Understanding & mapping Urban heat islands for Management of Heatwaves

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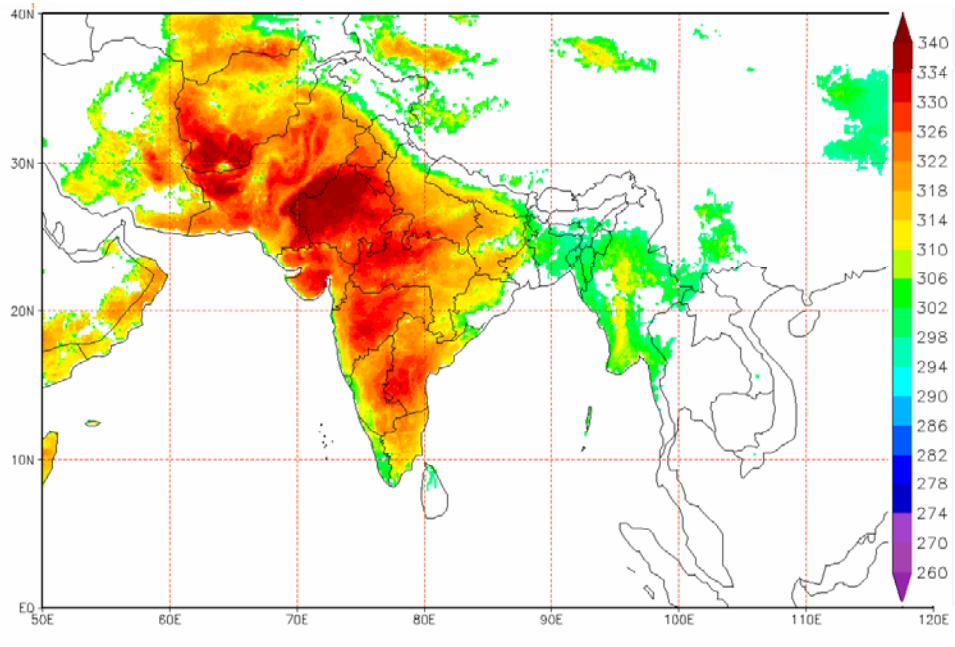
TARU LEADING EDGE

Background

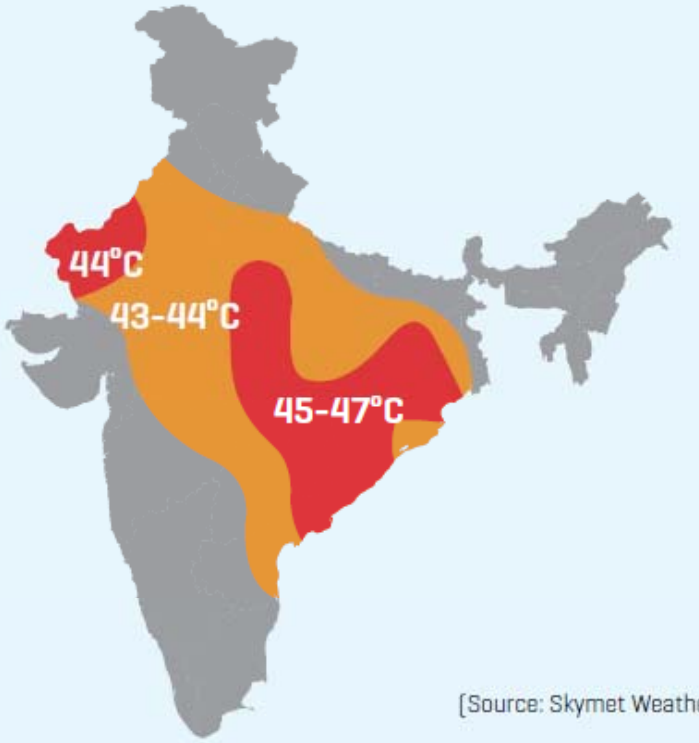
- European heatwaves in the northern hemisphere summer of 2003 was responsible for the deaths of tens of thousands of people, as were the Russian heatwaves, forest fires and associated air pollution in 2010.
- 2016 was the warmest year ever recorded, globally as well as in India. Of all the deaths due to extreme weather conditions across the country severe **heat wave claimed the largest chunk of the total deaths at 40%** (IMD, 2017)
- In 2015, heatwave in India **killed more than 2,300 people**, making it the 5th highest in world history in terms of number of deaths.
- Most of the deaths concentrated in Andhra Pradesh, Telangana, Punjab, Odisha and Bihar.
- More than **22,000 people have died of heat-related causes** in India since 1992 (NDAM, 2015).



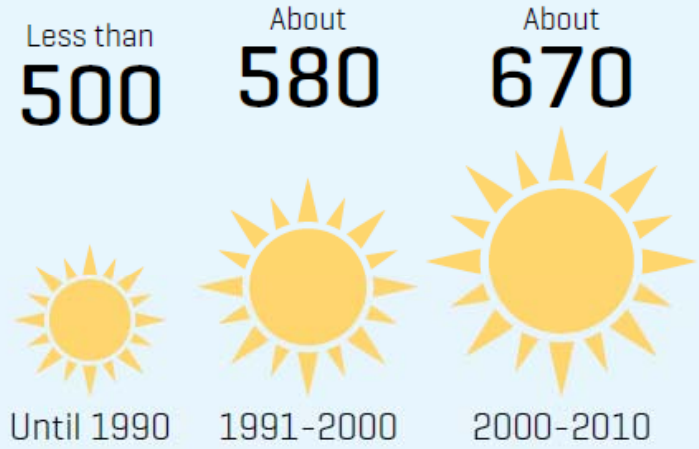
Heatwave conditions in India on 30th April 2016
(Source: - MOSDAC, Space Applications Centre, ISRO)

