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Heat-Resilient Greenery: Planting Strategies for Urban Medians in Bhubaneswar City, Odisha

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Abstract

Urban medians in rapidly growing cities like Bhubaneswar, Odisha, offer valuable yet underutilized opportunities for integrating climate-resilient green infrastructure. Despite facing harsh conditions—intense heat, compacted soils, limited root space, pollution, and water scarcity—these strips can serve as effective microclimate buffers. Given Bhubaneswar's tropical climate and vulnerability to heatwaves, strategically selecting hardy, low-maintenance plant species is essential for transforming medians into functional, sustainable urban assets. This review analyzes the ecological and infrastructural conditions of Bhubaneswar's urban medians, identifies essential plant traits for survival in high-stress environments, and recommends suitable native and adaptive species. It also highlights global and local case studies, proposes heat-mitigating design strategies, and explores options such as smart irrigation and modular planting. Emphasizing interdisciplinary collaboration, the review positions median planting as a vital component of Bhubaneswar's climate resilience efforts and suggests pathways for future research and sustainable urban greening policies.

Keywords: Urban medians, Bhubaneswar, heat-resilient plants, green infrastructure, climate adaptation

Introduction

Bhubaneswar, the capital city of Odisha, has emerged as one of India's leading smart cities, undergoing rapid urban expansion driven by infrastructure development, population growth, and increasing vehicular density. This swift urbanization has led to escalating environmental stress, including increased surface temperatures, air pollution, and loss of green cover (Patnaik & Swain, 2019). Within this changing urban landscape, road medians—narrow strips of land dividing carriageways—represent an often-overlooked yet strategically significant space for ecological intervention.

Despite their limited size and visibility, urban medians offer immense potential for microclimate regulation, pollution reduction, and biodiversity support. When vegetated with

appropriate plant species, these medians can help cool surrounding environments, filter airborne pollutants, and break the monotony of built infrastructure (Tiwari, 2021). In Bhubaneswar's tropical wet and dry climate, where summer temperatures frequently exceed 40°C and heatwaves have become more common (India Meteorological Department [IMD], 2022), the need for thermally adaptive urban design solutions is critical.

However, median strips present challenging growing conditions, including compacted soils, shallow rooting zones, vehicular emissions, and minimal irrigation support. Traditional ornamental plantings often fail to thrive or demand unsustainable maintenance. This has created a compelling case for the use of native and drought-tolerant species—plants that can withstand high temperatures, irregular water supply, and urban pollution with minimal upkeep (Sjöman & Nielsen, 2010).

This review highlights the urgent need to reimagine Bhubaneswar's Road medians as part of a larger green infrastructure network. By selecting heat-resilient, low-maintenance plant species and integrating smart landscape design, the city can enhance its climate adaptation strategies while also improving visual appeal and ecological health.

Climate Overview of Bhubaneswar

Bhubaneswar, the capital of Odisha, is located at 20.2961° N latitude and 85.8245° E longitude, placing it in the tropical wet and dry climatic zone as per the Köppen climate classification (Aw) (Kottek et al., 2006). This classification is marked by high seasonal variability, including hot summers, concentrated monsoonal rainfall, and mild winters—all of which directly influence plant survival and landscape design outcomes in urban settings.

a. Temperature Range:
   The city experiences extremely hot summers, with daytime temperatures rising to 40–45°C between April and June. In contrast, the winter season from December to February brings milder temperatures, typically ranging between 12–15°C (India Meteorological Department [IMD], 2023).

b. Rainfall Patterns:
   Bhubaneswar receives annual precipitation between 1,400–1,600 mm, most of which occurs during the Southwest monsoon (June to September). Outside the monsoon period, rainfall is minimal, contributing to drought stress during dry months (Odisha State Climate Profile, 2020).

c. Humidity and Wind Conditions:
   Relative humidity varies significantly, reaching 60–90% during the monsoon season, while often dropping to 35–40% during peak summer, increasing the atmospheric dryness and transpiration rates (IMD, 2023). Wind speeds are generally light to moderate, though pre-monsoon squalls can displace loosely rooted vegetation.

These climatic characteristics make Bhubaneswar's urban medians particularly vulnerable to heat stress, water scarcity, and pollution—conditions that must inform plant selection and landscape planning. The selection of native, drought-tolerant, and heat-resilient

plant species is vital for ensuring low-maintenance, sustainable green infrastructure in such high-exposure zones.

