THE COOL SCHOOL MANUAL

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1. Introduction

In recent years, the world has experienced unprecedented levels of heat, setting new temperature records across continents. With the increasing likelihood of global average temperatures to breach the 1.5°C threshold in the next five years (2024–28),[1] extreme weather events especially heatwaves continue to increase in both frequency and intensity.

With temperatures hitting new highs notably early this year, the Indian subcontinent saw a dramatic rise in heat-related events. Extreme temperatures not only covered a larger area but also lasted significantly longer than usual. The data from the Indian Meteorological Department (IMD) indicates that regions spanning Rajasthan, Delhi, Haryana, Chandigarh, West Bengal, and Odisha recorded double the number of heatwave days as compared to previous years by June 2024.[2]

Prolonged heat exposure can cause illnesses ranging from mild symptoms, like prickly heat and heat cramps, to severe conditions like heat stroke. Heat stroke is a critical emergency as it impairs brain function due to uncontrolled increase in body heat and can be fatal without rapid cooling.

According to a United Nations report *Call to Action on Extreme Heat*, around 40,000 suspected cases of heatstroke and over 100 confirmed deaths were reported across India since the onset of summer by mid-June this year.[3] Moreover, a study in Surat has analysed the association between ambient heat and mortality during the summer months between 2001 and 2012. It was revealed that the average number of deaths per day increased by 11 per cent when the daily maximum temperature rose from below 35°C to 40°C or higher.[4] Another study in Nagpur said that there were higher number of deaths during the extreme heatwaves in 2010 and 2014 as compared with those in the surrounding years. It recorded 580 more deaths, a 30 per cent increase, in 2010 as compared to the average number of deaths in 2009 and 2011 in the same period. Similarly, there were 306 additional deaths, a 14 per cent increase, in 2014 as compared to the average number of deaths in 2012 and 2013[5] during the same months. These studies show a strong relationship between temperature and mortality. The correlation is not fully reflected in official records because heat-related deaths are often undercounted, with only the immediate cause of death being recorded.

Extreme heat is here to stay

As cities progress into an era of climate extremes, they are already experiencing a rapid shift in weather patterns and environmental conditions. A study conducted by the Centre for Science and Environment (CSE) in nine cities—Delhi, Jaipur, Pune, Kolkata, Nagpur, Ahmedabad, Chennai, Hyderabad and Bhubaneswar—analysed heat patterns over a period of 10 years (2014–23). It was found that five of these cities, irrespective of their climate or geography, had experienced extreme heat during the summer months.

These extreme temperatures thus engulf most parts of our cities during the summers, consequently affecting a dramatically larger population than in the past. The challenges posed by this heat, including but not limited to morbidity and mortality, are expected to rise in future years as the scenario is predicted to worsen. With an increasing number of people exposed to the persistent heat, the discussion today needs to focus on understanding what extreme temperatures translate to in terms of health and more importantly, how they affect various groups of people. Numerous heat-related incidents across the world have documented that children are the most vulnerable to rising temperatures.

Rising vulnerability of children to extreme heat

According to a 2020 UNICEF report[6] titled *Coldest Year of the Rest of Their Lives*, a total of 559 million children are currently exposed to an average of 4.5 or more heatwaves each year. As per the report, a heatwave is defined as a period of 3 or more days when the maximum temperature for each day falls within the top 10 per cent of the local 15-day average. The report also predicts that these heatwaves would be stronger, more widespread, last longer, and be more frequent in the future. By 2050, every child on Earth, which is about 2 billion children, will face more frequent heat waves even if the world manages to stay within the 1.7°C warming limit above pre-industrial levels.[7]

Children are more vulnerable to the impacts of extreme heat and heatwaves than adults due to several factors. Physiologically, children are less effective at regulating body heat as compared to adults. Children also often spend a significant portion of their day in schools and participate in outdoor activities during peak temperature periods, increasing their exposure to heat.

Marginalized and economically weaker children are at increased risk

While all children are vulnerable to extreme heat, this vulnerability is further amplified for those from marginalized or economically weaker sections. These children often face malnutrition, which reduces their ability to cope with heat stress. This is a more widespread issue for children belonging to the economically weaker sections—many of whom attend schools covered under the PM POSHAN (Mid Day Meal) scheme. These include primary and secondary schools (government, government-aided, and local bodies), Education Guarantee Scheme (EGS)/Alternative Innovative Education (AIE) centres, madrasas and maqtabs supported under the Sarva Shiksha Abhiyan (SSA), and National Child Labour Project (NCLP) schools.[8]

Data from the Joint Review Mission under the PM POSHAN scheme highlights the nutritional deficits among children in these schools.[9] For example, in Uttar Pradesh (2018), 42 per cent of the 753 children assessed—predominantly from these schools—were found to be malnourished,[10] and in Telangana (2022), about 25 per cent of 1,919 children examined for the study had suffered from undernutrition.[11] Malnutrition has been linked to reduced resistance to heat. For instance, potassium, an essential electrolyte, helps maintain fluid and blood volume, while magnesium regulates nerve and muscle function, blood pressure, and body temperature. These nutrients are vital for the body to cope with heat.[12] However, deficiencies in these and other essential nutrients, often caused by inadequate dietary intake and hydration, can significantly exacerbate the challenges of heat exposure.

Children from these marginalized communities face compounded challenges, including limited access to achieve thermal comfort. The government schools they attend often lack adequate infrastructure to mitigate extreme heat, such as proper ventilation, shading, and cooling solutions. According to a 2022 assessment by the Municipal Corporation Delhi's (MCD) education department, a total of 368 sites (31.05 per cent) required major building repairs, and 198 (16.7 per cent) needed minor repairs. Only half (51.05 per cent) of the buildings were deemed to be in good condition.[13] Issues such as damaged roofs, insufficient shading, and limited airflow not only undermine thermal comfort but also jeopardize the safety and well-being of students.

Rising threat of the shift towards air conditioning in schools

Most schools in India rely on natural ventilation during extremely hot periods. However, the pressing need for relief from the sweltering heat has pushed schools to adopt air conditioning as a quick fix to resolve the increasing risk of heat stress among students. This trend may push more schools to retrofit air conditioners into their buildings and may lead to them becoming a standard feature in new schools.

Retrofitting air conditioning in school buildings is challenging as well as capital-intensive. These may involve upgrading the existing infrastructure requiring significant modifications in terms of electrical systems, insulation, ventilation etc. that may disrupt the existing layouts. The initial investment for purchasing and installing air conditioning systems may be substantial. Thus, schools would have to allocate funds not only for the AC units but also for the necessary infrastructure upgrades. Additionally, air conditioning systems incur ongoing maintenance and operational costs. The energy consumption of AC units, especially when used throughout the day, can lead to significantly higher electricity bills, leading to hikes in school fees. This could place a financial burden on many families.

Moreover, air conditioners release waste heat into the environment exacerbating the urban heat island effect in the immediate area. Several studies have concluded that the residual heat from air conditioners have a profound impact on the ambient temperatures. One such study conducted in the city of Phoenix, USA observed that the waste heat released from AC systems increased the mean air temperature by more than 1°C at night.[14] Another study covering various districts in Paris found that the local temperature variations resulting from urban heat island effect are proportional to the waste heat rejected locally by ACs.[15] Thus, although air conditioners may help to tackle the extreme heat in schools, it also increases the ambient temperatures.

According to the National Building Code (NBC), Volume 2, 2016, people living year-round in air-conditioned spaces are likely to develop an expectation for consistent and cool temperatures. They may become particularly sensitive to any deviations from the narrow comfort zone to which they have grown accustomed. In contrast, those who live or work in naturally-ventilated buildings, where they can control their immediate environment, tend to acclimatize to the variable indoor temperatures that mirror local daily and seasonal climate changes. As a result, their thermal perceptions, preferences, and tolerances are likely to span a wider range of temperatures.

Therefore, continuous exposure to ACs in classrooms may reduce children's tolerance as well as their ability to adapt to the rising temperatures. Additionally, stepping outdoors during peak heat periods after prolonged periods in air-conditioned classrooms may expose children to a sudden change in temperature. This abrupt shift may lead to a thermal shock as their bodies are forced to adjust to the significant temperature difference in such a short duration. Thermal shock may trigger various health issues in children such as runny nose, asthma attacks, muscular pains, sinusitis, flu, cold, sore throat, severe pains and muscle aches.

Thus, while air conditioning may offer short-term relief, it fails to address the broader issue of safeguarding children from extreme heat while maintaining their health and ensuring accessibility for all.

Why this report?

The CSE's current research addresses the need to improve the school ecosystem to build resilience against heat, ensuring that children can adapt to the increasing challenges posed by harsh weather conditions. Through this report, CSE has suggested steps that can be adopted by the management to improve the thermal environment in schools. The report also lists responsible, climate-appropriate passive solutions revolving around students' routines and school infrastructure, to achieve adequate thermal comfort with minimal energy consumption and environmental impact.

2. Children are more vulnerable to extreme heat

The human perception of thermal conditions involves both the external heat interactions with the body and it's physiological response to these conditions.[16]The energy exchanges between the body and its surrounding environment are influenced by local meteorological factors such as air temperature, water vapour pressure, near-surface wind speed, and incoming short- and long-wave radiation from all directions as well as personal factors like the insulation provided by clothing and metabolic rate.[17] The body can regulate the resulting temperatures from these energy exchanges to keep it within a comfortable range. However, if it fails to adapt to hot or cold environmental conditions, it can lead to thermal discomfort.

Since thermal comfort is a perceived sensation, the body's satisfaction with environmental conditions is subjective. It is influenced by factors like metabolism, clothing, age, gender, and physical variables.[18] Age plays a significant role in thermal comfort perception, with children often experiencing and responding to heat differently than adults, making them vulnerable to the impacts of extreme heat and heatwave events (see *Figure 1: Factors responsible for increased heat vulnerability of children*). They respond differently to hot conditions due to various physiological and behavioural factors:

i. **Surface area–to–body mass ratio:** Children possess a greater surface area relative to their body mass as compared to adults, causing them to lose heat faster in cold environments and gain heat more quickly in hot environments.[19] During extreme heat periods, children absorb more heat per unit of body mass than adults.

ii. **Metabolic rate:** Children typically have a higher metabolic rate as compared to adults,[20] leading to increased body heat production per body mass making them more prone to overheating in hot conditions.

iii. **Thermoregulation:** The thermoregulatory system of children is inferior during peak heat conditions as compared to adults, owing to under-developed sweat gland capacity and lower sweat rate.[21] This inhibits them from cooling down as efficiently as adults since sweating is the human body's key response to cool itself during extreme heat.

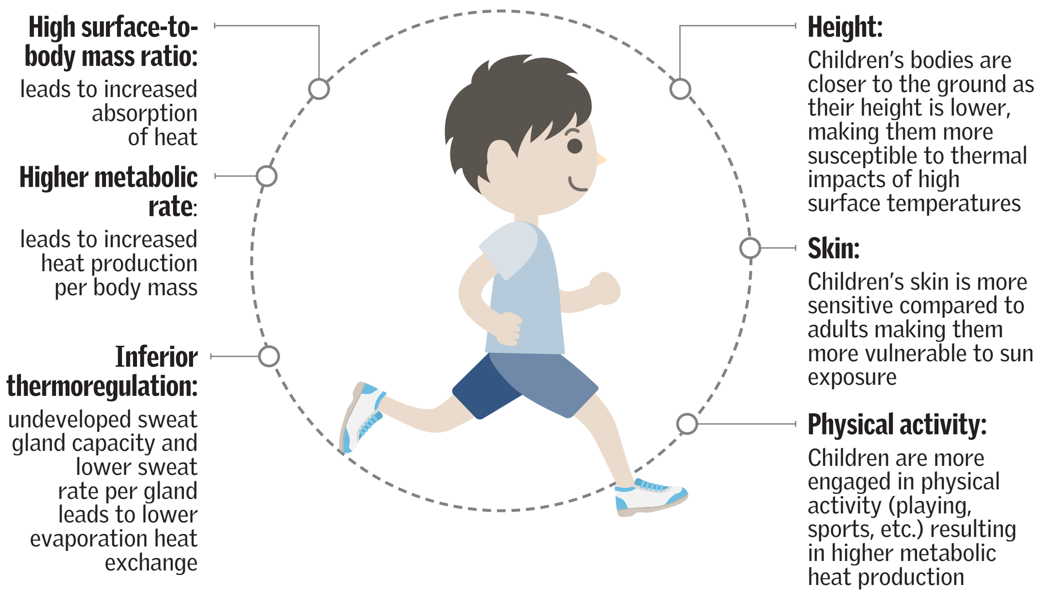
iv. **Height:** Unprotected surfaces exposed to solar radiation can become extremely hot during summer, absorbing and releasing significant amounts of heat.[22]

Children's bodies are closer to the ground as their height is lower, making them more susceptible to thermal impacts of heat radiating from high surface temperatures.

v. **Skin:** Children's skin is more sensitive as compared to adults, making them more vulnerable to sun exposure[23] and related-problems like sun burn.

vi. **Physical activity:** Engagement in physical activity outdoors (playing, sports, etc.) for children is considerably higher than adults. Exerting outdoors during warm periods may result in a higher metabolic heat production leading to heat stress.[24]

Figure 1: Factors responsible for increased heat vulnerability of children

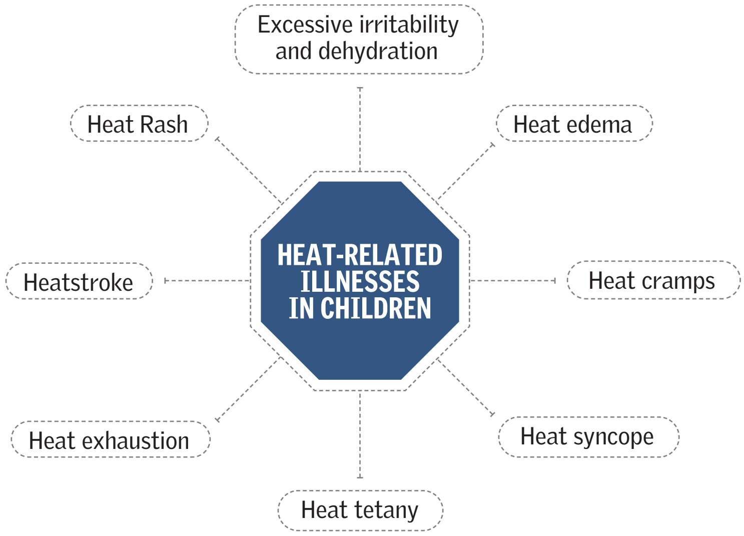


Source: CSE (Compiled from sources)

Thus, children are not only more exposed to extreme temperatures but also less effective in adapting to heat as compared to adults. Spending extended periods of time in high heat conditions makes children more vulnerable to heat-related illnesses as well as slower cognitive function and impaired concentration, causing learning loss.[25] According to the 'National Action Plan on Heat Related Illnesses' report prepared under the National Programme on Climate Change and Human Health (NPCCHH), heat-related illnesses (HRI) in children cover a range of conditions[26] (see *Figure 2: Heat-related illnesses in children as per the National Action Plan on Heat Related Illnesses prepared under NPCCHH*).