WORST'S YET TO COME

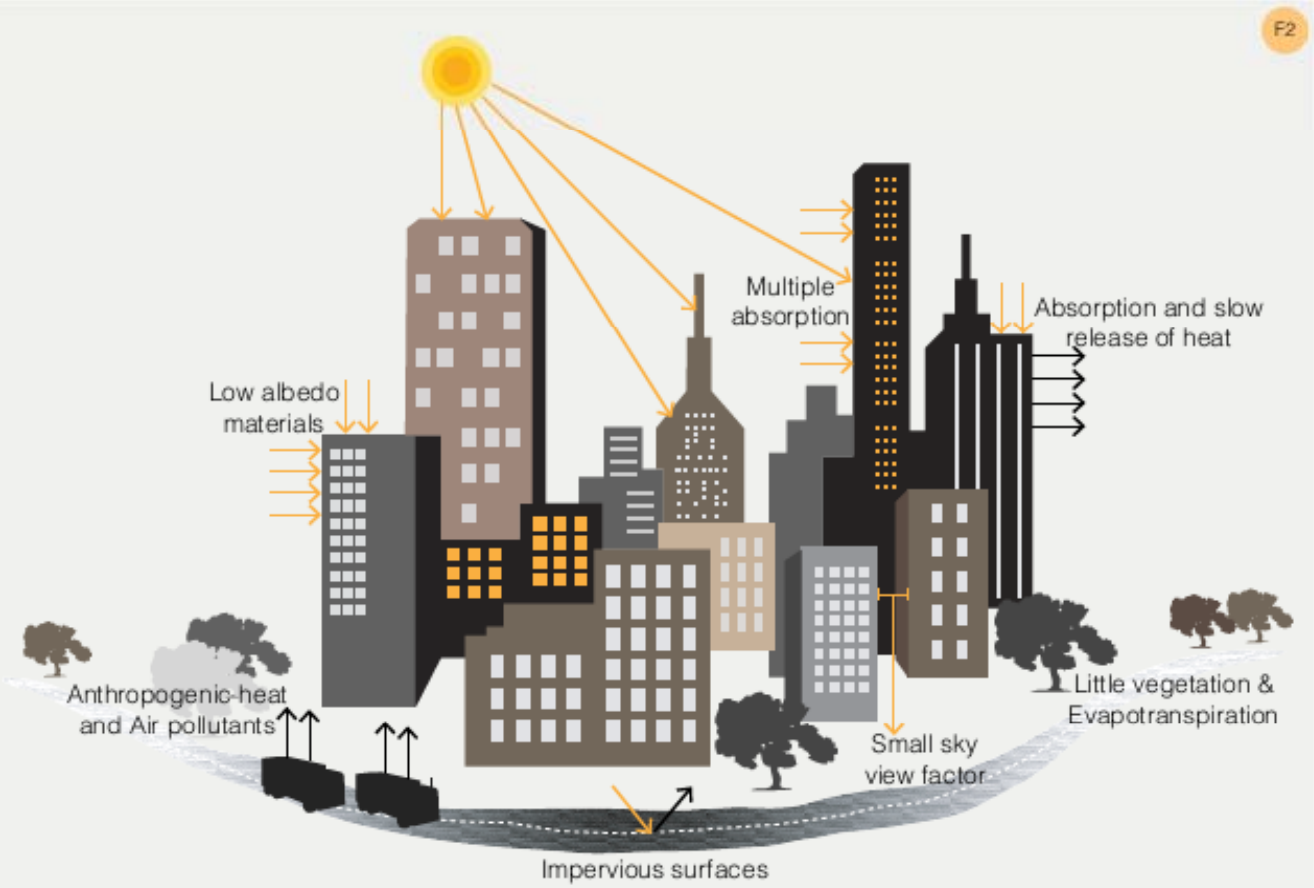
An India Meteorological Department report says that heatwaves **(40°C+ temperatures)** are recurring more frequently and with greater intensity every year.



[Source: Skymet Weather]



[Source: IMD]



Air temperatures in densely built urban environment are higher than the temperatures of the surrounding rural areas. This increase in temperatures within urban areas is know as ***"Urban Heat Island"*** *(UHI) phenomenon. The higher temperature is due to retention of heat by buildings, concrete surfaces and asphalt. Also air pollution and lesser vegetation contribute to UHI effect.*

1.2 Causes of UHI

In the recent past, UHI effect has been studied and documented in several cities around the world. Growing aspirations are bringing together financial institutions, researchers, entrepreneurs and services industry to the cities. Easy access to resources and innovative technology are leading to expansion of cities.

