This module, titled "Nature-Based Solutions to Tackle Urban Heat in Cities," is second part of a three-part capacity building training developed by WRI India, UrbanShift, and Cities4Forests. It aims to equip learners with knowledge and strategies to address urban heat through nature-based solutions.

Contents

The content of this self study module is divided into 5 parts:

1. **Urban Heat and Temperature rise:** Understanding is urban heat and what causes rise in temperatures,
2. **Its impacts on health:** Effects of extreme heat on human health
3. **Scientific approaches to greening and Nature based solutions:** Step by step approaches to adapt to urban heat,
4. **Case studies:** Real world examples from cities that have attempted to bring down urban temperatures and
5. **Plans and policies:** Some reference of plan/policies/programs that are needed for short-term and long-term heat resilience through greening.

Video: Tackling Urban Heat in Mumbai

The video shows how geospatial tools can be used to understand high heat risk zones in a city. This helps in strategizing where to prioritize greening activities

Source: GoogleEarthEngine, YoutTube, 2022

This segment highlights Google Earth Engine, a powerful geospatial tool, demonstrating how it can be leveraged to measure and visualize urban heat patterns. The purpose of including this tool in the presentation is to emphasize the importance of data-driven decision-making in urban greening initiatives. By generating heat maps, planners and policymakers can identify high-risk zones where temperatures are most severe, allowing for targeted interventions such as tree planting, green roofs, or cool pavement installations.

Furthermore, these geoanalytic tools provide evidence-based insights that are critical for advocating urban greening policies with local governments. Accurate heat mapping not only helps prioritize resource allocation but also strengthens the case for climate-responsive urban planning, ensuring that interventions are both strategic and impactful.

The video is about google earth engine, a geo-spatial tool, which can be used to measure heat and create targeted approaches towards greening. The heat map through this tool or other geoanalytic tools is extremely useful to carefully plan where to prioritize greening in the city and also for advocating the same with local governments.

How to Define Urban Heat?

In the sections below we'll explore the following key question:

- What exactly is urban heat, and how do we define it?
- Why do cities feel significantly hotter than surrounding areas?
- What are the real-world impacts of this increased heat on people and communities?

In this section, we'll break down these critical questions by examining:

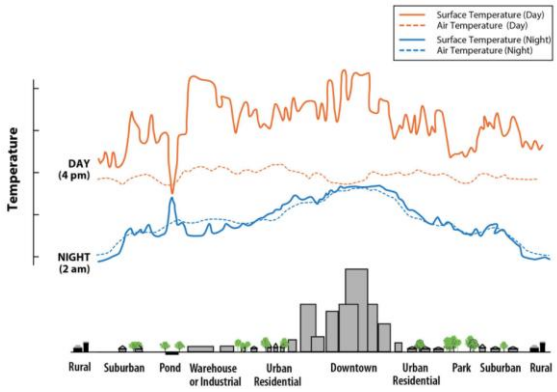
- **Urban Heat Islands (UHIs):** What they are, how they form, and why they matter
- **Land Surface Temperature (LST):** How scientists measure urban heat patterns

Through clear explanations, real-world examples, and visual aids, you'll gain a comprehensive understanding of urban heat dynamics.

Urban Heat Islands

An **urban heat island** (UHI) is a phenomenon where **urban** area is significantly warmer than its surrounding rural areas due to intense human activities.

Land surface temperature and Air temperature at various spots has to be recorded to calculate UHI.

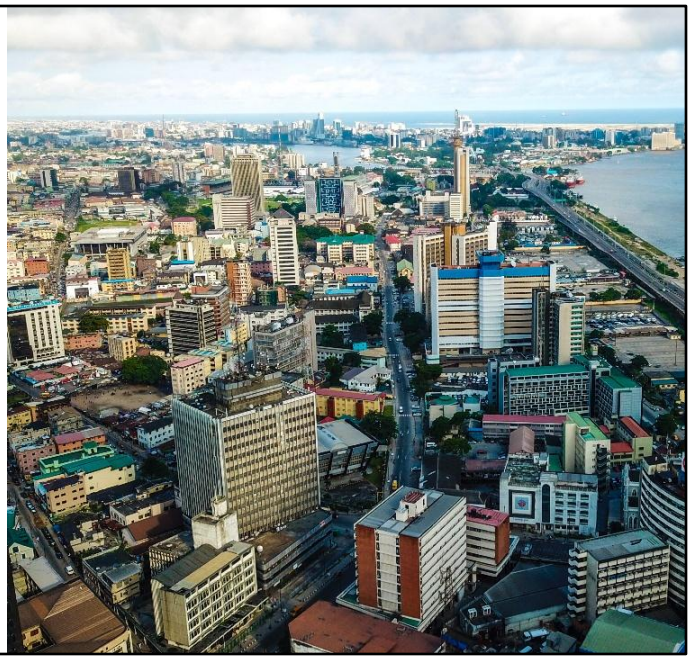


Source: *U.S. Environmental Protection Agency*

The slide explains the concept of urban heat islands. As depicted in the image, temperatures tend to be higher in urban areas due to extensive built-up surfaces, in contrast to surrounding rural areas, which retain significant green and blue spaces. Additionally, nighttime temperatures remain elevated in cities because heat-absorbing surfaces such as concrete, asphalt, asbestos, and glass take longer to cool compared to rural areas with lower built densities.

Urban Heat Islands:
A. Lagos, Nigeria (1986-2017)

- Urbanization in Lagos led to a significant temperature rise—up to 6.4°C higher in urban areas compared to rural surroundings.
- Vegetation loss of 20% and increased built-up areas fueled the urban heat island effect.
- Adaptation Strategy: Expanding green spaces and enhancing urban forestry are critical to cooling the city.



Let's look at some case studies from Lagos and New York that demonstrate the concept of UHI better.

Lagos, Nigeria, serves as a striking example of how rapid urbanization can intensify the Urban Heat Island effect. According to a 2022 study published in *Advances in Climate Change Research*, urban areas in Lagos experienced a temperature increase of up to 6.4 degrees Celsius compared to surrounding rural areas between 1986 and 2017.

This significant temperature rise is linked to a 20% loss in vegetation cover and a dramatic increase in built-up areas during this period. The loss of greenery reduced the city's natural cooling capacity, while the proliferation of impervious surfaces, such as roads and buildings, trapped more heat.

To mitigate this impact, the study emphasizes adaptation strategies like expanding green spaces and urban forestry. These measures are essential for cooling urban areas, improving air quality, and enhancing overall resilience to climate change.

This example underscores the importance of integrating nature-based solutions into urban planning, particularly in rapidly developing cities like Lagos.

Source: https://www.sciencedirect.com/science/article/pii/S2666049022000202

In New York City, for example, the annual mean air temperature can be 1.8–5.4°F (1–3°C) warmer than its surroundings, with evening differences as high as 22°F (12°C). The UHI effect has significant environmental and public health impacts, including increased energy demand, higher air conditioning costs, elevated air pollution and greenhouse gas emissions, and a rise in heat-related illnesses and mortality.
To combat these challenges, cities can implement strategies such as increasing vegetation through parks and green roofs, using reflective materials for pavements and buildings, and enhancing urban planning to include more green spaces. These measures can help mitigate the UHI effect and promote a healthier urban environment.

Source:
https://www.nyc.gov/assets/dep/downloads/pdf/environment/education/10-analyzing-urban-heat-island-effect.pdf

Land Surface Temperature (LST)

- **Land surface temperature** is how hot the "surface" of the Earth would feel to the touch in a particular location. From a satellite's point of view, the "surface" is whatever it sees when it looks through the atmosphere to the ground.
- It could be snow and ice, the grass on a lawn, the roof of a building, or the leaves in the canopy of a forest.
- LST is mapped by Remote Sensing method.

Source: *Text:* NASA Earth observations; Image: *International Journal of Urban Sciences · June 2018*

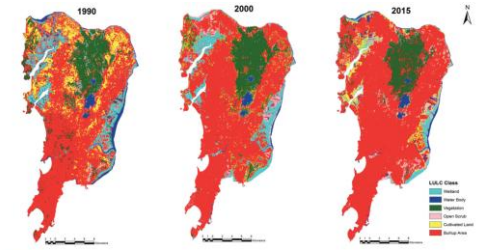


Figure 2. Land use/land cover map of Mumbai in 1990, 2000 and 2015.

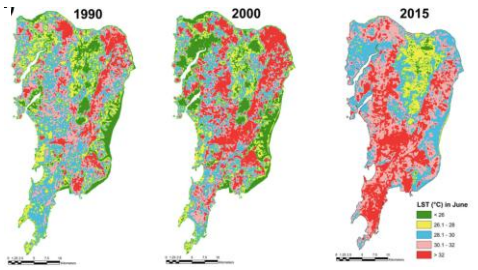


Figure 3. Land surface temperature in Mumbai city (1990–2015): (A) January, (B) June and (C) October.

In the video referenced earlier (Slide 3), the heat map was measuring **Land Surface Temperature (LST)**. But what exactly is LST?

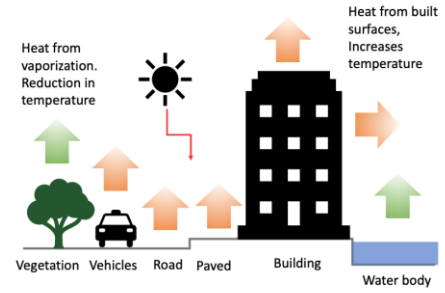
Land Surface Temperature (LST) is the measurement of how hot the Earth's surface would feel to the touch from a satellite's perspective. Different surfaces, such as rooftops and vegetation, exhibit varying temperatures, which are captured in heat maps.
The figure presented here demonstrates **the heat map of Mumbai, India**.

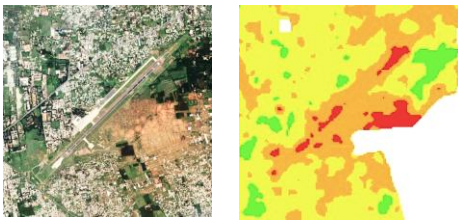
- The **top three maps** illustrate changes in land use over time.
- The **bottom three maps** show the corresponding changes in temperature due to these land-use shifts.

For example, areas within forests that previously had lower temperatures (below **26°C**, shown in green) have experienced a reduction in vegetation density, leading to an increase in temperature (**26–28°C**, represented in yellow). Similarly, mangrove regions that have been replaced by built-up areas also show noticeable temperature increases.
These heat maps serve as **important indicators** of rising temperatures, especially in **vulnerable neighborhoods**, helping identify areas that may experience more intense heat stress.

Causes of LST

- Greenhouse gas emissions globally
- Vegetation is being replaced by asphalt and concrete (impervious surfaces) for roads, buildings and paved public places. These surfaces absorb—rather than reflect—the sun's **heat**, causing surface temperatures and overall ambient temperatures to rise.
- Exposed bare soil – dried agricultural land or open plots
- Large scale infrastructure projects





Source: Coimbatore airport in satellite image and corresponding LST (created by Author)

As illustrated in the figure, certain materials—such as concrete in buildings, asphalt on roads, and metal in vehicles—absorb and retain heat from the sun. This leads to an increase in both surface temperatures and overall ambient temperatures in urban areas.
In contrast, trees, vegetation, and water bodies help cool their surroundings through evapotranspiration and vaporization, reducing temperatures and providing a natural cooling effect.

For example, in the satellite image of Coimbatore city, a large infrastructure project like an airport exhibits higher land surface temperatures due to the extensive use of concrete and asphalt for structures and runways. In comparison, the surrounding green areas show significantly lower temperatures, highlighting the role of vegetation in reducing heat.

