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**Climate-Resilient Landscaping in Peshawar: Integrating Heat and Cold Tolerance with Social and Therapeutic Benefits**

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**Abstract**

Urban areas across the world are increasingly exposed to climate variability, particularly rising temperatures, irregular rainfall, and seasonal temperature extremes. These changes pose serious challenges for the sustainability of urban landscapes, especially in rapidly expanding cities where green spaces are declining. Peshawar, located in northwestern Pakistan, experiences a subtropical climate characterized by extremely hot summers with temperatures exceeding 40 °C and relatively cold winters approaching freezing conditions. Such climatic extremes require the selection of landscape plants capable of tolerating both heat and cold stress while maintaining ecological, aesthetic, and functional value. At the same time, urban green spaces are increasingly recognized for their social and therapeutic roles, contributing to psychological well-being, stress reduction, and community interaction. The present study aimed to identify and evaluate climate-resilient plant species suitable for urban landscaping in Peshawar while simultaneously assessing their social and therapeutic benefits. Plant species were selected using criteria including heat tolerance, cold tolerance, drought resistance, adaptability to urban soils, ornamental value, and potential contribution to psychological and social well-being. Information was synthesized from scientific literature, horticultural references, field observations of urban landscapes, and expert consultation with horticulture and landscape professionals. An integrated evaluation framework combining climate adaptability, landscape functionality, and therapeutic attributes was used to assess plant suitability. The analysis identified several species, including *Bougainvillea* spp., *Lagerstroemia indica*, *Azadirachta indica*, *Ficus religiosa*, *Hibiscus rosa-sinensis*, *Rosa* spp., *Lantana camara*, and *Moringa oleifera*, as highly suitable for climate-resilient urban landscapes in Peshawar. These plants demonstrated strong tolerance to temperature extremes and drought conditions while offering multiple environmental and social benefits such as shade provision, ornamental beauty, air purification, cultural significance, and psychological relaxation. The study highlights the importance of integrating climate resilience with human-centered landscape design in urban planning. The adoption of climate-adapted ornamental and functional plants can enhance environmental sustainability while promoting healthier and more socially engaging urban environments. The findings provide practical guidance for urban planners, municipal authorities, and landscape architects in designing resilient and therapeutic green spaces in cities experiencing climatic stress.

## 1. Introduction

Urban areas worldwide are increasingly facing the dual challenge of climate extremes and rapid urbanization, which often reduce green cover and intensify heat and cold stress (Das et al. 2024). Peshawar, situated in a subtropical zone, experiences high summer temperatures and cold winter conditions, creating a pressing need for landscape designs that are resilient to climatic extremes (Aslam et al., 2024).

Beyond environmental adaptation, urban green spaces provide critical **social** and therapeutic benefits. Numerous studies have demonstrated that exposure to green environments can enhance psychological well-being, reduce stress, and promote social interaction. This makes the selection of landscape plants not only an ecological concern but also a public health consideration (Jabbar et al. 2022).

Despite the growing recognition of climate-resilient landscaping, there is limited research focusing on plant species that simultaneously tolerate extreme heat and cold while offering therapeutic and social benefits (Oyenuga et al. 2025) especially in the context of Peshawar. Addressing this gap is crucial for designing sustainable urban landscapes that improve both environmental resilience and human well-being.

The present study aims **to** identify and evaluate climate-resilient plants suitable for Peshawar's urban landscapes, with an emphasis on their ability to withstand heat and cold extremes while contributing to social and therapeutic horticulture benefits. By integrating environmental adaptation with human-centered design, this research seeks to provide practical guidelines for developing resilient and health-promoting green spaces in the region.

## 2. Review of Literature

Urban landscapes play a critical role in mitigating the effects of climate extremes, improving environmental quality, and enhancing human well-being. Studies worldwide have shown that climate-resilient plant species—those tolerant to heat, drought, and cold—can sustain urban greenery even under adverse climatic conditions. These species reduce urban heat islands, improve air quality, and contribute to ecosystem services in cities (Gill et al., 2007).

In the context of South Asia, including Pakistan, urban areas are increasingly vulnerable to climate variability. Peshawar, with its hot summers exceeding 40°C and cold winters approaching 0°C, demands landscape plants that can tolerate these extremes while maintaining aesthetic and functional value. Recent studies in the region have highlighted the potential of drought-tolerant shrubs, native trees, and hardy ornamental plants for sustainable urban landscaping (Ahmad et al., 2022; Khan et al., 2020).

Beyond environmental adaptation, the therapeutic and social roles of plants are gaining recognition. Research in environmental psychology and landscape design has shown that green spaces can reduce stress, improve mental health, and encourage social interaction (Ulrich, 1984; Maas et al., 2009). Horticultural therapy programs have successfully demonstrated that interaction with plants—through gardening, viewing, or caring for greenery—enhances cognitive, emotional, and social well-being, particularly in urban populations (Tutova et al. 2025).

Despite these insights, there is a gap in research combining climate resilience with therapeutic and social benefits in urban landscapes of Pakistan. Most studies have focused either on plant survival under extreme weather or human health benefits, but rarely on an integrated approach. Addressing this gap is essential for cities like Peshawar, where urban expansion and climatic extremes coexist, and green spaces must serve both ecological and societal functions (Hyder et al., 2024).