- Heat rash or prickly heat
- Excessive irritability and dehydration

Figure 2: Heat-related illnesses in children as per the National Action Plan on Heat Related Illnesses prepared under NPCCHH



Source: https://ncdc.mohfw.gov.in/wp-content/uploads/2024/05/1.Nation-Action-plan-on-Heat-Related-Ilnesses.pdf

- Heat edema: swelling of feet, ankles or hands
- Heat cramps
- Heat syncope: fainting or light headedness caused by prolonged standing in hot environments
- Heat tetany: hyperventilation, respiratory problems and numbness related to short periods in intense heat environments
- Heat exhaustion: rise in body temperature due to prolonged heat exposure leading to dehydration, vomiting, fatigue, headache and mild confusion
- Heatstroke: core body temperature rising to 40°F and may lead to drowsiness, confusion, delirium, hallucination, seizures, coma or multi-organ dysfunction

In 2020, a survey of 335 primary school teachers from 35 elementary schools in seven Indian cities within the hot climate region was conducted.[27] The schools, all naturally ventilated, were selected from the most heat wave-prone states. The teachers reported various symptoms of heat stress in students, with 70 per cent of students complaining of tiredness and 62 per cent reporting heavy sweating during the summers. Additionally, a total of 43 per cent of students complained daily about discomfort due to hot temperatures, and 52 per cent complained often (more than once a week). More than 40 per cent of schools reported over 10 incidents of students fainting or falling ill due to heat exhaustion in the previous year.

The Central Board of Secondary Education (CBSE), in collaboration with the World Health Organization (WHO), has also undertaken similar efforts to assess student health through the Global School-based Student Health Survey (GSHS 2022).[28] The survey examined various aspects of student health and behaviour by assessing dietary behaviours, hygiene, mental health, physical activity, etc. However, it did not address heat-related illnesses in students, highlighting a critical gap in the current understanding of student health, especially as the number of heat-related illnesses among children continues to rise. It is crucial to include this aspect in future health surveys to address heat preparedness and implement appropriate guidelines in schools.

Apart from health-related issues, several studies have also uncovered a relationship between the thermal environment and student performance at school. A study conducted by the World Bank's Development Research Group revealed a correlation between rising temperatures and declining academic performance in Ethiopia. The study analysed data from over 2.47 million students across the country who took the Ethiopian Higher Education Entrance Certificate Examination between 2003 and 2019. By examining test scores alongside school-level temperature data, the study assessed how variations in the number of hot days (above 33°C) in a year affected students' performance in academics. The findings showed that each additional 10 hot days in a school year has led to a 2.28 per cent decline in performance on college entrance exams. Moreover, it was found that students exposed to higher temperatures during their school year performed worse as compared to those who experienced relatively cooler conditions.[29]

3. Hottest days are not vacation days anymore

The first line of defence in protecting children from extreme climatic conditions is to schedule school vacations during harsh weather months. However, the effectiveness of these systems in protecting children from today's sweltering heat and their resilience against future challenges posed by a changing climate needs to be assessed. To determine whether the current safety measures set to avoid extreme heat continue to safeguard the children, the CSE analysed the heat index in Delhi for the vacation months (May–June) and the working months (July–September) from 2014–23.

The Heat Index (HI) is a measure that combines air temperature and relative humidity to estimate the human-perceived equivalent temperature. It represents how hot the human body feels at a certain temperature for different values of humidity in shaded areas.[30] For instance, an air temperature of 32°C at a relative humidity of 70 per cent would be perceived as 41°C whereas the same temperature would feel like 43°C at 75 per cent relative humidity (see *Figure 3: Heat index*).

Figure 3: Heat index

Relative Humidity / Temperature	80 °F (26.67 °C)	82 °F (27.78 °C)	84 °F (28.89 °C)	86 °F (30.00 °C)	88 °F (31.11 °C)	90 °F (32.22 °C)	92 °F (33.33 °C)	94 °F (34.44 °C)	96 °F (35.56 °C)	98 °F (36.67 °C)	100 °F (37.78 °C)	102 °F (38.39 °C)	104 °F (40.00 °C)	106 °F (41.11 °C)	108 °F (42.22 °C)	110 °F (43.33 °C)
40%	80 °F (26.67 °C)	81 °F (27.22 °C)	83 °F (28.33 °C)	85 °F (29.44 °C)	88 °F (31.11 °C)	91 °F (32.78 °C)	94 °F (34.44 °C)	97 °F (36.11 °C)	101 °F (38.33 °C)	105 °F (40.56 °C)	109 °F (42.78 °C)	114 °F (45.56 °C)	119 °F (48.33 °C)	124 °F (51.11 °C)	130 °F (54.44 °C)	136 °F (57.78 °C)
45%	80 °F (26.67 °C)	82 °F (27.78 °C)	84 °F (28.89 °C)	87 °F (30.56 °C)	89 °F (31.67 °C)	93 °F (33.89 °C)	96 °F (35.56 °C)	100 °F (37.78 °C)	104 °F (40.00 °C)	109 °F (42.78 °C)	114 °F (45.56 °C)	119 °F (48.33 °C)	124 °F (51.11 °C)	130 °F (54.44 °C)	137 °F (58.33 °C)	
50%	81 °F (27.22 °C)	83 °F (28.33 °C)	85 °F (29.44 °C)	88 °F (31.11 °C)	91 °F (32.78 °C)	95 °F (35.00 °C)	99 °F (37.22 °C)	103 °F (39.44 °C)	108 °F (42.22 °C)	113 °F (45.00 °C)	118 °F (47.78 °C)	124 °F (51.11 °C)	131 °F (55.00 °C)	137 °F (58.33 °C)		
55%	81 °F (27.22 °C)	84 °F (28.89 °C)	86 °F (30.00 °C)	89 °F (31.67 °C)	93 °F (33.89 °C)	97 °F (36.11 °C)	101 °F (38.33 °C)	106 °F (41.11 °C)	112 °F (44.44 °C)	117 °F (47.22 °C)	124 °F (51.11 °C)	130 °F (54.44 °C)	137 °F (58.33 °C)			
60%	82 °F (27.78 °C)	84 °F (28.89 °C)	88 °F (31.11 °C)	91 °F (32.78 °C)	95 °F (35.00 °C)	100 °F (37.78 °C)	105 °F (40.56 °C)	110 °F (43.33 °C)	116 °F (46.67 °C)	123 °F (50.56 °C)	129 °F (53.89 °C)	137 °F (58.33 °C)				
65%	82 °F (27.78 °C)	85 °F (29.44 °C)	89 °F (31.67 °C)	93 °F (33.89 °C)	98 °F (36.67 °C)	103 °F (39.44 °C)	108 °F (42.22 °C)	114 °F (45.56 °C)	121 °F (49.44 °C)	128 °F (53.33 °C)	136 °F (57.78 °C)					
70%	83 °F (28.33 °C)	88 °F (30.00 °C)	90 °F (32.22 °C)	95 °F (35.00 °C)	100 °F (37.78 °C)	105 °F (40.56 °C)	112 °F (44.44 °C)	119 °F (48.33 °C)	126 °F (52.22 °C)	134 °F (56.67 °C)						
75%	84 °F (28.89 °C)	88 °F (31.11 °C)	92 °F (33.33 °C)	97 °F (36.11 °C)	103 °F (39.44 °C)	109 °F (42.78 °C)	116 °F (46.67 °C)	124 °F (51.11 °C)	132 °F (55.56 °C)							
80%	84 °F (28.89 °C)	89 °F (31.67 °C)	94 °F (34.44 °C)	100 °F (37.78 °C)	106 °F (41.11 °C)	113 °F (45.00 °C)	121 °F (49.44 °C)	129 °F (53.89 °C)								
85%	85 °F (29.44 °C)	90 °F (32.22 °C)	96 °F (35.56 °C)	102 °F (38.89 °C)	110 °F (43.33 °C)	117 °F (47.22 °C)	126 °F (52.22 °C)	135 °F (57.22 °C)								
90%	86 °F (30.00 °C)	91 °F (32.78 °C)	98 °F (36.67 °C)	105 °F (40.56 °C)	113 °F (45.00 °C)	122 °F (50.00 °C)	131 °F (55.00 °C)									
95%	86 °F (30.00 °C)	93 °F (33.89 °C)	100 °F (37.78 °C)	108 °F (42.22 °C)	117 °F (47.22 °C)	127 °F (52.78 °C)										
100%	87 °F (30.56 °C)	95 °F (35.00 °C)	103 °F (39.44 °C)	112 °F (44.44 °C)	121 °F (49.44 °C)	132 °F (55.56 °C)										

Key to colours

- Caution
- Exreme Caution
- Danger
- Extreme Daner

Source: Source: https://www.weather.gov/tbw/heat

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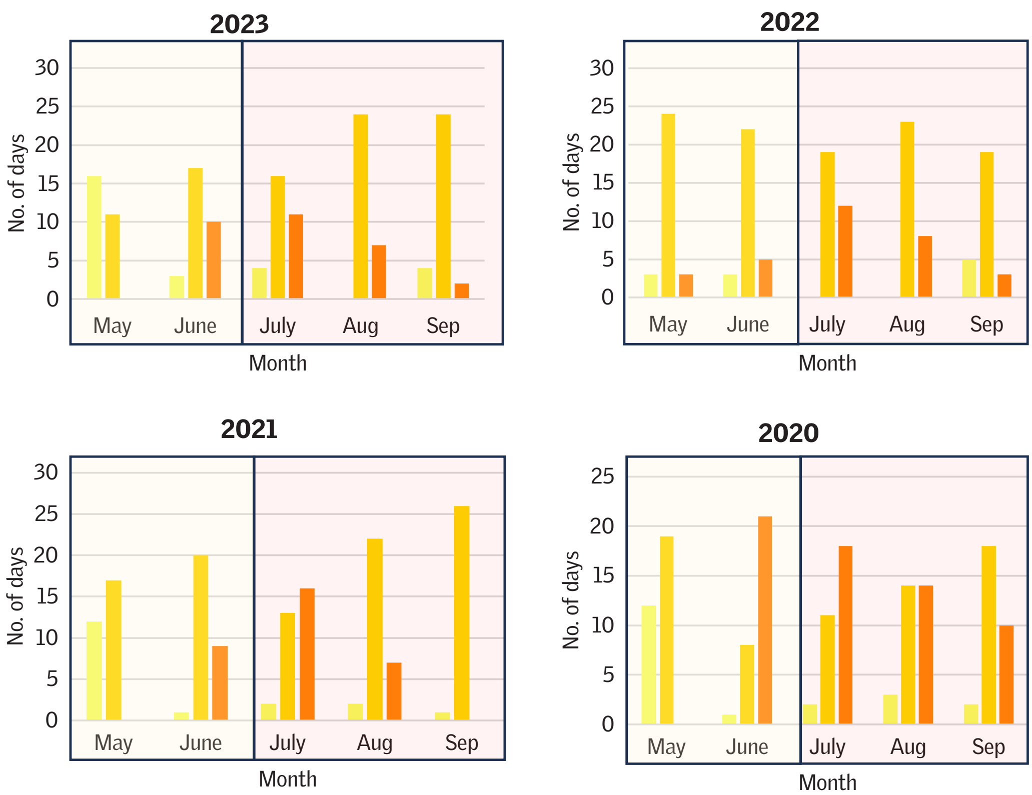
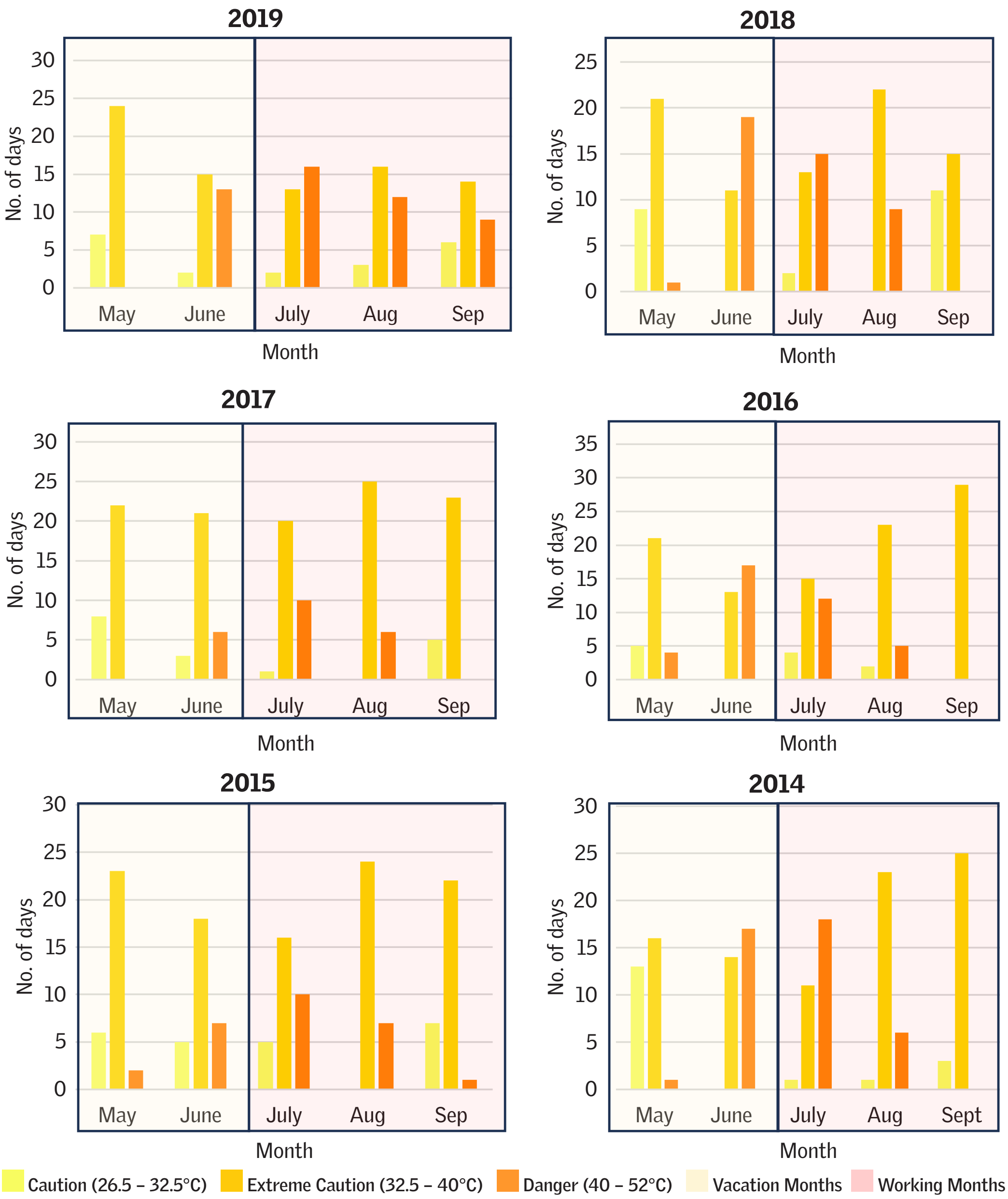
Humidity influences how temperatures are perceived by humans because higher humidity levels in the atmosphere slow down the evaporation of sweat from the skin. This, in turn, hampers the body's ability to regulate its temperature through evaporative cooling. Some State Heat Action Plans, such as the one in Andhra Pradesh, use this index to assess the severity of heat, issue warnings, and implement guidelines accordingly.