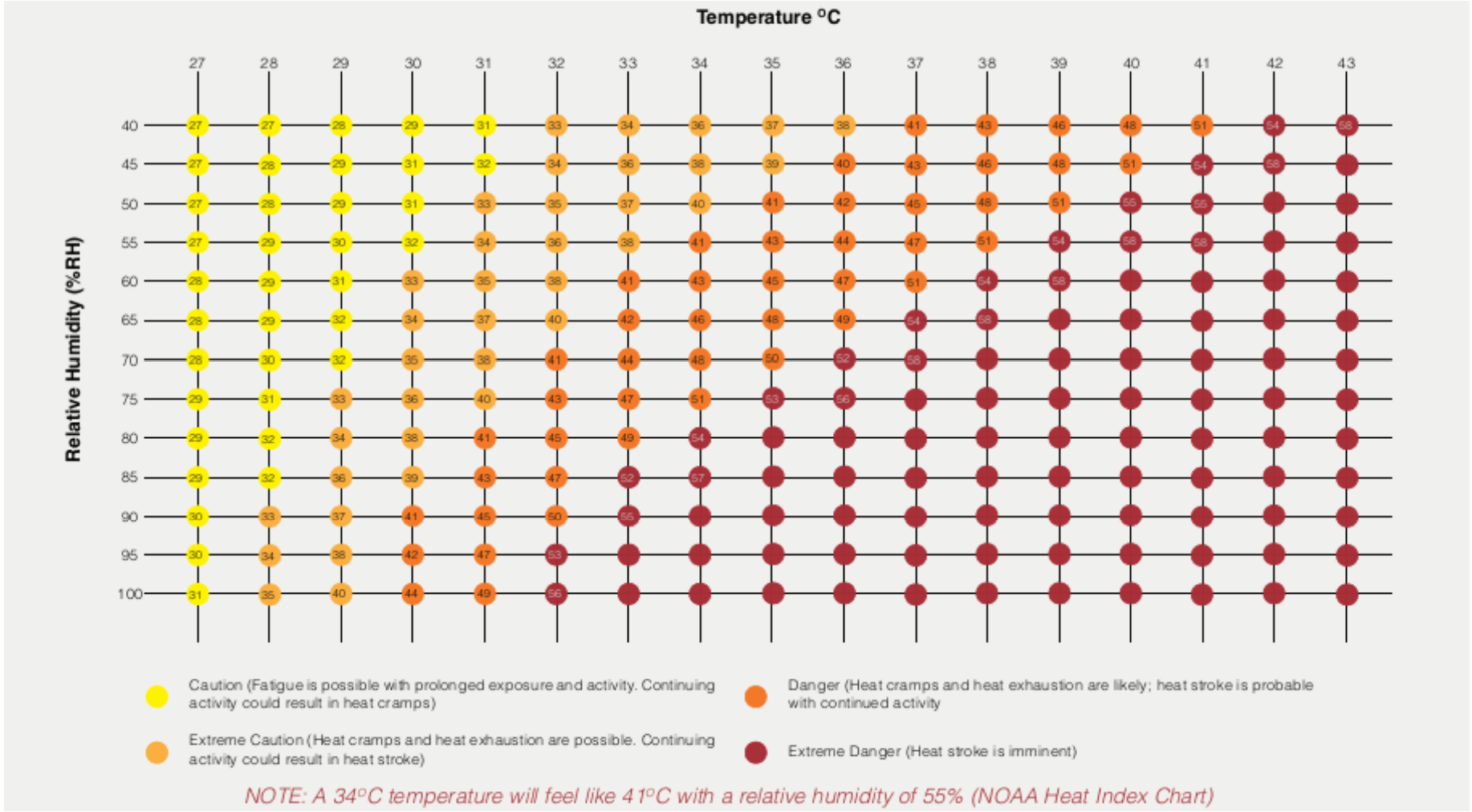
The heat gets trapped in impervious surfaces like concrete and asphalt, while disturbing the atmosphere above the city. While cities mostly have the highest concentration of pollution arising due to human activity, augmentation of heat and pollutants intensifies the urban heat island effect [2]

Several environmental factors like wind condition, humidity, precipitation, etc. play a crucial role in defining the UHI effect. Such factors are affected by increased population density and size of the city. While population density influences the land-use pattern within an urban area, there is a growing need to re-look at the traditional practices of planning. It is also predicted that in future climate change may increase the potential hazard of UHI effect [3].

Heatwave Issues

- Aggravated by heat island effect responsible for the higher heatwave mortality associated with urban centers.
- Heat impact is engulfing many areas. Besides the cities and villages these also include industries like factories and mining that emit as well as absorb considerable heat.
- Heat is significantly affecting the natural habitat as well. Increased forest fires are example of this phenomena causing huge damages to human, environmental and animal lives.
- Most severe impact of heat is felt on water resources which evaporates fast during heatwave conditions thereby increasing coping vulnerability of humans, natural habitat and economic activity including agriculture and livestock
- Indoor heat exposure is another problem that can be bifurcated into two types – household based activities, e.g., cooking using biofuels; and industrial activities that take place indoors.

Metrics for heat impacts on people: Thermal comfort index



NOTE: A 34°C temperature will feel like 41°C with a relative humidity of 55% (NOAA Heat Index Chart)

