatures are expected to significantly reduce yields for staples like **rice and wheat**, particularly in tropical zones already near temperature tolerance thresholds.

Extreme Temperature Events

- **Heatwaves:** Heatwaves have become more frequent, intense, and longer-lasting. In 2024, cities like **Delhi** and regions in **Pakistan** recorded temperatures exceeding **50°C**.
- **Day vs. Night Trends:** There is a clear increase in **warm nights** and a decrease in cold nights across the region.
- **Humidity & Heat Stress:** Wet-bulb temperatures (combining heat and humidity) are approaching the limit of human survivability (**35°C**) in parts of Sindh (**Pakistan**) and coastal **India**.

Rising temperatures in South Asian countries have profound direct and indirect impacts on the livestock sector, primarily through increased thermal stress and disruptions to feed and health systems.

Direct Physiological Impacts

- **Milk Production Losses:** Heat stress significantly reduces milk yield in cattle and buffaloes. For every **1°C rise** in temperature above an animal's threshold, milk yield in regions like Punjab, Pakistan, can drop by approximately **1.72 litres per month**. In India, milk production from crossbred cows could decrease by **5–14%** due to global warming.
- **Growth and Weight Gain:** High temperatures reduce feed intake (dry matter intake) by **3–5%** per additional degree Celsius. This leads to lower metabolic activity, reduced body weight gain, and higher maintenance energy requirements.
- **Reproductive Failures:** Heat stress reduces fertility in both males and females. Conception rates in dairy cattle can drop by **20–27%** during summer months due to disrupted estrus cycles and early embryonic death.

What is threshold for heat?

A Thermal variable at which the risk of adverse health outcome increases substantially.

What are thermal variables?

- Tmax
- Tmin
- Tmean
- HI
- PT/AT
- Humidex
- WBGT
- UTCI

Tmax – most widely used variable

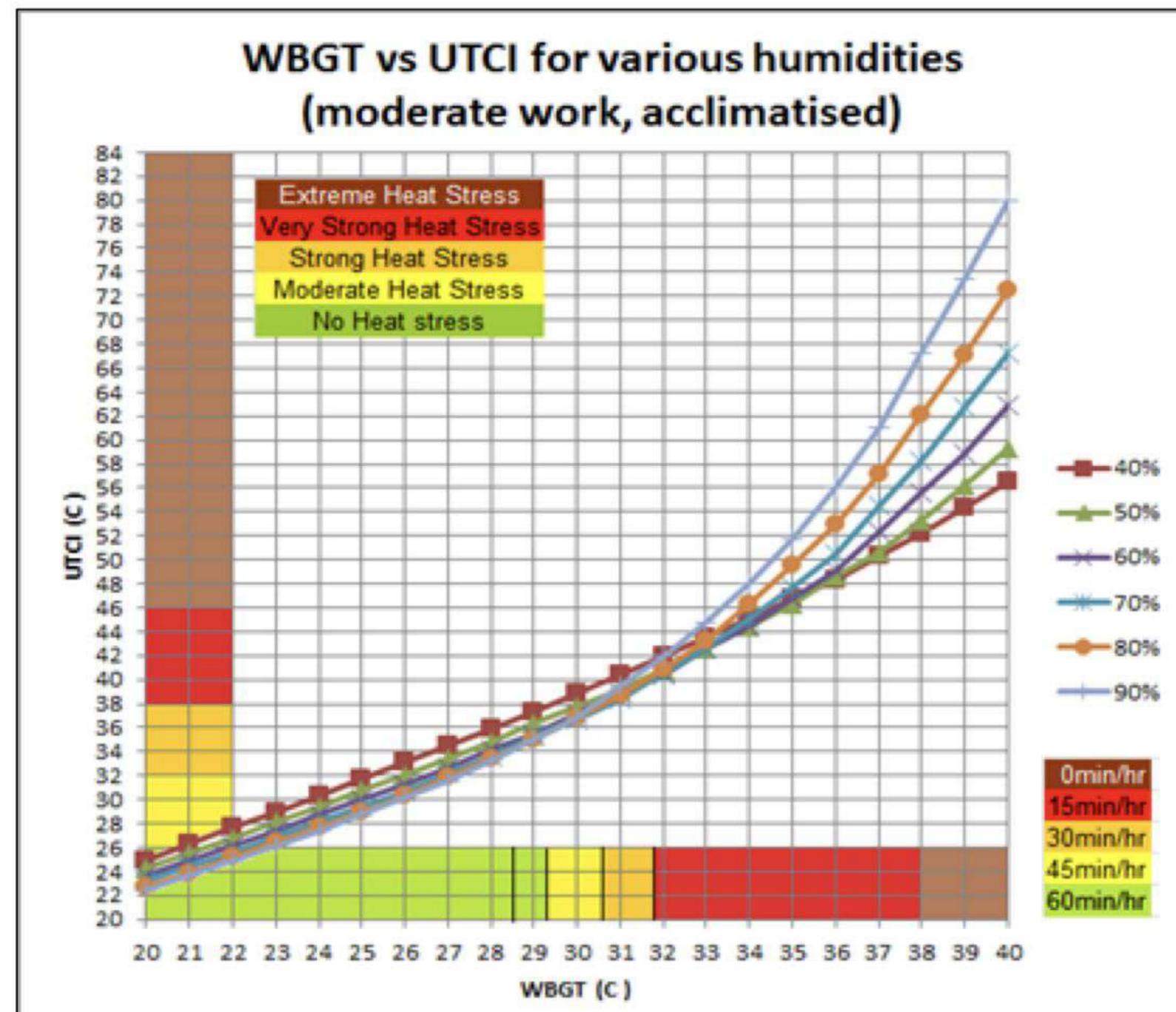


Figure 4 The India Meteorological Department defines heatwaves by how far daytime temperatures exceed normal or fixed thresholds.

Criteria 1:	Heatwave is considered if maximum temperature of a station reaches - <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  40°C or more for plains </div> <div style="text-align: center;">  37°C or more for coasts </div> <div style="text-align: center;">  30°C or more for hilly regions </div> </div>
Criteria 2:	Once criteria 1 is satisfied, the departure from normal (calculated based on 1981-2010) should be <ul style="list-style-type: none"> • Between 4.5°C to 6.4°C for a heatwave day • More than 6.4°C for a severe heatwave day
Criteria 3:	If criteria 1 and 2 are met in at least in 2 stations in a Meteorological subdivision for at least two consecutive days, a heatwave/severe heatwave is declared on the second day

However, If the maximum temperature is $\geq 45^\circ\text{C}$ and $\geq 47^\circ\text{C}$, A heatwave and severe heatwave is directly declared.

Source: India Meteorological Department (IMD). "FAQ on Heat Wave." India Meteorological Department, n.d.

Heat Wave/Warm Night Criteria

- **Heat wave Criteria for plain region**
 - a. Based on Departure from Normal
 - **Max. temp. $\geq 40^\circ\text{C}$**
 - **Heat Wave: Departure from normal is 4.5°C to 6.4°C**
 - **Severe Heat Wave: Departure from normal is $>6.4^\circ\text{C}$ or more**
 - b. Based on Actual Maximum Temperature
 - **Heat Wave: When actual maximum temperature $\geq 45^\circ\text{C}$**
 - **Severe Heat Wave: When actual maximum temperature $\geq 47^\circ\text{C}$**
 - **Criteria for describing Heat Wave for coastal stations: Actual max. temp $\geq 37^\circ\text{C}$**
 - **Heat Wave: Departure from normal is 4.5°C to 6.4°C**
 - **Severe Heat Wave: Departure from normal is $>6.4^\circ\text{C}$ or more**
 - **Criteria for describing Heat Wave for Hill stations: Actual max. temp $\geq 30^\circ\text{C}$**
 - **Heat Wave: Departure from normal is 4.5°C to 6.4°C**
 - **Severe Heat Wave: Departure from normal is $>6.4^\circ\text{C}$ or more**
 - **Warm Night: It should be considered only when max. temp. $\geq 40^\circ\text{C}$.**
 - **Warm Night: Minimum temperature departure from normal is 4.5°C to 6.4°C**
 - **Very Warm Night: Minimum temperature Departure from normal is $>6.4^\circ\text{C}$ or more**
- If above criteria are met at least in 2 stations in a Meteorological sub-division for at least two consecutive days and it declared on the second day.**

Heat Index

- Heat index/Apparent temperature: Feel like temperature to the human body when relative humidity is combined with the air temperature, important for the human body's comfort.
- When the body gets too hot, it begins to sweat to cool itself off. If the sweat/perspiration is not able to evaporate, the body cannot regulate its temperature.
- Evaporation is a cooling process. When perspiration is evaporated off the body, it effectively reduces the body's temperature. When the atmospheric moisture content (i.e. relative humidity) is high, the rate of evaporation from the body decreases.

$$\text{Heat Index} = -42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783 \times 10^{-3}T^2 - 5.481717 \times 10^{-2}R^2 + 1.22874 \times 10^{-3}T^2R + 8.5282 \times 10^{-4}TR^2 - 1.99 \times 10^{-6}T^2R^2$$

T – Dry air temperature (F)
 R - Relative humidity (percentage)

Heat index values are for shady locations. If you are exposed to direct sunlight, the heat index value can be increased by up to 15°F.

The Perceived Temperature (PT) and Apparent Temperature (AT) are "feels like" indices used to measure heat stress during heat waves by combining dry-bulb air temperature with relative humidity and, in some cases, wind speed. These indices represent the temperature at which the human body feels a specific level of discomfort, often revealing that humid conditions make moderate temperatures feel much hotter. [🔗](#)

Key Aspects of PT/AT for Heat Waves

- **Definition:** Apparent Temperature (AT) was developed in the late 1970s and early 1980s to measure indoor/outdoor thermal sensation based on a model of a walking human in the shade. It incorporates air temperature, relative humidity, and wind speed.
- **Purpose:** These indices are superior to maximum temperature alone because they account for the body's inability to cool itself via sweat evaporation in high humidity.

