Extreme heat and coastal hazards: Solutions

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1

Problem

The frequence, severity and intensity of coastal disasters—floods, cyclones, storm surges— are increasing as an impacts of rising global temperatures due to climate change. Similarly, extreme heat events are becoming more frequent and severe around the globe. This escalation highlights the critical need for adaptive solutions that can mitigate the impacts of these disasters. Adaptive strategies such as resilient infrastructure, early warning systems, and sustainable urban planning, are essential to protect vulnerable populations and ecosystems. Implementing these solutions can enhance community resilience, reduce economic losses, and safeguard public health in the face of an uncertain and changing climate.

The review showcases strategies utilized around the world for coastal and heat disasters and encourages their wider adoption.

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Criteria

The solutions were selected based on the following criteria to be utilized in the Coastal City Resilience and Extreme Heat Action Project (CoCHAP).

Urban

To be easily integrated into existing urban environments

Low cost

To have a low initial cost for urban municipalities and communities with limited budgets.

Community engagement

To involve the local community in the planning, implementation, and monitoring stages

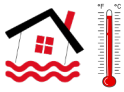
Replicability

The solution should be scalable and adaptable to different city sizes and needs.

Each solution slide is marked with a symbol to signify the relevance with the natural disaster.

Coastal hazards 

Extreme heat 

Both 

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3

Solutions

1. Rooftop farming (Egypt)
2. Cool pavement (USA)
3. Mangrove restoration (Vietnam)
4. Blue green infrastructure (Nepal)
5. Green spaces (Netherlands)
6. Permeable pavement (USA)
7. Green corridors (Columbia)
8. Miyawaki forest (India)
9. Heat mapping (USA)
10. Climate smart agriculture (Bangladesh)
11. Solar Neighborhood (Spain)
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4

Solution 1: Rooftop farming

Rooftop farming is an underutilized intervention where roofs of buildings are covered with vegetation.

Benefits

Rooftop farming reduces urban heat island effect by:

- decreasing local temperatures,
- decreases flooding by increasing storm water retention and precipitation release through evapotranspiration,
- providing air pollutant filtration,
- decreasing building energy use through increased insulation, and natural cooling.

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5

Case study: Rooftop farming

Project: *Ezbet El-Nasr 1*

Ezbet El-Nasr, Cairo, Egypt | 2014 - 2017 | USD $190 for 3 beds | Completed

Solution

Installing a hydroponic system of waterbeds on rooftops consisting of 3-4 beds per rooftop. The beds are made from wooden frames, plastic sheets, foam panels, and cups with peat moss and pyrolite substrate. A water pipe supplied water, maintained by a pump and filter.

Implementing bodies

Schaduf and **German Development Agency (GIZ)** implemented the project in collaboration with two NGOs - **Participatory Development Programme in Urban Areas (PDP)** and **Research Center on Urban Agriculture and Food Security (RUAF)**.

Outcomes

- Reduced urban heat island effect through vegetations
- Improved living conditions and air quality
- Reduced vulnerability to food price fluctuations
- Generated income for families

Recommendations

- Identify the families in a participatory way
- Secure funding ahead of time
- Properly inform the families about financial arrangements.
- Ensure knowledge transfer about rooftop farming
- Ensure regular water supply and electricity

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6

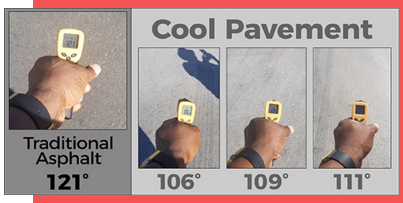
Solution 2: Cool pavement

Cool pavements are reflective or permeable pavements that help lower surface temperatures and reduce the amount of heat absorbed into the pavement. Cool pavement reflects a higher portion of the sunlight that hits it, hence absorbing less heat.

Benefits

Cool pavements can:

- reduce stormwater runoff and improve water quality,
- reduce the heat island effect and reduce temperatures in the city,
- cool neighborhood areas that don't have much shade from the sun.



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7

Case study: Cool pavement

Learn more:

Project: *Cool Pavement Program*

Phoenix, Arizona, USA | 2019 onwards | ? | In-progress

Solution

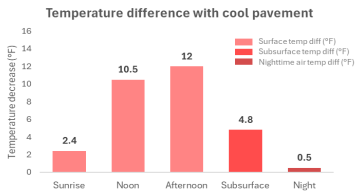
A water-based asphalt treatment is applied on top of the existing asphalt pavement. It's made with asphalt, water, an emulsifying agent (soap), mineral fillers, polymers and recycled materials. It contains no harmful chemicals and is compatible with traditional asphalt.