The National Oceanic and Atmospheric Administration (NOAA) defines Heat Index ranges and their corresponding classes of caution to humans as Caution (26.5–32.5°C), Extreme Caution (32.5–40°C) and Danger (40–52°C). Prolonged exposure to these ranges may result in adverse impacts on human health that increases in severity as we go up each category. The NOAA found that in last 10 years, nearly every year had at least 10 days per month classified under the 'Extreme Caution' spilled into the months of July-September, with about 15-25 days of the same in 2023 (see *Graph 1: Number of days by Heat Index severity during vacation and working months (2014–23))*.

Graph 1: Number of days by Heat Index severity during vacation and working months (2014-23)





Heat Index	Category	Health effects
26.5-32.5°C	Caution	Fatigue is possible with prolonged exposure and activity. Continuing activity could result in heat cramps
32.5-40°C	Extreme Caution	Heat cramps and heat exhaustion are possible. Continuing activity could result in heat stroke
40-52°C	Danger	Heat cramps and heat exhaustion are likely, heat stroke is probable with continued activity
above 52°C	Extreme danger	Heat stroke is imminent

Source: https://www.weather.gov/tbw/heat

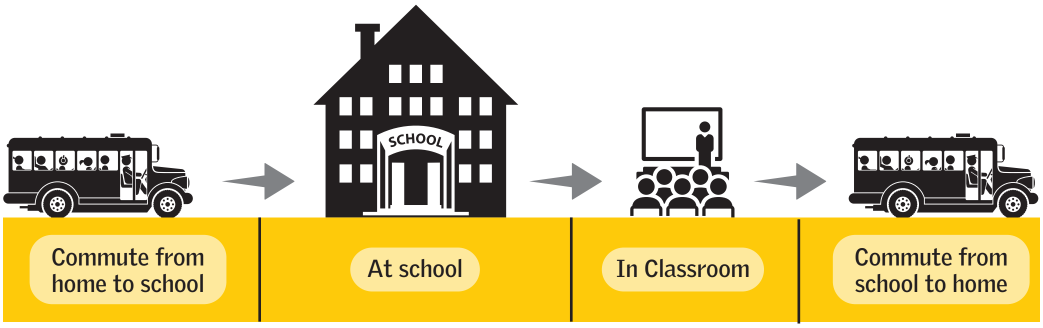
The data showed that there were about 42–70 days classified under ‘Extreme Caution’ and up to 20 days classified under the ‘Danger’ categories during the working months (July–September) over a ten-year period, with an average of 58 ‘Extreme Caution’ days per year within these months.

This shift in extreme heat patterns from vacation to working months indicates that children are still exposed to extreme heat while at school, despite the summer vacations intended to protect them from harsh temperatures. As a result, students face the risk of heat stress due to uncomfortable thermal conditions throughout the school day. This underscores the urgent need to understand students’ routines at school and identify where they might experience discomfort, devise interventions to help them adapt to the rising hot environment and its potential impacts on their health and education.

4. Stages of discomfort at school

Addressing this need, CSE conducted an analysis isolating the various stages within the routine of a student and the discomfort associated with them at school. The four stages underlined are: Commute from home to school, at school, in classroom and commute from school to home (see *Figure 4: Stages of discomfort*).

Figure 4: Stages of discomfort



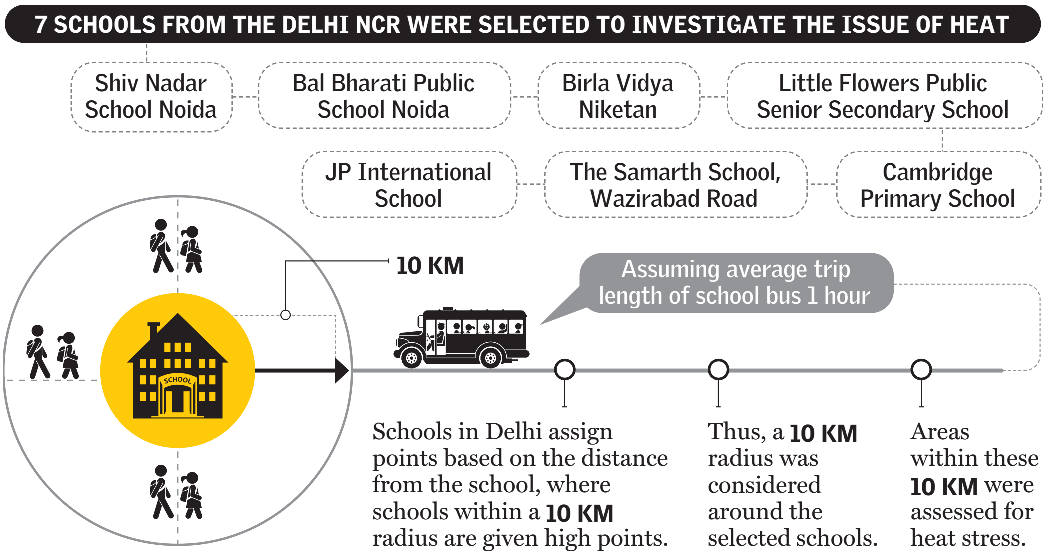
Source: CSE

Thermal discomfort during commute from home to school

The study selected seven schools from the Delhi NCR, to identify the presence and extent of thermal discomfort experienced by students on their commute to school. The issue of heat was investigated around them as those are areas that children pass through to get to school. Delhi school authorities assign points as per the proximity criterion with the highest weightage given to those neighbourhood that are within a 10 km radius from the school.[31] Thus, an area falling under 10 km radius of each selected school was assessed for heat stress (see *Figure 5: CSE study assessing areas around schools to investigate the issue of heat*).

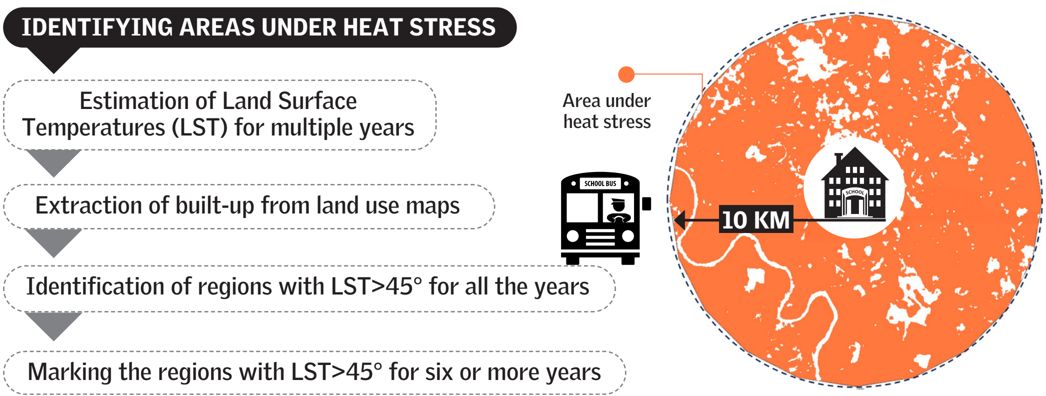
Identifying heat-stressed areas: The heat-stressed areas were identified on the basis of Land Surface Temperatures (LST) which were retrieved using satellite data for the selected study area (Delhi). The LSTs were analysed over a ten-year period, and areas with LSTs recurrently exceeding 45°C for more than six years were classified as being under heat stress (see *Figure 6: Identification of areas under heat stress*).

Figure 5: CSE study assessing areas around schools to investigate the issue of heat



Source: CSE

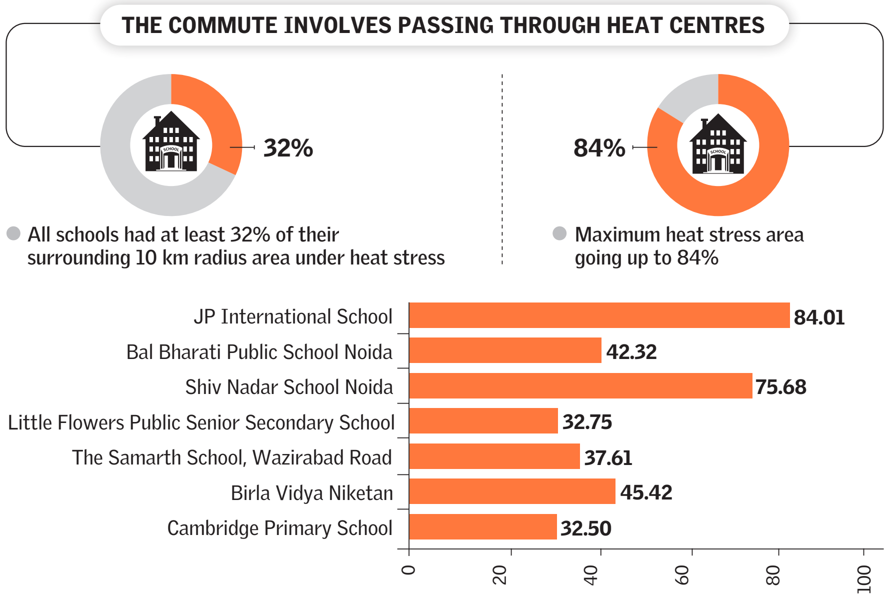
Figure 6: Identification of areas under heat stress



Source: CSE

The results indicated that all schools had at least 32 per cent of their surrounding 10-kilometer radius area classified as being under heat stress (see *Figure 7: Percentage area under heat stress for each of the selected schools*). The maximum heat-stressed area was as high as 84 per cent. Students boarding the bus from the farthest point of the analysed area (around 10 km away) are at the highest risk of prolonged exposure to heat stress while commuting to school. This exposure is more intense during the journey back home after school hours as the sun's intensity is typically stronger during noon.

Figure 7: Percentage area under heat stress for each of the selected schools



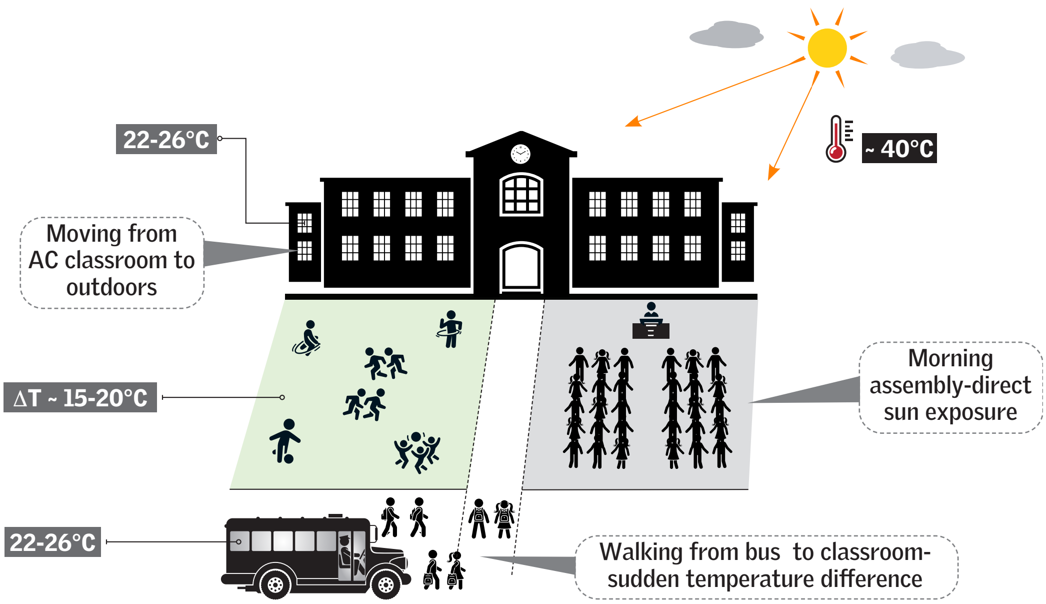
Source: CSE

Thermal discomfort at school

The next stage of discomfort for students occurs when they arrive at school after their commute. The transition to classrooms or morning assemblies may result in a sudden temperature change. This exposure to sudden and drastic change in temperature is called a thermal shock. It is even more pronounced for students who travel in air-conditioned buses where the temperature is typically maintained at 22–26°C.[32] Stepping out into the summer heat can result in a rapid temperature difference of 15–20°C, causing the body temperature to rise within 10–15 minutes. The body's cooling mechanism, which maintains its temperature within a range of 36.3–37.3°C through sweating and increasing blood flow to the skin, becomes overwhelmed by such a significant temperature difference in a short duration. Thermal shock caused by rapid temperature fluctuations can manifest as various health issues in children such as sneezing, dry eyes and skin, respiratory, infections and muscle spasms.[33]

Morning assemblies, a regular part of the school routine, often require students to be exposed to extreme heat for extended periods. The assemblies typically last for at least 30 minutes on open grounds where children are exposed to direct sunlight, leading to excessive sweating, heat exhaustion, and even fainting in some cases. Additionally, students may spend a considerable amount of time moving between classrooms during the day, further exposing them to extreme heat (see *Figure 8: Thermal discomfort at school*).

Figure 8: Thermal discomfort at school



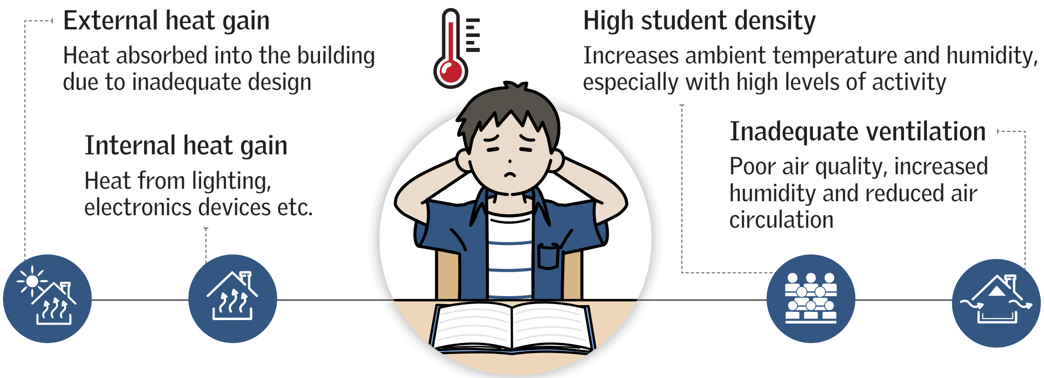
Source: CSE

Thermal discomfort in classrooms

Children spend majority of their school time in classrooms. High student density in classrooms can increase the ambient temperature and humidity, especially when physical activity levels are high, contributing to discomfort.[34] Additionally, other sources of internal heat gain, such as lighting, electronic devices, and lack of ventilation, can exacerbate the issue.[35] The National Education Policy 2020 (NEP) recommends that the student-to-classroom ratio (SCR) should ideally be within 30.[36] However, data from the Unified District Information System for Education (UDISE) portal, a Management Information System initiated by the Department of School Education and Literacy, providing educational statistics covering over 1.489 million schools, 9.5 million teachers, and 265 million children,[37] revealed that as of 2018, more than 70,000 government schools across India had an SCR above 50, with stark variations across states.[38] Classrooms may also experience higher temperatures due to increased external heat gain owing to inadequate building design. This is exacerbated in overcrowded classrooms where the internal heat gain is influenced by the number of students raising the overall temperature, making the environment warmer and more uncomfortable (see *Figure 9: Factors causing thermal discomfort in classrooms*).