Components of the Index

1. **Air Temperature (Ta):** The base temperature.
2. **Relative Humidity (RH):** High humidity inhibits the evaporation of sweat, which is the body's main cooling mechanism.
3. **Wind Speed (v):** Higher wind speeds can increase cooling (wind chill) but also add heat in extreme conditions. [🔗](#)

Categorization of Heat Levels (Perceived/Apparent Temp)

- **27–32°C (81–90°F):** Caution - Fatigue is possible with prolonged exposure.
- **32–41°C (90–106°F):** Extreme Caution - Heat cramps/exhaustion possible.
- **41–54°C (106–130°F):** Danger - Heat exhaustion/stroke likely.
- **Over 54°C (>130°F):** Extreme Danger - Heatstroke is imminent. [🔗](#)

- **IMD Experimental Heat Index:** The India Meteorological Department (IMD) launched an experimental heat index, a form of apparent temperature, to provide a "real-feel" forecast. It classifies hazard levels:
 - **Green:** Less than 35°C (Low risk)
 - **Yellow:** 36-45°C (Moderate risk)
 - **Orange:** 46-55°C (High risk)
 - **Red:** >55°C (Extreme danger/Immediate heatstroke risk)
- **Impact of Humidity:** A high PT/AT value indicates that the body cannot easily dissipate heat, increasing the likelihood of heat cramps, exhaustion, and stroke. [🔗](#)

HEAT ACTION PLAN GUIDANCE

Enabling Good Practices



Heat Action Plan Elements & Good Practices

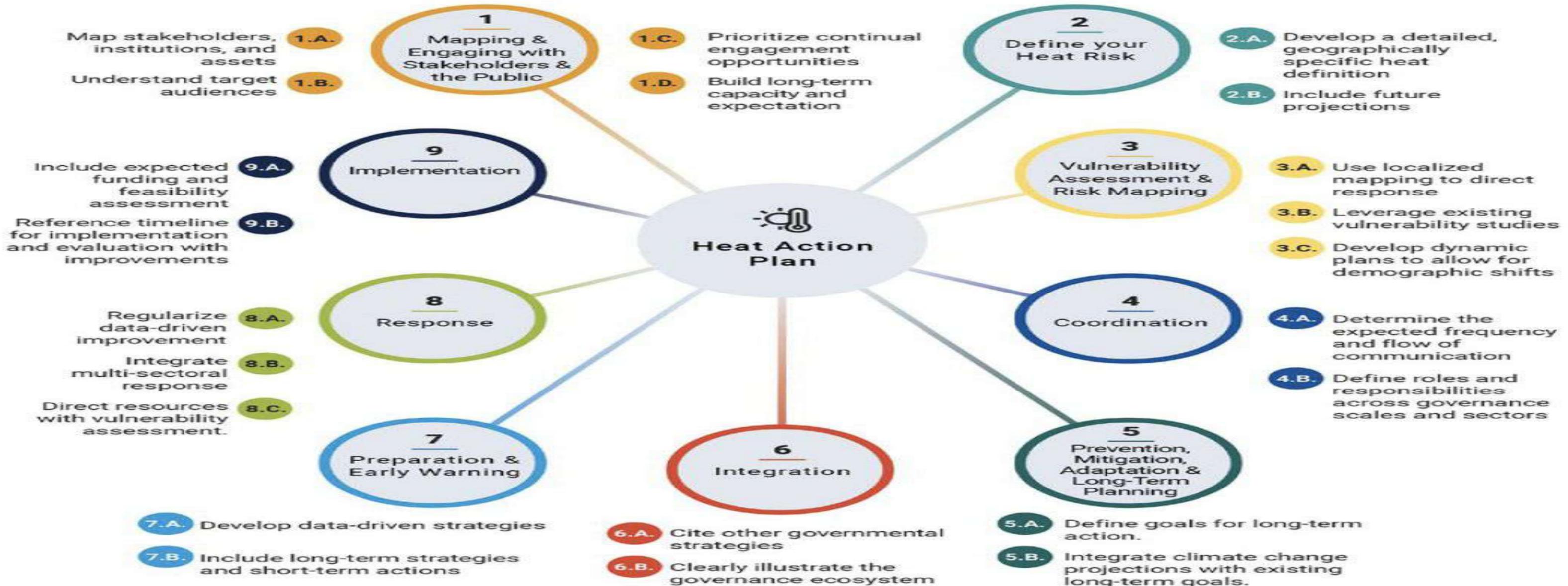
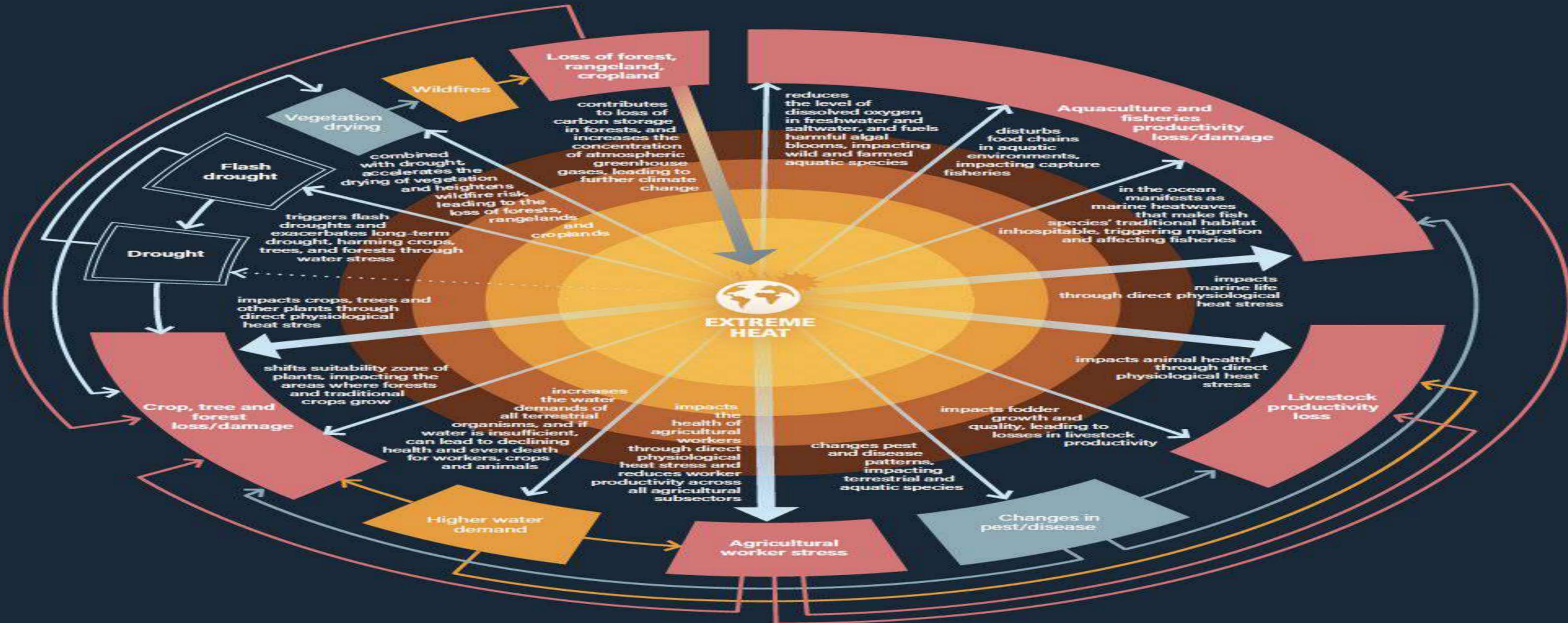
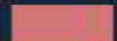


FIGURE 1. Impact pathways from extreme heat to agriculture



Source: Authors' own elaboration

Legend

-  Direct pathways from heat to outcomes
-  Indirect pathways from heat to outcomes
-  Meteorological phenomenon
-  Outcomes

Rising temperatures across South Asia have a severe impact on the poultry sector, primarily due to the birds' limited ability to sweat and their reliance on panting to dissipate heat. [🔗](#)

Production and Productivity Losses

- **Reduced Growth in Broilers:** Heat stress significantly lowers feed intake as birds attempt to reduce metabolic heat production. For example, chronic heat can reduce the weight gain of broilers by **3%** or more and worsen the feed conversion ratio (FCR).
- **Egg Quality and Yield:** In laying hens, every unit increase in the **Heat Stress Index (HSI)** can lead to a **1.29% decline** in hen-day production and a decrease in average egg weight. Heat stress also causes thinner eggshells and increased breakage due to respiratory alkalosis from excessive panting.
- **Reproductive Performance:** Fertility in breeder stocks can plummet; one study noted that broiler male fertility dropped to **42%** when temperatures reached 32°C. [🔗](#)

Economic and Supply Chain Impacts

- **Surging Prices:** High mortality and stunted growth often lead to supply shortages, causing retail chicken prices to soar by over **one-third** during peak summer months.
- **Operational Costs:** Maintaining bird health requires expensive cooling infrastructure, such as foggers, exhaust fans, and evaporative cooling pads, which increase electricity and water consumption. [🔗](#)

2. Infrastructural Resilience

- **Passive Cooling:** Health facilities are adopting structural changes such as **cool roofs**, green cover, and solar-powered backup systems to ensure cooling appliances remain functional during the power surges common in heatwaves.
- **Urban Cooling Centers:** Cities like Jodhpur have pioneered **net-zero community cooling stations** using wind towers and misting fans to provide refuge for high-risk outdoor workers.
- **Integrated Surveillance:** Under the [National Programme on Climate Change and Human Health \(NPCCHH\)](#), digital platforms like the **IHIP portal** now track suspected heatstroke cases and deaths in real-time across districts to trigger local health alerts. [🔗](#)