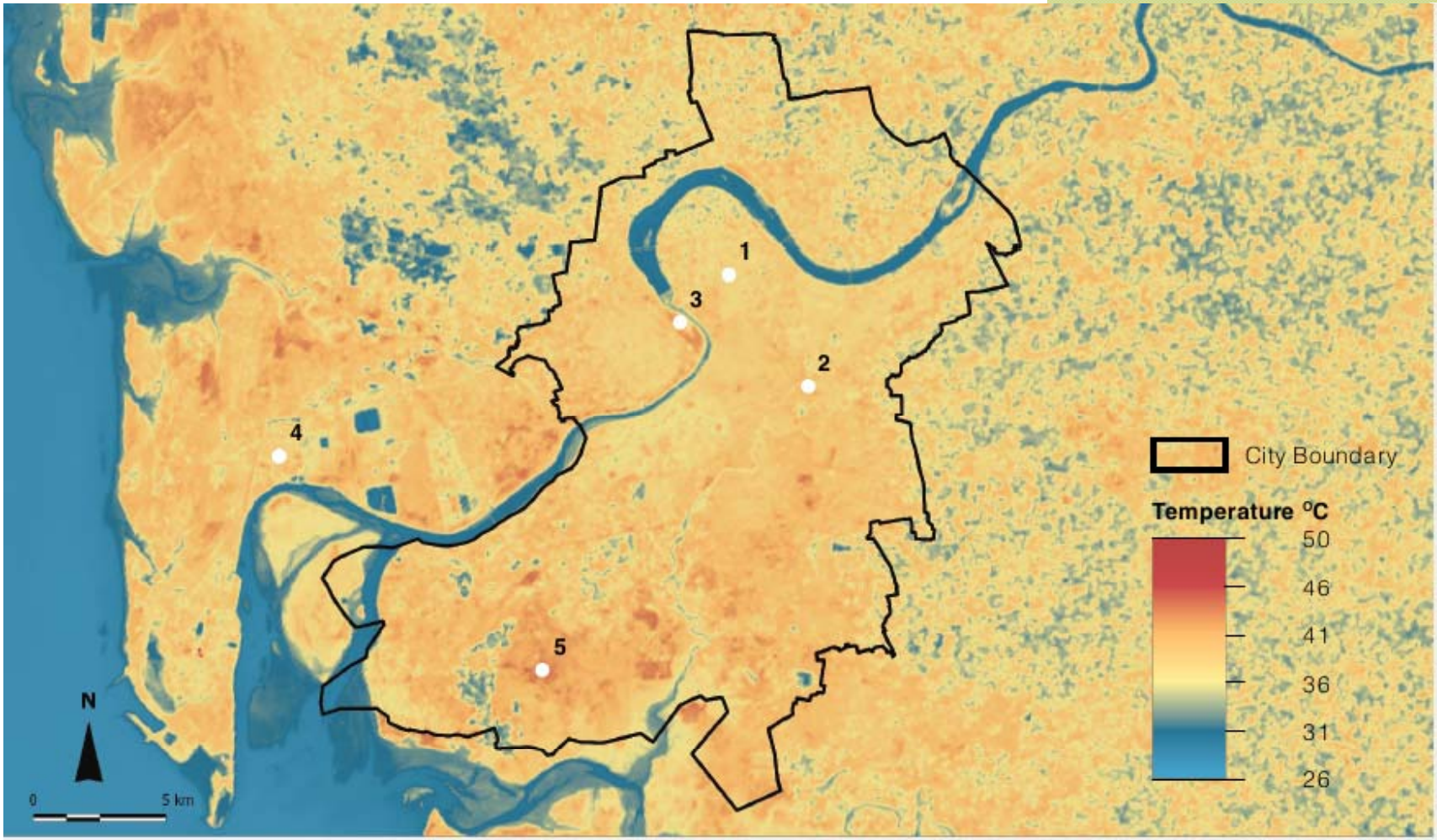
Impacts

- Along with other tropical countries, India too is feeling the impact of climate change in terms of increased instances of heatwaves which are more intense in nature with each passing year, and have a devastating impact on human health thereby increasing the number of heat wave casualties.
- Governments faced considerable challenges in tackling this issue, even when they have recognized the gravity of the situation.
- One reason is that heatwave is a slow evolving disaster that persists for many weeks unlike other fast events such as floods and tropical storms.
- IMD defined criteria for declaring Heatwaves in India
- Overall response to such extreme events remain scattered, weak and uncoordinated.

Measuring heat across scales

- Satellite measurements provide a synoptic view of the heat islands
  - Landsat 8 (Thermal Infrared Sensor (TIRS))
  - Terra & Aqua (Modis sensors)
- Ground level measurements needed to take specific action at local levels
- Indoor heat is a major issue- Building/Room level interventions necessary
- Contextual issues such as ventilation, Colling appliances, water & electricity availability etc. determine the indoor temperatures building/local levels
- Vulnerable people may require additional cooling.

IOT sensor nodes can provide cheap and granular measurements to monitor temperature in both indoor and outdoor environments and to build city level and local heat maps
Specifc Triggers can be set up to warn people.



The image shows the land surface temperature of Surat city captured in April 2013.