The accumulated heat in classrooms can be relieved through adequate ventilation and switching on electrical fans. However, the UDISE data for 2021–22 showed

Figure 9: Factors causing thermal discomfort in classrooms



Source: CSE (Compiled from sources)

that 15 per cent of government schools in India do not have a functional electricity connection,[39] further complicating the implementation of effective cooling solutions.

Thermal discomfort during commute from school to home

Children wait outdoors in open areas after school for their commute back home where they are exposed to the harsh sun, causing significant thermal discomfort. The discomfort may be worse if the children are moving outdoors right from air-conditioned classrooms as they face a sudden temperature difference, resulting in increased chances of heat stroke. Children commuting by bus or other means of travel may be exposed to further extreme heat while passing through areas under heat stress. This exposure may be more intense during the journey back home after school hours when the sun's intensity is typically stronger.

These identified stages of discomfort, therefore, highlight the thermal challenges faced by children in school and underscore the importance of integrated design and management intervention to address these challenges effectively.

5. Current policy mechanisms to safeguard children from extreme heat

Various Central and State authorities have recognized the importance of safeguarding children by creating a safe and conducive environment at schools to ensure optimal learning and well-being. The Ministry of Education's Department of School Education and Literacy (DoSEL) has developed Guidelines on School Safety and Security which states that it is the responsibility of school management to provide a safe and comfortable school infrastructure.[40] According to the NEP 2020, ensuring decent and pleasant service conditions at schools is the first requirement for an ideal environment and culture.[41]

Need for guidelines to be incorporated in heat action plans

In June 2008, India introduced the National Action Plan on Climate Change (NAPCC) with eight missions outlining priorities for climate change mitigation and adaptation along with laying out details of implementation through the designated missions. The NAPCC recognized children, among other groups, as the most vulnerable to the impacts of climate change. The National Disaster Management Authority (NDMA) 2019, issued the *National Guidelines for Preparation of Action Plan- Prevention and Management of Heat Wave* report to provide a framework for developing Heat Action Plans in response to heatwaves. Heat Action Plans are strategies developed at the state- or city-level to enhance preparedness and reduce the negative impacts of extreme heat. These plans outline various strategies and measures to prepare for, respond to, and recover from heatwaves. Recognizing the issue of disproportionate impact of extreme heat on different groups, the action plans provide a vulnerability assessment to establish priorities and activities for vulnerable groups, and set thresholds for heat alerts. According to a study that analysed 37 heat action plans out of over 100 in India, at least 33 (unclear in further 5) recognize children as being vulnerable to heat related illnesses.[42]

The Heat Action Plans include various measures to safeguard children during peak temperatures, including adjustments to school hours, avoiding outdoor activities, and early school closures. The plans also outline adaptive measures for hot days, such as ensuring hydration, modifying uniforms, providing first-aid, and conducting training and mock drills.

The CSE studied the Heat Action Plans of nine states, cities, and districts- Rajasthan, Ahmedabad, Delhi, Jodhpur, Bhubaneswar, Thane, Surat, Rajkot and Rewari, to develop a comprehensive set of guidelines. These guidelines encompass all the aspects covered in the individual plans and can be adopted to protect children during peak heat periods (see *Table 1: Heat action plan comparative*).

Table 1: Heat action plan comparative

Guideline	Thane	Surat	Rewari	Rajkot	Rajasthan	Jodhpur	Delhi	Bhubaneswar	Ahmedabad
Adjusting School Hours and Schedules									
Reschedule school hours	√		√		√		√		
Avoid exams during heat alerts					√				√
Implement early closures	√						√		
Limiting outdoor activities									
Restrict outdoor activities	√	√	√	√			√	√	√
No open-air classes			√		√		√		
Ensuring adequate cooling and hydration									
Cooling equipment	√			√			√		√
Adequate water supply	√		√		√		√		√
Provide heat protection materials		√	√	√	√			√	√
Infrastructure and environmental modifications									
Cool roofs	√		√						
Green campus initiatives			√		√				√
School bus safety					√				
Education, training, and awareness									
Heat illness prevention training		√	√	√			√	√	√
Awareness campaigns			√		√		√	√	√

Guideline	Thane	Surat	Rewari	Rajkot	Rajasthan	Jodhpur	Delhi	Bhubaneswar	Ahmedabad
Display Information, Education and Training (IEC) materials					√			√	
Health and safety measures									
School health programs				√	√	√	√	√	√
Emergency preparedness			√		√				
Nutritional support					√				√
Communication and alerts									
SMS alert systems						√			
Community involvement			√		√				

Source: CSE

Comprehensive set of guidelines for protecting children during extreme heat periods

1. **Adjusting school hours and schedules**
   - **Reschedule school hours:** Adjust school timings to start early in the morning (e.g. 6 a.m. to 11 a.m.) and avoid peak heat hours (12 p.m. to 4 p.m.).
   - **Avoid exams during heat alerts:** Schedule examinations before the onset of peak heat period and avoid conducting them during heat alerts.
   - **Implement early closures:** Consider early school closures during extreme heat days or when heatwaves are declared.
2. **Limiting outdoor activities**
   - **Restrict outdoor activities:** Prohibit outdoor games, sports, and physical education classes during peak heat hours. Conduct any necessary outdoor activities during the coolest part of the day.
   - **No open-air classes:** Ensure that no classes or activities are conducted in open-air settings during heatwaves.
3. **Ensuring adequate cooling and hydration**
   - **Cooling equipment:** Ensure that all schools have functional cooling equipment such as fans and coolers where possible. Develop cooling centres in schools.

- **Adequate water supply:** Ensure continuous access to clean drinking water. Encourage students to stay hydrated throughout the day.
- **Provide heat protection materials:** Distribute drinks such as Oral Rehydration Solution (ORS), buttermilk, cool drinking water, and other cooling supplies to students.

4. **Education, training, and awareness**
    - **Heat illness prevention training:** Organize child-friendly educational sessions and heat illness preventative training in schools. Conduct 'Teach the Teachers' workshops to equip educators with heat protection skills and materials.
    - **Awareness campaigns:** Conduct awareness programmes for students, teachers, and parents on heat-related illnesses, prevention strategies, and emergency response.
    - **Display information, education and communication (IEC) materials:** Place informative posters and distribute pamphlets on heat-related illness prevention in schools and Anganwadi centres.
5. **Health and safety measures**
    - **School health programs:** Urban Health Centres should collaborate with the Department of Education to develop and execute school health programs that focus on heat stress management.
    - **Emergency preparedness:** Train teachers and conduct mock drills to prepare for heat-related emergencies. Develop a Standard Operating Procedure (SOP) for reducing the impact of extreme heat on students.
    - **Nutritional support:** Ensure that nutritional services, such as mid-day meals and Anganwadi provisions, are provided uninterrupted during heatwaves. Provide ORS and other hydrating liquids.
6. **Communication and alerts**
    - **SMS alert systems:** Develop SMS alert systems to send direct heatwave warnings and guidelines to school administrators, teachers, and parents.
    - **Community involvement:** Engage with the community through self-help group (SHG) meetings, nutrition days, and awareness camps to educate about the dangers of heatwaves and protective measures.
7. **Infrastructure and environmental modifications**
    - **Cool roofs:** Apply reflective paint on school roofs to reduce heat absorption.
    - **Green campus initiatives:** Encourage the plantation of trees around school premises to create shady areas and promote a green campus.

Figure 10: Comprehensive guidelines for protecting children from extreme heat

CSE STUDIED THE HEAT ACTION PLANS HAPS FOR 7 STATES AND CITIES-
Thane, Surat, Rewari, Rajkot, Rajasthan, Jodhpur, Delhi, Bhubaneswar and Ahmedabad

Reschedule timings
- Adjust school timings to **avoid hottest** part of the day
- Closing schools during severe heat conditions or limiting hours

Hydration and cooling
- Ensure **adequate water supply** in schools
- Ensure all schools have cooling equipment in working condition
- **Relax uniform norms**

Limit outdoor activity
- **Restrict outdoor physical activities** and games during peak heat hours
- **Avoid open air classes**, add shade to playgrounds

Community engagement
- Engage parents and community in **awareness programs**
- Use bulk messaging to alert parents about severe heat conditions

Health and nutrition
- **Ensure nutritional services** such as mid-day meal schemes are uninterrupted
- **Provide ORS**, buttermilk and other **hydration methods**

Education & Prevention
- Conduct **preventative training** for children and teachers on heat protection
- Distribute **heat protection materials** and display informative posters in schools

Infrastructure & environment
- **Promote green campuses** to reduce heat exposure
- Employ cool roof strategies
- Develop cooling centres in schools

Source: Compiled from HAPs. Created by CSE

From the analysis of Heat Action Plans, it is evident that there is a strong emphasis on optimizing school infrastructure by incorporating sustainable solutions such as cool roofs, greening etc., to better cope with rising temperatures. To improve existing school infrastructure in line with these Heat Action Plans, multiple strategies can be adopted, ranging from low-cost operational interventions to retrofits within the school building, to address the various stages of discomfort faced by children at school.

6. Interventions to beat the heat

The interventions to help children adapt to harsh temperatures during school can be eased by altering both student routines and building design. The CSE has devised a guided framework of such interventions, which can be applied to target each identified stage of discomfort within a child's school routine. This framework addresses thermal comfort issues specific to each stage and aims to improve students' overall well-being and learning environment. By focusing on the different stages of a school day—from the commute and classroom time to outdoor activities—CSE's framework offers comprehensive solutions that enhance comfort and safety, ensuring that students are better equipped to cope with extreme heat.

Interventions to beat the heat during commute

Students face considerable exposure to extreme temperatures during their commute to and from school as they pass through areas under heat stress. Roads made of dark asphalt absorb most of the heat energy and release it back into the surrounding environment, increasing the ambient air temperature. Thus, it is critical to cut down direct sun exposure along these roads that children may travel on during their commute. Trees along the side of the road significantly cool down urban areas during the day by evapotranspiration and also providing shade. They can reduce air temperature by up to 2.8°C[43] and are particularly effective in cooling open spaces by preventing direct solar radiation from reaching the ground for most of the day. A study by CSE analysing surface temperature variations under different conditions during Delhi summers found that tree shade during peak heat periods resulted in temperature reductions ranging from 12–21.5°C.[44] Therefore, planting trees is one of the most effective strategies to implement city-wide to ensure comfortable commute for children.

Interventions to beat the heat at school

Children may encounter thermal discomfort at school in several ways. These include getting down from their buses at drop-off zones and walking to classrooms through pathways that may be unshaded and paved with impervious materials, as well as spending extended periods in morning assemblies and outdoor activities. To mitigate this, interventions should focus on providing adequate shade and reducing impervious surfaces in open areas.

Shading: Children experience both the ambient air temperature and direct solar radiation when outdoors. To shield them from direct solar radiation in open areas where they may spend extended periods for activities, various shading solutions can be employed:

- **Planting trees:** Shade from the trees may efficiently block direct solar radiation for most part of the day and may result in temperature reductions ranging from 12–21.5°C.[45]

Source: CSE

Tree shaded pickup and drop off zone for students at Air Force Bal Bharati School, New Delhi.

Source: https://iitgn.ac.in/about

Shading device in the middle of the academic block in IIT Gandhinagar

- **Sun shades:** Another way to block direct solar radiation is to provide shading devices over open spaces. A study analysing the effect of sun sails over school courtyards revealed that they significantly improve the thermal comfort of courtyards as well as reduce the ambient air temperatures by up to 0.5°C.[46]

- **Permeable Pavements:** Open spaces such as assembly grounds, drop-off zones, or pathways often consist of impervious ground surfaces that absorb, and later release, heat into the surrounding environment. This radiated heat significantly impacts outdoor thermal comfort, in addition to direct solar radiation and ambient air temperatures. By using permeable pavers, which allow water infiltration, surface temperatures can be reduced through evaporation. Replacing hard surfaces with permeable pavers can lower air temperatures by approximately 0.8–2.1°C.[47]

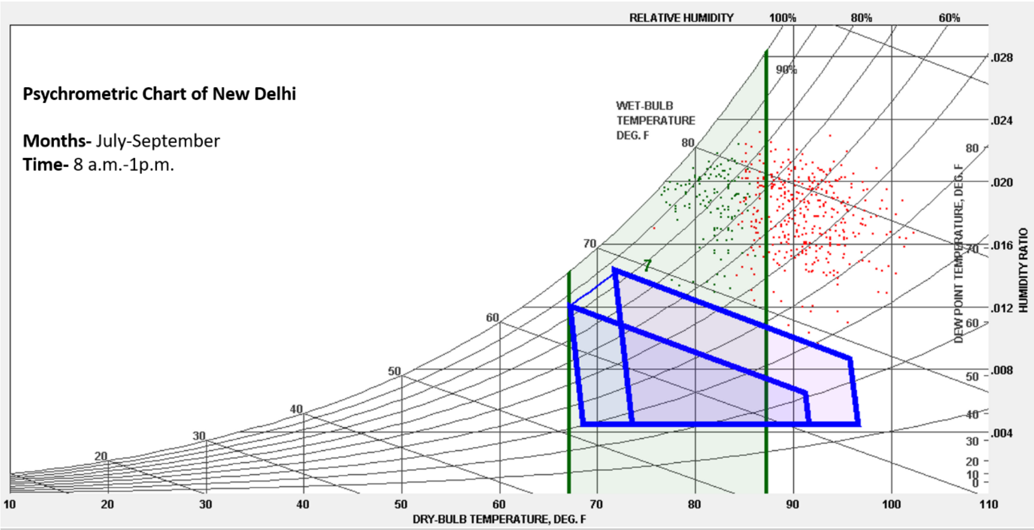
Source: https://en.wikipedia.org/wiki/Permeable_paving

Permeable pavements

Interventions to beat the heat in classroom

To understand the effectiveness of various thermal comfort strategies that may be adopted by existing schools, CSE conducted a study using the psychrometric chart for three cities—Delhi, Ahmedabad and Chennai lying in the composite, hot and dry and warm and humid climatic zones, respectively (see *Figure 11: Psychrometric chart for New Delhi*). A psychrometric chart helps to determine the relationship between temperature, humidity, and thermal comfort.

Figure 11: Psychrometric chart for New Delhi



Source: Created by CSE using Climate Consultant 6.0

The Climate Consultant 6.0 was utilized to visualize the hours within the selected timeframe on the psychrometric chart. The analysis covered the period from July to September, focusing on the hours between 8:00 a.m. and 1:00 p.m., when children are typically at school. Therefore, the total time-frame taken is 552 hours.