Challenges for Median Planting:

Urban median strips, while visually promising, are among the most challenging environments for sustained greenery. In a city like Bhubaneswar—where climate extremes, urban development pressures, and resource limitations converge—these medians face multiple, interlinked challenges. These limitations must be acknowledged and systematically addressed if such spaces are to serve their intended ecological and aesthetic functions.

Prolonged Dry Spells and Water Scarcity

Bhubaneswar experiences a distinct wet and dry seasonal cycle, with rainfall concentrated almost entirely in the monsoon months (June–September). During the remaining 8–9 months, especially in peak summer (March–June), median plantations are subjected to prolonged dry periods without natural precipitation or supplemental irrigation. High surface evaporation, coupled with poor water-holding capacity in median soils, leads to chronic drought stress for plantings (IMD, 2023).

Moreover, due to limited municipal resources, regular watering—especially during dry months—is often infeasible. As such, plant mortality is high unless xerophytic or drought-tolerant species are chosen (Singh & Panigrahi, 2020).

Urban Heat Island (UHI) Intensification

The urban heat island effect is especially pronounced in road corridors where asphalt, concrete, and vehicles dominate. Research indicates that surface temperatures in urban medians can exceed ambient air temperatures by up to 10°C, due to heat absorption and radiation by surrounding infrastructure (Tiwari, 2021). This microclimatic heat stress imposes extreme physiological demands on plants, particularly shallow-rooted or non-native species. Without thermal resilience, plantings often fail within a single summer season.

In Bhubaneswar, where summer temperatures often cross 45°C, median strips effectively become heat sinks, amplifying plant stress and increasing water demands, even for hardy species (Odisha Climate Profile, 2020).

Poor Soil Quality, Depth, and Compaction

Urban medians are typically composed of construction fill, compacted subsoil, and degraded topsoil. Due to repeated vehicular vibration and lack of soil remediation, these strips often present poor porosity, low nutrient levels, and shallow rooting zones—conditions that inhibit root establishment and healthy plant growth (Sjöman & Nielsen, 2010). In Bhubaneswar, road widening and construction have further compacted these medians, leading to minimal infiltration and limited biological activity.

Additionally, construction runoff and debris frequently contaminate median soil, introducing toxic elements or altering pH balance—factors detrimental to most ornamental or native plant species.

Intermittent Flooding in Low-Lying Areas

During the monsoon season, urban drainage systems in Bhubaneswar are frequently overwhelmed, leading to temporary waterlogging in low-lying road sections—including medians (Patnaik & Swain, 2019). This introduces the challenge of dual stress: drought in dry months and flooding in wet months. Most landscape species cannot tolerate alternating extremes in moisture availability, and prolonged saturation can result in root rot, fungal infections, or plant dieback.

Strategic site grading, the use of raised planting beds, and flood-tolerant species are necessary to mitigate this risk.

Limited Maintenance and Institutional Capacity

Effective green infrastructure requires consistent monitoring and care, yet maintenance of Bhubaneswar's medians remains irregular due to resource and staffing constraints faced by the Bhubaneswar Municipal Corporation (BMC). Tasks such as weeding, pruning, mulching, irrigation, and pest control are often deprioritized in favor of infrastructure or sanitation needs (Singh & Panigrahi, 2020).

This inconsistency means that any vegetation introduced must be self-sustaining, low-maintenance, and resilient to neglect. Without institutional support, high-input ornamental plants become unsustainable, and medians risk becoming overgrown, neglected, or entirely barren.

Literature Review

Urban median planting and heat-resilient greenery have gained increased scholarly attention, especially in rapidly urbanizing Indian cities like Bhubaneswar. The following review synthesizes relevant studies on climate vulnerability, urban heat island mitigation, plant trait selection, green infrastructure policies, and regional planning frameworks.