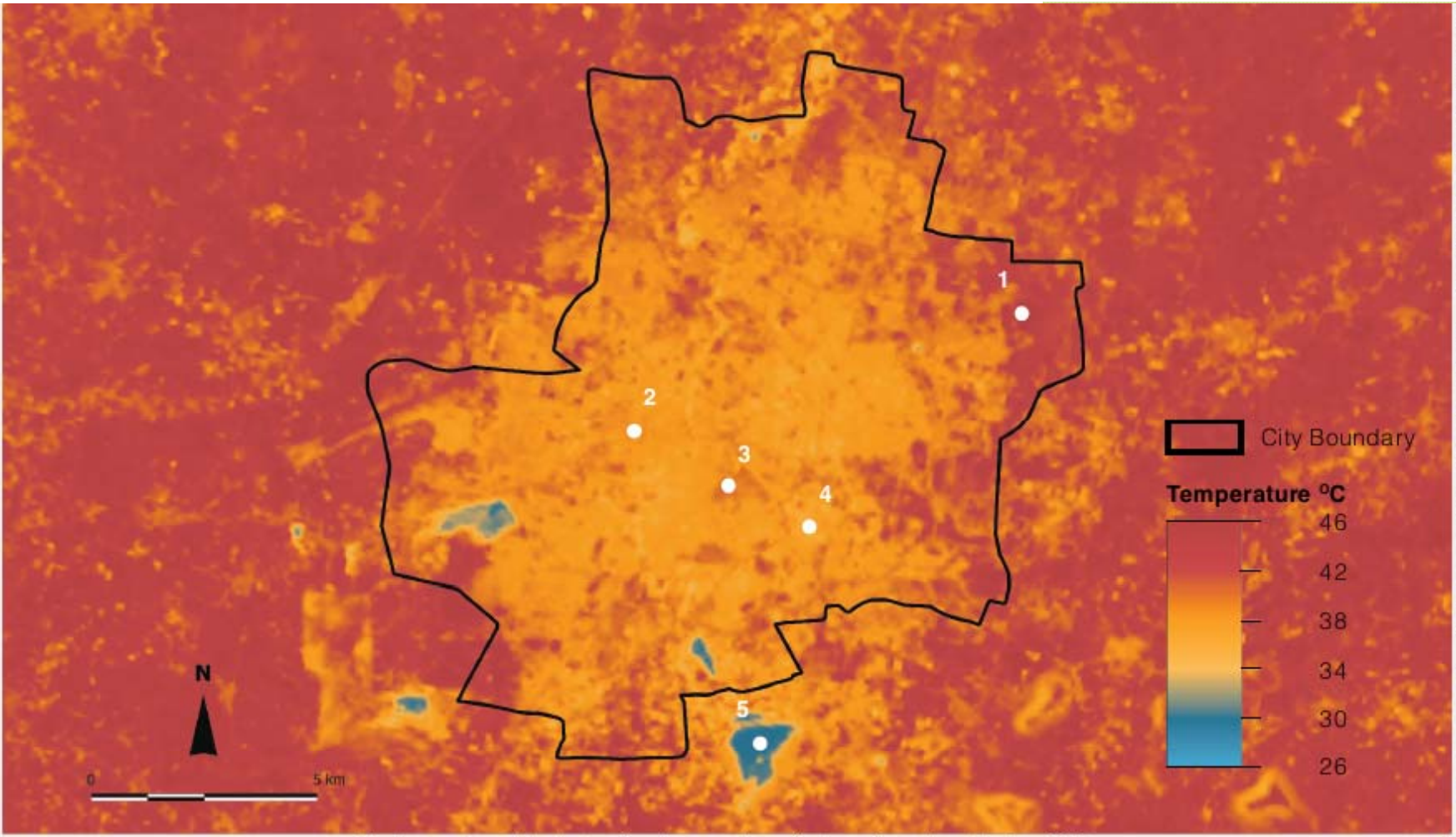
1. Residential : Avg. Temp. 37°C

2. Commercial : Avg. Temp. 39°C

3. River Bank : Avg. Temp. 39°C

4. Industrial Park : Avg. Temp. 38°C

5. Non Agricultural Land : Avg. Temp. 42°C



1. Open Land : Avg. Temp. 42°C

2. Residential : Avg. Temp. 41°C

3. Commercial : Avg. Temp. 43°C

4. Green Space : Avg. Temp. 39°C

5. Water Body : Avg. Temp. 39°C

The image shows the land surface temperature of Indore city captured in May 2013.

2. MITIGATING Rising Temperature

Almost all cities across India are reporting unprecedented summer heat extremes, which is probably due to conflation of heat island and global climate change. With the limited number of weather stations in cities, we are unable to identify hotspots and address the heat challenge. Keeping the city cooler and reduce the thermal stress will require diverse sets of actions such as increasing vegetative cover and pervious areas, cool roofs and ventilation systems, changes in outdoor working hours, diffusion of space cooling devices.

What Problems does it Address ?

- Urban heat island effects.
- Indoor and outdoor thermal discomfort.
- Ventilation and thermal discomfort challenges in Informal settlements.
- Increase in morbidity and mortality due to conflation of extreme heat and air quality.
- Increased energy consumption in air-conditioned buildings.
- Lack of granular information on hot spots.

An estimated 1.2 billion people, 16% of the global population, still do not have access to electricity. An estimated 2.7 billion people, or almost 40% of the global population who are concentrated in sub-Saharan Africa and developing Asia, still rely on the traditional use of biomass for cooking. (Source: World Energy Outlook, 2016)

What should we do ?

Science & technologies

- Develop cool/green roof and passive ventilation technologies for diverse building types.
- Develop a network of high-density low quality temperature and humidity sensors.

Policy & Praxis

- Declare extreme heat as a major health risk.
- Develop and implement heat action plans.
- Devolve local actions for mitigating urban heat effects to the communities.
- Identify the vulnerable populations and implement special measures to protect them.
- Launch mass campaigns to increase vegetative cover and reduce impervious areas.

Information

- Monitor indoor & outdoor thermal and humidity data and advocacy to take mitigative actions.
- Identify hotspots and suggest mitigative measures.
- Provide open access to heat data from neighbourhood levels and release media advisories.

Economy & Finance

- Estimate social, economic & health costs of heat extremes and benefits of "cooling the city".