Mortality and Health Risks

- **Massive Die-offs:** Extreme heatwaves have historically caused millions of poultry deaths in South Asia. In a notable event in India, a heatwave killed nearly **17 million birds** in a single month.
- **Increased Mortality Rates:** During severe heat, mortality rates can surge to **10%**, which is more than triple the usual summer average. Some broiler farms in parts of South India have reported mortality exceeding **50%** when temperatures range between 37°C and 42°C.
- **Immunosuppression:** High temperatures suppress the immune system, making flocks more vulnerable to diseases like **Newcastle Disease, E. coli, and Coccidiosis**. [🔗](#)

Public health infrastructure in South Asia is rapidly evolving from reactive emergency response to systematic climate-resilient planning, primarily led by national and city-level **Heat Action Plans (HAPs)**. [🔗](#)

1. Clinical & Emergency Readiness

- **Specialized Units:** Major hospitals in cities like Delhi (e.g., AIIMS, Safdarjung) have established dedicated **heatstroke emergency units** equipped with immersion cooling tubs, ice-making refrigerators, and rectal thermometers for rapid core-temperature monitoring.
- **Standardized Protocols:** New 2024–2025 guidelines from the [National Centre for Disease Control \(NCDC\)](#) mandate the stockpile of cooling kits (ice packs, intravenous fluids, ORS) and the training of frontline workers to use evidence-based rapid cooling techniques.
- **Ambulance Preparedness:** Emergency services are being upgraded with "cool transport" capabilities, including ambulances stocked with cold water and ice packs to stabilize patients during transit. [🔗](#)

3. Strategic Governance

- **District-Level Planning:** The focus has shifted to granular mapping; more than 10 states in India have formally notified heatwaves as "state-specific disasters," unlocking dedicated funds for healthcare capacity building and relief.
- **Early Warning Systems (EWS):** In collaboration with meteorological departments, 7-day probabilistic forecasts are now used to trigger "red alerts," allowing hospitals to proactively clear beds and adjust staff shifts before a heatwave hits.
- **Cross-Sectoral Coordination:** Newer plans increasingly link human health surveillance with animal health alerts (One Health approach), recognizing that livestock or poultry die-offs often serve as early indicators of extreme heat stress.

Guidance for safe drinking water services in South Asia focuses on maintaining water quality and ensuring adequate hydration as rising temperatures increase both biological contamination risks and human physiological needs.

1. Household Water Treatment & Safe Storage (HWTS)

To mitigate the increased survival of pathogens in warmer water, households should follow **WHO-recommended** treatment protocols:

- **Disinfection:** Boiling is the most common method, but chlorination is often preferred because it provides a "residual effect," protecting water from re-contamination during storage.
- **Filtration:** Using mechanical filters (e.g., [RO, UV, or UF systems](#)) to remove turbidity is essential, as suspended particles can "hide" pathogens from chemical disinfectants.
- **Safe Storage:** Treated water must be stored in strong, **non-transparent containers** with tight-fitting lids and narrow openings (or taps) to prevent contact with hands or dust.

4. Climate-Resilient Infrastructure

- **Solar-Powered Systems:** To ensure continuous supply during heat-related power outages, many regions in Pakistan and Afghanistan are transitioning to **solar-powered pumping stations**.
- **Source Protection:** Communities are advised to move latrines downstream and build physical fences around open water sources to prevent animal-waste contamination, which spikes during high-evaporation periods.

2. Hydration Guidelines During Heatwaves

Standard hydration advice changes significantly during South Asia's extreme heat events:

- **Minimum Intake:** While 2.5–3 litres is standard, a minimum of **7.5 litres per capita per day** is required for lactating women or those active in high temperatures. In emergency heat conditions, this should rise to **15–20 litres** to cover basic hygiene needs.
- **Proactive Drinking:** Guidance from the [National Centre for Disease Control \(NCDC\)](#) emphasizes drinking water even if not thirsty, as thirst is a lagging indicator of dehydration.
- **Electrolyte Balance:** Supplementing plain water with salt-containing homemade drinks like buttermilk (lassi), lemon water, or **Oral Rehydration Salts (ORS)** is recommended to replace lost minerals.

3. Institutional Monitoring & Surveillance

Public water services are adopting more rigorous testing frameworks to handle climate-induced quality shifts:

- **Testing Frequency:** Under India's [Jal Jeevan Mission](#), sources must be tested at least **twice a year for bacteriological** contamination and once for chemicals.
- **Community Surveillance:** Training programs, such as those led by [UNICEF South Asia](#), empower local "Pani Samitis" (Water Committees) to use **Field Test Kits (FTKs)** for real-time monitoring of biological and chemical hotspots.
- **Critical Thresholds:** Water with **Total Dissolved Solids (TDS)** above 1,000 ppm is considered dangerous for long-term consumption, contributing to kidney stones and digestive issues—a growing concern in regions with falling water tables.

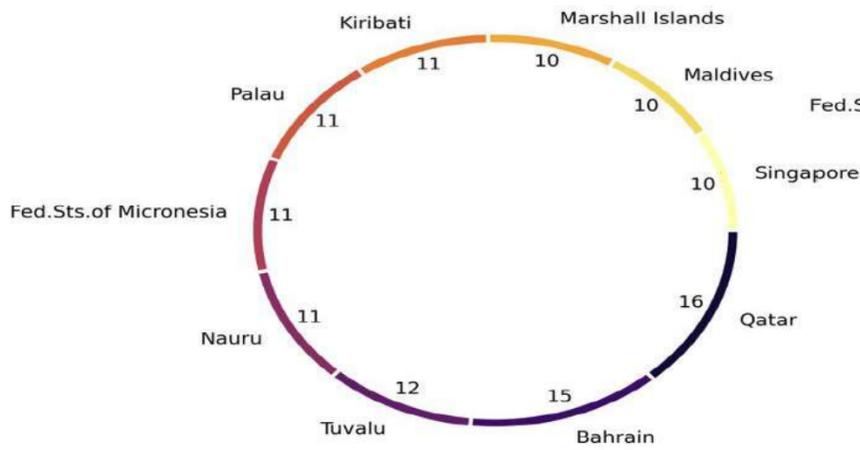
Table 4. Present national action plans and strategies for heatwave and climate change mitigation in South Asian countries. The grey colored shaded areas denote heatwave-specific policies or actions in each country

Countries	Nation/Local Action Plans	Interventions
Afghanistan	<ul style="list-style-type: none"> » National Adaptation Program of Action for Climate Change (NAPA) » Disaster Management Strategy (2014–2017) » Nationally Determined Contribution (NDC), 2016 	<ul style="list-style-type: none"> » Climate-smart water and agriculture management; resilient natural capital » Shock-responsive social protection, multi-hazard risk information, and early warning » Resilient infrastructure and clean energy
Pakistan	<ul style="list-style-type: none"> » Technology Needs Assessment for Climate Change Adaptation, 2016 » National Disaster Risk Reduction Policy 	<ul style="list-style-type: none"> » Energy decarbonization » Agriculture–water nexus » Climate-resilient infrastructure and communities
	<ul style="list-style-type: none"> » National Disaster Management Authority: Heat Action Plan 	<ul style="list-style-type: none"> » Community outreach to build public awareness » Early warning systems and inter-agency coordination: three-tier alerting system
Nepal	<ul style="list-style-type: none"> » National Disaster Response Framework (NDRF) » National Adaptation Programme of Action (NAPA) to Climate Change 	<ul style="list-style-type: none"> » Water and resilient natural capital » Climate-resilient cities, towns, viable state, and local governments » Clean energy » Climate-smart transport networks » Human development for economic and environmental resilience
	<ul style="list-style-type: none"> » Red Cross Red Crescent Climate Centre: Heat actions plans for Nepalgunj in Nepal 	<ul style="list-style-type: none"> » Guidance note on early warning, early actions (EWEA)
Bhutan	<ul style="list-style-type: none"> » Bhutan National Adaptation Program of Action (NAPA) » Disaster Management Act of Bhutan, 2013 	<ul style="list-style-type: none"> » Sustainable renewable natural resources » Resilient infrastructure » Human capital for resilience » Macro-fiscal resilience and risk-informed decision-making
India	<ul style="list-style-type: none"> » National Action Plan on Climate Change (2008) 	<ul style="list-style-type: none"> » Decarbonization (energy and transport) » Agriculture–water–energy–air nexus » Sustainable urbanization » Public awareness campaigns » Department coordination and water supply
	<ul style="list-style-type: none"> » National Resource Defense Council (NRDC): Heat Action Plan (HAP) 	<ul style="list-style-type: none"> » Cool roofs and adaptive measures » Community outreach to build public awareness » Early warning systems and inter-agency coordination: three-tier alerting system » Addressing vulnerable groups
Bangladesh	<ul style="list-style-type: none"> » National Adaptation Program of Action (NAPA), 2005 » Climate Change Strategy and Action Plan (BCCSAP), 2008 	<ul style="list-style-type: none"> » Adaptive delta management and coastal resilience » Human capital for resilience » Community-supported agriculture » Low-carbon and resilient infrastructure » Green growth and macro-fiscal resilience
	<ul style="list-style-type: none"> » Red Cross Red Crescent Climate Centre: Heat actions plans for Rajshahi in Bangladesh 	<ul style="list-style-type: none"> » Guidance note on early warning, early actions (EWEA) » Development of information, education, and communication (IEC) material
Sri Lanka	<ul style="list-style-type: none"> » National Adaptation Plan (NAP) for Climate Change Impacts in Sri Lanka » National Policy on Disaster Management 	<ul style="list-style-type: none"> » Resilient infrastructure and livelihoods » Integrated landscape management, agriculture, watershed management, and forests » Clean energy
Maldives	<ul style="list-style-type: none"> » Strategic Action Plan 2019–2023 » Maldives Climate Change Policy Framework » National Adaptation Program of Action (NAPA) 	<ul style="list-style-type: none"> » Coastal and infrastructure resilience » Government, island, and atoll council capacity, development » Livelihoods resilience » Clean energy

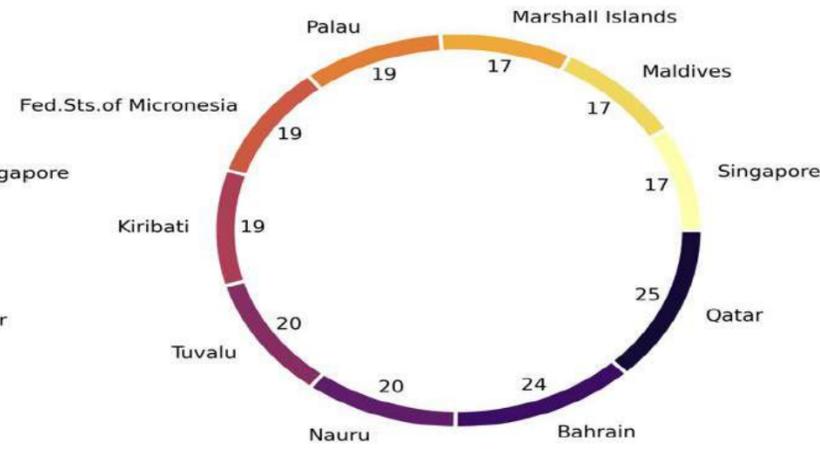
Table 5. Potential adaptation and mitigation strategies for heatwaves in South Asian Countries.