No.	Study/Author(s)	Year	Focus/Key Findings	Reference
1	Roy, Nayak & Mohanty	2015	Increasing heat wave vulnerability in Bhubaneswar linked to urbanization	Roy et al. (2015)
2	Singh & Singh	2016	Temperature trends and heat stress in Odisha	Singh & Singh (2016)
3	Pattnaik, Swain & Nayak	2018	Urban sprawl contributing to rising surface temperatures in Bhubaneswar	Pattnaik et al. (2018)
4	Tiwari et al.	2020	Role of roadside vegetation in urban cooling in Indian smart cities	Tiwari et al. (2020)
5	Gupta & Sharma	2017	Urban green cover reduces surface heat flux in tropical Indian cities	Gupta & Sharma (2017)
6	Kumar, Singh & Reddy	2019	Vegetation in medians lowers pavement temperatures	Kumar et al. (2019)

No.	Study/Author(s)	Year	Focus/Key Findings	Reference
7	Sharma & Joshi	2021	Street trees mitigate urban heat island effects in Indian metros	Sharma & Joshi (2021)
8	Sjöman & Nielsen	2010	Importance of functional traits in selecting urban tree species	Sjöman & Nielsen (2010)
9	Dodd, Gates & Clifton	2018	Trait-based framework for heat and drought resilient urban plants	Dodd et al. (2018)
10	Rao, Singh & Das	2022	Physiological traits of native species in urban medians in Bhubaneswar	Rao et al. (2022)
11	Bhubaneswar Smart City Proposal	2017	Recommends green corridors along medians but lacks species specificity	Bhubaneswar Smart City Proposal (2017)
12	Patnaik & Swain	2019	Evaluation of urban greening gaps in Bhubaneswar, focusing on species adaptability and irrigation	Patnaik & Swain (2019)
13	Singh, Panigrahi & Others	2020	Median strip planting strategies in Indian cities, calling for climate-resilient designs	Singh et al. (2020)
14	Kumar et al.	2018	Successful median plantings in Hyderabad emphasizing local species and community participation	Kumar et al. (2018)
15	Gillner, Vogt & Roloff	2017	Tree species resilience in paved urban environments in Europe	Gillner et al. (2017)
16	Zhao et al.	2019	Green infrastructure designs for urban heat mitigation in Chinese cities	Zhao et al. (2019)
17	Abunnasr, El-Masry & Al-Masri	2020	Drought-tolerant species for Mediterranean urban medians	Abunnasr et al. (2020)
18	Tan et al.	2021	Singapore's median planting integrating evapotranspiration data	Tan et al. (2021)
19	Mehta, Chatterjee & Raghavan	2018	Institutional and maintenance challenges in Indian urban green spaces	Mehta et al. (2018)
20	Rao & Joshi	2021	Policy gaps in urban landscaping regulations in Odisha	Rao & Joshi (2021)
21	Sharma & Singh	2022	Public perception of urban medians and challenges in acceptance of low-water plants	Sharma & Singh (2022)
22	Verma et al.	2020	Smart irrigation systems linked to weather sensors in Indian cities	Verma et al. (2020)
23	Das, Chatterjee & Bhattacharya	2021	Modular planting systems for adaptive urban median greening	Das et al. (2021)
24	Nair, Dasgupta & Kumar	2019	Soil amendments and biochar improve median soil fertility and water retention	Nair et al. (2019)

No.	Study/Author(s)	Year	Focus/Key Findings	Reference
25	Joshi, Patel & Singh	2023	Remote sensing to monitor green cover dynamics along urban road corridors	Joshi et al. (2023)

Gaps Identified in Urban Median Planting in Bhubaneswar

Despite the recognized potential of urban medians as green infrastructure elements, several critical gaps limit their effectiveness in Bhubaneswar:

1) Limited Species-Specific Planning
   Most median planting projects rely on generic plant selections without thorough evaluation of species' heat tolerance, drought resistance, root structure, or pollution resilience. This often leads to high mortality rates and poor performance under Bhubaneswar's tropical climate stressors (Patnaik & Swain, 2019; Rao et al., 2022). The lack of detailed species selection criteria undermines the ecological and aesthetic goals of median landscaping.
2) Poor Irrigation Infrastructure
   The absence of reliable and efficient irrigation systems severely restricts plant survival, especially during prolonged dry spells. Current practices often involve manual or irregular watering, which is inadequate for sustaining green cover. Smart irrigation technologies and drip systems remain underutilized due to budget constraints and limited technical expertise within municipal bodies (Verma et al., 2020; Mehta et al., 2018).
3) Lack of Adaptive Design Strategies
   Existing median designs rarely incorporate modular or adaptive planting approaches that can respond to changing climate conditions or urban development pressures. There is minimal integration of soil amendments, permeable pavements, or microclimate zoning within median layouts. Additionally, urban median projects often lack interdisciplinary planning that combines ecological science, urban design, and public engagement (Das et al., 2021; Sharma & Joshi, 2021).
4) Maintenance and Institutional Challenges
   Maintenance regimes are inconsistent, and many median spaces suffer from neglect due to limited staff, unclear responsibilities, and insufficient funding. This results in overgrown or under-maintained medians, reducing their functional and aesthetic value (Mehta et al., 2018; Rao & Joshi, 2021).
5) Public Perception and Awareness
   Low public awareness about the environmental benefits of median greenery, coupled with a preference for traditional ornamental plants, creates social resistance to adopting drought-tolerant and low-maintenance species. This perceptual barrier limits acceptance and community involvement (Sharma & Singh, 2022).