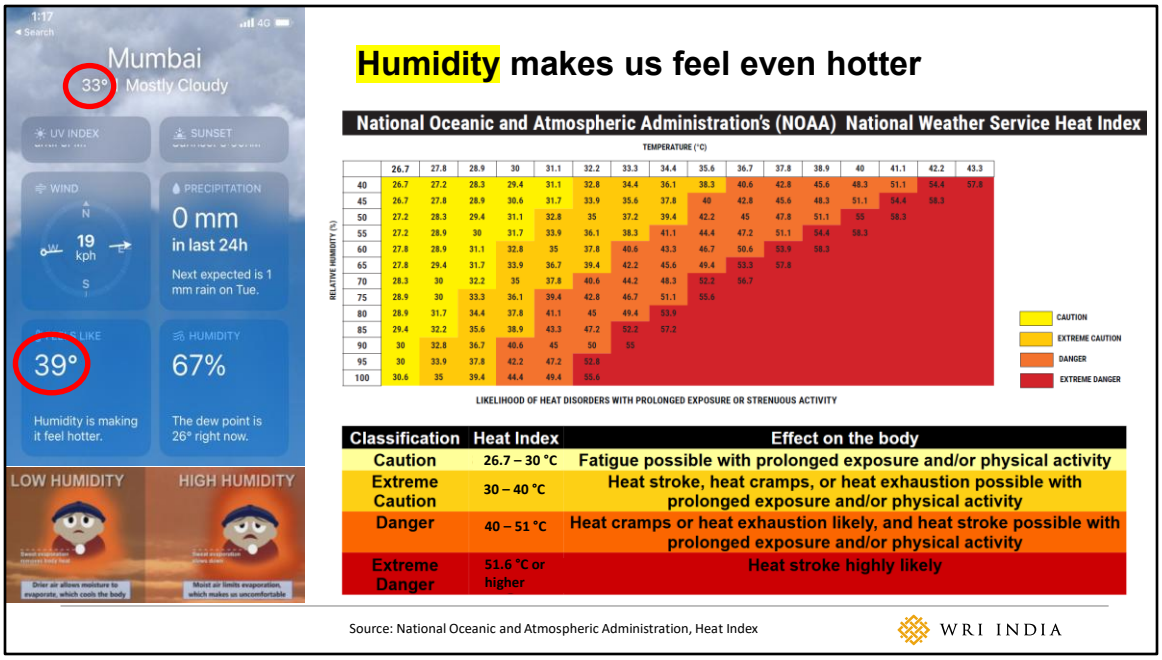
Impact on health

In this section, we will explore the Heat Index—a measure that combines temperature and humidity to indicate how hot it feels to the human body.

We will also examine the effects of heat on human health, including:

- Increased risk of heat-related illnesses such as heat exhaustion and heatstroke.
- Worsening of pre-existing health conditions like cardiovascular and respiratory diseases.
- The disproportionate impact on vulnerable populations, including the elderly, children, and outdoor workers.

By understanding these impacts, we can better identify strategies to mitigate urban heat risks and build more heat-resilient cities.



Heat is often called a silent killer because its effects can be gradual yet deadly. However, what makes it even more dangerous is humidity—a lesser-known but powerful factor that amplifies how hot we actually feel.

This is where the Heat Index comes in. It combines air temperature and humidity to measure the "feels-like" temperature, which is what truly impacts our bodies.

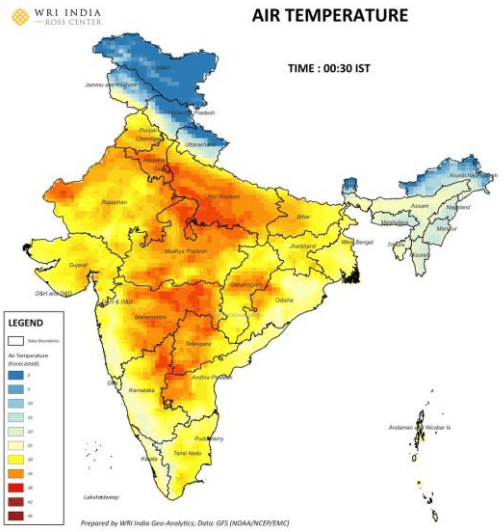
Why Does Humidity Make It Worse?

- Our body cools itself by sweating, but the process works only when sweat evaporates.
- In humid environments, the air is already saturated with moisture, slowing down sweat evaporation.
- As a result, the body struggles to cool itself, making us feel hotter than the actual temperature.

For example, in Mumbai, when the temperature is 33°C, it can actually feel like 39°C due to high humidity levels. This is why heat warnings are issued based on the Heat Index rather than just temperature alone.

Heat Waves

- Heatwave is a prolonged period of much-warmer-than-average weather of that region. They are caused due to high pressure zones and trapping heat.
- Climate change is a significant factor contributing to increasing frequency and intensity of heatwaves.
- Greenhouse gas emissions, heat-absorbing surfaces in cities, contribute further by trapping heat for longer.



Source: WRI India blog on 'Measuring and Mapping a Heatwave', 2022 (Author: Raj Bhagat Palanichamy)

What are Heat Waves?

A heat wave is a prolonged period of unusually high temperatures, significantly warmer than the average for a particular region. These extreme temperatures can last for days or even weeks, posing serious risks to human health.

Why do Heat Waves occur?

Heat waves occur when high-pressure systems trap warm air in a region, preventing cooler air from moving in. This phenomenon is exacerbated by climate change, which intensifies heat waves by making them longer, hotter, and more frequent.

However, local factors also make heat waves worse:

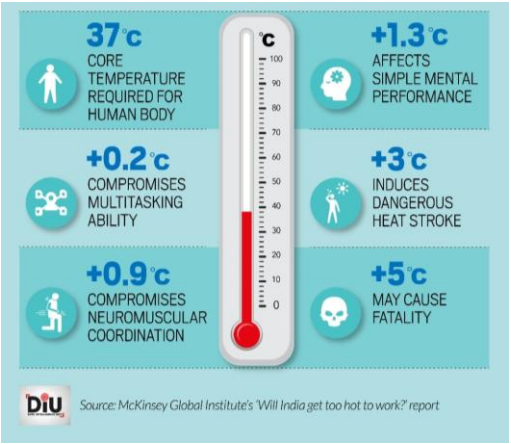
- Urbanization: Concrete, asphalt, and metal structures absorb and retain heat, raising temperatures in cities.
- Greenhouse Gas (GHG) Emissions: Increased emissions from vehicles, industries, and energy use contribute to rising global and local temperatures.
- Lack of Cooling Infrastructure: Many people cannot afford air conditioning or access cooling shelters, leaving them vulnerable to extreme heat.

How does urban heat impact health?

Temperature extremes
1. Comprises the body's ability to regulate its internal temperature.

2. Loss of internal temperature control leads to
- heat cramps,
- heat exhaustion,
- heatstroke.

3. It also worsen chronic conditions such as cardiovascular disease, respiratory disease, cerebrovascular disease, and diabetes-related condition.



Source: *Capacity Building on Climate Change in Mumbai*, co-developed with BMC's EHO dept

Our body maintains a core temperature of 37°C, but with every degree rise beyond this, heat begins to impact us—both physically and mentally.
When temperatures exceed 37°C, especially during prolonged heat waves, the effects can range from mild discomfort to life-threatening conditions.

Temperature Thresholds:
- +**0.9°C above normal:** may/can Impairs neuromuscular coordination, potentially leading to reduced precision and slower reactions in some individuals.
- **+3°C:** Can significantly increase the risk of life-threatening heatstroke, with symptoms such as confusion, loss of consciousness
- **+5°C:** Conditions are often associated with sever physiological stress and heightened risk of fatal outcomes in the absence of immediate medical intervention.

As heat waves become more frequent and intense, protecting vulnerable populations becomes critical.

According to the **World Health Organization (WHO)**, certain groups are at higher risk during extreme heat events:

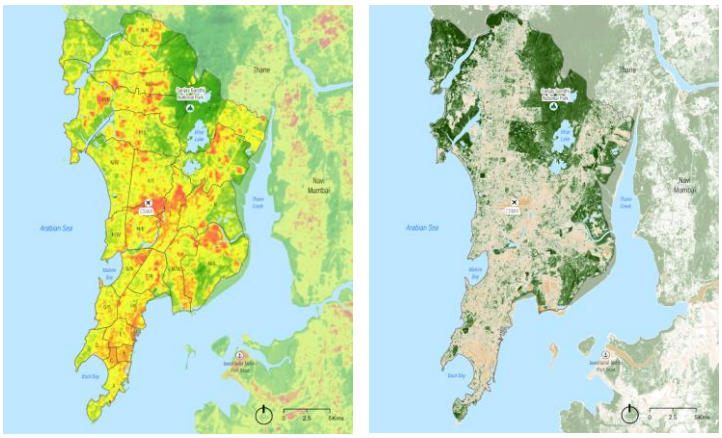
- **Older Adults and Persons with Disabilities** – Reduced ability to regulate body temperature increases their vulnerability.
- **People with Pre-Existing Health Conditions** – Those with cardiovascular diseases, respiratory illnesses, and diabetes face greater health risks.
- **Pregnant Individuals** – Heat stress can affect both maternal health and fetal development.
- **Infants and Children** – Their bodies heat up faster than adults, making them highly sensitive to extreme temperatures.
- **Outdoor and Manual Workers** – Construction workers, farmers, and street vendors face prolonged exposure to heat.
- **People in Substandard Housing** – Poor ventilation and lack of cooling options worsen heat stress.
- **Low-Income, Displaced, or Homeless Individuals** – Limited access to cooling, hydration, and medical care puts them at severe risk.
- **Athletes and Outdoor Event Attendees** – High-intensity physical activity in hot environments increases the chances of heat-related illnesses.

Heat & Greening: Correlation

This section will explain how **heat** is correlated with **green cover**.

Urban areas with less vegetation experience higher temperatures due to the heat-absorbing properties of concrete and asphalt, leading to the Urban Heat Island (UHI) effect. Increasing green cover through trees, parks, and vegetation helps cool cities by providing shade, promoting evapotranspiration, and improving air quality. Nature-Based Solutions (NbS), such as urban forests, green roofs, and water bodies, offer sustainable ways to reduce heat stress while enhancing climate resilience, biodiversity, and overall urban well-being.

Correlation: LST x Green Cover



Source: MCAP, 2021

With reduction in a city's green cover there is a rise in land surface temperature. The LST map and green cover map can be created to observe this correlation over the years.

Over the years, the loss of green cover in Mumbai has directly contributed to rising land surface temperatures (LST) in affected areas. Studies have shown a clear relationship between vegetation loss and temperature increase.
This also means that **restoring green spaces in high-temperature zones can help cool these areas**.

Minimizing Local Temperatures

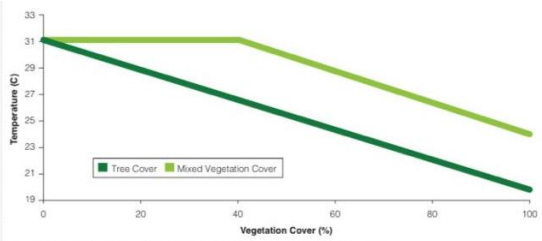


Figure 1: The modelled relationship between vegetation cover and land surface temperature

"When vegetation cover is greater than 40% of a total area, a 10% increase in vegetation leads to a reduction in LST of more than 1C. However, when mixed vegetation cover is less than 40%, there is no reduction in LST."

Source: NSW Office of Environment

Studies have shown a direct correlation between green cover loss and rising temperatures. For example, a report from New South Wales (NSW) found that increasing tree cover by 10% in a given area can reduce temperatures by approximately 1°C. However, to maximize cooling benefits, it is crucial to have a diverse mix of vegetation rather than relying on a single species, as mixed vegetation enhances resilience and provides better climate adaptation.

Minimizing Local Temperatures: A. Kigali, Rwanda (1990-2020)

Urban expansion led to a 502% increase in built-up areas, with a simultaneous 29% decrease in open land.

- This resulted in higher land surface temperatures, particularly during the dry season, with increases of up to 0.51°C per decade.