Approach	Adaptation Strategies	Stakeholders	Significance
Outdoor cooling strategies	- Pavements: Use of higher albedo materials	- Government administrators and urban planners	- High albedo can reduce the urban heat island effects
	- Urban parks: Different vegetation species utilization	- Government administrators and urban planners	- Reduce temperature and increase evapotranspiration
	- Urban shading	- Community and government administrators	- Improved outdoor thermal comfort
	- Urban blue-green space	- Urban planners	- Cooling effects
Infrastructural	- Blue-green infrastructure in buildings	- Government administrators, urban planners and community	- Reduce temperature and increase evapotranspiration
	- Structural parameters of buildings: height of a building, percentage of built area, rooftop spectral attributes, aspect, slope	- Urban planners, community and architects	- Building density and height dictate the value of the surface temperature
Passive cooling strategies(indoor)	- Green roofing, louvre shading devices	- Government administrators, urban planners, and community	- Effective roof insulation
	- Double glazing, light color coatings with high reflection		- Reduce the heat gain
	- Natural ventilation: wind catcher and cross ventilation		- Introduce cool air in the building
Heat action plans (HAPs)	- Heatwave early warning systems	- National agencies, government administrators, and researchers	- Heatwave preparedness
	- Assessment of vulnerability: safeguard outdoor workers- Develop a heat vulnerability index for high-risk subgroups		- Reduce health risk and vulnerability
	- Assessment of disease burdens associated with the heatwave		- Risk assessment and mitigations
Administrative and policy	- Spatial mapping approach for urban planners	- Government administrators, researchers, and urban planners	- Guided planning of urban cities
	- Developing collaborative partnerships to bridge technical deficits	- Government administrators	- Better policy dialogues
	- Building political consensus for climate action	- Government administrators, national, and international agencies	- Better policy dialogues
	- Local planning initiatives while building broader support for substantial climate action	- National/local agencies, government administrators, and NGOs	- Better policy dialogues and community awareness
	- Better flexibility in the number of ambulances, increased response times	- Healthcare agencies, government administrators	- Health sector preparedness for health hazards
	- Establish medical support via telephones as an effective pre-hospital measure for people and hospitals.		
	- Developing workplace policies to avoid occupational hazards	- Policymakers, national/international agencies	- Occupational health
	- Distribution of oral rehydration solutions (ORS) as a preventive measure	- Healthcare agencies, government administrators, and NGOs	- Health sector preparedness
Behavioral	- Raise awareness: regular showers, drinking plenty of water, spending summer nights outside on lawns or the rooftops, and tree shelters during peak summer hot hours	- National agencies, government administrators, NGOs, and community	- Reduced vulnerability, awareness, and behavioral changes

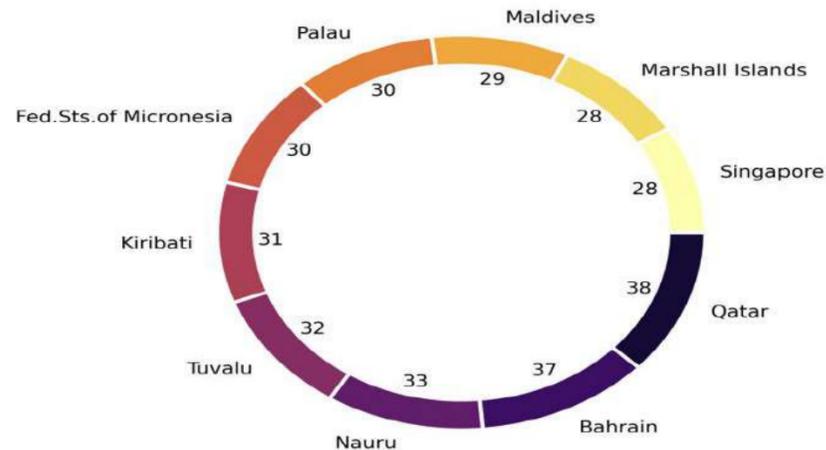
a. Present:
Coolest Hour Per Capita Loss
Global Mean: 2 Hours/Person



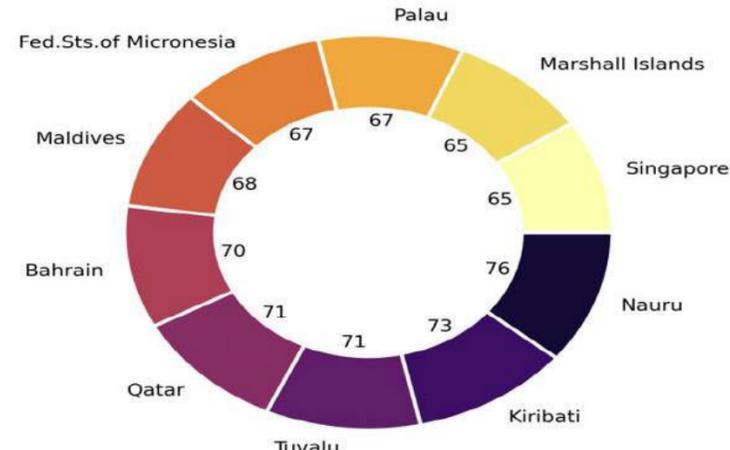
b. ΔT Global: +1°C:
Coolest Hour Per Capita Loss
Global Mean: 4 Hours/Person



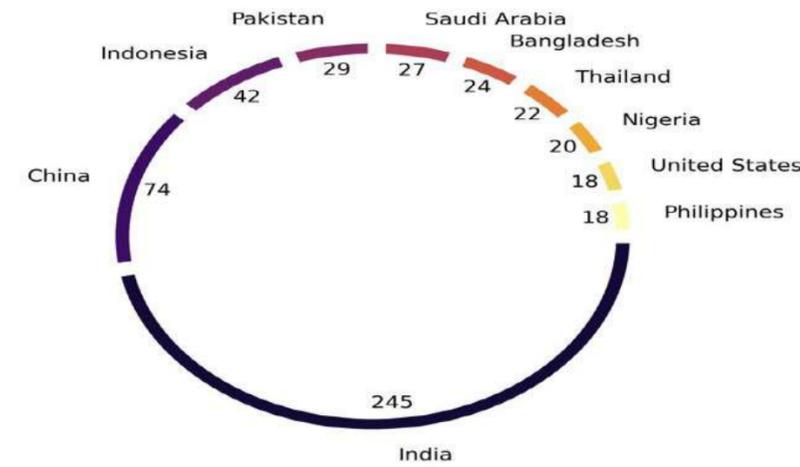
c. ΔT Global: +2°C:
Coolest Hour Per Capita Loss
Global Mean: 7 Hours/Person



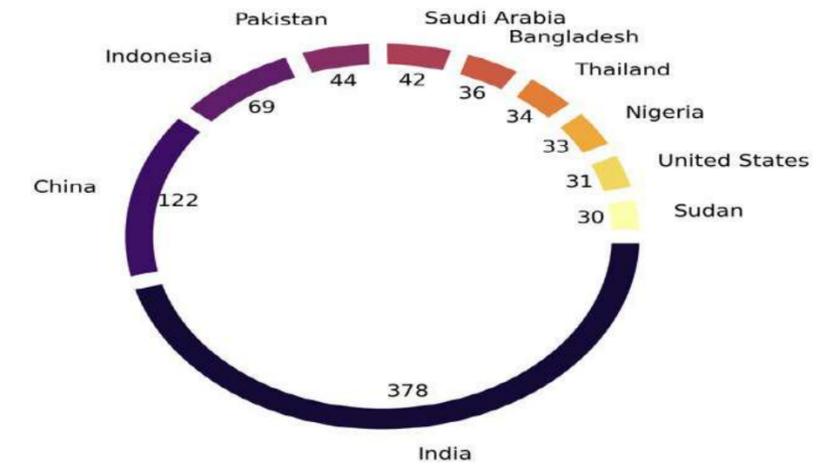
d. ΔT Global: +4°C:
Coolest Hour Per Capita Loss
Global Mean: 18 Hours/Person



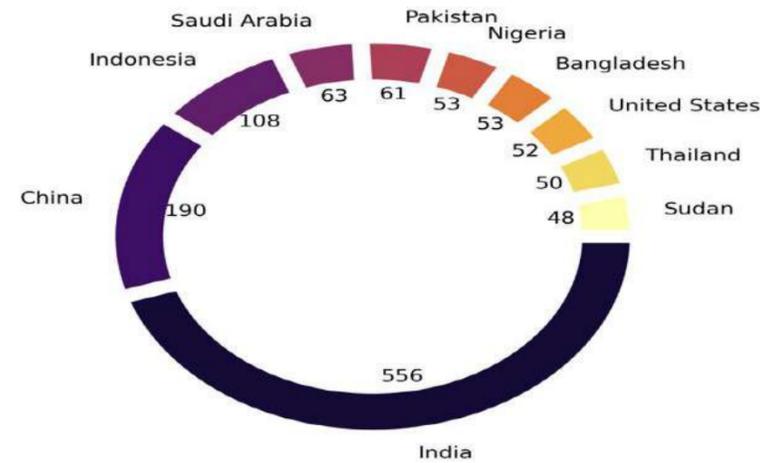
a. Present:
12-Hour Workday Productivity Losses
Global Sum: 670 Billion (2017 PPP\$)