Roadmap for Planning Heatwave Management in India

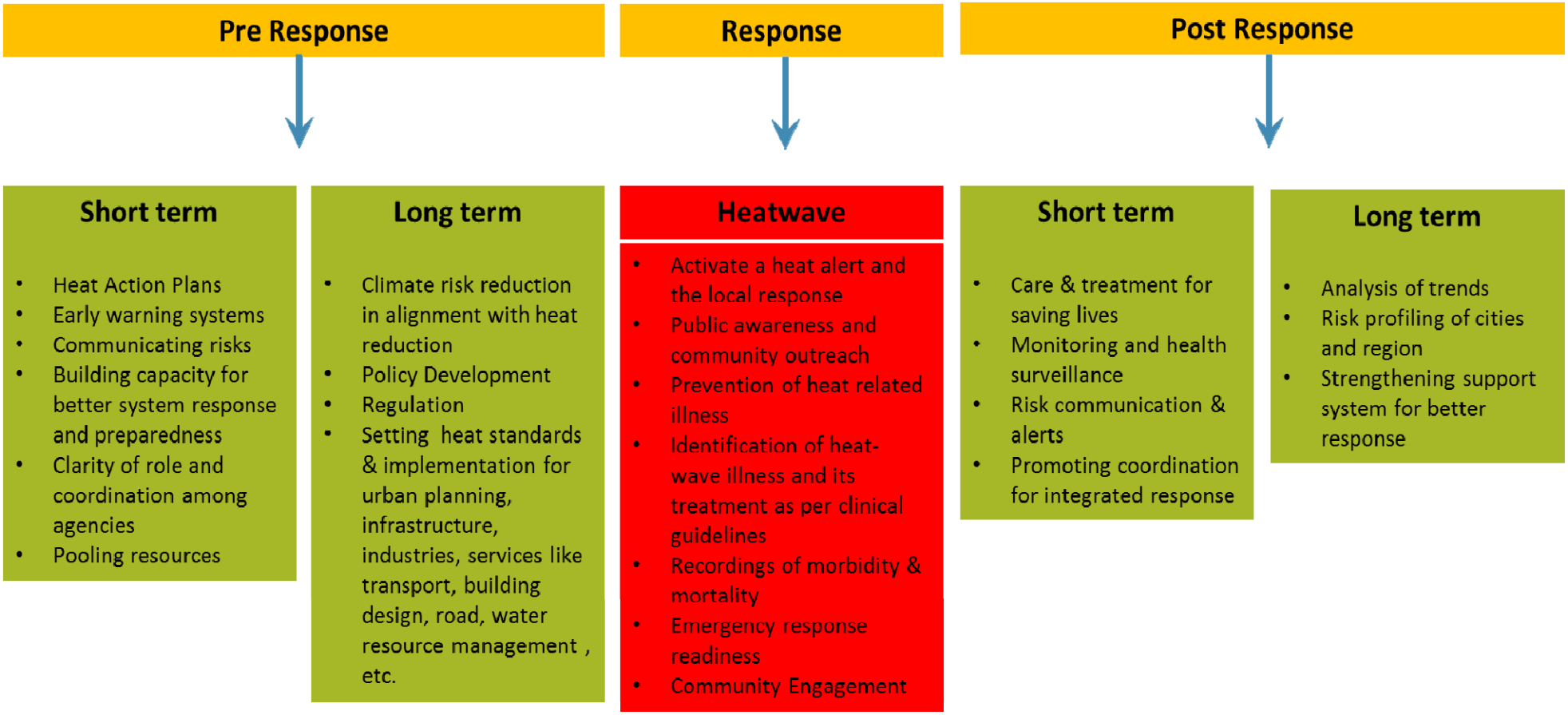
Expert group was formed to guide the process:

- Dr. Anand Krishnan, Professor, Centre for Community Medicine, AIIMS
- Dr. Anil K Gupta, Head, Division of Policy Planning, NIDM
- Dr. Anuradha Shukla, Chief Scientist, CRRI
- Ms. Meena Sehgal, Fellow, TERI
- Dr. Rais Akhtar, Adjunct Faculty, IIHMR
- Dr. Sangeet Srivastava, Assistant Professor, The Northcap University,
- Dr. Shyamala Mani, Professor, NIUA

TARU

CDKN Climate & Development Knowledge Network

Heatwave Management Framework



Lead Institution and Stakeholders

Sector/Areas	Sub-Sectors	Exposure	Sensitivity	Lead National Institution	Role/Responsibility
Urban	Transport, building road and other infrastructure and services	High	High	Ministry of Urban Development	To address heat sensitive urban planning, infrastructure, services and management issues
Health	Health system for care and treatment	High	High	Ministry of Health & Family Welfare	To ensure care of heat illness and support preparedness, monitoring and surveillance
Environment	Ecology, forest and other natural systems and habitat	High	High	Ministry of Environment and Forest; and Ministry of Earth Sciences (through IMD)	To help reduce the climate risk in alignment with heat reduction To integrate heat data with larger preventive systems at government and citizen levels
Water	Ground water, surface water, rainwater	High	High	Ministry of Water Resources, River Development and Ganga Rejuvenation	To help manage water resources in alignment with heat risks
Disaster	Earthquake, fire, heatwave, drought	High	High	Ministry of Home Affairs (though NDMA)	To respond and coordinate efforts during heatwave disasters
Industries	Service manufacturing sectors	High	High	CII/FICCI/Others	To help implement heat management framework

Mainstreaming and Programme Intervention

- Reflect on opportunities and challenges for integration of heatwave management activities into institutions through mainstreaming framework. For example, the NHAP could include a requirement that heat load and health factors be considered by relevant agencies in building approval processes and in the planning of water, road, transport and energy infrastructure.