Implementing body

The **Phoenix Street Transportation Department** and **Office of Sustainability** administered the implementation and evaluation of Cool Pavement Pilot Program in partnership with **Arizona State University (ASU)**. The pilot ended in 2021, and cool pavement is now a permanent part of the **Street Transportation Department's** street maintenance program.

Outcomes

- Cool pavement reduces surface temperatures by up to 12°F compared to conventional pavement.
- May lower long-term road maintenance needs and costs, offering economic and environmental benefits.
- Has a small but positive impact on air temperature.



Recommendations

- Long-term quality tests on pavement.
- Assess air temperature impacts on energy, water, and health.
- Develop guidelines for managing surface dirt and climate-related degradation in Phoenix.
- Explore alternative darker pavement coatings for better public perception without performance loss.

Implementing agency: Phoenix Street Transportation Department, Office of Sustainability

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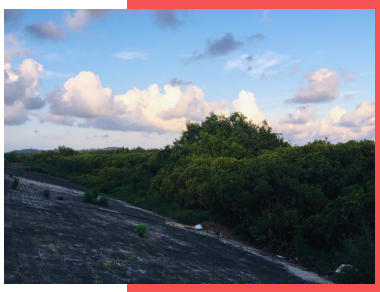
8

Solution 3: Mangrove restoration



Mangrove restoration is the process of regenerating mangroves in areas where they previously existed.

Benefits

Mangrove forests provide essential functions and services to coastal communities including:

- acting as carbon sinks thereby mitigating the effects of climate change,
- providing nutrients for marine life,
- enhancing protection to coastal communities from associated storm surges and erosion,
- capturing soil during periods of heavy precipitation thus stabilizing shoreline sediments,
- safeguarding sea dykes,
- reducing the risk of flooding and protecting livelihoods.

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9

Case study: Mangrove restoration

Project: *Mangrove restoration*

Thai Binh, Thai Binh Province, Vietnam | 1994 - 2010 | USD $582 per hectare of planted trees | Completed

Solution

The Vietnam Red Cross (VNRC) and communities have planted and protected mangroves in coastal communities, covering an estimated 9,000 hectares to safeguard sea dykes, reduce flooding risk and protect livelihoods. From 1999 to 2013, the mangrove area in Vietnam increased by about 6.4%, partly due to the VNRC project. The project has increased aquaculture product yields by more than 200%.

Implementing body

The **VNRC** launched this project in support with the **Danish Red Cross (DRC)**. The **VNRC** scaled up the initiative to include over 100 communities in seven additional coastal provinces - the **Japanese Red Cross (JRC)** also provided funding for six provinces through the **IFRC**.

Outcomes

- Activities covered 9,000 hectares of mangroves
- Reached 350,000 beneficiaries directly
- Reduced dyke damage by:
  - USD $96,371 (without expected damage from typhoons)
  - USD $355,368 (with expected damage from typhoons)

Recommendations

- Significantly enhance the program management set up including sufficient monitoring, guidance, and increased frequency of reporting.
- Focus on sustaining and enhancing protection and care mechanisms rather than additional planting.
- Broaden the focus to facilitate a more comprehensive approach to disaster risk reduction instead of a narrow focus on trees and mangroves planting.

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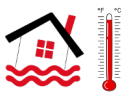
10

Solution 4:
Blue green infrastructure



Blue-green infrastructure (BGI) aims to integrate sustainable water and green space management into urban development. This includes conserving traditional water sources like ponds and stone spouts, creating a digital inventory, and developing a web platform for BGI visualization. Additionally, the approach involves ongoing research, policy dialogues, and engagement with stakeholders to promote resource-efficient and locally adapted solutions in rapidly urbanizing areas.

Benefits

Blue green infrastructure includes:

- preserving and strengthening existing habitats and ecosystems through biodiversity conservation
- climate change adaptation by implementing solutions to capture/store water to increase its availability and prevent shortages from droughts
- creating or improve outdoor spaces to help people escape from urban heat

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11

Case study: Blue green infrastructure

Project: *Blue Green Infrastructure Mapping*

Kathmandu, Central Hill Zone, Nepal | 2021 onwards | $ - | In-progress

Solution

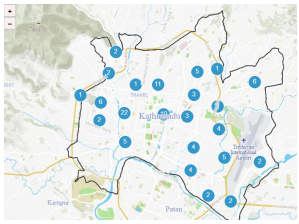
The Blue-Green Infrastructure (BGI) Mapping is the initiative for Identification, Mapping, and Promotion of Blue and Green Infrastructures for Sustainable Urban Ecosystem in the city of Kathmandu. All the datasets will be made public through both the open data portal and the OpenStreetMaps.