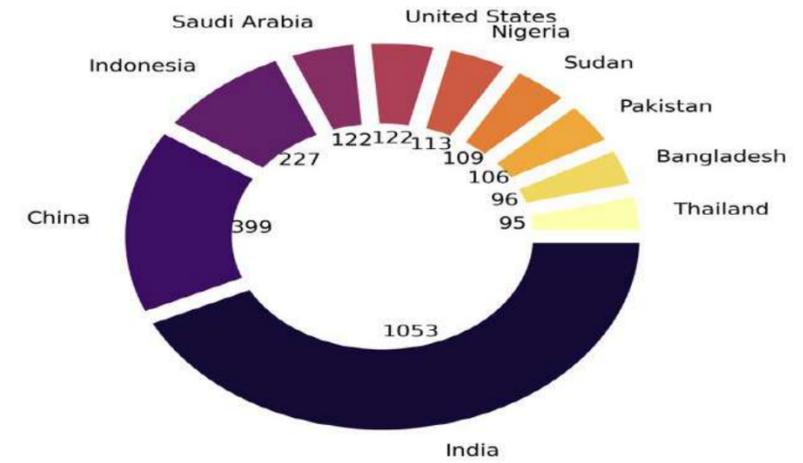
b. ΔT Global: +1°C:
12-Hour Workday Productivity Losses
Global Sum: 1069 Billion (2017 PPP\$)



c. ΔT Global: +2°C:
12-Hour Workday Productivity Losses
Global Sum: 1626 Billion (2017 PPP\$)



d. ΔT Global: +4°C:
12-Hour Workday Productivity Losses
Global Sum: 3286 Billion (2017 PPP\$)



Supplementary Figure 11. The 10 countries with the most losses in heavy labor due to heat exposure at the coolest hour of the day in the present (2001-2020 mean), and with +1°C, +2°C, and +4°C of additional warming. The global mean (average of 163 countries; Table S2) of labor lost is shown above each plot, the numbers around the center of the circle show individual losses per country, and the thickness of the donut plots increase as the global mean of labor lost increases with warming. Units are in hours/person/year.

Supplementary Figure 13. The 10 countries with the most economic productivity (2017 PPP\$) losses in the 12-hour workday in heavy labor due to heat exposure in the present (a, 2001-2020 mean), and with +1°C, +2°C, and +4°C of additional warming (b-d). The global mean of productivity lost (average of 163 countries with available data; Supplementary Table 1) is shown above each plot, the numbers around the center of the circle show individual losses per country, and the thickness of the circle increases as the global mean of productivity lost increases with warming. All units are in hours/person/year.



THE WORLD'S Hardest Working Countries

25hrs

Average Weekly Hours Worked

55hrs

North America

Top 3 in each region

- 1 Jamaica 43.5hrs
- 2 SLV 43.0hrs
- 3 HND 42.8hrs

Europe

- 1 Montenegro 44.2hrs
- 2 ALB 41.4hrs
- 3 BIH 40.8hrs

Asia

- 1 Bhutan 54.5hrs
- 2 ARE 48.4hrs
- 3 JOR 47.8hrs

South America

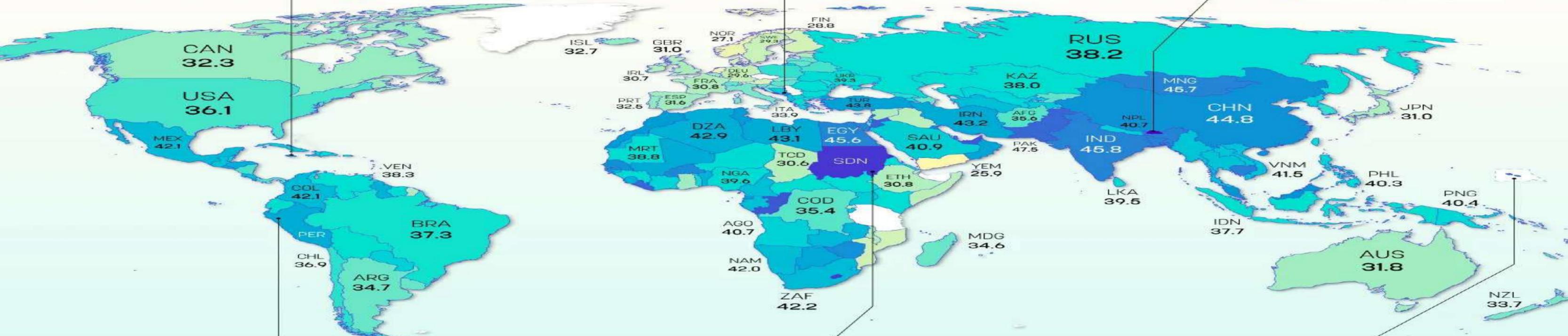
- 1 Peru 43.2hrs
- 2 GUY 42.6hrs
- 3 COL 42.1hrs

Africa

- 1 Sudan 50.8hrs
- 2 LSO 50.2hrs
- 3 COG 48.7hrs

Oceania

- 1 Samoa 44.5hrs
- 2 PNG 40.4hrs
- 3 GUM 36.9hrs



Source: International Labour Organization (ILO) and OECD. Data compiled by World Population Review; ILO figures are 2025 projections (as of Nov 2024), OECD figures from 2023.



Where Data Tells the Story



REGIONAL WORKSHOP ON IMPACT-BASED FORECASTING | 09-13 FEBRUARY 2026

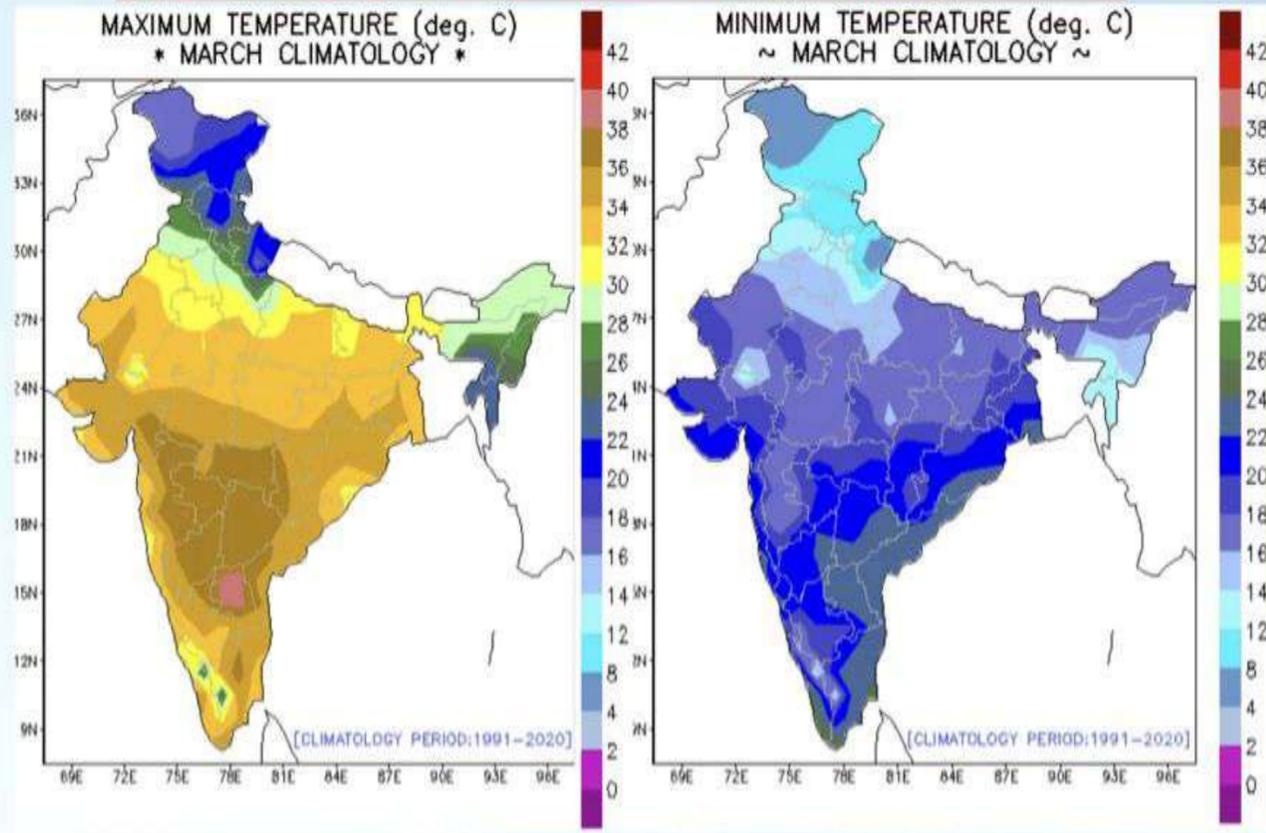


REGIONAL WORKSHOP ON IMPACT-BASED FORECASTING
Training-of-Trainers and National Demonstration Planning for Temperature-Related Hazards