Research Method

This study is based on:

Aspect	Details	Description/Notes
Local Climate Data	Temperature, rainfall, humidity, seasonal variations	Data collected from Bhubaneswar Meteorological Department and local weather stations to understand environmental stressors.
Soil Data	Soil texture, compaction levels, nutrient content, pH	Field soil sampling and laboratory analysis to assess soil suitability and limitations for planting.
Field Observations	On-site surveys of existing median vegetation and stress conditions	Visual health assessment of plants, mortality rates, pest/disease incidence, and microclimate impacts.
Native Flora Database	Odisha Forest Department's records	Comprehensive list of indigenous species adapted to the regional climate and soil conditions.
Plant Selection Criteria:		
- Heat & Drought Tolerance	Ability to survive prolonged high temperatures and dry periods	Focus on species demonstrating physiological resilience such as deep roots, waxy leaves, and stomatal control.
- Pollution Resistance	Capacity to withstand vehicular emissions and particulate matter	Preference for species known for pollutant absorption and tolerance of urban air quality challenges.
- Compact Size	Limited height and root spread to avoid infrastructure damage	Selection of dwarf shrubs, grasses, and small trees with non-invasive roots suitable for narrow medians.
- Low Maintenance	Minimal irrigation and pruning requirements	Species requiring infrequent watering and resistant to pests to reduce upkeep costs and efforts.
- Non-Invasive Root Systems	Roots that do not damage pavements or underground utilities	Critical to avoid costly infrastructure repairs and ensure public safety.

Findings

Plant Traits for Survival

Heat and Drought Resistance: Bhubaneswar experiences intense heat during the summer months, with temperatures frequently exceeding 40°C, accompanied by periods of scarce rainfall and high evapotranspiration rates. Plants used in urban medians must be highly tolerant to these conditions to survive without requiring frequent irrigation, which is often logistically and economically challenging. Adaptations that support heat and drought resistance include thick cuticles, waxy or hairy leaves to reduce water loss, deep or fibrous root systems

to access water from lower soil layers, and the ability to enter dormancy during extreme drought.Notable examples for Bhubaneswar medians**:**

- Lantana camara: A resilient shrub with thick, rough leaves that tolerate drought and heat, and produce colorful flowers that attract pollinators.
- Portulaca grandiflora (Moss Rose): A succulent groundcover that stores water in its fleshy leaves, thrives in full sun, and withstands drought with minimal care.
- Bougainvillea glabra: Known for vibrant, long-lasting bracts and extreme drought tolerance; also well-suited to prune into compact forms.
- Muhlenbergia capillaris (Pink Muhly Grass): A native ornamental grass that is highly drought-tolerant and provides aesthetic value with its pink inflorescences.
- Tecoma stans (Yellow Bells): A small shrub with tubular yellow flowers, tolerant to drought and poor soils, providing seasonal color.

These plants reduce water demand, maintain green cover under extreme heat, and help lower median maintenance costs.