In Delhi, it was noted that a total of 137 of the 552 hours already constitute for comfortable conditions. Similarly, for Ahmedabad and Chennai, the comfort zone spans over 266 hours and 104 hours, respectively. Various strategies and their potential impact on thermal comfort were analysed for the three cities. These strategies can be adopted by schools as low-cost interventions or retrofitting measures to enhance their thermal environment, in addition to other interventions in different aspects of the school infrastructure.

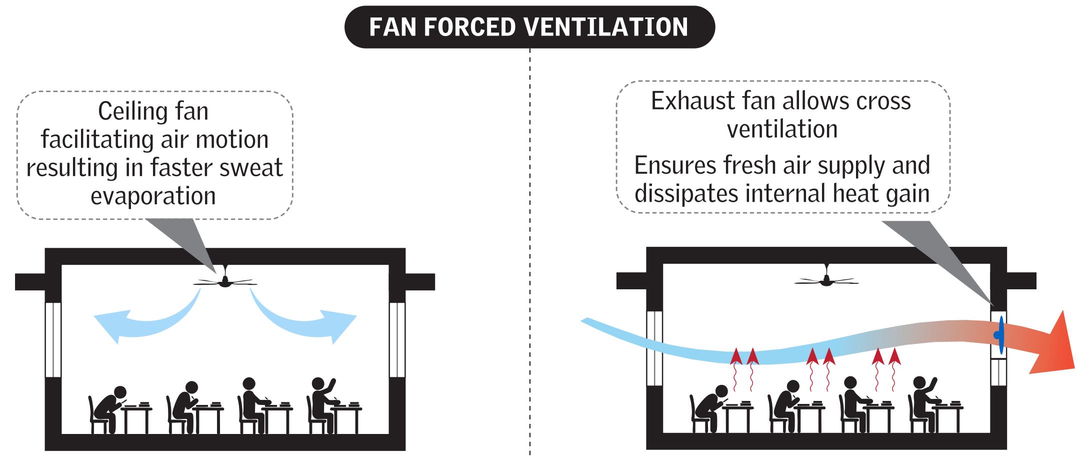
Low-cost operational interventions

There are several low cost and easily assessable strategies that focus on the existing building infrastructure to tap its potential in filtering out the harsh climate. These strategies can significantly improve the indoor environment conditions and also reduce the cooling load.

Fan forced ventilation

One way to produce a cooling effect on the body is through air movement which facilitates faster sweat evaporation from the skin. According to the National Building Code (NBC) 2016, a certain minimum desirable wind speed is needed for achieving thermal comfort at different temperatures and relative humidities. For instance, even at a temperature of 32°C with humidity levels as high as 80 per cent, comfort can be achieved if wind speed of 3.04 m/sec can be obtained. This air motion can be achieved through mechanical ventilation using electrical fans. Ceiling fans or wall fans are among the most accessible methods for providing effective ventilation in classrooms (see *Figure 12: Forced ventilation in classrooms via ceiling fans and exhaust fans*). Exhaust fans can also be used to enhance cross ventilation, thus ensuring sufficient air changes within the classrooms. They can effectively flush out the internal heat that accumulates due to high occupancy and activity.

Figure 12: Forced ventilation in classrooms via ceiling fans and exhaust fans

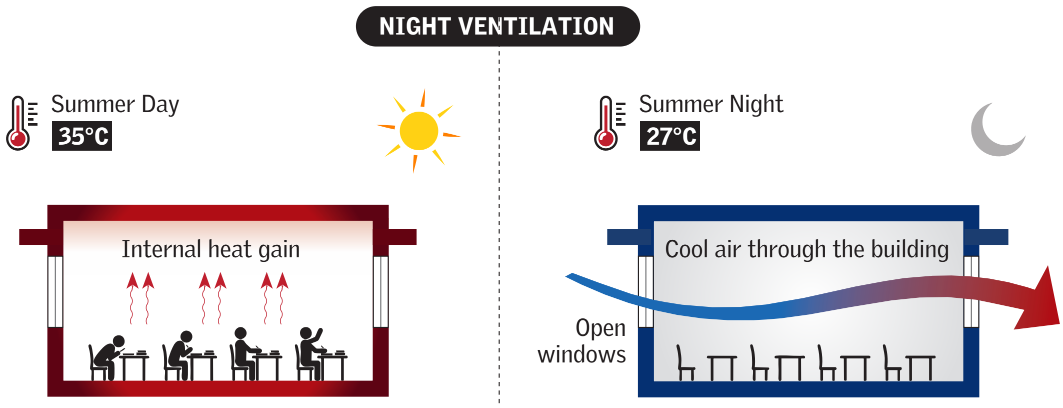


Source: CSE

Night ventilation

Night temperatures are significantly lower than daytime temperatures. This creates an opportunity to cool down indoor spaces further to nighttime levels. Night ventilation leverages this temperature difference by flushing cool night air through the building to remove the internal heat accumulated during the day. The building is made of materials that can absorb heat and slowly release it when there is a temperature difference. During the day, the building structure absorbs heat. Consequently, warm air accumulates indoors throughout the day, due to heat gain from the building materials as well as from student activity. This heat is then released back into the spaces after sunset. Night ventilation allows the cool night air to act as a heat exchanger, resulting in cooler indoor temperatures the following day. Schools can implement this strategy by leaving classroom windows open during the night and early morning, allowing the heat gained throughout the day to dissipate and achieve cooler indoor conditions the next day (see *Figure 13: Night ventilation strategy for classrooms*). Additionally, mechanical methods such as exhaust fans can draw in cool night air and remove the heat accumulated during the day by cross ventilation, effectively trapping cool air inside the classroom.

Figure 13: Night ventilation strategy for classrooms



Source: CSE

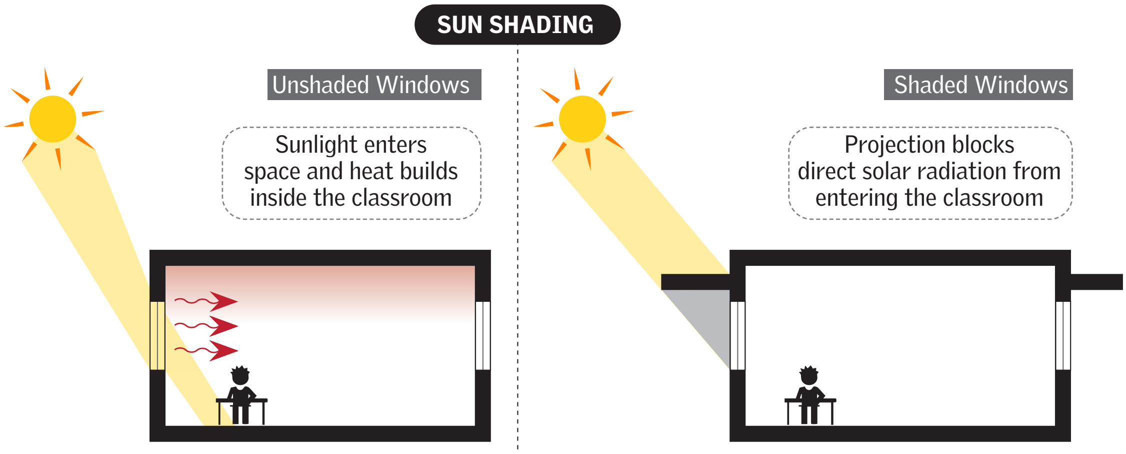
Retrofitting for existing school buildings

Retrofitting involves upgrading existing buildings to improve their performance, efficiency, and comfort without the need for complete reconstruction. By integrating solutions such as sun shading, vertical greening, cool roofs, and evaporative cooling, schools can significantly improve indoor conditions, making them more comfortable and energy-efficient.

Sun shading of windows

A survey of teachers across seven cities revealed that the most uncomfortable hours as observed during school are from 11 a.m. to 2 p.m.[48] This is the time of day when solar radiation reaches its peak, as the sun is highest in the sky and its rays are most direct, resulting in maximum solar energy reaching the surface. A primary source of heat gain inside the building is the solar radiation that is absorbed through the windows. Designing sun shades or projections over the classroom windows is an effective cooling strategy as it prevents solar heat from entering the building (see *Figure 14: The effect of unshaded vs shaded windows on thermal comfort of a classroom*). This strategy can be used in combination with others to enhance the thermal comfort and reduce cooling load.

Figure 14: The effect of unshaded vs shaded windows on thermal comfort of a classroom



Source: CSE

Bamboo shading devices retrofitted around the classrooms to reduce solar heat gain, in Penna Foundation School in Andhra Pradesh

Source: https://www.dezeen.com/2024/01/30/collectiveproject-talaricheruvu-rural-school-india-bamboo-canopy/

From the psychrometric analysis of Delhi, it was noted that sun shading can potentially add 400 comfortable hours by shielding the building from solar heat gain. Similarly, for Ahmedabad and Chennai, sun shading can potentially increase the comfortable hours by 345 hours and 429 hours, respectively. It is an effective year-round strategy for all climatic zones. Sun shading can provide the most significant contribution in Chennai among all the three cities, provided that the shading elements be designed carefully to ensure they do not obstruct ventilation, allowing for adequate air circulation necessary in the warm and humid climate.

Schools can retrofit windows with inappropriate shading or placement by adopting tailored shading strategies based on the window's orientation, and considering the sun's varying angles throughout the day. For south-facing windows, horizontal projections such as overhangs or awnings, may be effective in blocking the high-angle sun during midday, reducing direct sunlight penetration and minimizing heat gain. Conversely, for windows on the east and west façades, where the sun is lower in the sky during the morning and late afternoon, vertical projections like fins or louvers may be more suitable for providing shade during these peak solar exposure times.

Vertical greening

Vertical greening, involving the use of a variety of plants that can climb and spread over the building is an effective strategy for retrofitting in schools. The vegetation provides shade to the exterior walls, protecting them from solar radiation, and cools the surrounding air through the process of evapotranspiration. Schools can also retrofit vertical greening systems by constructing vertical frames or trellises

Source: CSE;

Retractable horizontal sun shading device over windows at CSE office, Tughlakabad, New Delhi

Source: https://shift.org.in/iiitd.php

Vertical fins acting as sun shading device at IIIT Delhi

Source: CSE

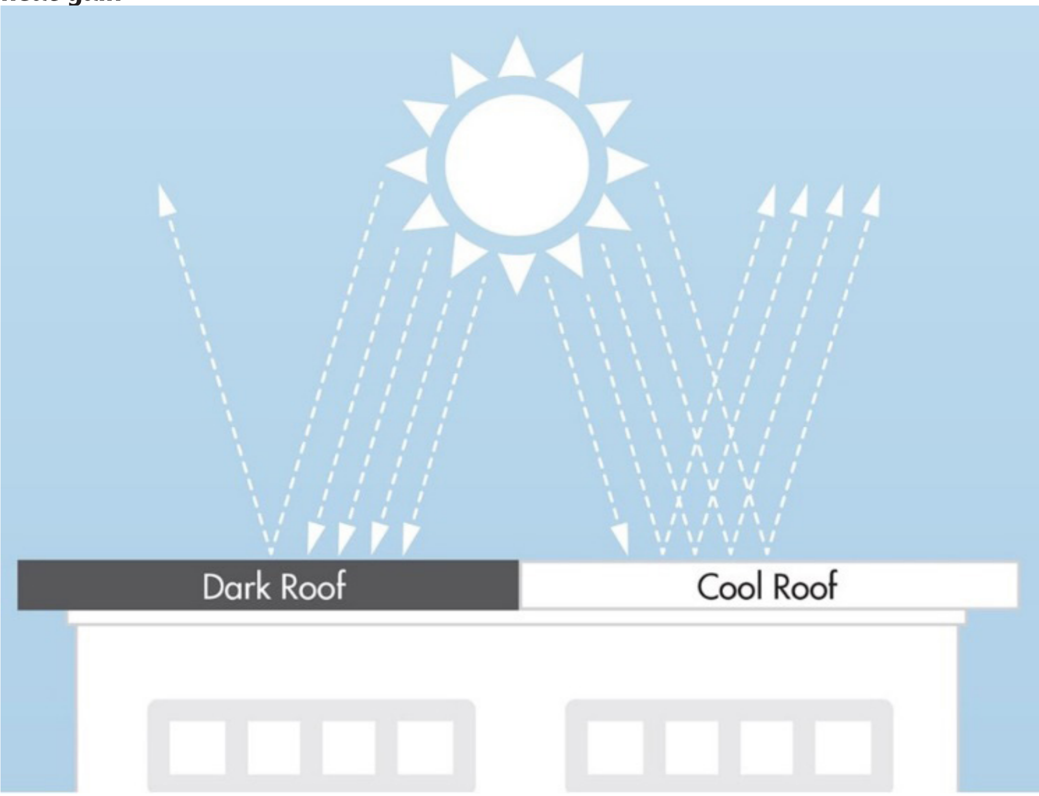
Vertical greening to block direct solar radiation and reduce ambient temperatures through evapotranspiration

in front of external walls, especially those exposed to direct sunlight, allowing the plants to climb over these structures and significantly reduce the heat absorbed by the building.

Cool roof

Cool roofs may be an effective retrofitting strategy that significantly enhance the thermal comfort of school buildings by reducing heat gain through the roof. The effectiveness of a roof in reflecting solar radiation back to the atmosphere is measured by the Solar Reflectance Index (SRI), which is determined by its solar reflectance (SR) and thermal emittance (TE). Solar reflectance is the fraction of solar energy reflected by the roof, while thermal emittance measures the roof's ability to radiate absorbed heat. Roofing materials with higher SRI values remain cooler than those with lower SRI, particularly on sunny days, thus improving the occupants' comfort (see *Figure 15: Cool roofs can reflect direct solar radiation resulting in reduced indoor heat gain*). Schools can implement the cool roof strategy by selecting materials with high SRI, such as white tiles or high-SRI paints. This approach is particularly effective in school buildings, which are typically low-to-medium rise. Since a larger proportion of a building's volume is directly influenced by the roof, implementing a cool roof made up of high SRI roofing materials can significantly reduce temperatures in a greater portion of the building, especially compared to high-rise structures. In schools, cool roofs can lower indoor temperatures by 2.1–4.3°C[49] for top-floor occupants, greatly enhancing comfort for students.