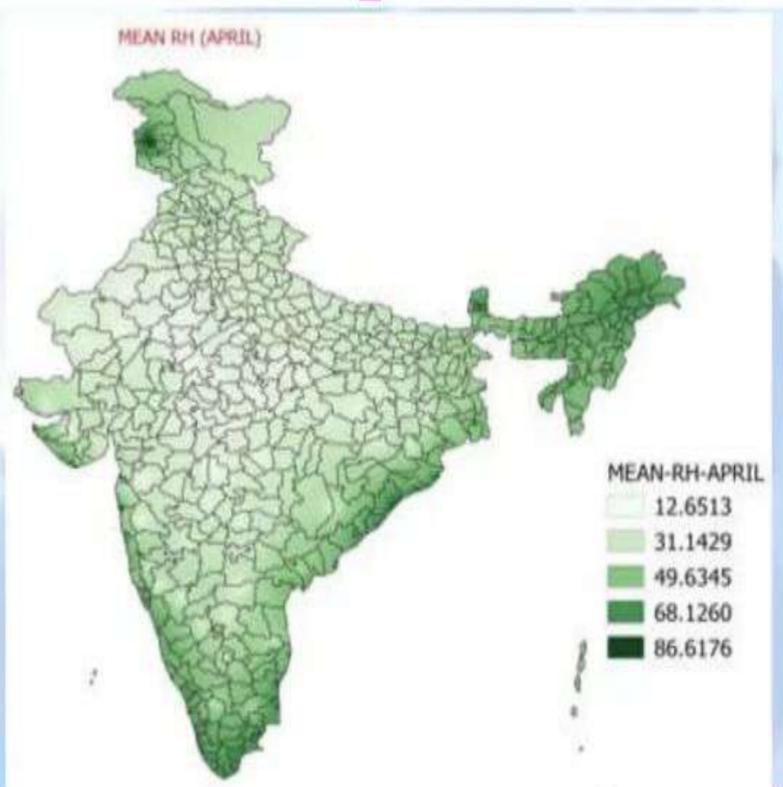
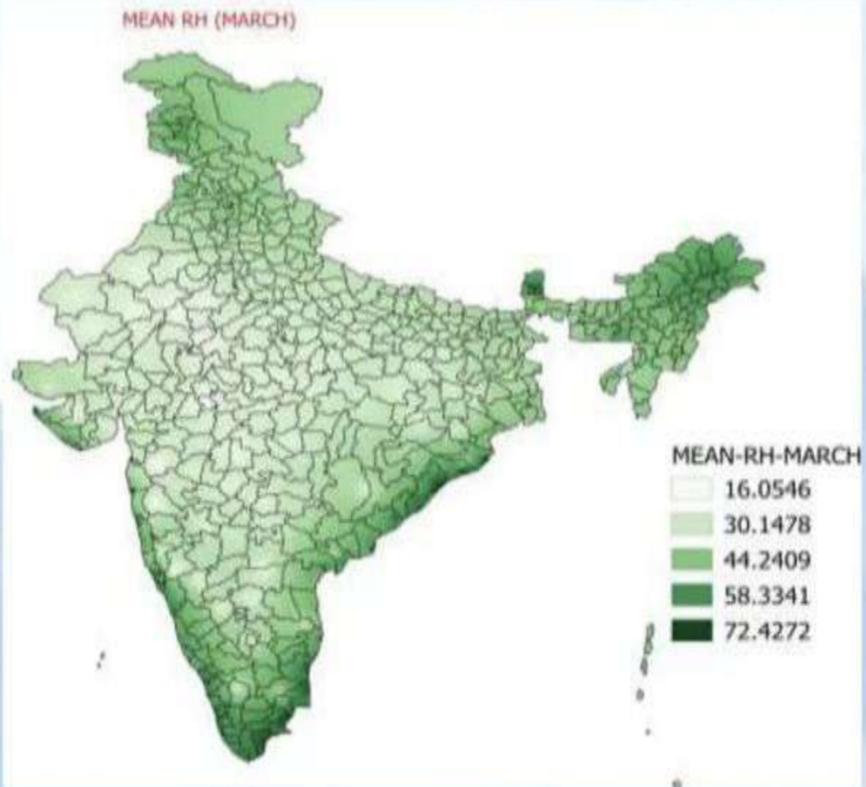
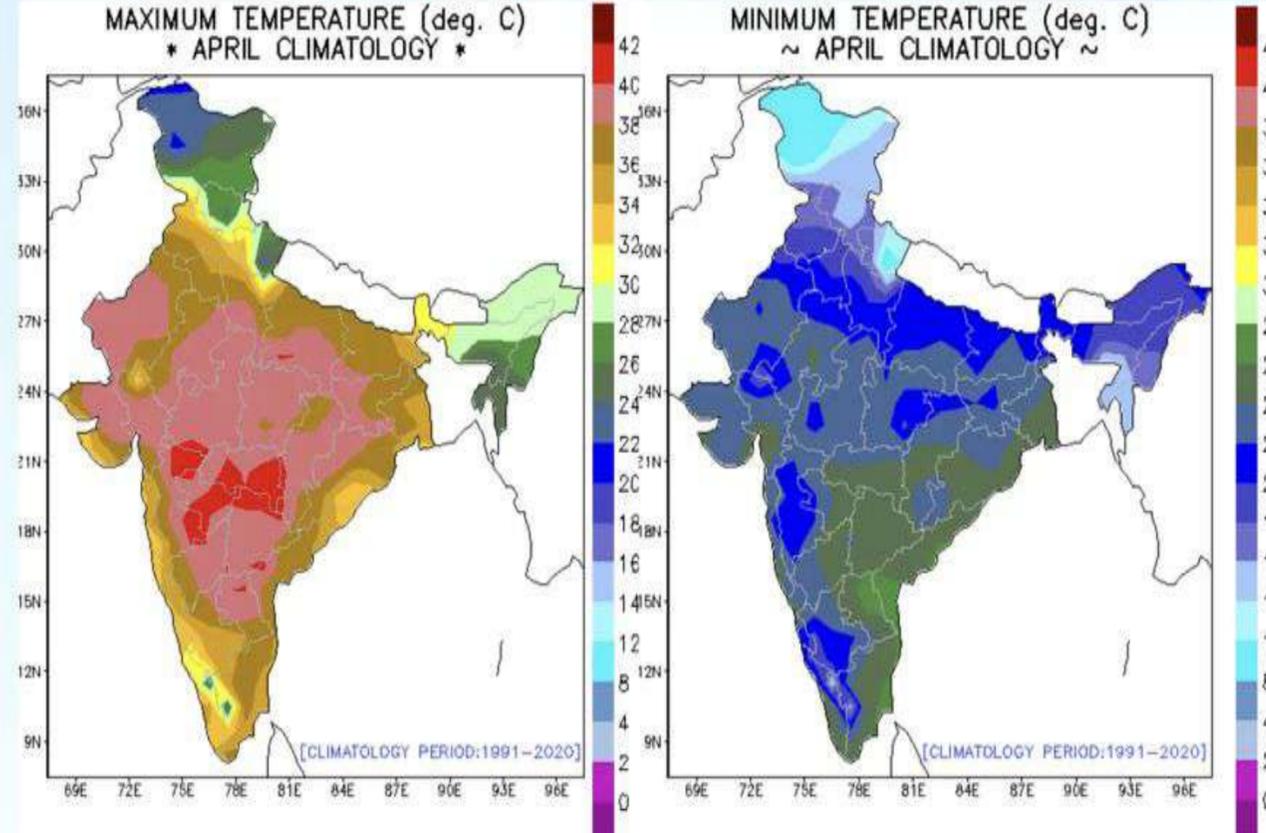
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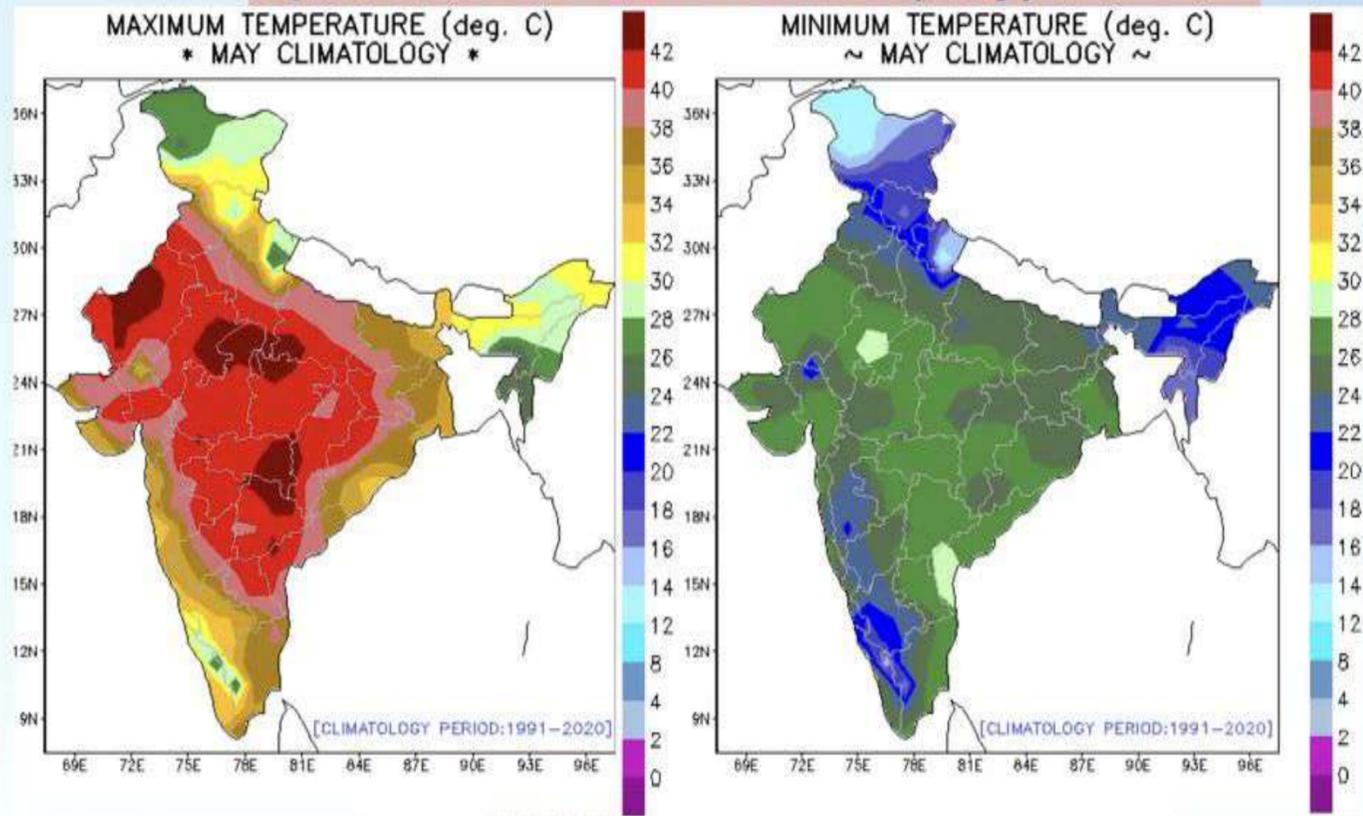
Spatial Patterns of Normal (March)