- NHAP could also support heat health communication to be part of the communication agendas of public agencies.

- Develop Guidelines/ Programmes on coherent intervention themes. The programme could consider support for: *guidance on policy frameworks, planning and implementation, institutional arrangements, citizen engagement and mainstreaming; surveillance and EWSs; development of communication strategies and material; strengthening of care and treatment services; capacity building; R&D; innovation; etc*

..should be heat resilient

Who can do what ?

Communities (C)

- Increase area under vegetation & cool pavements in neighbourhoods.
- The indoor and outdoor temperature extremes can be reduced by 5°C using simple technologies such as increasing tree cover and cool/green/black roofs. (P+Cs)
- Insist on green housing technologies & retrofit the old buildings.
- Install public IOT sensors to monitor & report weather & air pollution. (G+Cs)

Government (G)

- Set up real time sensor network for monitoring temperature, humidity & air quality. (Cs)
- Prepare heat & air quality action plans including area/socio-economic group specific actions.
- Release regular location specific bulletins on heat conditions & hotspots.
- Declare & enforce "No Outdoor Work" periods & provide cool shelters. (Cs)
- Develop regulations for & promote green/cool/black roofs & cool pavements. (Cs+P)
- Protect & increase the green/pervious areas within the city. (C+Cs+P)
- Organise thermal comfort design competitions for dominant building types & retrofits. (C+P+Cs)

Private Sector (P)

- Develop & promote local/engineered insulating building materials. (G+Cs)
- Design built environments to withstand wind & temperature extremes.
- Use cool roofs, cool pavements in new developments.
- Allocate CSR funds to identify low-cost thermal comfort solutions. (Cs)

Civil Society (Cs)

- Manage public IOT networks & release granular heat stress information bulletins. (G+P)
- Prepare a catalogue of thermal comfort options.
- Develop heat triggers & granular advisories specially focused on vulnerable population.
- Conduct empirical research to understand UHI & its impacts.
- Develop low-cost thermal comfort options for new & old buildings.
- Build public awareness of health risks from urban heat.
- Promote tree plantations at schools, public buildings, colonies, etc. (C+G)
- Build capacities of health workers to recognise & treat heat-related illnesses.

Capacity Building and Communication

- A comprehensive capacity building plan, including a summary of capacity building needs of all major stakeholders, options to increase capacity and arrangements for their implementation.
- A comprehensive communication plan, including a summary of communication needs of all major groups, direct and indirect communication methods for responding to identified needs and arrangements for implementation.
- Citizen Engagement Plan which details the way forward in terms of reaching citizens with identified messages and ensuring individual and collective action in response to heat health issues (complementing institutional efforts in the direction).
- A budgetary assessment related to capacity building and communication activities with cost-effective analysis of different interventions.

Cool Roofs

Cool Roofs

Cool roofs have reflective surfaces that reduce heat transfer through the roof into the building. These roofs have the potential to reduce energy demands for air conditioning by enhancing the thermal performance of the roof by reflection and insulation. The term cool roof encompasses an extensive array of roof types, colours, textures, paints, coats and slope applications.

Characteristics Of Resilience

Flexible · Redundant · Modular · Resourceful · Learning · Safe-fail

Requirements

- Thorough check of the condition of the existing roof including cracks, tears, blisters, exposed foam and open seams.
- Proper cleaning of the surface with water.
- Trained personnel to lay the cool roof.

Broken China Mosaic

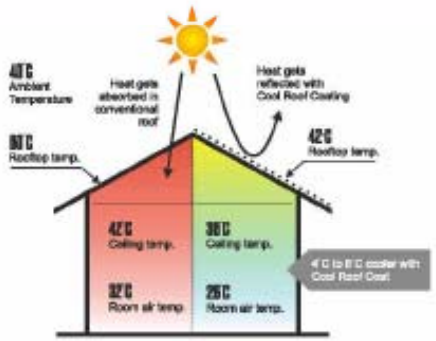
This is the most commonly used technique in India that uses well-graded broken pieces of glossy glazed tiles. These tiles, preferably white, are embedded in wet mortar to provide a smooth surface. This mosaic provides an inexpensive cool roofing option, with the roof reflecting up to 80 per cent of the incident solar energy as compared to 20–40 per cent by a conventional roof. It is cost-effective as waste glazed tiles are cheap.

Inverted Earthen Pot

Covering flat roofs with inverted earthen pots is an easy and cost-effective method to reduce solar gain. In this method, the roof is covered by inverted earthen pots, placed in continuous rows and the space between the pots is filled with cement or lime mortar. The air gaps created by the inverted pots create insulation, thereby reducing heat transfer. It is a traditionally used low cost method of increasing the roof insulation.

Slate or Tile

These roofing products are commonly used in buildings with sloping roofs. Slates and tile products are available with sun-reflective surfaces in a wide range of colours. Additionally, the dense earthen composition of slate and tile products provides increased thermal mass, yielding additional energy savings. White coloured tiles have a high solar reflectance of about 70 per cent, which is almost double the reflectance level of regular red tiles.