Pollution and Dust Tolerance

Urban medians located alongside busy roads are subjected to constant pollution from vehicle exhaust, dust, and particulate matter. This exposure can block stomata, reduce photosynthesis, and cause leaf damage. Plants with rough, hairy, or waxy leaf surfaces can trap or shed dust efficiently. Furthermore, some species possess detoxifying mechanisms, such as producing antioxidants or sequestering heavy metals, which allow them to thrive despite poor air quality.Key species for pollution tolerance:

- Ficus religiosa (Peepal Tree): A large native tree known for filtering air pollutants effectively and contributing to urban biodiversity.
- Nerium oleander: A tough evergreen shrub with leathery leaves that resist dust accumulation and tolerate urban pollution.
- Azadirachta indica (Neem): A drought-resistant tree with proven air purifying qualities, commonly used in Indian cities for roadside planting.
- Callistemon citrinus (Bottlebrush): Its needle-like leaves minimize dust accumulation and withstand traffic pollution.
- Pongamia pinnata (Indian Beech): Tolerant to saline and polluted soils, fixes nitrogen improving soil health.

These species not only survive in polluted environments but also improve air quality, contributing to urban health.

Flood and Monsoon Adaptability

Bhubaneswar's tropical monsoon climate brings intense rainfall concentrated between June and September, which often leads to waterlogged soils and temporary flooding, particularly in medians located at lower elevations or poor-drainage areas. Plants must be able to tolerate hypoxic (low oxygen) soil conditions, resist root rot, and recover rapidly after flooding. Adaptations include the development of aerenchyma tissue to transport oxygen to roots and the ability to switch metabolic pathways to survive anaerobic conditions.Flood-tolerant species include:

- Saccharum officinarum (Sugarcane): A robust grass that can survive flooded soils and is tolerant of heavy moisture.
- Typha latifolia (Cattail): Commonly found in wetlands, able to thrive in saturated soils and standing water.
- Alstonia scholaris (Indian Devil Tree)**:** A native tree with strong adaptability to both **drought** and temporary waterlogging.
- Cyperus alternifolius (Umbrella Sedge)**:** A sedge that prospers in moist and waterlogged conditions, useful for drainage enhancement.
- Colocasia esculenta (Taro)**:** Grows well in wet soils and adds texture diversity to medians.Including these species in flood-prone median areas ensures green cover continuity during and after the monsoon season.

Compact Form with Shallow Roots

Urban medians in Bhubaneswar are narrow strips flanked by roads and underground utilities such as water lines, electricity cables, and drainage pipes. Hence, planting species with compact growth habits and shallow, non-invasive root systems is critical to prevent damage to infrastructure, reduce maintenance burdens, and maintain visibility for traffic safety. Compact plants also facilitate easier pruning and replacement when necessary.Recommended compact species:

- Festuca glauca (Blue Fescue): A fine-leaved ornamental grass that grows in tight clumps with shallow roots, ideal for narrow medians.
- Ixora coccinea: A dense, compact shrub with bright flowers that remain manageable in size and root spread.
- Portulaca oleracea (Purslane): A low-growing succulent groundcover with minimal root intrusion, excellent for ground stabilization.
- Bougainvillea (Dwarf cultivars): Controlled dwarf varieties are suitable for confined spaces without aggressive roots.
- Jatropha integerrima: A small shrub that grows upright without extensive root spread, adding color and structure.

Such species balance greenery with practical urban infrastructure considerations, ensuring longevity and safety.

Year-Round Visual Appeal

The success of urban median landscaping depends not only on plant survival but also on providing continuous visual interest to enhance the cityscape, improve mental well-being for residents and commuters, and foster public support for green initiatives. Species offering evergreen foliage or staggered flowering seasons create dynamic, colorful displays throughout the year.Aesthetically valuable species include:

- Hibiscus rosa-sinensis: Tropical evergreen shrub with large, showy flowers blooming year-round in warm climates.
- Duranta erecta: An evergreen shrub with delicate purple flowers and ornamental berries that add seasonal interest.
- Codiaeum variegatum (Croton): Known for its striking multicolored foliage that remains vibrant year-round.
- Pentas lanceolata: A flowering perennial that blooms multiple times a year, attracting butterflies and pollinators.
- Clerodendrum inerme (Glorybower): A hardy shrub with fragrant white flowers providing seasonal aroma and beauty.

The strategic combination of such species in medians promotes aesthetic continuity, biodiversity, and urban ecological health.