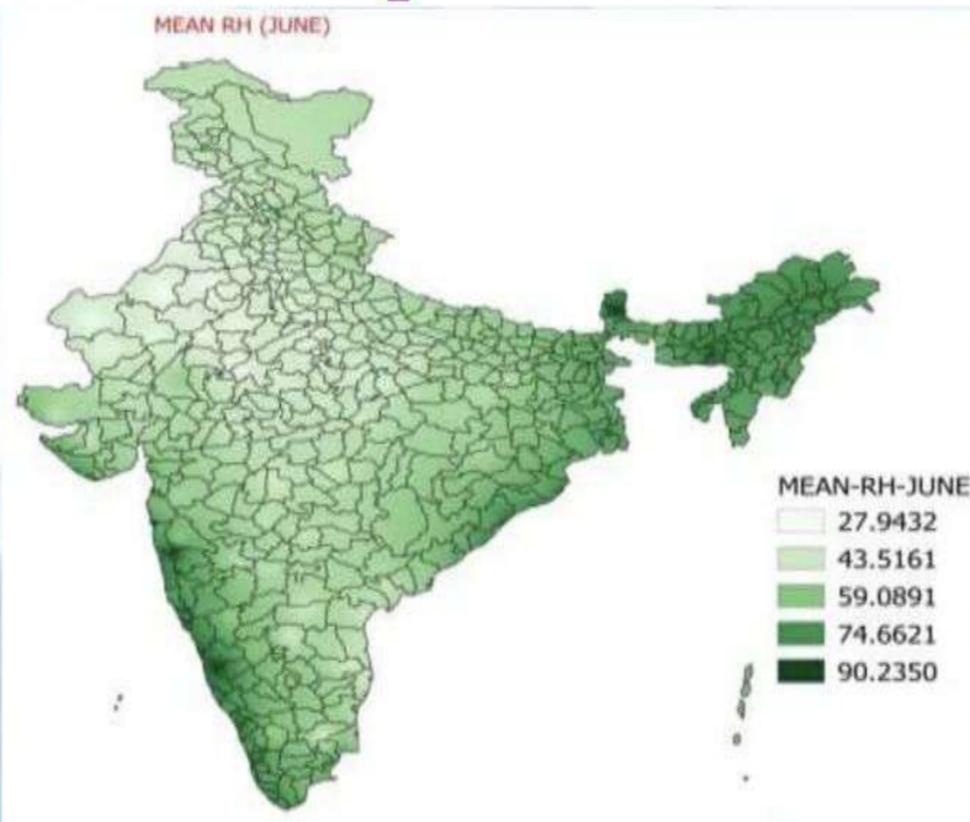
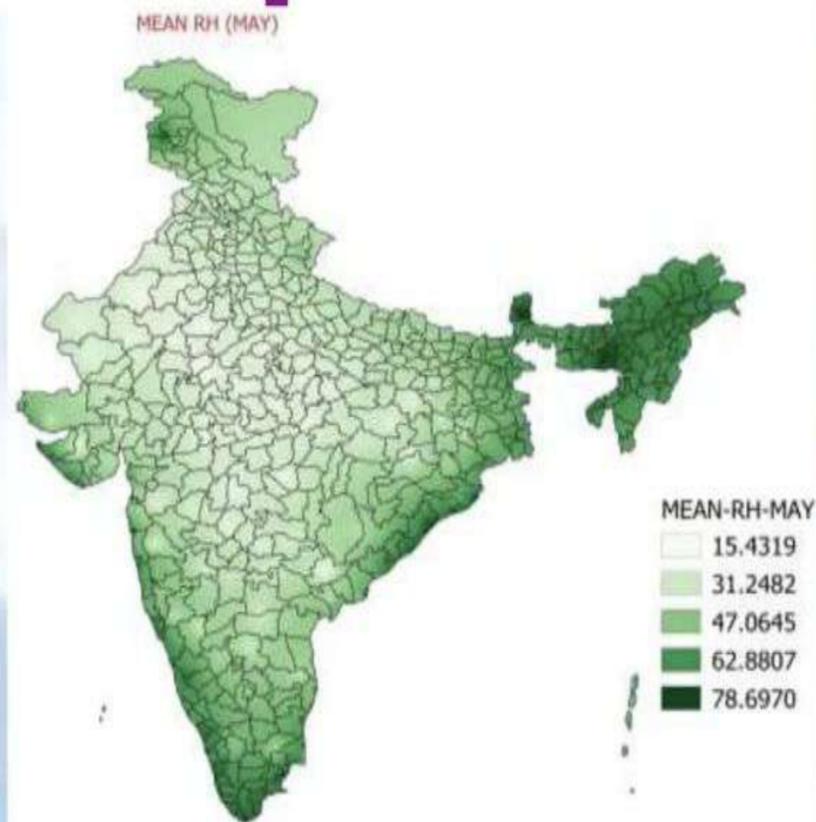
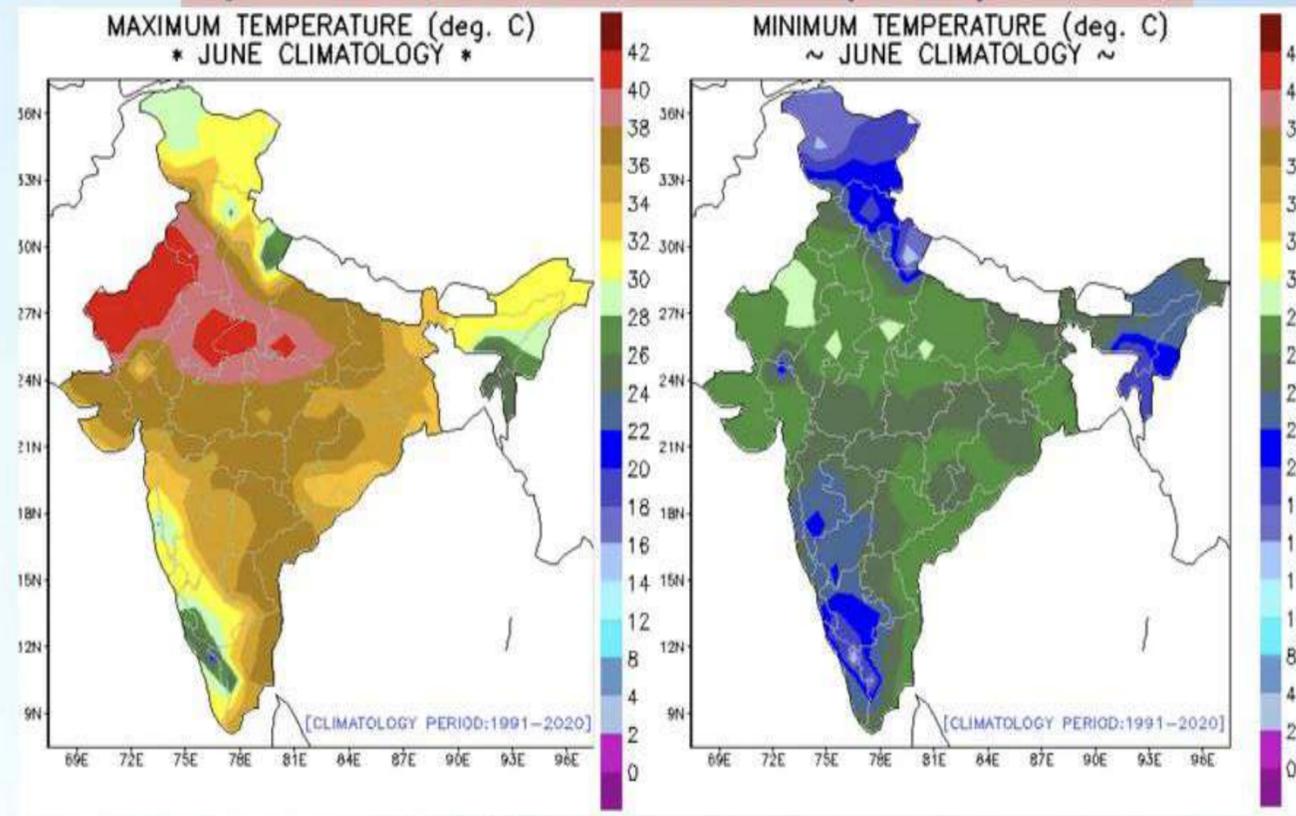
Spatial Patterns of Normal (April)



Spatial Patterns of Normal (May)