Mitigation:

- Expanding green spaces and urban afforestation helped stabilize and slightly increase forested areas by 141% over the same period.

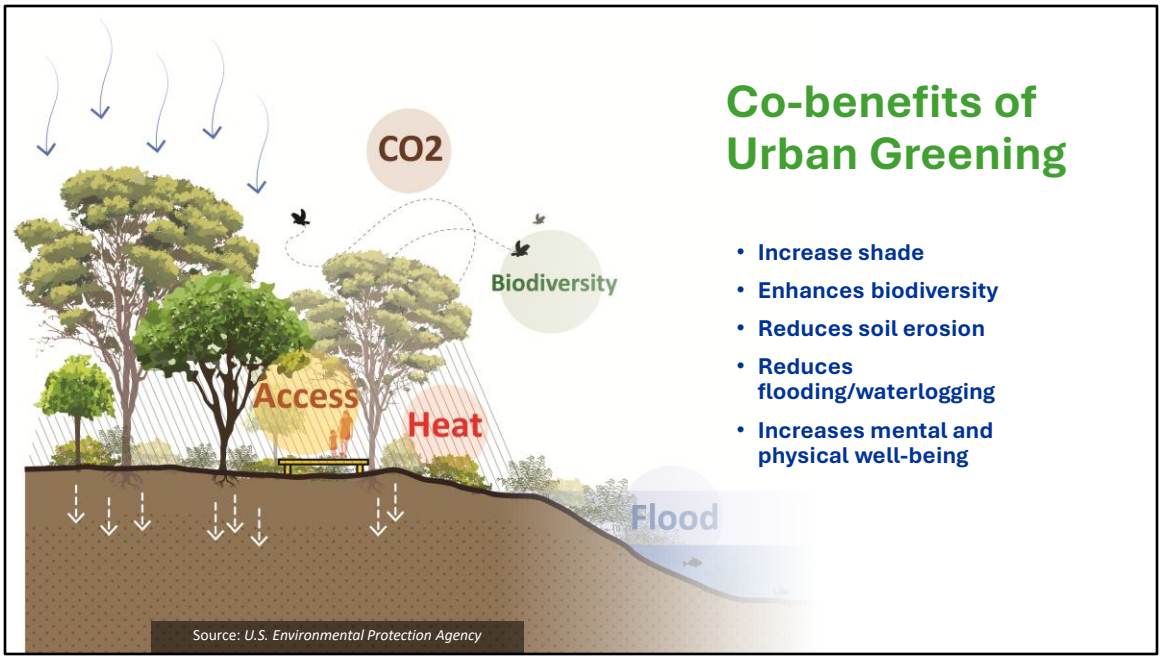
Impact:

- Urban tree planting initiatives aim to reduce heat, improve air quality, and mitigate the urban heat island effect.

Let's look at some case studies from Kigali and Barcelona that demonstrate the concept better:

Kigali, Rwanda, offers a compelling example of the impact of urbanization on local temperatures and the measures taken to mitigate these effects. Between 1990 and 2020, urban expansion in Kigali led to a staggering 502% increase in built-up areas, accompanied by a 29% decrease in open land.
This shift significantly contributed to higher land surface temperatures, particularly noticeable during the dry season, with an observed temperature increase of up to 0.51 degrees Celsius per decade.
To address this challenge, Kigali has implemented strategies focused on expanding green spaces and urban afforestation. These measures have successfully helped stabilize and increase forested areas by 141% over the same period.
Moreover, urban tree-planting initiatives in Kigali aim to reduce heat, improve air quality, and mitigate the urban heat island effect. This case demonstrates the critical role of nature-based solutions in balancing urban growth and environmental sustainability.

Source: https://www.sciencedirect.com/science/article/pii/S266597272400120X



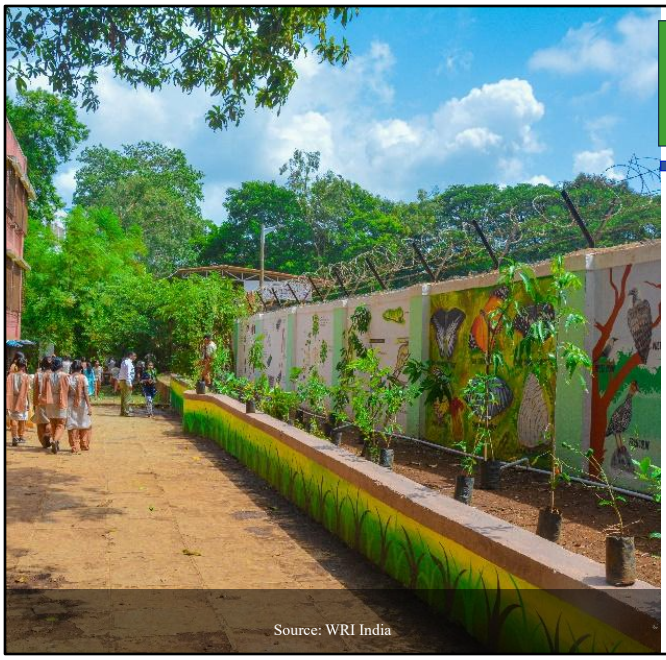
There are numerous benefits and co-benefits to urban greening. Urban greening not only helps lower temperatures but also supports biodiversity, prevents soil erosion, reduces the risk of flooding, and offers numerous health benefits.

Nature based Solutions are:

1. Solutions that offer benefits to the urban ecosystem and maintain or **restore key ecological processes** that are characteristic to or reflect the natural condition expected in a region.
2. Solutions that mitigate climate risks and enhance human well-being by promoting social, cultural, recreational, and health **co-benefits**
3. Solutions that help transition towards a **nature-positive economy** while maintaining resource efficiency and promoting circularity.

Scientific Approach to Greening

It is essential to adopt a scientific approach to urban greening for long-term success. While large-scale tree plantation drives are often organized by societies and NGOs, many fail over time due to a lack of proper planning and scientific methods. The following sections will explore a range of solutions that use evidence-based strategies to ensure effective and sustainable greening.



5 Key Steps for Scientific Greening

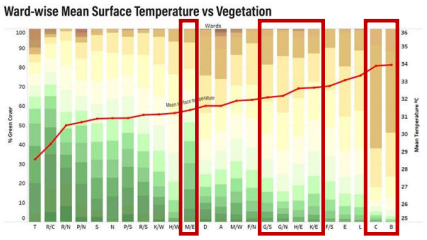
1. **Prioritize high-risk areas**
2. **Ecosystems approach**
3. **Adopt water-positive planting**
4. **Engage with local communities**
5. **Maintenance plan**

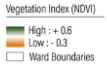
Scientific greening is essential to ensure that urban greenery provides long-term environmental and social benefits. Without a strategic approach, tree-planting efforts may fail due to poor species selection, lack of water management, or inadequate maintenance. Many large-scale plantation drives, despite good intentions, do not survive because they do not consider factors like soil conditions, local climate, or biodiversity. A scientific approach involves selecting the right plant species, ensuring sustainable water use, integrating green spaces with existing ecosystems, and involving local communities in long-term care. It also helps address multiple urban challenges, such as reducing heat stress, improving air quality, preventing soil erosion, and enhancing overall urban resilience. By adopting scientific greening methods, cities can create healthier, cooler, and more sustainable environments for people and nature alike.

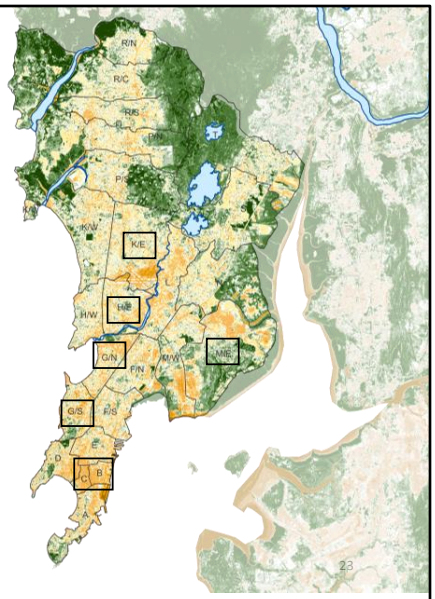
The five steps for scientific greening are elaborated with examples in the consequent section.

1. Prioritize Sites

- C, B, G/S, G/N, H/E, K/E wards with lesser vegetation experience higher surface temperature.
- M/E ward has 20.1% population (highest in Mumbai) not having access to daily urban recreational spaces (within 1 km) and exposed to high heat stress.



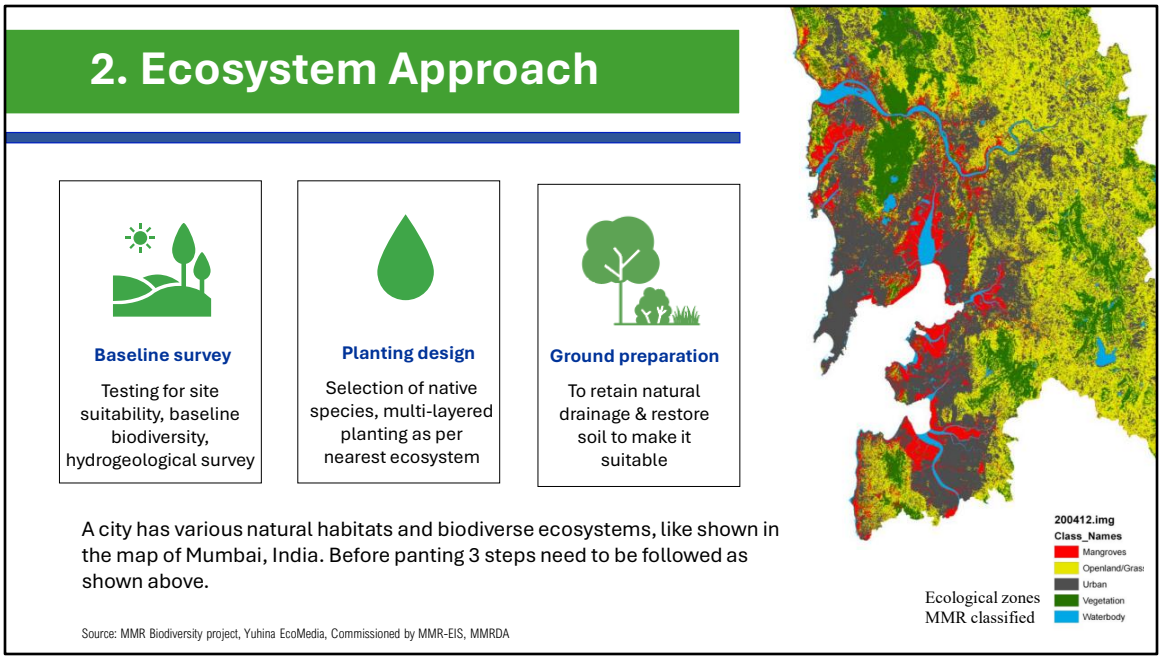




Source: MCAP, 2021

Prioritize High-Risk Areas – Focus on locations that experience extreme heat, high pollution levels, or are vulnerable to flooding. Identifying and targeting these areas ensures that greening efforts have the maximum environmental and social impact.

Example:
Mumbai is divided into 24 wards. Land surface temperatures reveal that wards that have higher surface temperatures are ones with lesser vegetation.
Most of the high heat risk areas also happen to overlap with low-income neighbourhoods that use high heat absorbing surfaces like tin, asbestos, etc. as roofing materials. Intervening through increasing green cover sensitively to create suitable living conditions in these locations can be seen as a priority.

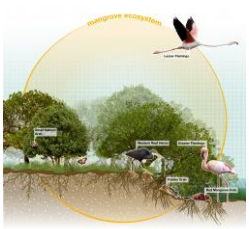


Ecosystems Approach – Instead of isolated tree planting, consider the entire ecosystem. This means promoting diverse plant species, preserving natural habitats, and creating interconnected green spaces that support local biodiversity.