Implementing body

The initiative is led by the NAXA and the Institute of Himalayan Risk Reduction (IHRR). The consortium is partnering with the Geomatic Engineering Society at Kathmandu University to organize the Mapathon activity.

Outcomes

- Enhanced capacity for climate hazard management.
- Improved water management and flood protection.
- Restoration of freshwater ecosystems and green spaces.
- Promotion of naturalistic urban design.
- Increased protected areas and ecosystem conservation.
- Reduced biodiversity loss and urban management costs.
- Strengthened social cohesion and local involvement.
- Enhanced community safety against climate-related risks.



Recommendations

- Integrate green infrastructure and mixed-use developments to reduce environmental impact.
- Invest in infrastructure capable of withstanding extreme weather and climate change.
- Protect biodiversity and critical natural resources near urban centers.
- Collaborate with communities, environmental groups, and the private sector for balanced development.

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12

Solution 5: Green spaces

Green spaces promote creating, restoring, and/or enhancing greenery through planting trees, fruits, and vegetables in urban areas.

Benefits

Green spaces help in:
- enhancing sustainable urbanization,
- restoring ecosystems and their functions,
- developing climate change mitigation,
- improving risk management and resilience.

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13

Case study: Green spaces

Project: *Operatie Steenbreek*

Netherland | 2015 - now | - (low budget) | In-progress

Solution

Operatie Steenbreek is a foundation that organizes awareness raising campaigns and helps with regards to greening private gardens. Many gardens and streets in the Netherlands are covered with tiles that cannot absorb the rainwater from heavy rainfall. This project encourages citizens to remove the tiles and stones from their gardens/backyards and replace it with grass, plants and trees for better drainage and to increase the biodiversity.

Implementing body

Operatie Steenbreek works with affiliated **municipalities**, **provinces**, **water boards**, **project developers**, **housing corporations**, **knowledge** and **educational institutions** and other **social** organizations.

Outcomes
- Enhanced climate resilience and risk management
- Flood risk reduction and improved water management
- Increased biodiversity and ecological connectivity
- Restoration and enhancement of green and blue infrastructures
- Improved air and water quality
- Greater accessibility and quantity of green spaces
- Boosted community engagement and sense of ownership
- Increased cultural richness and social interaction
- Improved public health and well-being

Recommendations
- Create a structured organization to support citizen-led greening initiatives.
- Utilize "NbS ambassadors" to share information and methods with citizens.
- Clarify roles in governance to enhance project management and overcome barriers.

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14

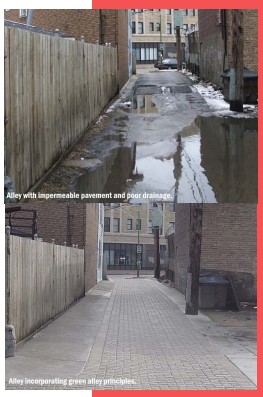
Solution 6: Permeable pavements

Permeable pavement refers to a surface that is porous in nature so that the rainwater falling on the surface or surface water run-off penetrates the pores whereby it is stored in a reservoir before being infiltrated into the soil.

Benefits

Permeable pavements can:

- Restore hydrological balance and reduces runoff water quantity
- Reduce pollutant levels through physical, biological, and chemical means
- Lower urban temperatures, reducing stress on lakes
- Control runoff at the source and promotes groundwater recharge
- Lower installation and maintenance costs compared to traditional infrastructure
- Reduce the usage of de-icing products in winter



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15

Case study: Permeable pavements

Project: *Chicago's Green Alley Program*

Chicago, Illinois, USA | 2006 - now | - | In-progress

Solution

The application used different combinations of permeable pavement techniques based on site conditions. These included use of green pavement materials with conventional drainage, use of full alley infiltration using permeable pavement, use of center alley infiltration using permeable pavement, and use of green pavement materials with a subsoil filtration system.

Implementing body

The **Chicago Department of Transportation** has been upgrading the city's alleys with green pavement materials and designs to better manage stormwater and prevent flooding. The Green Alley program began with five pilot projects and soon expanded for use on a regular basis.

Outcomes

- Improved stormwater management.
- Reduced heat.
- Utilized recycled material.
- Conserved energy and reduced glare.
- Engaged community in laneway greening.

Recommendations

- Increase maintenance for permeable surfaces to ensure optimal functionality.
- Conduct cleaning routines before pavements become deeply clogged with debris.
- Use traditional street sweepers at least twice a year (fall and spring) as part of a regular maintenance schedule.