Figure 15: Cool roofs can reflect direct solar radiation resulting in reduced indoor heat gain



Source:https://constructionxperts.co.in/cool-roof-and-its-long-term-advantages/

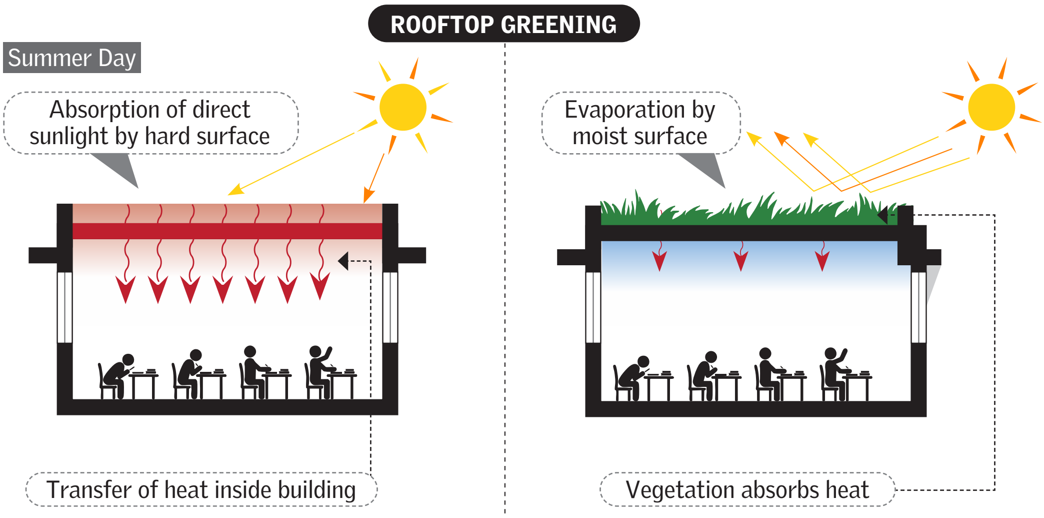
Source: CSE

Cool roof strategy using white tiles (left) and reflective paint (right)

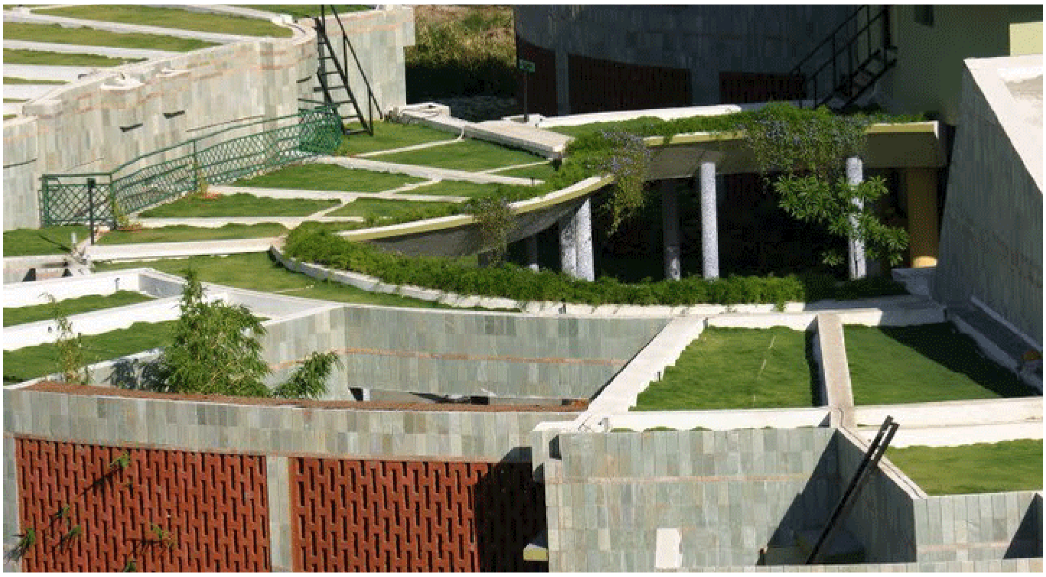
Green roof

Another way to minimize heat gain through roofs is to apply roof greening. This involves the addition of vegetation and soil layers on top of a building's existing roof structure. The layers of soil and plants act as natural insulators, reducing the amount of heat transferred through the roof into the building. During hot weather, the vegetation absorbs and reflects sunlight while the soil layer buffers against temperature fluctuations, keeping the indoor environment cooler. Plants on green roofs naturally release moisture through a process called evapotranspiration that cools the surrounding air (see *Figure 16: Green roof*). This evaporative cooling effect can further reduce the roof temperature and, consequently, the heat entering the building. Schools can adopt green roof strategy by building terrace gardens on the roof over classrooms to reduce indoor temperatures.

Figure 16: Green roofs reduce indoor heat gain through sunlight absorption and evapotranspiration



Source: CSE



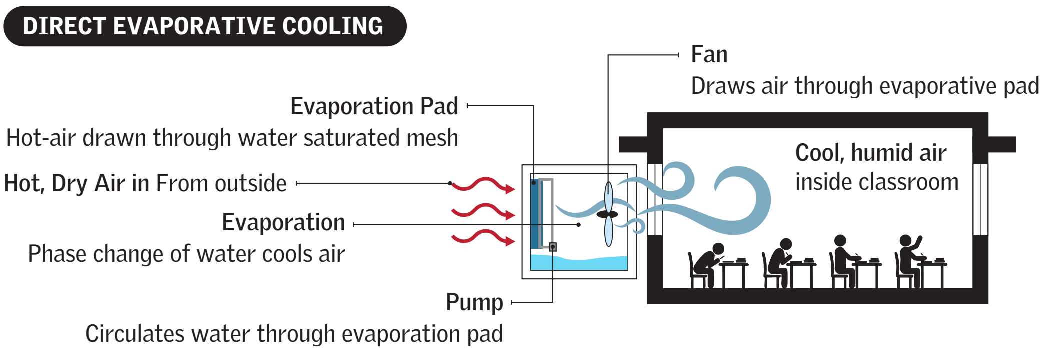
Green roof at the CII-Sohrabji Godrej Green Business Centre in Hyderabad

Source- https://www.greenroofs.com/projects/cii-sohrabji-godrej-green-business-centre-ciigbc/

Direct evaporative cooling

Direct evaporative cooling is a cooling technique that uses the process of water evaporation to lower the temperature of air. It is particularly effective in hot and dry climates where humidity levels are low. The process involves passing the hot air through a medium that is kept moist by water. As the air moves through this medium, water evaporates, absorbing heat from the air and lowering its temperature. The now cooler and slightly more humid air is then circulated into the space, reducing the overall temperature by up to 10°C (see *Figure 17: Direct evaporative cooling strategy*). This cooling strategy can potentially increase number of comfortable hours in the case of Delhi and Ahmedabad, respectively.

Figure 17: Direct evaporative cooling strategy



Source: CSE

Indirect evaporative cooling

In Indirect Evaporative Cooling (IEC), the incoming air is cooled by forcing the warm outside air through pipes that carry water. The air does not come into direct contact with the water but it interacts only with the water-filled pipes. This allows heat to be exchanged without the air absorbing any moisture. Integrating IEC systems into existing school infrastructure can result in significant energy savings and create a more comfortable learning environment.

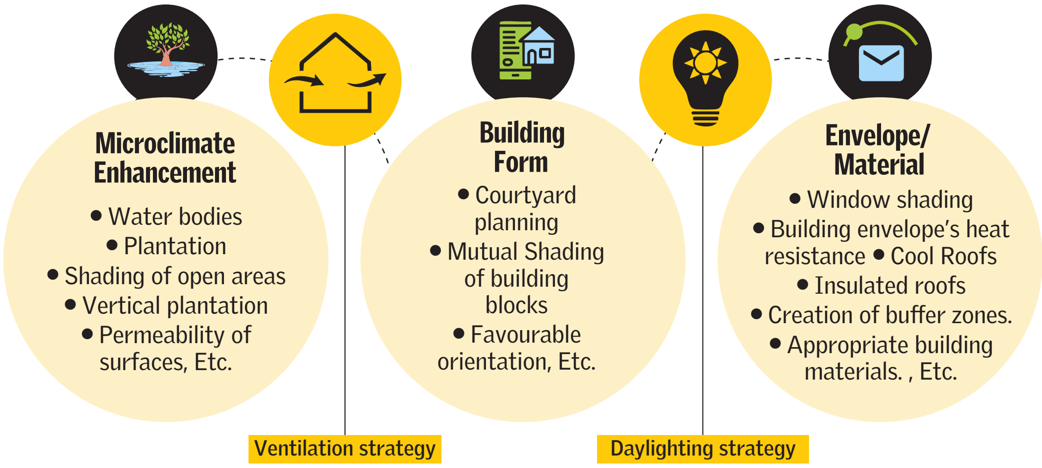
7. Beat the heat in new school construction through the integration of passive design principles

Building codes such as the National Building Code (NBC) 2016, which focuses on overall building design, safety, and comfort, emphasizing on adequate ventilation, natural lighting, and general comfort, and the Energy Conservation Building Code (ECBC), developed by the Bureau of Energy Efficiency (BEE) which sets minimum energy performance standards for buildings, including schools, highlight the need for sustainable solutions, ensuring that any infrastructure improvements are not only effective in providing thermal comfort but are also environmentally responsible. This has paved the way to build sustainability-driven solutions for schools to enable them to withstand the impacts of extreme heat and ensure a conducive environment for students' well-being and learning.

To achieve heat resilience in future school infrastructures, it is crucial to approach building design logically from the conceptual phase. One effective approach is to incorporate passive design principles, which involve using the building's orientation, materials, and natural elements like sunlight and wind to maintain a comfortable indoor environment. By thoughtfully addressing the climate context from the start, passive design can significantly reduce the risk of heat stress and thermal discomfort, minimizing the need for air conditioning and ensuring a more sustainable and comfortable school environment.

CSE's publication *The Cooling Web*, delves into various examples throughout the country that employ traditional wisdom in combination with modern solutions to achieve cooling within a reasonable expense of energy and resources. It enlists numerous passive strategies focusing on different aspects of design to achieve an optimal thermal environment. A logical and climatically-appropriate cooling ecosystem should ideally exhaust all passive measures before moving to active cooling technologies. This includes measures such as microclimatic enhancement to cut down ambient air temperatures, using appropriate building forms and using efficient building envelopes. Passive measures should be the first line of defence and could be sufficient in providing the occupants with their thermal comfort requirements.

Figure 18: Passive design strategies to achieve optimum microclimate, building form, building envelope



Source: The Cooling Web, CSE

To optimize heat gain and enhance thermal comfort, strategies can be focused on three key aspects of the building ecosystem—microclimate enhancement, building form, and building envelope (see *Figure 18: Passive design strategies to achieve optimum microclimate, building form, building envelope*).

Microclimate enhancement: This involves strategies that aim to lower the ambient temperature thereby, reducing the cooling load. Enhancing the microclimate is, therefore, the first step towards a comfortable environment. This involves designing site layouts to include shading elements (trees, canopies, etc.) and natural heat sinks (water features, vertical plantation, permeable surfaces, etc.). This can help moderate temperatures and create a more comfortable microclimate around the building.

Building form: Optimizing the building form is based on the principle of reducing direct solar radiation absorbed and optimizing air flow to remove the heat trapped within the building mass. This is achieved by incorporating courtyard planning, mutual shading and favourable building orientation into the building layout.

Ventilation strategy: Ventilation strategies such as cross-ventilation are directly influenced by both the microclimate and the building form. They serve as the mechanism that link external climatic conditions with the internal environment, shaping the building's response to its surroundings. By aligning the design of windows and vents with the prevailing wind patterns, buildings can effectively harness external climatic conditions to maintain comfortable internal environments. The CSIR-Central Building Research Institute (CSIR-CBRI) has developed a tool which can calculate the window opening size based on the size of the room for the desired air change rates. The tool takes into account the average wind speed in the city, wind direction (coefficient value changes if wind hits the window perpendicularly or obliquely) and the placement and number of windows (coefficient value changes if there is a single window in the room). The tool can also be used to determine the preferred direction and size of windows to achieve thermal comfort for its occupants. Stakeholders involved in the designing process of schools can use this tool to assess and optimize window placement and design, improving ventilation and passive cooling in classrooms.

Building envelope: The building layout as well as the materials govern the amount of heat gained or lost by the building envelope. Thus, judicious layout planning and material selection according to the local climatic conditions play a major role in reducing the indoor temperatures. The various aspects that modify the building envelope to achieve thermal comfort are window shading, cool roofs, insulated roofs, creation of buffer zones and use of appropriate building materials. In high-occupancy spaces like schools, ensuring fresh air through natural ventilation is the key to health and thermal comfort.

8. Successful practices adopted in schools across the country

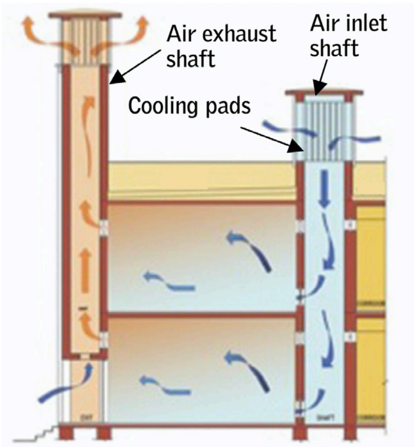
Several schools across the country have already implemented innovative solutions to combat the heat. Some of the successfully implemented solutions are:

Water Bells: A successful method for addressing the heat in schools is Kerala's 'Water Bell' initiative that began in 2019. This program schedules three daily water breaks by ringing a bell to remind students to drink water. By encouraging consistent hydration, the initiative helps prevent dehydration in students and enhances well-being in hot conditions. This approach has also been embraced by schools in Karnataka and Telangana.

The Water bell initiative–Schools ring a bell thrice a day to ensure children drink enough water

Source- https://thebetterindia.com/204035/drink-water-bell-health-benefits-school-kerala-karnataka-telangana-odisha-india/

Evaporative cooling: The Shri Swami Vivekanand Vidhya Vihar in Nadiad, Gujarat has incorporated the evaporative cooling strategy to achieve a cooler indoor environment. The school building comprises of vertical shafts for air intake and exhaust. Cooling pads in the air inlet shafts are kept wet constantly by spreading water to maintain low temperatures inside the classrooms. Hot air rises and flushes out through the outlet shafts on the periphery of the building.