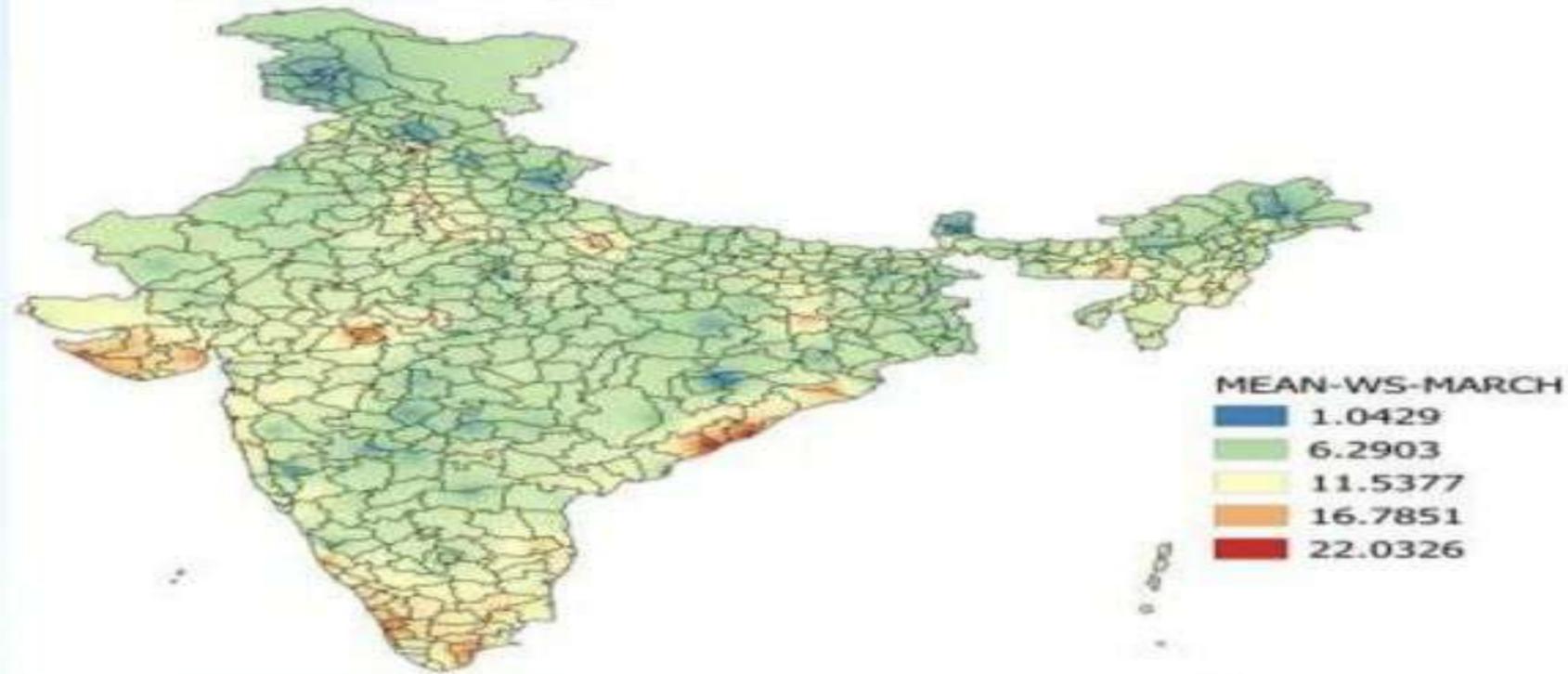


Spatial Patterns of Normal (June)

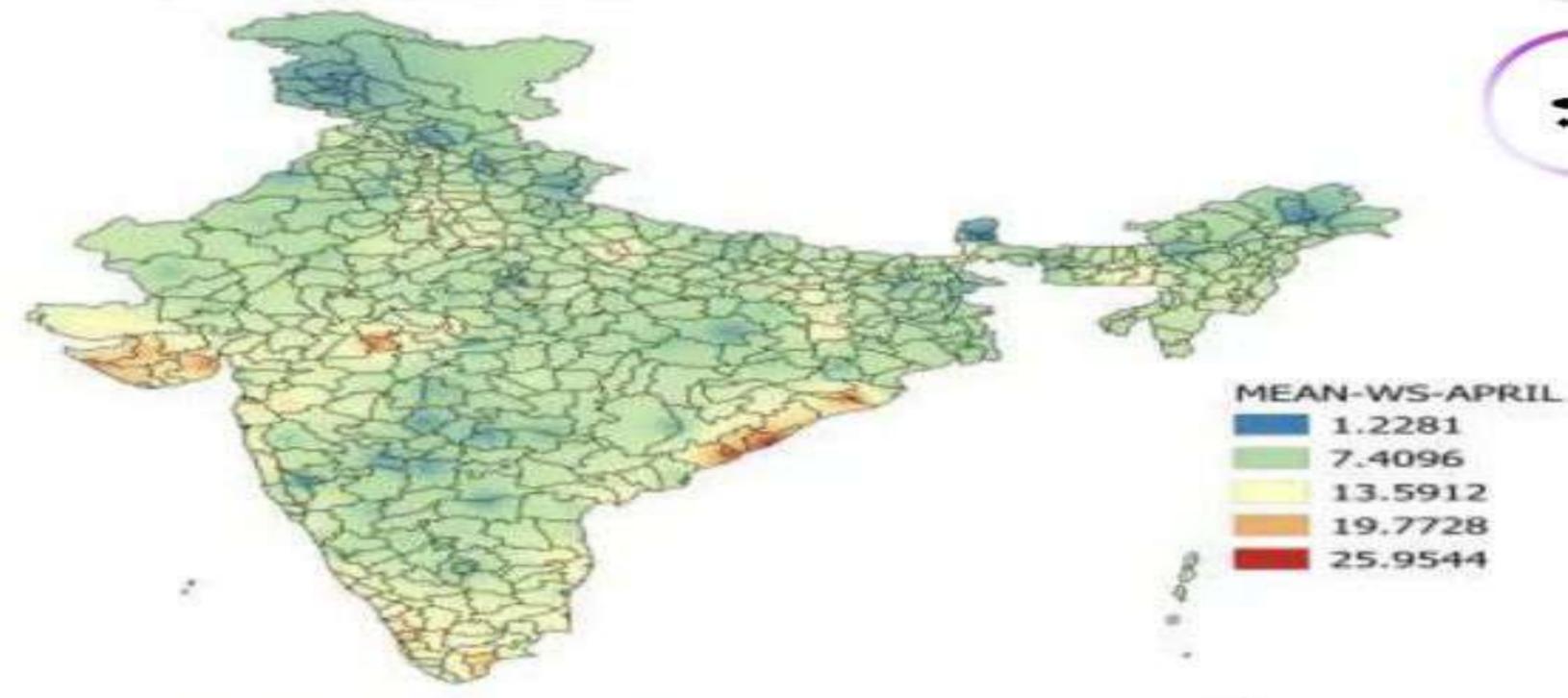


Monthly mean Wind Speed (Knots)

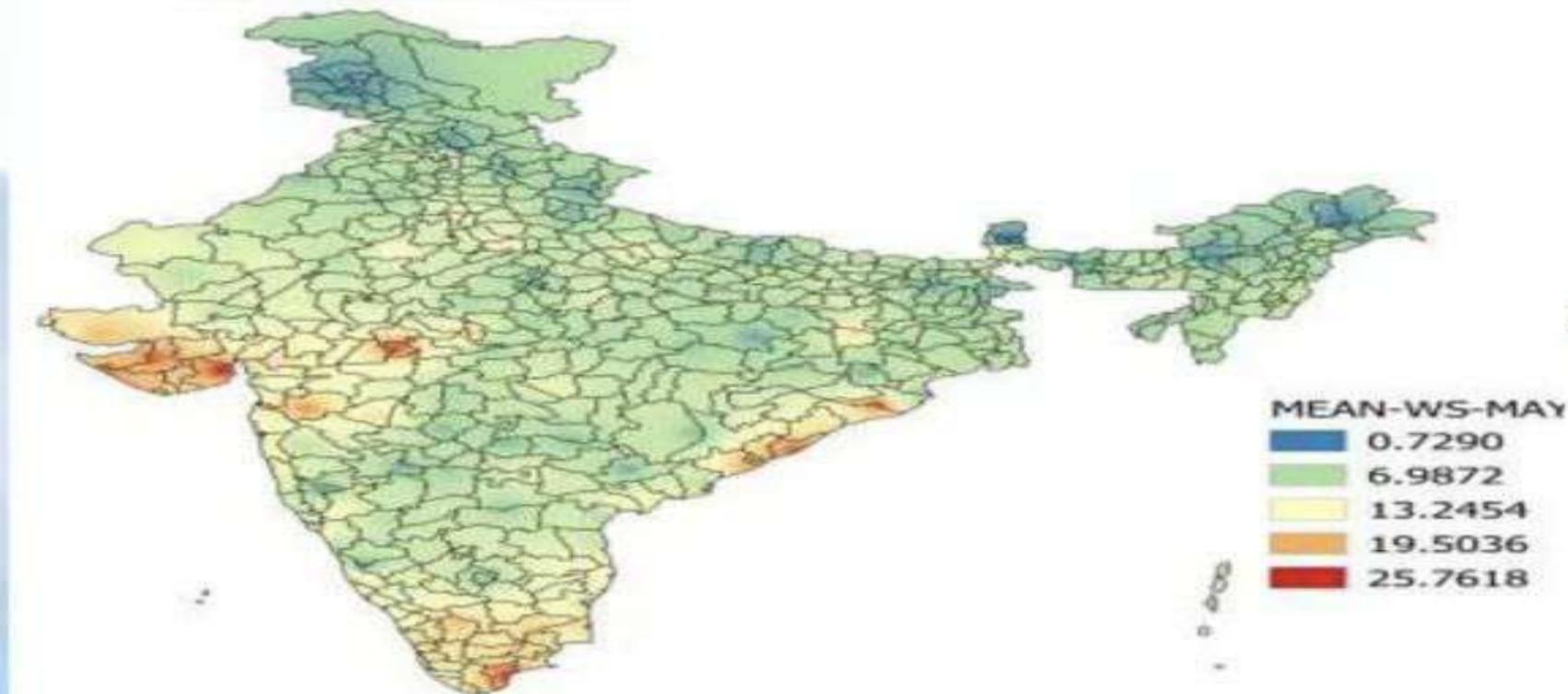
MEAN WIND SPEED (MARCH)



MEAN WIND SPEED (APRIL)



MEAN WIND SPEED (MAY)



MEAN WIND SPEED (JUNE)