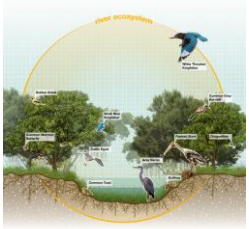
Cities contain diverse natural habitats and ecosystems, as seen in the map of Mumbai, India, which includes mangroves, forests, rivers, and other green spaces. To ensure successful and sustainable greening, three key steps must be followed before planting:

- Conduct a Baseline Survey – A thorough assessment of existing plant species, biodiversity, soil conditions, and hydrogeological features is essential. Experts such as ecologists, biologists, and water specialists should be involved in this process to ensure accurate data collection.
- Select Native Species – Planting should prioritize species that are naturally suited to the local environment. Native plants support biodiversity, require less maintenance, and are better adapted to the climate and soil conditions.
- Prepare the Ground – In urban areas, soil is often degraded due to pollution from construction debris, waste, or other contaminants. Restoring soil health through remediation techniques is crucial before planting to ensure plant survival and long-term ecosystem health.

2. Ecosystem Approach

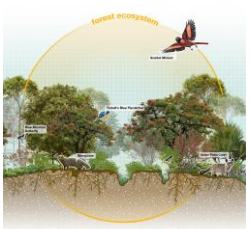


Mangroves



Riparian along water bodies

Urban parks



Forest

Be cognizant of the broader natural habitat and ecosystem along which the site is located to decide the species. These are some broader ecosystems observed in the case of Mumbai, India.

Source: Greening Mumbai: Handbook for scientific greening on small balconies to large plots, BMC, 2023

This example highlights the diverse natural habitats in Mumbai, each aligned with specific ecosystems. Effective urban greening must respect these ecological conditions to ensure sustainability.

For instance, when greening near mangrove ecosystems, it is crucial to consider saline soil conditions and prioritize native mangrove-associated species rather than exotic or invasive trees that could disrupt the delicate balance of the ecosystem. Trees from other habitats may struggle to survive or perish due to saline soil infiltration, reinforcing the need for site-specific, scientifically informed greening strategies.

3. Water Requirement Consideration

Source: Eco-STP(recycles sewage water of 42,000 litres/per day), Marol Urban Forest, WRI India

- Installing water recycling units like Eco-STP or other DEWATS (Decentralised Waste-Water Systems) to reduce dependance on fresh water for irrigation
- Installing Rain-Water Harvesting systems
- Being mindful of water requirements for 'Miyawaki' type of plantation which is water-intensive. Hence, avoid planting in dry/arid regions.

Adopt Water-Positive Planting – A successful greening strategy must prioritize water sustainability. Selecting native and drought-resistant species reduces irrigation needs while implementing water retention techniques such as rainwater harvesting.Mmulching, and soil enrichment helps sustain plant growth with minimal external water dependency.

Before planting, it is essential to establish a water strategy to ensure a reliable supply, preferably using recycled water rather than freshwater. In this example, an Eco-STP (Decentralized Wastewater Treatment System) was installed on-site, enabling the reuse of treated sewage water for irrigation. Additionally, enhancing groundwater recharge through site-specific solutions ensures long-term vegetation sustainability, reducing maintenance efforts over time.

4. Engage Communities

Participatory approach towards greening by adopting engaging practices at all stages:

- Site selection
- Baseline assessment, community knowledge
- Training, capacity building on scientific greening
- Planting activity
- Maintenance mechanism

Engage with Local Communities – Involving local communities in both the planting and maintenance of green spaces is crucial for long-term success. When residents, local organizations, and stakeholders participate in greening efforts, it fosters a sense of ownership, ensuring better protection and sustainability of planted areas.

One effective way to engage communities is through educational programs in schools, residential societies, and sports clubs. These groups are often the closest beneficiaries of urban green cover and can play a vital role in nurturing and maintaining it over time. By raising awareness and encouraging active participation, communities can help create and sustain healthier, greener urban environments.

5. Maintenance

- Creating charter and capacity building of stakeholders for maintenance of NBS
- Financial model for long-term sustenance to be created before implementation
- Building ownership of greening solutions in community-led projects, identifying associated community organizations

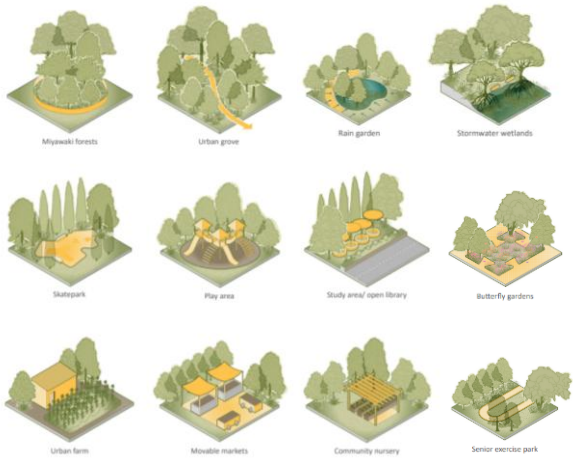
Develop a Maintenance Plan – Scientific greening does not end with planting; a well-structured maintenance plan is essential for long-term success. In fact, planning for maintenance should be the first step before planting begins. Key considerations include securing long-term budgets, ensuring trained personnel for upkeep, and aligning maintenance efforts—such as watering schedules, soil replenishment, and pest control—with the specific needs of the planted species. Regular monitoring and care are crucial to ensuring plant survival and maximizing the long-term benefits of urban greenery.

Greening across Urban Forms

Urban greening can be implemented in various spaces to maximize environmental and social benefits. This section explores key opportunities for greening, including:

- **Open Spaces and Natural Areas** – Parks, riverbanks, wetlands, and vacant lands can be restored and enhanced with native vegetation.
- **Buildings** – Green roofs, vertical gardens, and terrace plantations help cool buildings and improve air quality.
- **Streets** – Tree-lined avenues, roadside plantations, and green medians provide shade, reduce heat, and enhance walkability.

Open Spaces & Natural Areas

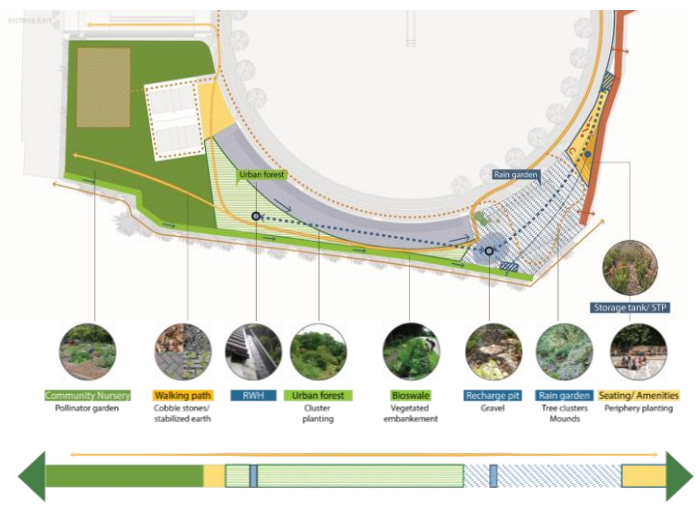


- Enhancement, conservation of natural areas like mangroves, forests, rivers need to be adopted.
- Open spaces act as important sites to adopt various greening approaches suitable to the needs of the community, as shown in the adjacent diagram.

Ground open spaces are often the primary focus of urban greening projects. As shown in the figure, different greening strategies can be adopted based on the site's needs. These include peripheral greening around play areas, urban groves, community nurseries, and butterfly gardens, each contributing to biodiversity and cooling. However, greening efforts must be site-specific, considering local conditions and requirements.

While expanding green cover is important, the first priority should always be protecting and conserving existing natural areas such as mangroves, forests, and riparian vegetation along rivers and lakes. Strengthening these ecosystems is essential for maintaining biodiversity, improving resilience, and enhancing the overall environmental quality of our cities.

Climate Sensitive Design Principles



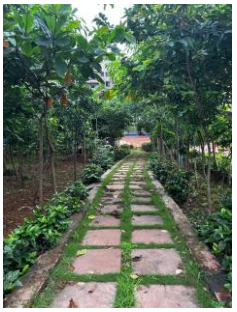
Climate Sensitive Design Principles for blue-green infrastructure focus on integrating natural systems like vegetation, water bodies, and permeable surfaces to enhance urban resilience. They emphasize stormwater management, heat mitigation, biodiversity conservation, and improving air and water quality while adapting to local climate conditions.

In the examples below from Mumbai, Faro, Ghana, we'll understand the concept better.

The project in this slide was implemented along the edges of a large sports complex in Andheri, Mumbai, showcasing Nature-based Solutions (NbS) with a focus on water positivity. It highlights the environmental benefits of NbS while also fostering city-wide participation. The initiative involves external stakeholders, including Resident Welfare Associations (RWAs), encouraging them to contribute land and funds for both implementation and long-term maintenance.

Climate Sensitive Design Principles





Area of plot: 3000 sq.m.
No. of trees planted and conserved: 2000 | No. of shrubs: 4000

- Collaborative processes for site identification; communications and awareness strategy for biodiversity awareness and citizen support for volunteering; co-development of site program
- Funding through CSR channels facilitated by the ULB and Residents' welfare associations.

The project emerged from a citywide greening campaign that encouraged youth participation in tree planting, engaged government stakeholders in identifying potential greening sites, and attracted donor funding. As a pilot initiative, it aimed to test whether a city-level campaign could help establish systems for climate-sensitive blue-green infrastructure design. While the pilot was highly successful, scaling it up posed challenges, including the need for government capacity building, improvements in administrative processes, long-term budget allocation for maintenance, and resources to mobilize youth for expansion.

Faro, Cameroon: Community-Led Ecological Restoration

Objectives:
- Restoration of degraded forest areas
- Promotion of food security and biodiversity through fruit-bearing and indigenous trees
- Mitigation of water scarcity through solar-powered water management systems

Species planted:
- Mango, orange, baobab, moringa (important for reforestation and food security)

Community engagement:
- Active participation of local communities, especially the Tchamba and Voko people
- Rural Resource Centre (RRC) established for knowledge exchange and training on sustainable land management

Partners:
- African Wildlife Foundation (AWF)
- ECOFAC6 project (funded by the European Union)
- Ministry of Forestry and Wildlife

Impact:
- Improved dietary diversity and local economic opportunities
- Enhanced resilience to climate challenges like drought

An example of climate sensitive urban design comes from Faro, Camerron.
In Faro, community-led ecological restoration has emerged as a powerful solution to combat land degradation and strengthen local resilience. The main objectives of this initiative are to restore degraded forest areas, promote food security and biodiversity by planting fruit-bearing and indigenous trees, and mitigate water scarcity through the use of solar-powered water management systems.

The project has focused on planting species such as mango, orange, baobab, and moringa, which are crucial for both reforestation and food security.
What makes this initiative particularly impactful is its strong community engagement. The Tchamba and Voko communities have been at the forefront of this effort, actively participating in restoration activities. A Rural Resource Centre has been established to facilitate knowledge exchange and provide training on sustainable land management practices.

Key partners in this initiative include the African Wildlife Foundation (AWF), the ECOFAC6 project funded by the European Union, and Cameroon's Ministry of Forestry and Wildlife.
The outcomes have been transformative. Local communities now enjoy improved

dietary diversity and increased economic opportunities through the sale of fruits and related products. Additionally, this ecological restoration has enhanced the region's resilience to climate challenges like drought, ensuring a more sustainable future for the people of Faro.