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16

Solution 7:
Green corridors

Green corridors are planned or unplanned linear landscape elements that allow multiple ecological, social, cultural and other uses compatible with sustainable land use. The objective of a green corridor is always to link important natural areas in a city by means of a strip or corridor characterized by rich vegetation.

Benefits

Green corridors facilitate in:

- Increasing biodiversity by having more green areas in the urban environment.
- Reducing air pollution and noise pollution in the city.
- Helping prevent heat islands from forming, effectively lowering the temperature.
- Contributing to a better storm water management.
- Promoting non-polluting mobility: bicycles or scooters, for example.

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17

Case study: Green corridors

Project: *Greener Medellín for You*

Medellín, Antioquia, Columbia | 2016-2019 | USD $16.3 | Completed

Solution

75 citizens hailing from disadvantaged backgrounds were trained by Medellín's Joaquin Antonio Uribe Botanical Garden to become city gardeners and planting technicians. They have helped to plant 8,800 trees and palms in the 30 corridors that cover 65 hectares. In one of the city's busier thoroughfares, 596 palms and trees have been planted, as well as more than 90,000 species of lesser plants

Implementing body

To address extreme heat phenomenon in Medellín, the **city** implemented a three-year 'greener Medellín for you' program, significantly shifting its urban design paradigm.

Outcomes

- Helped to reduce average city temperatures by 2°C.
- Enabled carbon uptake via plant growth.
- Captured particulate matter to improve air quality.
- Increase urban biodiversity through the creation of more wildlife-friendly habitats.

Recommendations

- Prioritize the busiest and most polluted areas green infrastructure projects, as these areas offer the greatest potential for environmental and social benefits.
- Utilize national and local legislation to secure funding and public support for green initiatives.
- Engage citizens through democratic voting to build legitimacy and drive the implementation of projects like Green Corridors.

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18

Solution 8: Miyawaki forest

The Miyawaki method is an afforestation technique for cultivating fast-growing groves of native plants, with the dense, mixed planting intended to simulate the layers of a natural forest.

Benefits

Miyawaki forests:

- support a wide range of plant and animal species, enhancing local biodiversity,
- sequester carbon dioxide more effectively than monoculture plantations, helping to mitigate climate change,
- filter pollutants, improving air quality in urban areas,
- reduce urban heat island effects by providing shade and transpiration cooling,
- improve soil structure, fertility, and water retention,
- enhance groundwater recharge and reduce surface runoff, preventing soil erosion and flooding.

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19

Case study: Miyawaki forest

Project: *Sona Comstar Manesar - Native species*

Manesar, Haryana, India | 2024 - now | - | In-progress

Solution

The process includes fencing, borewell, site inspection, excavation of soil for 3 ft, manuring, rotovator, marking, drip irrigation and finally plantation.

Implementing body

CATCH Foundation initiated a Third project in Manesar-NSG to transform a barren land into a flourishing Miyawaki dense forest. The project received support from **Sona Comstar**. as part of their **Corporate Social Responsibility (CSR)** initiative. The CATCH Foundation team utilized the CATCH Forest Conservation System to plant and maintain the forest in Manesar-NSG for a duration of 3 years.

Outcomes

Trees planted: **45767**

Area covered: **6.3 hectares**

Species planted: Ambo, Bauhania, Amla, Arjun, Badam, Bakaneem, Banyan Tree, Bor, Chandni, Ficus Religiosa, Goras Ambali, Gulmohar, Jack Fruit, Jamun, Kadam, Kamini, Kanji, Karanj, Kashid, Kesudo, Koner (Karan), Lemon, Mahuva, Mango, Petro Farm, Rain tree, Sag, Shetur, Sisso, Woodapple, babul, neem

Recommendations

- Limit species selection to around 30 to effectively simulate a natural forest.
- Avoid planting creepers and climbers; they will naturally emerge over time.
- Use only indigenous plant species to prevent ecological imbalances and minimize maintenance.
- Regularly prune fast-growing plants to maintain forest health.

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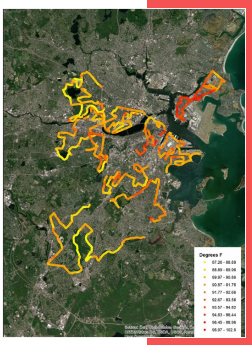
20

Solution 9: Heat mapping



Heat mapping technique enables the identification of different temperature across different regions spatially.

Benefits

Heat maps:
- help in identifying priority zones requiring immediate action,
- allow comparison of temperature between various regions,
- raise awareness around extreme heat.