Suggested Plant Categories and Examples:

Category	Common Name	Botanical Name	Key Benefits
Native Grasses	Lemongrass	*Cymbopogon citratus*	Aromatic, drought-tolerant, pest-repelling
	Vetiver Grass	*Vetiveria zizanioides*	Deep roots prevent erosion, highly heat-tolerant
	Golden Beard Grass	*Chrysopogon aciculatus*	Hardy groundcover, suitable for poor soils
	Blue Fescue	*Festuca glauca*	Compact, drought-resistant, ornamental foliage
	Pink Muhly Grass	*Muhlenbergia capillaris*	Airy, ornamental look, excellent heat tolerance
Ground Covers	Purslane	*Portulaca grandiflora*	Succulent, bright blooms, survives intense heat and drought
	Joseph’s Coat	*Alternanthera ficoidea*	Colorful foliage, excellent ground cover
	Purple Heart	*Tradescantia pallida*	Drought-tolerant, striking purple foliage
	Spider Plant	*Chlorophytum comosum*	Hardy, adaptable, good for partial shade

Category	Common Name	Botanical Name	Key Benefits
	Carpet Grass	*Axonopus compressus*	Erosion control, shade-tolerant, soft texture
Shrubs	Lantana	*Lantana camara*	Long-blooming, attracts butterflies, drought-resistant
	Yellow Bells	*Tecoma stans*	Heat-tolerant, trumpet-shaped yellow flowers
	Firebush	*Hamelia patens*	Bright red-orange flowers, attracts pollinators
	Ixora	*Ixora coccinea*	Dense flowering shrub, compact size
	Oleander	*Nerium oleander*	Highly pollution-tolerant, evergreen (note: toxic if ingested)
Small Trees	Tagar (Crape Jasmine)	*Tabernaemontana divaricata*	Fragrant white flowers, minimal root intrusion
	Frangipani	*Plumeria spp.*	Tropical appeal, drought-tolerant, fragrant flowers
	Yellow Bauhinia	*Bauhinia tomentosa*	Small stature, yellow bell-shaped flowers
	Crape Myrtle	*Lagerstroemia indica*	Extended blooming period, ornamental bark
	Golden Shower Tree	*Cassia fistula*	Hardy, heat-resistant, vibrant yellow flowering in summer

Case Study Inspirations

1. **Singapore: Median Landscaping with Tropical Plants and Smart Irrigation**

   Singapore is a global exemplar in urban greening, especially along its roads and medians. The Land Transport Authority (LTA) integrates tropical ornamental species such as Ixora, Heliconia, and Cordyline in median strips, which are selected for their high visual impact and ability to withstand humidity and urban stress. One innovative feature is the use of **s**olar-powered smart irrigation systems with moisture sensors, which automatically adjust watering schedules based on weather data. This minimizes water use and ensures plant health even during prolonged dry spells.

2. **Pune & Hyderabad, India: Xeriscaping and Native Flora Integration**

   Pune and Hyderabad have adopted **xeriscaping** principles—landscaping that reduces or eliminates the need for irrigation—particularly in urban medians and roadside green belts. Species such as *Bougainvillea*, *Tecoma stans*, and native grasses are used due to their resilience to drought, low maintenance requirements, and visual appeal. The Pune Municipal Corporation also focuses on *rain-fed species* and mulch-based ground cover to conserve soil moisture and reduce weed growth. These strategies have shown a measurable reduction in maintenance costs and water usage.

3. **Odisha Forest Department: Roadside Planting with Indigenous Species**

   The Odisha Forest Department has been implementing median and roadside greening using hardy, indigenous species like *Cassia fistula*, *Azadirachta indica* (Neem), and *Polyalthia longifolia* (Ashoka). These species are selected for their ability to withstand Odisha's seasonal extremes—hot summers, heavy monsoons, and moderate winters. The use of native plants also promotes local biodiversity and reduces the dependency on intensive irrigation or fertilization. Additionally, the department encourages collaboration with urban bodies for consistent upkeep of these medians.

Results and Discussion

Benefits of Median Planting:Urban median planting in Bhubaneswar has the potential to serve multiple ecological, environmental, and aesthetic functions. The results of field observations, climate data correlation, and review of successful case studies indicate several core benefits:

Surface Temperature Reduction

Strategically planted medians contribute to lowering localized surface temperatures through shading and plant-driven evapotranspiration. Studies show that urban vegetation can reduce pavement temperatures by up to 10–15°C during peak summer hours (Tiwari et al., 2020). In Bhubaneswar, where summer temperatures exceed 40°C, this effect can significantly moderate the urban heat island impact.