The section of direct evaporative cooling system (left); Air inlet and outlet shaft in Shri Swami Vivekanand Vidhya Vihar classrooms in Nadiad, Gujarat (right)

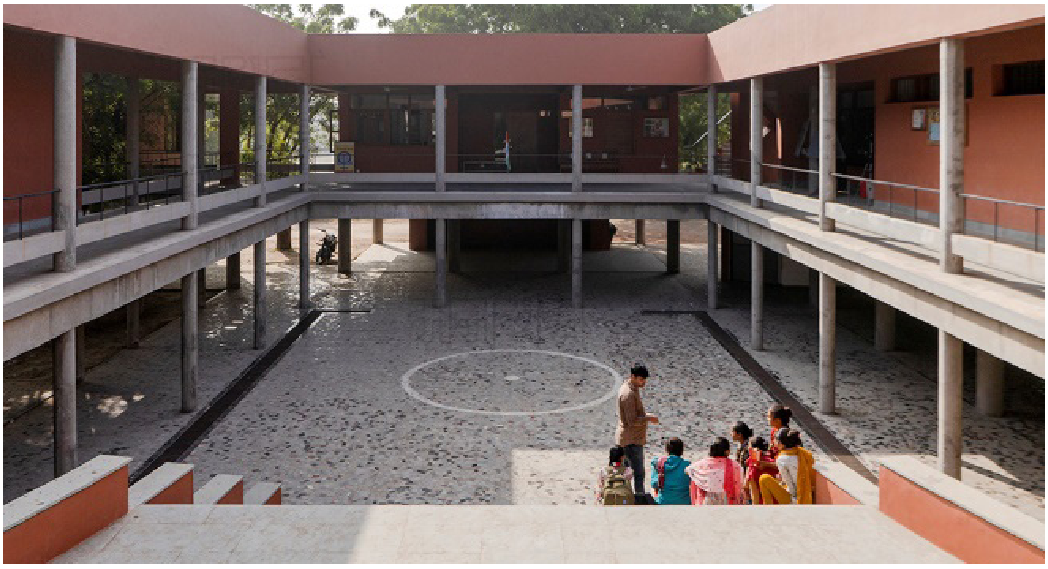
Source: https://cdn.cseindia.org/userfiles/Parul%20Zaveri.pdf

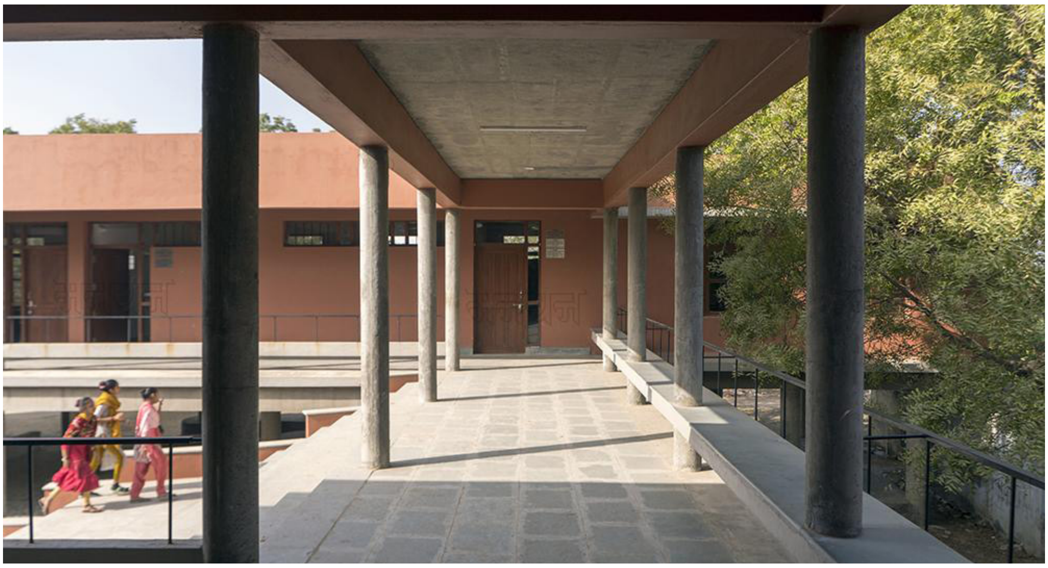
Sun shading for outdoor spaces: The Penna Foundation School in a village in Andhra Pradesh, has used canopies made of bamboo to shade spaces to protect children from direct solar radiation while engaging in outdoor activities.

Sun shade constructed from bamboo for open spaces in Penna Foundation School, Talaricheruvu, Andhra Pradesh

Source: https://www.dezeen.com/2024/01/30/collectiveproject-talaricheruvu-rural-school-india-bamboo-canopy/

Courtyard planning: A Mahatma Gandhi Education Trust School in Mandal, Gujarat has incorporated courtyard planning. The school is built around different scales of courtyards. The classrooms are organized around the existing neem trees, creating an interval of shaded courtyard after each classroom. The multiple courtyards provide ventilation as well as mutual shading for outdoor activities.

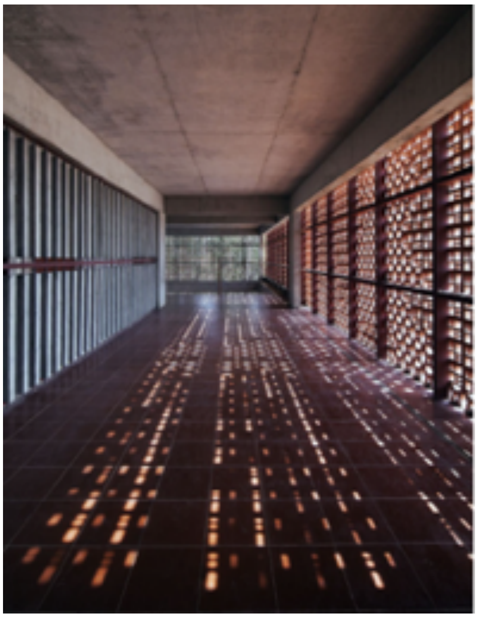




Courtyard planning that facilitates ventilation and mutual shading in Mahatma Gandhi Education Trust School in Mandal, Gujarat

Source: http://manayanarchitects.com/portfolio/the-courtyard-school/

Jaalis: The Delhi Public School in Bengaluru has incorporated vernacular terracotta jaalis (traditional shading and ventilation screens) around various parts of the building, including both sides of each classroom, to ensure adequate cross-ventilation. These jaalis reduce sun exposure, particularly on the building's western face where they are used in breakout areas. Based on the sun's direction, the design includes horizontal and vertical pergolas along with a combination of two different jaali patterns on the exterior.



Terracotta Jaali (left) and vertical shading devices (right) adopted in Delhi Public School, Bengaluru to minimize direct solar heat gain

Source: https://www.archdaily.com/384790/dps-kindergarden-school-khosla-associates

Structural cooling: The Government Sarvodaya Co-Ed School in Mehram Nagar, New Delhi, is in the process of installing an innovative structural cooling system designed to enhance thermal comfort. This system works by extracting heat from the building structure during the day through a network of water-filled pipes embedded within the building floors. The heat absorbed by the water is then transferred to a swimming pool, which serves as a heat sink. At night, the swimming pool water naturally cools down through radiation and evaporative cooling, effectively resetting the system for the next day.

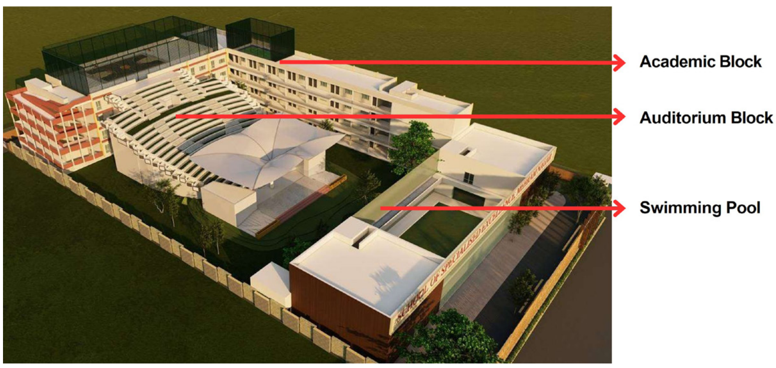


Image: Structural cooling being installed in Government Sarvodaya Co-Ed School in Mehram Nagar, New Delhi

Source: Oorja Energy Engineering

Learning from global initiatives to address heat risks in Indian schools

Countries like Australia and the United States offer valuable lessons on addressing heat risks in schools. In Australia, the 'Greening Our Cities' program, funded by the New South Wales Government, aims to increase urban tree canopy coverage, benefiting schools through initiatives like 'Cooling the Schools'. This program works with schools to plant native trees, reducing urban heat and enhancing green spaces. Over 130 schools have engaged in this program, planting over 23,000 trees and reaching nearly 10,000 students.[50] Such initiatives have mitigated heat by integrating climate action into curricula.

Similarly, Australia's Sustainable Schools Program Online (SSP Online) provides schools with online modules and tools that help them log and track their resources. The program helps schools improve sustainability by reducing emissions, managing energy and water use, increasing biodiversity, and achieve sustainability certifications. Schools can engage in climate action while developing a whole-school approach that includes operations, curriculum, and community outreach.[51]

In the US, California has recognized the growing need for heat action plans in schools as rising temperatures become more frequent. The UCLA Luskin Center for Innovation has recommended that school districts develop heat plans similar to the other national policies for extreme weather events such as storms. This approach has gained traction in California, with state legislation now under consideration that would require schools to have heat plans by 2027.[52] The legislation also advocates for creating shaded spaces in schools to protect children from heat.

9. Way forward

Government authorities must assess the current state of infrastructure in schools: Various autonomous bodies under the Department of School Education and Literacy, Ministry of Education, conduct surveys to collect information on school education in India. However, the latest education statistics are three years old. These survey reports include information on the availability of ancillary facilities in schools, such as water coolers and toilets but lack a more detailed and updated reports on school infrastructure, specifically focusing on cooling appliances (e.g., fans, coolers). This data is critical for gauging the cooling needs and understanding the current state of infrastructure, which helps in the development of appropriate policies to retrofit schools with the necessary facilities, and ensure adequate thermal conditions.

This needs to be a special focus in government-run schools which have a large population of children from economically weaker sections, as they face greater vulnerability to extreme heat due to compounded challenges such as malnutrition, inadequate hydration and poor school infrastructure. Assessing the current state of public school infrastructure is the crucial first step. Identifying deficiencies in infrastructure such as non-functioning cooling appliances, damaged roofs, inadequate shading, and poor ventilation will guide targeted interventions. Upgrading infrastructure is essential to safeguard students' health and ensure that schools remain safe, comfortable, and conducive to learning amidst rising temperatures.

Need for comprehensive surveys to examine effects of extreme heat on students: It is essential to gather comprehensive evidence and assess how heat risks are impacting the Indian school education sector. This includes examining the effects of extreme temperatures on students' health, attendance, academic performance, and overall well-being. Authorities must prioritize understanding the critical link between student health and thermal comfort. While the Central Board of Secondary Education (CBSE), in collaboration with the World Health Organization (WHO), has undertaken efforts like the Global School-based Student Health Survey (GSHS 2022) to assess various aspects of student health, heat-related illnesses remain an overlooked area. Incorporating heat-related health parameters into future surveys is essential to develop targeted guidelines and equip schools to manage extreme heat effectively.

Need to assess thermal comfort conditions within school to guide thermal comfort standards: A significant challenge in addressing heat-related risks in schools is the lack of reliable data on thermal conditions, such as temperature, ventilation, and humidity levels within school spaces. Detailed assessments of thermal conditions within these spaces must be conducted. A data-driven approach will be pivotal in identifying vulnerabilities, improving heat preparedness, and implementing appropriate measures to safeguard students' well-being.

The data should be used to develop national- and state-level guidelines aimed at ensuring student safety and resilience in extreme heat conditions. This could be in the form of thermal comfort standards specifically tailored to the unique challenges of school environments, similar to those initiated by the government for the affordable housing sector. The standards could include a set of specific guidelines that apply to new constructions, as well as retrofitting existing schools. It should establish clear criteria for thermal comfort, taking into account factors such as the number of children in classrooms, building typology, local climate conditions, and the thermal performance of materials. These standards should then be incorporated into national- and state-level building codes like the National Building Code 2016 and the Energy Conservation and Sustainable Building Code.

However, the focus should be to move beyond just design and construction to the actual performance of the building over time. In order that the infrastructure meets the standards, policies must include a mechanism for re-certification. This would involve periodically assessing the thermal comfort levels of schools to ensure they continue to meet the desired standards. By implementing re-certification after a fixed interval, perhaps every two to three years, authorities can monitor the functioning of the building over time and identify any deterioration or necessary upgrades. Such a system ensures accountability and encourages continuous improvement, making thermal comfort an ongoing priority rather than a one-time consideration.

Existing schools must retrofit passive design strategies to ensure thermal comfort: The school management must conduct a thorough assessment of the existing infrastructure to identify specific areas where passive cooling strategies can be retrofitted to improve the thermal conditions of classrooms. Key retrofitting strategies include installing external shading devices such as overhangs, awnings, or louvered screens to effectively block direct sunlight and reduce heat gain and glare within classrooms. Applying reflective coatings or materials to rooftops, known as cool roofs, can help lower roof temperatures and significantly reduce indoor heat. Integrating vegetation on rooftops through green roofs provides natural insulation, absorbs heat, and reduces the surrounding air temperature. Vertical greening, using plants on vertical surfaces, can cool the building through evapotranspiration while minimizing direct solar heat gain. Additionally, implementing evaporative cooling systems that use water to cool the air through evaporation offers immediate and effective indoor cooling in hot climates. By adopting these passive cooling strategies, schools can create a more comfortable learning environment, reduce energy consumption, and enhance the overall well-being of students.

Need to establish a composite school policy for adaptive comfort and heat resilience: The existing heat action plans for several states and cities outline steps for school staff and management during extreme heat events. However, a more comprehensive framework is needed to address all aspects of school routines and student well-being. This should include measures such as adjusting schedules, limiting outdoor activities, ensuring hydration and reinforcing health and safety protocols. Authorities must also adapt policies to changing heat patterns by revising academic calendars and aligning vacation periods with the hottest months. A dynamic system to adjust schedules, including exams and vacations, based on annual climate data and localized heatwave predictions, should be established and become part of heat action plans of all regions affected by extreme heat

This may be implemented as a well-structured action plan tailored to address rising heat conditions in schools, with clearly defined steps triggered when the heat index crosses specific thresholds. Similar to the Graded Response Action Plan (GRAP) used to combat air pollution, this system could introduce progressive measures to protect students and staff as heat levels escalate.

Currently, the response from schools and authorities during peak heat is often reactive, uncoordinated, and driven by panic. A structured framework will make it easier for the local administration, district magistrates and courts to issue directives to schools and parents and help in curbing the escalation of a health crisis. Framing the action plan should involve health experts, organizations such as the WHO and borrow from epidemiological studies on the subject.

The plan may incorporate actions like adjusting school timings to start and end earlier, avoiding the peak hours of intense heat. Outdoor activities could be minimized or rescheduled to cooler hours of the day. Regular water breaks could be mandated, with reminders to encourage hydration and prevent heat-related illnesses. Additionally, the plan could involve issuing advisories with guidance on individual and community actions, such as wearing breathable clothing, staying in shaded or cool areas, breathing exercises for cooling etc. Flexibility in school uniforms—allowing lighter fabrics or designs suited for extreme heat could also be incorporated.

Integrating heat resilience curriculum and community engagement in schools: Schools should incorporate heat-related education into the curriculum to equip students and staff with the knowledge to mitigate risks and stay safe. This curriculum should cover practical aspects of heat management, such as when to open or close windows to regulate classroom temperature, the role of night ventilation in cooling, and strategies for maximizing natural ventilation during the day. Regular awareness campaigns, workshops, and training sessions should emphasize the importance of hydration, clothing, and heat protection strategies. These sessions can be tailored to both students and staff to ensure the entire school community understands how to navigate extreme heat safely. Furthermore, heat resilience training should be incorporated into school building and facility management programs. This will ensure that the staff are equipped with the skills to maintain thermal comfort and safety in school infrastructure. Finally, schools can play a pivotal role in community engagement, collaborating with local organizations or self-help groups to develop neighbourhood-based solutions for heat resilience. Community outreach programs can help sensitize families and equip them with tools to address heat-related challenges effectively at home and beyond.