Benefits

- Increased indoor comfort, especially during hot summer months.
- Reduced energy demand for space cooling, resulting in **energy savings, typically from 10 to 30 percent.**
- Decreased roof maintenance costs due to **longer roof life.**
- Lower air temperatures resulting in better thermal comfort to the occupants.
- Lower **carbon dioxide emissions** from electricity generating power plants.
- **Decrease of 5 °C to 10 °C** in room temperature.
- Regular cool roof methods like china mosaic, need least maintenance and **pay back the cost within a year** through energy saving.
- Some of the cool roof paints can also be **applied on the walls** to reduce the heat gain from walls.

Barriers

- High capital costs.
- Only useful for the top floors of the building. Some of the cool roof paints can be used to reduce heat gain from walls also.

Earth Air Tunnels

Earth Air Tunnels

It is a system for cooling the air by passing it through a system of underground tunnels or tubes. The system has been in use for thousands of years and the best examples can be seen in Islamic and Persian architecture. As the temperature at a depth of a few metres under the ground, remains lower and constant round the year, the air passing through the tunnel gets cooled. In India, it is commonly known as earth tunnels.

Characteristics Of Resilience

Flexible · Redundant · Modular · Resourceful · Learning · Safe-fail

Requirements

- A network of pipes made of concrete, PVC, steel, rigid or semi-rigid plastic.
- Proper length and depth of the tunnel below the ground.
- Proper space around the house to lay the system with minimal turns and bends to allow minimal friction losses.
- Controllable fans to help the system function at optimum levels.

What it is all about...

The temperature of the earth below 3-4 m depth remains constant throughout the year. The air that stays in the underground tunnels gets cooled over time. This system has an underground tunnel network and mechanism to continuously transfer the cool air into the building. The length of the tunnel network is carefully designed to cool specific volume of indoor space. The air inside the tunnel stays for a certain length of time beneath the ground and gets sufficiently cooled before it is drawn in to the building.

Design Guidelines

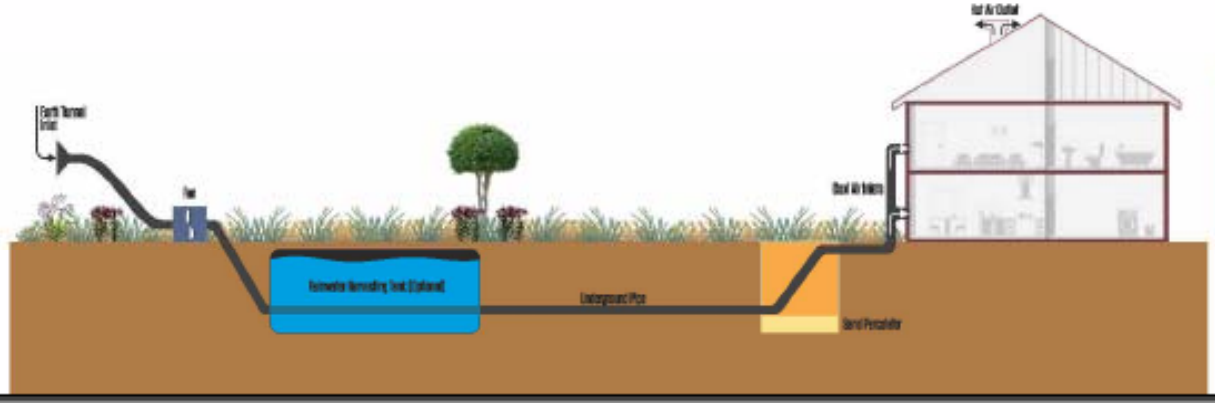
- The depth should be at least 4 m below the ground for constant ground temperature.
- The length of the tunnel should be limited to 60–70 m for optimum results.
- It can be constructed using any type of pipe, concrete or masonry.
- The diameter of the pipe should preferably be at least 0.15 m.
- The ground above the pipes should be loose or covered with lawn.
- Avoid 90° turns for smoother air flow.

Earth tunnels are aided by...

Wind Tower: It uses a tower or a stack where hot air rises up and moves out. The tower is like a chimney that projects out of the roof. It can also double up as a wind catcher. It helps in sucking in cool air and letting it flow down into the living areas and removes hot air from the leeward side of the wind.

Landscaping: The presence of vegetation helps in reducing the underground temperature considerably. The earth gets shade and is wetted by sprinkling water. This water seeps through and dampens the tunnel walls, thus cooling the passing air. Also, the presence of water helps in cooling the air through evaporation.

10°	2/3	100%	70%
Reduction in internal temperature, in comparison to the external temperature during peak hot seasons.	The average reduction in electricity when compared to using conventional air conditioners.	Availability of fresh air and reduction in the bacterial levels.	Cost saving with respect to conventional air conditioning system.



Benefits

- Earth air tunnels are effective alternatives to mechanical air conditioners, with negligible energy costs. They also help in enhancing the indoor air quality by circulating air.
- By reducing the energy consumed for air conditioning, they indirectly help in reducing greenhouse gases emissions from thermal power plants.
- This system allows circulation of fresh air that is not possible in conventional air conditioning. This system facilitates better indoor air quality and is especially beneficial for public buildings.
- As the use of mechanized air conditioning is reduced or eliminated, the bacterial and fungal load in the air is reduced. This helps eliminate various health issues that are caused by fungus and bacteria.

Barriers

- Land area around the building is required.
- High capital costs.

Did you know!!!

The earth air tunnel system installed at New Kar Bhuvan at Jaipur is used to provide comfort for an area of 2,200 sq. ft. at a comfortable indoor temperature of 28 °C, even when the temperature outside is above 40 °C.

Thank You

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