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21

Case study: Heat mapping

Project: *Wicked Hot Boston*

Boston, Massachusetts, USA | 2019 | - | Completed

Solution

In July and August 2019, the **Museum of Science (MOS)** gathered 50 citizen scientist volunteers comprised of non-government organization representatives, city planners, university students, community members, and professionals, participating in the Museum's first citizen science heat mapping initiative. The Wicked Hot Boston project collected vital data for measuring extreme heat during heat emergencies in and around ten neighborhoods of Boston, Brookline, and Cambridge.

Implementing body

This method was developed by **CAPA Strategies**, **Portland State University**, and the **Science Museum of Virginia**. **MOS** worked with **city planners** in Boston, Cambridge, and Brookline to apply these methods.

Outcomes

- Identified neighborhoods with high temperatures during heat waves.
- Modelled "real feel" temperatures using citizen science and satellite data.
- Documented temperature differences.
- Established a 15°F temperature difference between Boston's warmest and coolest neighborhoods.
- Engaged 100 participants in the project for heat resilience discussions.
- Contributed to community education through forums and story maps.
- Enhanced awareness and communication about heat challenges and resilience.

Recommendations

- Engage stakeholders in participatory heat mapping and interventions.
- Install semi-permanent heat sensors on buildings for real-time temperature and air quality data.
- Integrate bike networks with heat sensors for improved data collection.
- Monitor heat and air quality data over time to prioritize interventions and assess effectiveness.

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22

Solution 10:
Climate smart agriculture

Sorjan farming is a traditional agricultural technique that involves growing crops in raised beds and deep trenches or sinks.

Benefits

Sorjan farming:
- enables year-round vegetable production,
- enhances food security and nutrition,
- increases potential for maximum profit,
- mitigates soil salinity issues,
- prevents flood damage and waterlogged roots during monsoons,
- stores irrigation water for the dry winter months,
- supports effective water management,
- demonstrates climate-smart agriculture practices.

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23

Case study: Climate smart agriculture

Project: *Char Development and Settlement Project- Bridging (CDSP)*

Char Nangulia, Noakhali District, Bangladesh | 2010 - now | - | In-progress

Solution

Sorjan farming uses raised beds to grow upland crops in low- or medium-lying land areas. Farmers construct sorjan beds by stacking soil blocks on top of each other, creating a raised bed that sits above flood level. The sorjan layout depends on the field conditions and the farmer's creativity, but the average width of each raised bed is 1.2 meters, with a 30-degree slope and a height above flood level of 60 to 90 centimeters.

Implementing body

This technique is implemented through community-based approach where the local farmers implement sorjan farming in their regions. **International Fund for Agricultural Development (IFAD)**, **Embassy of the Kingdom of the Netherlands in Dhaka, Bangladesh** and **Government of Bangladesh** facilitated the documentation and evaluation of the technique.

Outcomes
- Reduced flooding
- Improved soil health
- Vegetable supply year round
- Economic benefits for the farmers

Recommendations
- -

Learn more:

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24

Solution 11:
Solar Neighborhood

Solar Neighborhood is an innovative solution to share and use renewable energy among neighbors. An example of public-private sector-community collaboration addressing a system level problem.

Benefits

- Contribute mitigation of carbon emissions through usage of renewable energy.
- No installation and maintenance cost for users (Solar panel companies upfront the cost).
- 30% savings on electricity bills.
- Promote sense of community through sharing of resources at the neighborhood level.

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25

Case study: Solar Neighborhood

Project: *Solar Neighborhood Project*

Zaragoza, Spain | 2020 | Euro 200,000 | Completed

Solution

Installing a photovoltaic system on the roof of a municipal building to offer neighbors within 500 meters away to join without any investment by subscribing to a service with a monthly fee.

Implementing bodies

This Solar Neighborhood pilot experiment is funded and implemented by EDP and ECODES, together with the EDP Foundation and the Schneider Electric Foundation, and with the collaboration of the Environment, Urban Planning and Social Action departments of the Zaragoza City Council.

Outcomes

- Nearby residents, local businesses, schools become a member of the system and receive "first access".
- No installation and maintenance cost for members.
- Up to 30% off in electricity bills.
- They can also rent their roofs and become a "solar host".

Replication/scaling up

This Solar Neighborhood concept is replicated in Fuenlabrada, for 1100 families by the Iberdola solar company. It will also have 13 dual ultra-fast and semi-fast chargers that allow up to 26 electric vehicles to be charged at the same time.

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26

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Rooftop farming

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27

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28