Source: https://www.awf.org/news/why-landscape-restoration-matters-communities-Africa

Water Innovations in Ghana

- **Decentralized Wastewater Recycling:** Ghana employs decentralized wastewater treatment systems in urban areas to recycle water for irrigation and green spaces. This reduces the need for freshwater, particularly in cities like Accra.
- **Rainwater Harvesting:** Rainwater harvesting systems are being promoted across both rural and urban areas to provide supplemental water during dry seasons, reducing the strain on conventional water supplies.
- **Urban Agriculture Innovation:** Safi Sana, a local startup, uses processed sludge from wastewater treatment for growing seedlings in vegetable nurseries, cutting down on water usage while promoting sustainable agriculture.
- **Impact:**
  - Improved water availability and reduced stress on freshwater resources.
  - Enhanced agricultural productivity with sustainable practices.
  - Mitigates urban water shortages during droughts.




The next example comes from Ghana.
Ghana has introduced innovative water management solutions to address the challenges of water scarcity and sustainability. These efforts have been implemented through a mix of community-based initiatives, partnerships with local organizations, and support from national and international bodies.
For instance, decentralized wastewater recycling systems are implemented in urban areas like Accra through collaborations between municipal authorities and private companies. These systems use localized wastewater treatment plants to recycle water for irrigation and green spaces, reducing the demand for freshwater resources.
Rainwater harvesting initiatives have been promoted across both rural and urban areas by the Ministry of Sanitation and Water Resources in partnership with local governments and NGOs. These systems are vital for supplementing water supplies during dry seasons and easing the burden on conventional sources.
Urban agriculture innovation, spearheaded by organizations like Safi Sana—a local startup—focuses on reusing processed sludge from wastewater treatment to grow seedlings in vegetable nurseries. This public-private initiative exemplifies how local entrepreneurship can work within existing frameworks to promote sustainable agricultural practices while minimizing water usage.
In terms of governance, these innovations rely on a decentralized model where local

governments, communities, and private sector actors collaborate. This approach ensures that solutions are tailored to local needs, while the national government provides oversight, policy guidance, and funding support.
The impact of these innovations has been profound, improving water availability, reducing stress on freshwater resources, enhancing agricultural productivity, and mitigating urban water shortages during droughts.

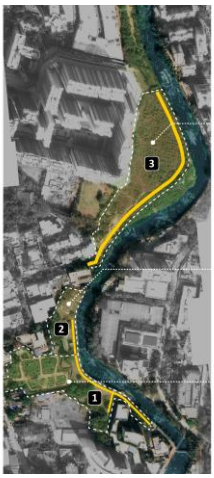
Source: https://www.sciencedirect.com/science/article/pii/S1462901119309645

Marol, Mumbai – Water Sensitive Urban Forest

Overview

- Approximately **9 acres of land parcel**(phase 1,2 nd 3) spanning across **about a kilometre of length along Mithi river in Mumbai**
- **Multi-departmental involvement** due to varying set of requirements

Phase 1 layout - Marol Urban Forest



Objectives

- Increase **the green cover** within one of the heat-stressed areas of Mumbai,
- **Enhance biodiversity** by incorporating native plant species,
- **Maximize permeability, improve soil health, and recharge groundwater.**
- Develop an accessible open space and riverfront for the citizens,
- Integrate nature-based solutions along the buffer zones of river

A recent example of climate-sensitive urban design comes from Mumbai, India, where a project along the Mithi River integrates nature-based solutions and urban greening. The initiative began by identifying vacant lands along the river that could serve as green buffers. Three such plots were selected to develop a water-sensitive urban forest and recreational spaces.

The first 2-acre patch has been successfully transformed, focusing on biodiversity enhancement, wastewater management, and sustainable irrigation. The project includes an urban forest and an Eco-STP (ecological sewage treatment plant) to treat sewage water, which is then reused for irrigation. This initiative showcases a multi-departmental approach, emphasizing collaboration to create resilient urban ecosystems.

Marol, Mumbai – Water Sensitive Urban Forest

Before

After

Images from Marol Urban Forest Phase 1 project, where dense plantation was executed along the river

This transformation has not only enhanced biodiversity but also led to a **2-degree reduction in Land Surface Temperature (LST)**, demonstrating the effectiveness of urban greening.

Source: Urban Forest- Marol (Photo credit: Studio Piplikput)

The before-and-after images highlight a significant increase in vegetation within just one year. This transformation has not only enhanced biodiversity but also led to a **2-degree reduction in Land Surface Temperature (LST)**, demonstrating the effectiveness of urban greening in creating cooler, more resilient environments

Marol, Mumbai – Water Sensitive Urban Forest

Source: Urban Forest- Marol (Photo credit: WRI India)

- Retention ponds in the project act as sponges to slow down surface water run-off as well as to enhance biodiversity.
- Elevated boardwalk is created to allow for biodiversity corridors under the structure and increase water permeability.

The project incorporates **retention ponds** designed to slow down water runoff while enhancing biodiversity. Additionally, an **elevated boardwalk** has been constructed to preserve natural biodiversity corridors beneath it, ensuring minimal disruption to ecosystems while improving water permeability.

Buildings

Greening strategies on buildings and within building compounds include

- Roof-top greening, green terraces, urban farming
- Vertical greening in balconies
- On-plot peripheral greening, parklets

Integrating green spaces within buildings and their compounds plays a crucial role in reducing urban heat, improving air quality, and enhancing biodiversity. Key strategies **include roof-top greening, green terraces, and urban farming**, which help insulate buildings, lower indoor temperatures, and promote local food production. **Vertical greening on balconies** provides additional cooling benefits while improving air quality. **On-plot peripheral greening and parklets** contribute to creating shaded and cooler microclimates.

In the following sections we will explore case examples from Chennai, Ahmedabad and South African cities on how they have innovated green spaces within their buildings.

Rooftop farming: Chennai Resilience Centre

A study by the **Chennai Resilience Centre** demonstrated the impact of rooftop greening as a retrofit in the 'Integrated Child Development Services' buildings. The results showed that classrooms directly beneath the greened terraces were **2–3°C cooler** compared to those under exposed rooftops. Additionally, the food grown on these rooftop gardens was used for **mid-day meals**, promoting both environmental and nutritional benefits for students.

Rooftop farming: Integrated Child Development Services, Chennai Resilience Centre

Stories from teachers and mothers of ICDS centers

"At the center, the teachers gave me Pasala keerai and explained its benefits. I did not know about it but because they gave me some, I made it at home in the form of a dry vegetable and kootu which is made along with dal. It was very tasty. My daughter loved the kootu and she kept asking for more."

(a mother of a child attending an ICDS center)

Source: https://urbanthottam.com
Chennai Resilience Centre

Rooftop Urban Farming: South Africa

Rooftop urban farming is emerging as a transformative practice in South African cities, addressing food security, environmental concerns, and community engagement.

Food Security
Provides fresh, locally grown produce, reducing dependence on lengthy supply chains

Environmental Improvement
Helps mitigate urban heat islands and promotes biodiversity

Community Involvement
Engages local communities in sustainable practices, fostering education and empowerment

In South African cities, rooftop urban farming is emerging as a transformative practice, addressing key challenges such as food security, environmental concerns, and community engagement. This approach is particularly gaining traction in places like Johannesburg's inner city, where hydroponic farming has been integrated into unused rooftop spaces.

From a food security perspective, rooftop farms provide fresh, locally grown produce that reduces dependence on lengthy supply chains. This is especially impactful in urban areas where access to affordable and nutritious food is often limited.

Environmentally, these farms contribute to mitigating urban heat islands by creating green spaces on rooftops. They also promote biodiversity by incorporating a variety of plants and fostering sustainable ecosystems within dense urban environments.

Community involvement is a core aspect of these projects. Rooftop farms actively engage local communities, providing education on sustainable practices and creating empowerment opportunities through skills training and employment. These efforts contribute to fostering a sense of ownership and pride among participants.

Overall, rooftop urban farming demonstrates how innovative urban solutions can simultaneously tackle environmental and social challenges, offering a scalable and sustainable model for cities across South Africa and beyond.

Sources:
https://www.biznews.com/good-hope-project/2018/11/05/rooftop-hydroponic-farming-joburg-inner-city-cbd
https://www.foodformzansi.co.za/urban-rooftop-farmer-making-a-difference-in-the-sky/
https://www.verticalfarmdaily.com/article/9481205/south-africa-western-cape-s-first-urban-rooftop-farm-launched/
https://www.farmersweekly.co.za/agri-technology/farming-for-tomorrow/joburg-rooftops-the-next-frontier-for-farming/
https://sustainableurbandelta.com/urban-farms-johannesburg/

Rooftop Urban Farming: South Africa

Hydroponics in Rooftop Farming:
A method of growing plants without soil, using nutrient-rich water solutions. This technique is particularly well-suited for urban environments where space is limited.

Advantages:
Hydroponics allows for higher yield in smaller spaces, efficient water usage, and faster growth cycles. For example, farmers like Sibongile Cele utilize hydroponic systems to grow vegetables such as spinach and basil, ensuring consistent production despite urban challenges.

Examples:
- Johannesburg Urban Agriculture Initiative: Over 50 rooftop farms planned, aiming to create jobs and boost local food production.
- Mcebo Wealth Rooftop Farm: This farm uses hydroponics to cultivate organic vegetables while serving the community.

Rooftop urban farming in South Africa, particularly in cities like Johannesburg, is revolutionizing agriculture in urban environments. At the heart of this transformation is hydroponics—a method of growing plants without soil by using nutrient-rich water solutions. This approach is ideal for urban areas where space is limited, offering innovative solutions to urban food security and sustainability challenges.

Hydroponics provides several key advantages. It allows for higher yields in smaller spaces, uses water more efficiently, and accelerates growth cycles. For example, farmers like Sibongile Cele use hydroponic systems to grow vegetables such as spinach and basil, ensuring consistent production despite the constraints of urban living.

Several initiatives highlight the success of this approach. The Johannesburg Urban Agriculture Initiative plans to establish over 50 rooftop farms to create jobs and boost local food production. Another example is Mcebo Wealth Rooftop Farm, which uses hydroponics to cultivate organic vegetables while engaging and serving the local community.

These projects not only address food security but also contribute to environmental sustainability. By reducing the need for transportation and minimizing soil degradation, rooftop farms help mitigate urban heat islands and promote biodiversity.

Rooftop farming in South Africa demonstrates how innovation, community engagement, and sustainable practices can transform unused urban spaces into thriving agricultural hubs, benefitting both people and the planet.

Sources:
https://www.biznews.com/good-hope-project/2018/11/05/rooftop-hydroponic-farming-joburg-inner-city-cbd
https://www.foodformzansi.co.za/urban-rooftop-farmer-making-a-difference-in-the-sky/
https://www.verticalfarmdaily.com/article/9481205/south-africa-western-cape-s-first-urban-rooftop-farm-launched/
https://www.farmersweekly.co.za/agri-technology/farming-for-tomorrow/joburg-rooftops-the-next-frontier-for-farming/https://sustainableurbandelta.com/urban-farms-johannesburg/

Cool Roof : Ahmedabad(Heat Action Plan)

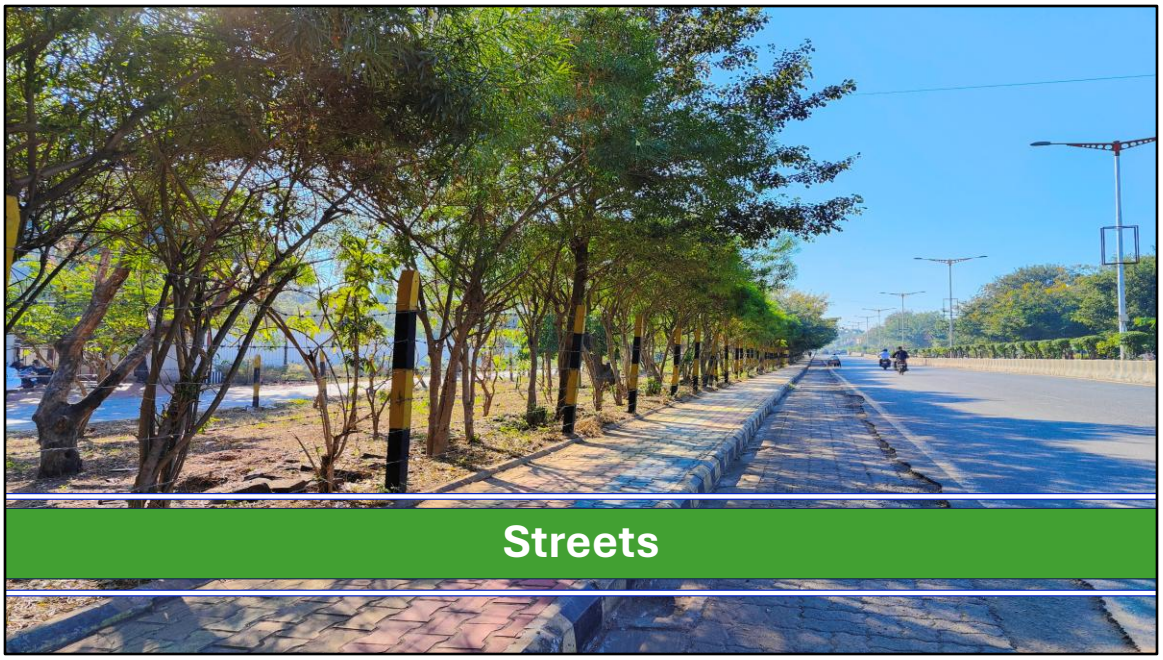
The cool roof involves coating the roof with a white paint or any other paint with high solar reflectivity or laying high reflectivity tiles over the roof.