- ***Support for Pollinators and Micro-Fauna***

  Native flowering plants such as *Lantana camara*, *Tecoma stans*, and *Cassia fistula* support urban biodiversity by attracting bees, butterflies, and birds. These micro-habitats enhance ecological connectivity, especially in fragmented cityscapes (Khera et al., 2009).

- ***Improved Air Quality and Dust Capture***

  Median plants help filter out particulate matter (PM2.5 and PM10) and vehicular emissions. Species like *Neem* and *Ashoka* are known for their phytoremediation abilities, trapping dust and absorbing pollutants such as nitrogen dioxide (NO□) and sulfur dioxide (SO□) (Rao & Sharma, 2017).

- ***Visual Beautification and Psychological Benefits***

  Landscaped medians enhance the aesthetic appeal of roadways and provide psychological comfort to commuters. Greenery along traffic corridors has been linked to stress reduction and improved urban livability (Ulrich et al., 1991).

Challenges Noted

Despite the documented advantages, several implementation and maintenance challenges persist in Bhubaneswar’s median planting efforts:

- ***Maintenance Gaps from Municipal Agencies***

  The lack of regular pruning, cleaning, and replanting often leads to degraded green strips. Municipal resource constraints and absence of skilled horticultural labor result in neglected medians, which can become eyesores or safety hazards.

- ***Plant Overgrowth Hindering Visibility***

  Certain fast-growing or poorly selected shrubs, like *Lantana camara*, can obstruct drivers' line of sight, increasing accident risk—particularly at intersections or turning zones. Proper height and spacing management is often lacking.

- ***Public Resistance to Native or Non-Ornamental Flora***

  There is often preference for exotic, ornamental plants, leading to resistance when native, xerophytic species are used—even though these are better suited to local conditions. This cultural barrier hampers ecologically sound planting choices.

- ***Lack of Integrated Irrigation Systems***

  Many medians rely on manual or rain-dependent watering, which leads to plant death during extended dry periods. The absence of drip or solar-assisted smart irrigation systems impairs long-term plant survival and increases maintenance costs (Tan et al., 2013).

Conclusion

Median greening presents a highly practical and impactful climate intervention for Bhubaneswar, offering both ecological and urban design benefits. Given the city's tropical climate, seasonal extremes, and increasing urbanization, it is essential to prioritize plant species that are native, drought-tolerant, and possess shallow root systems. These traits ensure long-term survival with minimal maintenance, reduce pressure on limited water resources, and prevent damage to underground infrastructure.To maximize both performance and visual appeal, median planting must be integrated into smart, modular systems—featuring prefabricated soil cells, efficient drainage, and IoT-enabled irrigation for optimal water use. Beyond their environmental role, medians should be reconceptualized as high-performance green infrastructure that contributes to urban cooling, air quality improvement, biodiversity support, and even psychological well-being. For this vision to take root, policymakers and urban designers must shift their perception of medians—from purely traffic dividers to multifunctional ecological assets. Strategic planning, community involvement, and a commitment to resilient urban design are key to transforming Bhubaneswar's roadways into living corridors that serve both people and the planet.

Suggestions for Future Research

To enhance the effectiveness and sustainability of urban median planting in Bhubaneswar and similar tropical cities, research should focus on several key areas. Controlled

survival trials can identify resilient native and adaptive plant species suited to harsh median conditions such as heat, poor soil, and limited water. Quantitative studies should assess the environmental impact of median greening, including temperature reduction, dust suppression, and noise mitigation. The adoption of IoT-enabled irrigation systems, using moisture sensors and automation, warrants evaluation for water efficiency and practicality. Public perception research can guide aesthetically and culturally acceptable planting strategies to ensure community engagement. Lastly, the development of modular planting prototypes tailored to space and environmental constraints can support scalable and low-maintenance urban greening solutions.

Feedback for Planners and Designers

To ensure successful and sustainable median planting in Bhubaneswar's tropical climate, urban planners should prioritize native, drought-tolerant, and non-invasive plant species that require minimal maintenance and support local biodiversity. Compact growth forms with shallow roots are ideal for maintaining visibility and protecting infrastructure. Enhancing soil quality through compost and sand, along with effective drainage solutions, is crucial for healthy plant growth. The use of reflective or permeable paving around median beds can help reduce heat buildup and improve water absorption. Additionally, public education initiatives can build community support for ecological aesthetics and promote long-term care of green medians.

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