Enhancing the PM POSHAN scheme to include nutrition that helps in heat resistance: The PM POSHAN scheme aims to provide a balanced and nutritious diet to children in government schools, ensuring that they receive essential nutrients for their growth and development. Strengthening the PM POSHAN scheme by integrating heat resilience measures such as providing electrolyte-based drinks, and meals designed to support both hydration and nutritional needs, can help mitigate the dual challenges of malnutrition and heat stress. Adding nutrients that help in heat resistance (such as potassium, magnesium etc.) can further enhance children's ability to cope with extreme heat, supporting their health and well-being.

References

1 WMO Global Annual to Decadal Climate Update 2024-2028. Available at https://library.wmo.int/viewer/68910/?offset=#page=7&viewer=picture&o=bookmarks&n=0&q=, as accessed on 22 July 2024

2 Vishwa Mohan 2024. *Heatwaves more than double of normal this year,* The Times of India. *Available at* https://timesofindia.indiatimes.com/city/delhi/heatwaves-more-than-double-of-normal-this-year-imd-data/articleshow/110977521.cms, as accessed on 22 July 2024

3 United Nations Secretary-General's Call to Action on Extreme Heat 2024. Available at https://www.un.org/sites/un2.un.org/files/unsg_call_to_action_on_extreme_heat_for_release.pdf

4 Vikas K. Desai, Shailesh Wagle, Suresh Kumar Rathi, Urvi Patel, Hemant S. Desai and Kaplesh Khatri 2015. *Effect of ambient heat on all-cause mortality in the coastal city of Surat, India,* Current Science, ResearchGate. Available at https://www.researchgate.net/publication/283572714

5 Priya Dutta, Lm Sathish, Dileep Mavankar, Partha Sarthi Ganguly and Sujata Saunik 2020. "Extreme Heat Kills Even in Very Hot Cities: Evidence from Nagpur, India", The *International Journal of Occupational and Environmental Medicine*. Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7740051/

6 United Nations Children's Fund 2022. *The Coldest Year of the Rest of their Lives: Protecting children from the escalating impacts of heatwaves*, UNICEF, New York. Available at https://www.unicef.org/media/129506/file/UNICEF-coldest-year-heatwaves-and-children-EN.pdf

7 Ibid.

8 Anon 2014. Joint Review Mission, Department of Education and Literacy, Ministry of Human Resource and Development. Available at https://pmposhan.education.gov.in/Files/Review/Fifth_Review/Delhi/Delhi_JRM_Report_13.pdf

9 Ibid.

10 Anon 2018. Joint Review Mission, Uttar Pradesh, Department of Education and Literacy, Ministry of Human Resource and Development. Available at https://pmposhan.education.gov.in/Files/Review/11th_JRM/UP/JRM%20Report%20-%20UP%20final%201.11.2018.pdf

11 Anon 2022. Report of 13th Joint Review Mission PM Poshan Scheme, Department of

Education and Literacy, Telangana, Ministry of Human Resource and Development. Available at https://pmposhan.education.gov.in/Files/Review/13th_JRM/Telangana/JRM%20Report%20_Telangana_20-12-2022%20final-Without_S_Menu.pdf

12 Deb Hipp 2023. These 3 supplements can help manage heat intolerance, The Check Up, Single Care. Available at https://www.singlecare.com/blog/heat-regulating-supplements/

13 Paras Singh 2023. A third of MCD schools need structural repairs, says audit, Hindustan Times. Available at https://www.hindustantimes.com/cities/delhi-news/over-30-of-primary-schools-in-delhi-require-major-repair-work-says-mcd-report-101681152989003.html

14 F. Salamanca, M. Georgescu, A. Mahalov, M. Moustaoui and M. Wang 2014. *Anthropogenic heating of the urban environment due to air conditioning*, Journal of Geophysical Research: Atmospheres, American Geophysical Union Publications, USA. Available at https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2013JD021225

15 Brice Tremeac, Pierre Bousquet, Cecile Sylvie De Munck and G. Pigeon 2012. *Influence of air conditioning management on heat island in Paris air street temperatures*, Applied Energy, Elsevier Ltd., United Kingdom. Available at https://www.researchgate.net/publication/256755480_Influence_of_air-conditioning_management_in_Paris_air_street_temperatures

16 Gerd Jendritzky, Richard de Dear and George Havenith 2012. *UTCI-Why another thermal index?*, International Journal of Biometeorology. Available at UTCI—Why another thermal index? | International Journal of Biometeorology (springer.com)

17 Mohammad Taleghani 2018. *Outdoor thermal comfort by different heat mitigation strategies- A review*, Renewable and Sustainable Energy Reviews, Elsevier Ltd. Available at Outdoor thermal comfort by different heat mitigation strategies- A review - ScienceDirect

18 Jennier K. Vanos, Grant R. McKercher, Kylie Naughton and Marc Lochbaum 2017. *Schoolyard Shade and Sun Exposure: Assessment of Personal Monitoring During Children's Physical Activity*, Photochemical and Photobiology. Available at Schoolyard Shade and Sun Exposure: Assessment of Personal Monitoring During Children's Physical Activity - PubMed (nih.gov)

19 Sean R. Notley, Ashley P. Akerman, Robert D. Meade, Gregory W. Mcgarr and Glen P. Kenny 2020. *Exercise Thermoregulation in Prepubertal Children: A Brief Methodological Review*, Medicine & Science in Sports & Exercise. Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7556246/

20 Wenwen Cheng and Robert D. Brown 2020. *An energy budget model for estimating the thermal comfort of children*, International Journal of Biometeorology. Available at https://www.researchgate.net/publication/341116415_An_energy_budget_model_for_estimating_the_thermal_comfort_of_children

21 Kazuyo Tsuzuki-Hayakawa, Yutaka Tochihara and Tadakatsu Ohnaka 1995. *Thermoregulation during heat exposure of young children compared to their mothers*, European Journal of Applied Physiology and Occupational Physiology. Available at https://link.springer.com/article/10.1007/BF00964108

22 Eric Kennedy, Heather Olsen, Jennifer Vanos, Daniel J. Vecellio, Marla Desat, Karina Richters, Alexandra Rutledge and Gregory R.A. Richardson 2021. *Reimagining spaces where children play: developing guidance for thermally comfortable playgrounds in Canada*, Canadian Journal of Public Health, Springer. Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8225778/#Sec1title

23 Ibid.

24 Lawrence E. Armstrong, Douglas J. Casa, Mindy Millard-Stafford, Daniel S. Moran, Scott W. Pyne and William O. Roberts 2007. *American College of Sports Medicine position stand. Exertional heat illness during training and competition*, Medicine & Science in Sports & Exercise. Available at American College of Sports Medicine position stand. Exertional heat illness during training and competition - PubMed (nih.gov)

25 Mikhail Ponomarenko, Irina Stepanenko and Nikolay Kolchanov 2013. *Heat Shock Proteins*, Brenner's Encyclopedia of Genetics, Heat Shock Proteins, Elsevier Inc. Available at https://www.researchgate.net/publication/293731559_Heat_Shock_Proteins

26 National Action Plan on Heat Related Illnesses 2021, National Programme on Climate and Human Health National Centre for Disease Control, Ministry of Health and Family Welfare. Available at https://ncdc.mohfw.gov.in/wp-content/uploads/2024/05/1.Nation-Action-plan-on-Heat-Related-llnesses.pdf

27 Betty Lala and Aya Hagishima 2023. *Impact of Escalating Heat Waves on Students' Well-Being and Overall Health: A Survey of Primary School Teachers*, Climate. Available at https://www.mdpi.com/2225-1154/11/6/126

28 Global School-based Student Health Survey India (Jaipur) 2022. Available at https://cdn.who.int/media/docs/default-source/ncds/ncd-surveillance/data-reporting/india/gshs/2022-gshs-india-jaipur-factsheet.pdf?sfvrsn=db2718cb_3&download=true, as accessed on 23 August 2024

29 Bhavya Srivastava, Kibrom Tafere and A. Patrick Behrer 2024. *High Temperature*

and Learning Outcomes: Evidence from Ethiopia, Development Economics, Development Research Group, World Bank Group. Available at https://documents1.worldbank.org/curated/en/099026303062419731/pdf/IDU1d26268e21171c147d21bed81a844d4d1d4b1.pdf?_gl=1*ixcmoh*_gcl_au*MTQ1NTE0NjM2Ni4xNzI0MjIzNDky

30 Andhra Pradesh State Disaster Management Authority (APSDMA)-Heat Wave Action Plan. Available at https://apsdma.ap.gov.in/files/c3ac94a37719c2fa07988550008a3bb4.pdf, as accessed on 23 August 2024.

31 Shradha Chettri 2024. *Delhi: Nursery admissions kick off today, proximity key factor,* The Times of India. Available at https://timesofindia.indiatimes.com/city/delhi/nursery-admissions-kick-off-today-proximity-key-factor/articleshow/88285871.cms, as accessed on 24 August 2024

32 Learn About the Ideal Temperature of an Air Conditioner 2024. Available at https://www.bajajfinserv.in/what-is-the-coldest-temperature-for-an-air-conditioner#:~:text=The percent20ideal percent20temperature percent20for percent20your,and percent20cost percent20you percent20more percent20money, as accessed on 27 August 2024

33 Pratishtha Tiwari 2019. *Alert! Sudden change from hot to cold can be harmful to your health*, The Times of India. Available at https://timesofindia.indiatimes.com/life-style/health-fitness/health-news/alert-sudden-change-from-hot-to-cold-can-be-harmful-to-your-health/articleshow/69354918.cms, as accessed on 30 August 2024

34 Oluyemi Toyinbo 2023. *Indoor Environmental Quality, Pupils' Health, and Academic Performance—A Literature Review*, Buildings, MDPI. Available at https://www.mdpi.com/2075-5309/13/9/2172

35 Cruceanu Iunia, Chadi Maalouf, Iolanda Colda and Mohammed Lachi 2013. *Parametric study and energy analysis of a personalized ventilation system*, International Journal of Mathematical Models and Methods in Applied Sciences. Available at https://www.researchgate.net/publication/235644322_Parametric_study_and_energy_analysis_of_a_personalized_ventilation_system

36 National Education Policy 2020. Ministry of Human Resource Development, Government of India. Available at https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf, as accessed on 30 August 2024

37 Unified District Information System for Education Plus (UDISE+) 2022. Department of School Education and Literacy, Ministry of Education, Government of India. Available at https://dsel.education.gov.in/sites/default/files/statistics/report_in_PDF/udise_21_22.pdf, as accessed on 2 September 2024

38 U-DISE Flash Statistics 2017-18 2020. National Institute of Educational Planning and Administration. Available at https://educationforallinindia.com/wp-content/uploads/2021/04/School-Education-in-India-Flash-Statistics-2017-18-NIEPA.pdf, as accessed on 2 September 2024

39 Unified District Information System for Education Plus (UDISE+) 2022. Department of School Education and Literacy, Ministry of Education, Government of India. Available at https://dsel.education.gov.in/sites/default/files/statistics/report_in_PDF/udise_21_22.pdf, as accessed on 2 September 2024

40 Guidelines on School Safety and Security 2021. Department of School Education and Literacy, Ministry of Education, Government of India. Available at https://dsel.education.gov.in/sites/default/files/2021-10/guidelines_sss.pdf, as accessed on 2 September 2024

41 National Education Policy 2020. Ministry of Human Resource Development, Government of India. Available at https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf, as accessed on 30 August 2024

42 Centre for Policy Research 2023. How is India Adapting to Heatwaves? An Assessment of Heat Action Plans with Insights for Transformative Climate Action. Available at https://cprindia.org/wp-content/uploads/2023/03/Heat-Report_27March-23_Updated-Table.pdf, as accessed on 3 September 2024

43 Noemie Probst, Peter M. Bach, Lauren M. Cook, Max Maurer and Joao P. Leitao 2022. *Blue Green Systems for urban heat mitigation: mechanisms, effectiveness and research directions*, Blue-Green Systems. Available at chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.nrdc.org/sites/default/files/india-heat-resilience-20220406.pdf

44 Sugeet Grover 2024. *India's urban open spaces have become unbearably hot. A planning expert shows how to reclaim these areas*, Down to Earth, Centre for Science and Environment, New Delhi. Available at https://www.downtoearth.org.in/governance/indias-urban-open-spaces-have-become-unbearably-hot-a-planning-expert-shows-how-to-reclaim-these-areas, as accessed on 3 September 2024

45 Ibid.

46 Dalia Elgheznawy and Sara Eltarabily 2021. *The impact of sun sail-shading strategy on the thermal comfort in school courtyards*, Building and Environment, Elsivier. Available at https://www.sciencedirect.com/science/article/abs/pii/S0360132321004480

47 Noemie Probst, Peter M. Bach, Lauren M. Cook, Max Maurer and Joao P. Leitao 2022. *Blue Green Systems for urban heat mitigation: mechanisms, effectiveness and*

research directions, Blue-Green Systems. Available at https://www.researchgate.net/publication/366209274_Blue_Green_Systems_for_urban_heat_mitigation_mechanisms_effectiveness_and_research_directions

48 Betty Lala and Aya Hagishima 2023. *Impact of Escalating Heat Waves on Students' Well-Being and Overall Health: A Survey of Primary School Teachers*, Climate. Available at https://www.mdpi.com/2225-1154/11/6/126

49 Telangana Cool Roof Policy 2023-2028. Municipal Administration and Urban Development Department, Government of Telangana. Available at https://www.nrdc.org/sites/default/files/2023-04/telengana-cool-roof-policy-booklet.pdf, as accessed on 3 September 2024

50 Anon 2024. Nature-based solutions help schools beat the heat, NSW Climate and Energy Action, NSW Government. Available at https://www.energy.nsw.gov.au/nsw-plans-and-progress/government-strategies-and-frameworks/taking-action-climate-change/schools

51 Anon 2021. Sustainable Schools Program, Everyday Climate Choices, ACT Government. Available at https://www.climatechoices.act.gov.au/policy-programs/sustainable-schools-program

52 Calli McMurray 2023. California Schools Start Hatching Heat Plans as the Planet Warms, California Healthline. Available at https://californiahealthline.org/news/article/california-schools-start-hatching-heat-plans-as-the-planet-warms/

Extreme temperatures gripping our cities are no longer confined to the summer months. As the mercury rises higher each year, children are becoming among the most vulnerable. Prolonged hours in thermally uncomfortable classrooms, hot commutes through heat-absorbing cityscapes, and outdoor activities during peak temperatures expose them to risks of dehydration, heat exhaustion, and heatstroke.

While policies like the National Disaster Management Authority's (NDMA) School Safety Policy and Heat Action Plans (HAPs) recognize children's vulnerability to heat, they fall short of offering specific, actionable measures to safeguard them in school environments. Broad recommendations often lack detail, and most plans remain advisory, with no mandatory enforcement or accountability mechanisms to ensure effective implementation in schools.

This report underscores the urgent need to transform school ecosystems to build resilience against rising temperatures. It offers actionable steps for school management to improve thermal comfort, integrating climate-responsive, passive solutions. These interventions are designed to integrate into students' routines and school infrastructure, ensuring their safety, adaptability, and well-being.

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