The experiments show that cool roof can reduce the inside temperature by almost 3-5 degree C, and therefore reduce the cooling requirement.

Locally-available sunlight-reflective white lime paint costs ₹0.50 (~$0.07) per square foot in Ahmedabad.

Source: Energy Team, WRI; New Cool Roof Programs in India – Ahmedabad (Part 2) | NRDC

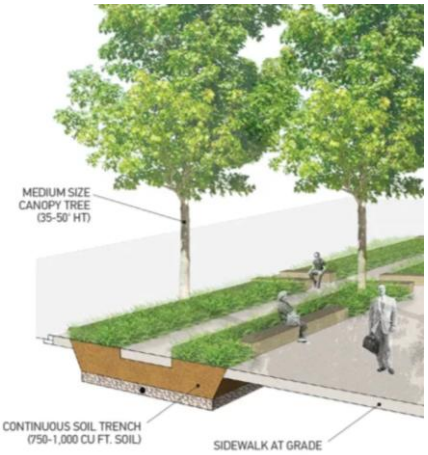
In Ahmedabad, Gujarat, experiments with **cool roofs** have shown promising results in reducing indoor temperatures. This technique involves coating rooftops with **highly reflective white paint**, which helps reflect sunlight and minimize heat absorption. As an **affordable and effective solution**, cool roofs have been widely adopted to improve thermal comfort in homes and buildings, particularly in low-income areas.



Greening and Nature-Based Solutions Along Streets

Streets play a crucial role in urban ecosystems, and integrating greening and nature-based solutions (NbS) can significantly improve thermal comfort, air quality, and biodiversity. Strategies such as tree-lined streets, bioswales, rain gardens, and green medians help reduce urban heat, manage stormwater, and create healthier public spaces. These solutions not only provide shade and cooling but also enhance walkability and overall well-being. In the following sections, we will explore different ways to incorporate greening along streets.

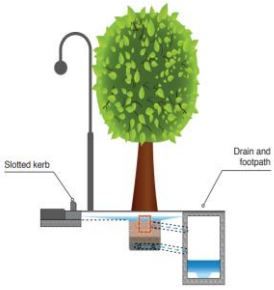
Roadside Landscape – Increasing Shade



Design to allow greening along roadsides, to increase permeability and shade

Roadside blue-green infrastructure can be designed to improve permeability, provide shade, and manage stormwater effectively. Solutions like rain gardens and bioswales help slow down water runoff, naturally filter pollutants, and increase green cover. These strategies not only enhance urban cooling but also contribute to healthier city streets.

Roadside Blue-Green Infrastructure

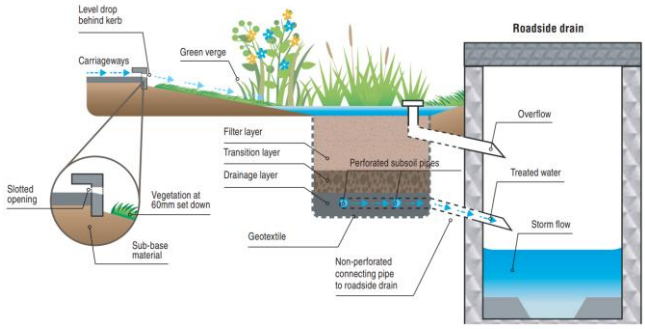


- Design of raingardens along roads, which increases green cover along roadside and slows the surface-runoff, increasing permeability.

Source: pub.gov.sg/-/media/PUB/Reservoirs/ABC/PDF/Condensed_Booklet_of_Engin_Procedures.pdf

Roadside Blue-Green Infrastructure

Multi-functional roadside landscape. Increasing green cover and permeable surface along with road safety and greening.



Source: pub.gov.sg/-/media/PUB/Reservoirs/ABC/PDF/Condensed_Booklet_of_Engin_Procedures.pdf

Application

- Roadside landscape on footpath
- Median landscape
- Traffic island landscape
- Retention areas

Ecosystem Approach: Medellin's Green Corridors

Project Overview:

- Launched in 2016 to combat urban heat, improve air quality, and restore biodiversity
- Initial phase: 120,000 plants, 12,500 trees along key transport routes

Expansion and Impact:

- By 2021: 2.5 million plants, 880,000 trees connecting roads, parks, streams, and vertical gardens
- Reduced city temperatures by 2°C, with some areas seeing up to 4°C reduction

Global Recognition:

- Won Ashden Award for cooling in 2022

Environmental Benefits:

- Air quality improved with CO2 absorption and pollution filtration
- Enhanced urban biodiversity through interconnected green spaces

Medellín's Green Corridors project, launched in 2016, is a prime example of using ecosystem-based strategies to combat urban heat, improve air quality, and restore biodiversity. This ambitious initiative was implemented by the city government of Medellín in collaboration with environmental experts, local universities, and community organizations, ensuring an inclusive and science-driven approach.

The biodiversity strategy behind the Green Corridors was carefully designed to create interconnected green spaces that support native flora and fauna. The project prioritized planting native and climate-resilient species to enhance ecological stability and promote pollination. These efforts have significantly increased urban biodiversity by creating habitat corridors that allow species to move freely through the city, connecting urban ecosystems with natural reserves in surrounding areas.

By 2021, the project had expanded dramatically, planting 2.5 million plants and 880,000 trees along roads, parks, streams, and vertical gardens. These green spaces not only provide cooling benefits but also serve as critical habitats for birds, butterflies, and other wildlife, reinforcing Medellín's commitment to nature-positive urban planning.

The project has earned global recognition, including the prestigious Ashden Award for Cooling in 2022. Its success is a testament to Medellín's ability to combine environmental science with community engagement, creating a replicable model for cities worldwide.

In addition to reducing city temperatures by up to 4°C in some areas, the Green Corridors have improved air quality by filtering pollutants and absorbing CO2. This demonstrates how

ecosystem-based solutions can simultaneously tackle multiple urban challenges, from heat mitigation to biodiversity conservation.

Sources:
https://www.bbc.com/future/article/20230922-how-medellin-is-beating-the-heat-with-green-corridors
https://www.c40knowledgehub.org/s/article/Cities100-Medellin-s-interconnected-green-corridors?language=en_US
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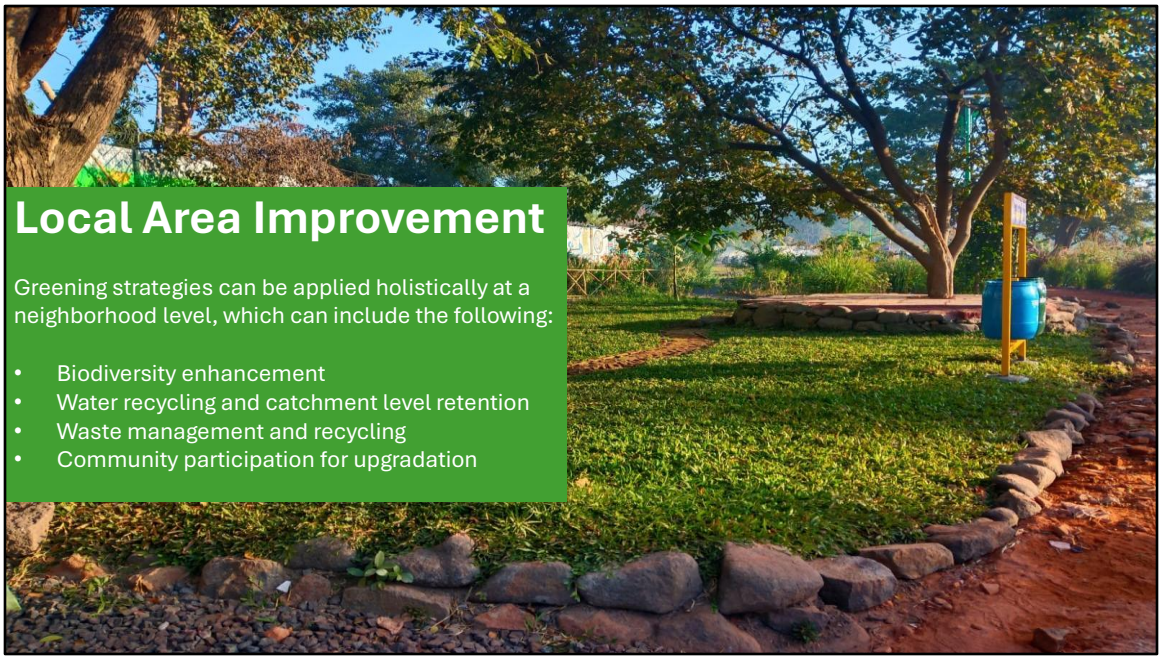
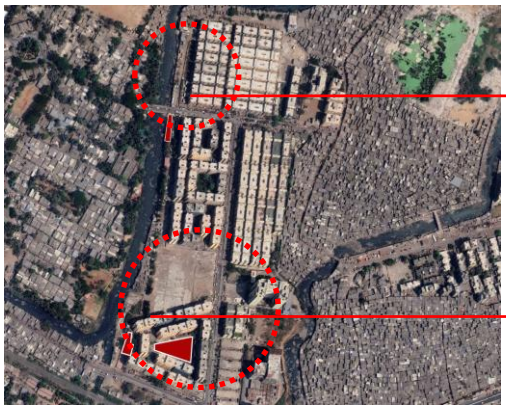


Local area improvement through greening strategies focuses on enhancing the urban environment at a neighborhood level by addressing community needs and ensuring sustainable growth over time. A holistic approach to greening can transform neighborhoods by integrating biodiversity enhancement, water recycling and retention, waste management, and community-led upgradation efforts. By implementing these strategies incrementally, cities can create resilient, livable, and climate-adaptive spaces that benefit both people and the environment.

Lallubhai Compound, Mumbai: Local Area Plan



- Lallubhai Compound is a Rehabilitation and Resettlement colony located in Mankhurd.
- Holistic solutions for greening were proposed and carried out in two plots

Example,
In Mumbai we assessed climate and social vulnerabilities to identify areas where nature-based solutions (NbS) and urban greening could have the most impact. In Lallubhai Compound, one of Mumbai's largest resettlement colonies, open spaces are scarce, and the few available plots—such as plots for Play Ground—are often contested, with different groups having competing needs.
Additionally, these spaces face long-term maintenance challenges, requiring a community-driven approach that integrates solutions for water scarcity, solid waste management, and sustainable upkeep. By involving local stakeholders, greening efforts can be more effective and long-lasting.

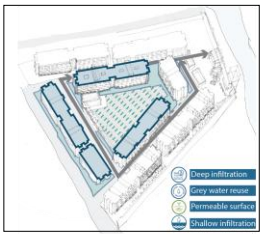
Lallubhai Compound, Mumbai: Local Area Plan

These images highlight greening interventions along peripheries and the transformation of spaces through place-making. The process involved co-designing and execution in collaboration with local communities, ensuring that the interventions are inclusive, context-sensitive, and sustainable

Lal Maidan as ‘Sponge Infrastructure’

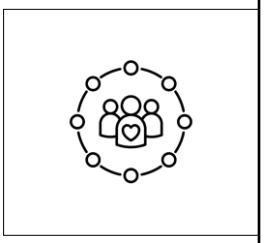
Objective: Ecological transformation of Lal maidan and its surroundings, using place-based, participatory approaches.

BIODIVERSITY RESTORATION



WATER MANAGEMENT

WASTE MANAGEMENT

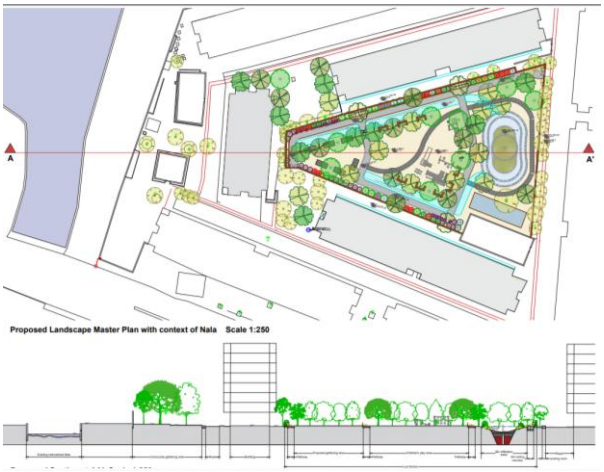


PEOPLE CENTRIC APPROACH

At Lal Maidan in Lallubhai Compound, Mumbai, we introduced sponge infrastructure—a nature-based approach to enhance water retention, reduce flooding, and support urban greening. Greening interventions must be seen as interconnected systems, influencing and being influenced by existing ecology, hydrogeology, health, and livelihoods. Recognizing these linkages ensures that urban greening is both effective and sustainable.

Through community engagement, co-design sessions, and regular meetings, we collaborated closely with local residents to understand their needs and priorities. Partnering with the local NGO YUVA, we adopted a holistic approach that integrated community participation at every stage—from planning to execution—ensuring long-term stewardship and meaningful impact.

Lal Maidan as ‘Sponge infrastructure’



- Biodiversity restoration & enhancement
- Eco-STP
- Bioswales
- Community spaces for recreation
- Waste management plan

Although these projects took time to implement, they fostered trust within the community, demonstrating that urban greening and revitalization are possible. This trust became the foundation for a larger open space plan, developed in collaboration with residents and supported by the local society.

The plan integrated biodiversity enhancement, recreation, water recycling, and waste management, with input from both the community and subject-matter experts. This participatory approach not only ensured context-sensitive design but also created a detailed planning report to guide implementation.

As a result, similar projects are now spreading across the neighborhood, driven by various initiatives led by our partners—expanding the impact of community-led greening efforts.

Lima Example: Ecological Infrastructure Strategy

Tactical Urbanism Approach: The program employs tactical urbanism strategies, engaging civil society and private-sector partners to recover and upgrade priority areas. This method emphasizes community involvement and swift, low-cost interventions.

Clear Green Space Targets: Lima's climate action plan sets ambitious goals, such as providing 9 square meters of green space per inhabitant and planting one tree for every three residents. The city aims to plant 4 million trees by 2030 and establish green corridors along all main metropolitan roads by 2050.

Significant Achievements: 17 public spaces totaling over 41,000 square meters have been improved at minimal cost. This includes repurposing abandoned plots, community areas, quiet roads, and parking spaces. Additionally, pedestrians have gained 12,000 square meters of street space, and 430 trees have been planted

Inclusive Design and Implementation: The program prioritizes early childhood needs and aligns with 'complete neighborhood' or '15-minute city' principles, ensuring accessible green spaces for all residents. It also promotes the use of local vegetation with low water requirements, providing shaded areas for different age groups, particularly children and the elderly

Lima's Ecological Infrastructure Strategy demonstrates how urban areas can tackle environmental and social challenges through low-cost, community-driven interventions. This program uses tactical urbanism strategies to recover and upgrade priority areas by engaging civil society and private-sector partners. The emphasis on swift, low-cost interventions ensures immediate and visible impacts, making this approach highly scalable.

The city's climate action plan has ambitious green space targets, including providing 9 square meters of green space per inhabitant and planting one tree for every three residents. By 2030, Lima aims to plant 4 million trees and establish green corridors along all main metropolitan roads by 2050. These initiatives align with the 'complete neighborhood' or '15-minute city' principles, which prioritize accessible green spaces for all residents. The use of native vegetation with low water requirements enhances sustainability while providing shaded areas for children, the elderly, and other vulnerable groups.

The program has already achieved significant milestones. For example, 17 public spaces totaling over 41,000 square meters have been improved at minimal cost. This includes repurposing abandoned plots, community areas, quiet roads, and parking spaces. Pedestrians have gained 12,000 square meters of street space, and 430 trees have been planted, creating more inclusive and livable environments.

Lima’s strategy showcases the power of participatory design and inclusive planning in addressing urban challenges. It is a testament to how ecological infrastructure can create greener, more equitable cities while fostering a sense of community ownership.

Source:
https://www.shiftcities.org/post/limas-participatory-low-cost-expansion-public-green-space

The Green Community Schoolyards Project

2023 – 2024 Finalist: Green Community Schoolyards in New York City

700,000
acres of impervious asphalt replaced with pervious surfaces

5 million
people now live within a 10-minute walk to a green space

220,000
children and community members have directly benefited from new schoolyards

The Green Community Schoolyards project in New York City is a 2023–2024 finalist for the WRI Ross Center Prize for Cities, and for good reason. This transformative initiative has reimagined traditional schoolyards by replacing 700,000 acres of impervious asphalt with pervious surfaces, making them greener, cooler, and more sustainable.

The impact of this project extends far beyond individual schools. Thanks to these efforts, 5 million people in New York City now live within a 10-minute walk of a green space. This contributes to improving urban livability and accessibility while addressing environmental challenges such as stormwater runoff and urban heat islands.

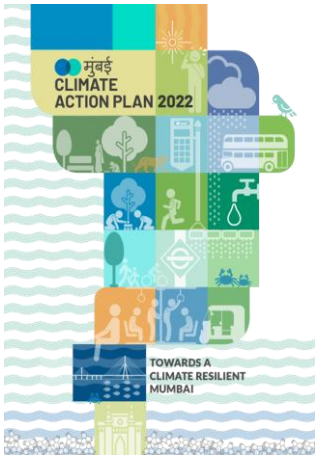
Additionally, 220,000 children and community members have directly benefited from these newly redesigned schoolyards. These spaces not only provide recreational opportunities but also promote community engagement and environmental education.

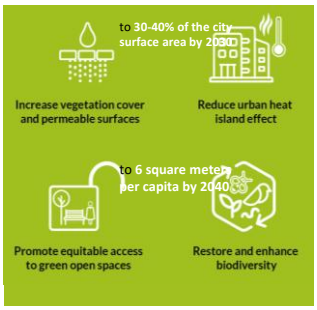
The Green Community Schoolyards project exemplifies how cities can leverage existing infrastructure to create equitable and inclusive green spaces. By focusing on schools, the initiative reaches children and their families, fostering a sense of ownership and pride in their local environment. It's a powerful model for other cities to follow in creating climate-resilient, people-centered urban spaces.

Source:
https://prizeforcities.org/project/green-community-schoolyards

This section explores key policies, programs, and strategic interventions that address heat risks through blue-green solutions. Building long-term resilience requires city-level planning and policy integration, ensuring sustained efforts toward climate adaptation. Some essential strategies include Climate Action Plans with blue-green goals, Heat Action Plans for long-term cooling preparedness, and Greening Manuals to support community-driven initiatives. Additionally, Tree Censuses, Landscape Plans, and Mapathons can help identify areas for greening, shade creation, and restoring underutilized spaces—strengthening urban heat resilience through holistic planning.

1. Climate Action Plans with blue-green goals





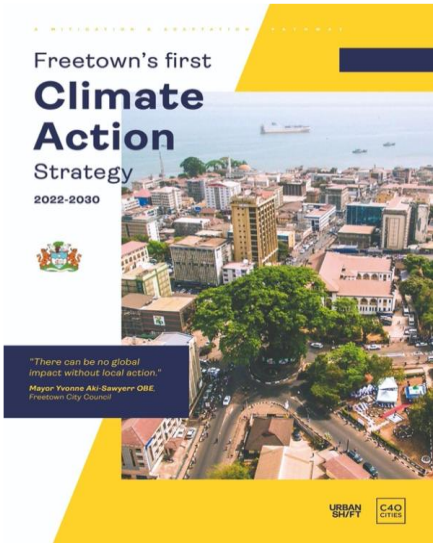
Urban Greening and Biodiversity

Urban Flooding and water resource management

The Mumbai Climate Action Plan (MCAP) sets ambitious goals, such as increasing green cover to 40% of the city's area by 2030 and ensuring 6 sq. mt of green space per capita. At the national level, in India, the National Mission on Sustainable Habitat (NMSH) under the National Action Plan on Climate Change (NAPCC) emphasizes urban greening and biodiversity conservation as key strategies for heat resilience. Programs like Nagar Van Yojana promote urban forests, while Atal Mission for Rejuvenation and Urban Transformation(AMRUT) focuses on developing green spaces in cities. However, greater efforts are needed to engage communities and integrate heat resilience goals with urban greening initiatives to ensure long-term impact.

Climate Action Plan

- Aims to address the city's vulnerability to climate change impacts
- Developed with assistance from UrbanShift and C40 CITIES



Freetown's Climate Action Plan, launched for the period 2022 to 2030, represents a significant step in addressing the city's vulnerability to the impacts of climate change. This strategy is part of a broader effort to make Freetown more resilient while promoting sustainable development.

The plan aims to tackle key challenges such as rising temperatures, flooding, and other climate-related risks that threaten the city's residents, infrastructure, and natural ecosystems. Its focus is on creating actionable and locally tailored solutions that align with the global climate agenda.

This ambitious plan was developed with assistance from UrbanShift and C40 Cities. These partners provided technical expertise, capacity-building support, and resources to help design a comprehensive and inclusive strategy.

By prioritizing both mitigation and adaptation measures, the Climate Action Plan underscores the importance of local leadership in combating global climate issues. As Freetown Mayor Yvonne Aki-Sawyerr puts it, 'There can be no global impact without local action.' This plan exemplifies the critical role of cities in the fight against climate change.

Source:
https://www.shiftcities.org/publication/freetown-climate-action-strategy

Cape Town: Climate Change Strategy

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Addressing climate risks such as droughts, heatwaves, flooding, and sea-level rise through comprehensive climate adaptation and mitigation strategies.

The strategy aims to create a climate-resilient city by 2050, benefiting all 4+ million residents, especially those most vulnerable to climate impacts.

The City of Cape Town's Climate Change Strategy is a forward-looking framework designed to address the growing risks of climate change, including droughts, heatwaves, flooding, and sea-level rise. This strategy integrates both climate adaptation and mitigation measures to create a comprehensive response.

The plan's primary goal is to create a climate-resilient city by 2050. It focuses on reducing Cape Town's vulnerability to climate impacts while ensuring equitable benefits for its population of over 4 million residents, particularly those most at risk.

Key initiatives include increasing water security, enhancing green infrastructure, promoting energy efficiency, and transitioning to renewable energy sources. The strategy also emphasizes the importance of protecting biodiversity, as the city recognizes the critical role ecosystems play in mitigating climate risks.

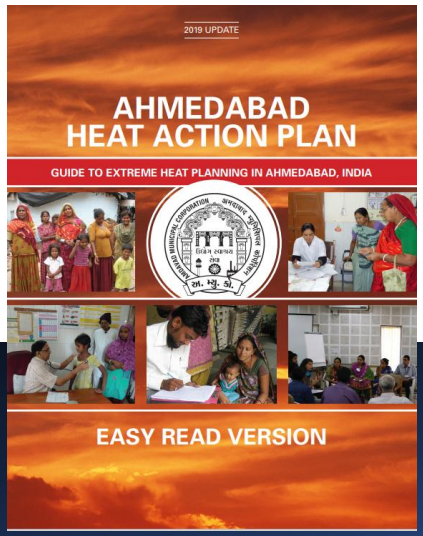
What sets this strategy apart is its inclusive approach. By engaging communities, businesses, and other stakeholders, Cape Town ensures that the strategy reflects local needs and priorities. The city is committed to making progress possible for everyone, ensuring sustainability and equity go hand in hand.

Cape Town's Climate Change Strategy serves as a model for other cities looking to take bold and holistic action against climate change, balancing immediate needs with long-term resilience.

Source:
https://resource.capetown.gov.za/documentcentre/Documents/City%20strategies%2C%20plans%20and%20frameworks/Climate_Change_Strategy.pdf

2. Heat Actions plans with long-term preparedness for cooling

Early warning, precautions and long-term actions



City-level Heat Action Plans (HAPs), such as the pioneering plan in Ahmedabad, India, serve as comprehensive frameworks to mitigate heat risks by integrating early warning systems with cooling strategies. These plans are designed to protect vulnerable populations, such as the elderly, children, outdoor workers, and low-income communities, from extreme heat events. HAPs typically include measures such as public awareness campaigns, establishing cooling centers, enhancing urban greening efforts, and promoting cool roofing solutions. Additionally, they emphasize data-driven decision-making, leveraging temperature and heat index monitoring to issue timely heat alerts. By integrating nature-based solutions, such as increasing tree cover and water bodies, alongside infrastructure adaptations, like reflective roofing and shaded streets, these plans offer a holistic approach to building urban heat resilience.

Cape Town's Cool Roofs Initiative

Urban heat challenges in Cape Town and the need for innovative solutions

Reflective Roof Coatings: Use of materials that reflect sunlight to reduce heat absorption

Energy Efficiency: Reduction in indoor temperatures leading to lower energy consumption for cooling

Improved Comfort: Enhanced living conditions for residents during hot summer months

Reduced Heat Island Effect: Mitigation of localized warming caused by urban infrastructure

Sustainability: Contribution to climate resilience and lower greenhouse gas emissions

Community Involvement: Engagement with local residents and businesses to adopt cool roofing technologies

Incentives: Programs to encourage the installation of cool roofs in both residential and commercial buildings.

In Cape Town, the South African National Energy Development Institute (SANEDI) has initiated a Cool Roofs and Insulation Collaboration, applying 26,000 square meters of reflective roofing technology. This project aims to demonstrate the effectiveness of combining cool roof coatings with insulation to passively reduce indoor temperatures during the hot summer months. Targeting communities like Masonwabi, Masiphumelele, and Morkel's Cottage, the initiative seeks to enhance thermal comfort in homes without relying on mechanical cooling systems. By engaging local residents and utilizing cost-effective materials, this approach not only mitigates the urban heat island effect but also promotes energy efficiency and community involvement in climate resilience efforts.

Cool Roofs: Freetown, Sierra Leone

Innovation: Installation of reflective mirror-like materials on rooftops to reduce indoor temperatures

Goal: Combat extreme heat exacerbated by climate change, particularly affecting low-income communities

Benefits:

Temperature Reduction: Decreases indoor temperatures by up to 10°C, making homes more livable during extreme heatwaves
Cost-Effective Solution: Affordable technology suitable for widespread adoption in densely populated urban areas
Environmental Impact: Reduces the need for air conditioning, lowering energy consumption and related emissions

Impact on Local Communities: Improved living conditions in areas where homes are often made of corrugated metal, which exacerbates heat

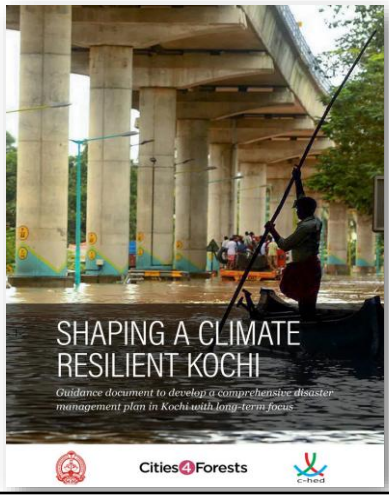


In Freetown, Sierra Leone, a recent initiative has introduced heat-reflective "mirror roofs" to combat extreme heat in densely populated communities. These reflective roofing sheets have been installed in areas like the Kroo Bay waterfront community, where residents have endured increasingly high temperatures. Initial results indicate that homes equipped with these roofs can be up to 6°C cooler, providing significant relief to inhabitants. This passive cooling solution is particularly beneficial in regions where access to electricity and air conditioning is limited, offering a sustainable and cost-effective method to enhance indoor comfort during heatwaves.

KOCHI: City Disaster Management Plan Framework

Enabling city agencies involved in disaster management to shift the model of city disaster management from rescue and recovery to resilience and preparedness

CDMP to impact 1+ million residents of Kochi



The **City Disaster Management Plan (CDMP) Framework** for Kochi aims to transform the city's disaster management approach from a reactive model of rescue and recovery to a proactive system focused on resilience and preparedness. By enabling city agencies to anticipate and mitigate risks, the plan seeks to strengthen urban resilience against climate-related disasters, including extreme heat events. With a reach of over 1 million residents, the CDMP integrates strategic planning, early warning systems, and coordinated response mechanisms to safeguard vulnerable communities and infrastructure, ensuring long-term sustainability and climate adaptation for the city.

3. Greening manual for encouraging locally-led efforts

Mumbai Greening Manual

Mumbai has undertaken city-level initiatives to strategically enhance green cover and biodiversity, including the development of a **citizen-friendly greening manual**. This manual is designed to encourage individuals, housing societies, and larger communities to participate in urban greening, from planting in balconies and small open spaces to transforming public parks. It provides a **step-by-step** guide on site selection, soil assessment, appropriate plant species selection, community engagement models, and long-term maintenance strategies. By making scientific greening accessible, this initiative empowers residents to contribute to a more sustainable and climate-resilient city.

Link:
https://portal.mcgm.gov.in/irj/go/km/docs/documents/HomePage%20Data/Related%20Links/GREENING%20MUMBAI-Citizen's%20handbook%20for%20greening%20initiatives.pdf

4. Tree Census, Public Biodiversity Register

Tree Census Format

No on Tree	Name of Tree	Location of tree	Girth in Cms	Height in feet	On the Tree					Health of the tree					Ground condn	Open Soil	Other comments
					FL	FR	P	N	B	DS	HLP	NL	TG C	HT H	OS/T/ C/CS	A/B/C /D/E	

Legend for Tree Census

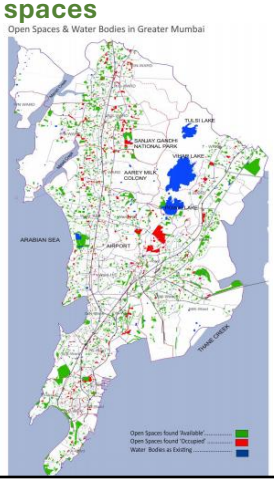
On the Tree	Mention **FL** for flowers , **FR** for fruits, **P** for Pods, **N** for nest, **B** for burrows
Health of Tree	Mention **DS** for diseased, **HTH** for healthy, **HLP** for Heavily lopped, **NL** If you find nails, If Tree guard choking mention **TGC**
Ground condition	Mention **OS** for Open Soil, **T** for tiled, **C** for cemented, **CS** for compressed mud
How much of Open soil around trunk	Write **A** if space is Nil, **B** for 0-2 ft, **C** for 2ft>4ft, **D** for 4ft>6ft, **E** for 6 feet and more.

Source: *(Left)* Community led Saket-17 Tree census, ChildrensEarth.org, *(Right)* Delha-Undekha, Youth-led documentation for two parks in Mumbai, Waatavaran, BMC, Ministry of Mumbai's Magic.

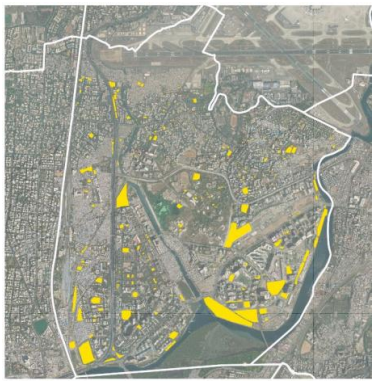
To ensure the maintenance and conservation of a city's biodiversity, periodic tree censuses are conducted as mandated exercises in many cities. These censuses provide critical data on the location, species, health, and canopy cover of urban trees. When conducted in a participatory manner, involving citizens, local organizations, and experts, tree censuses not only enhance transparency but also foster a sense of ownership and responsibility among residents. This participatory approach is essential for effective tree conservation, long-term monitoring, and informed urban planning that prioritizes green infrastructure.

5. Mapathons for identifying derelict, unused areas for greening, creating shade

Inventory of open spaces



Mapathon: Participatory data collection



Source: *(Left)* Adarkar Associates and MMR-EIS (Mumbai Metropolitan Region – Environment Improvement Society). 2015. Inventorisation of Open Spaces & Water Bodies in Greater Mumbai.
(Right) WRI India

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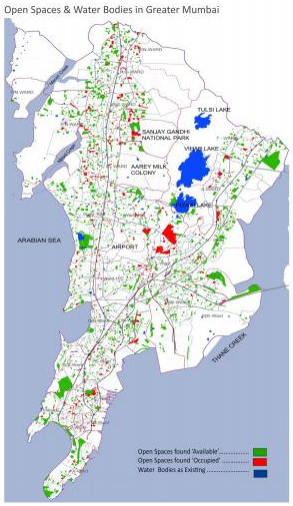
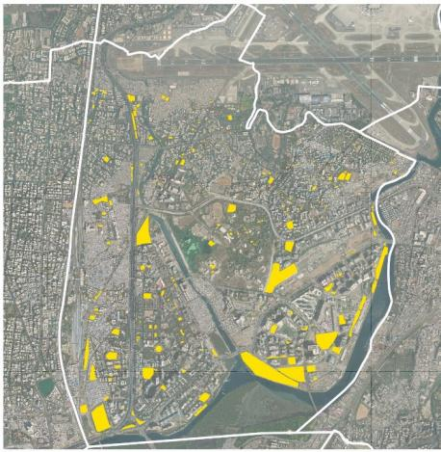
Inventory of open spaces



Mapathon: Participatory data collection



Source: *(Left)* Adarkar Associates and MMR-EIS (Mumbai Metropolitan Region – Environment Improvement Society). 2015. Inventorisation of Open Spaces & Water Bodies in Greater Mumbai.
(Right) WRI India

Other initiatives for identifying potential open spaces for greening involve creating a city-level inventory through systematic surveys and mapathons, where citizens actively participate in mapping underutilized or vacant spaces. These initiatives help in democratizing urban greening efforts, ensuring that communities play a role in identifying, prioritizing, and even maintaining green spaces. By integrating public participation with scientific mapping techniques, cities can strategically plan urban greening interventions, enhance biodiversity, and improve overall climate resilience.

Mapathons for identifying derelict, unused areas for greening, creating shade


Thank you