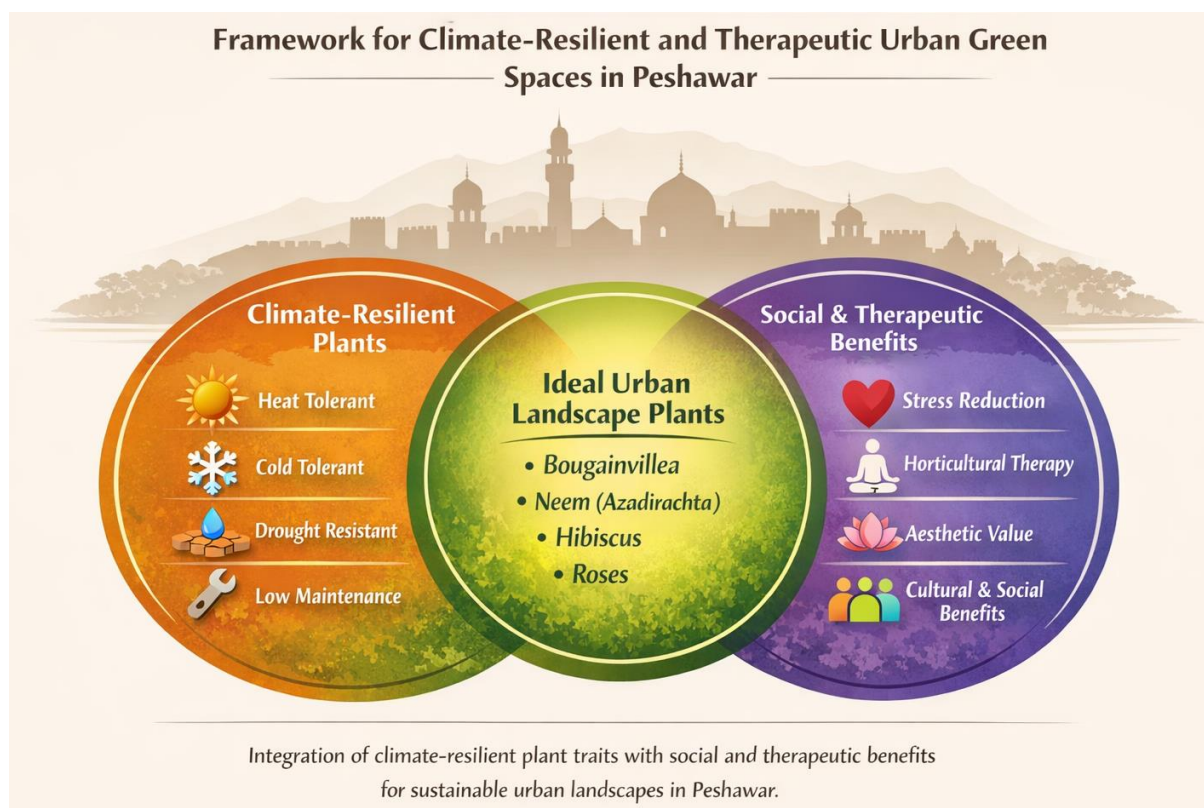
The present study seeks to bridge this gap by evaluating plant species suitable for Peshawar's extreme climate while considering their potential social and therapeutic impacts, thereby contributing to climate-resilient, human-centered urban landscaping.

**Table 2.1 Ten (10) Climate-Resilient Trees with Social and Therapeutic Benefits**

S.No	Plant Species	Climate Resilience	Social / Therapeutic benefits	Suitability for Peshawar
<b>Trees</b>				
01	Ficus religiosa (Peepal)	Heat tolerant, moderate cold tolerance	Spiritual and cultural significance, mental well-being	Urban parks and green corridors
02	Cassia fistula (Amaltas / Golden Shower Tree)	Highly tolerant to heat and drought; adapts well to dry and semi-arid climates	Highly tolerant to heat and drought; adapts well to dry and semi-arid climates	Highly tolerant to heat and drought; adapts well to dry and semi-arid climates
03	Bauhinia variegata (Kachnar / Orchid Tree)	Bauhinia variegata (Kachnar / Orchid Tree)	auhinia variegata (Kachnar / Orchid Tree)	auhinia variegata (Kachnar / Orchid Tree)
04	Melia azedarach (Dharek / Chinaberry Tree)	Melia azedarach (Dharek / Chinaberry Tree)	Melia azedarach (Dharek / Chinaberry Tree)	Melia azedarach (Dharek / Chinaberry Tree)
05	Grevillea robusta (Silver Oak)	Grevillea robusta (Silver Oak)	Grevillea robusta (Silver Oak)	Grevillea robusta (Silver Oak)
06	Callistemon citrinus (Bottlebrush)	Callistemon citrinus (Bottlebrush)	Callistemon citrinus (Bottlebrush)	Callistemon citrinus (Bottlebrush)
07	Jacaranda mimosifolia (Jacaranda)	acaranda mimosifolia (Jacaranda)	acaranda mimosifolia (Jacaranda)	acaranda mimosifolia (Jacaranda)
08	Delonix regia (Gulmohar / Flame Tree)	Delonix regia (Gulmohar / Flame Tree)	Delonix regia (Gulmohar / Flame Tree)	Delonix regia (Gulmohar / Flame Tree)
09	Alstonia scholaris (Devil Tree / Blackboard Tree)	Alstonia scholaris (Devil Tree / Blackboard Tree)	Alstonia scholaris (Devil Tree / Blackboard Tree)	Alstonia scholaris (Devil Tree / Blackboard Tree)
10	Moringa oleifera (Drumstick Tree / Sohanjna)	Moringa oleifera (Drumstick Tree / Sohanjna)	Moringa oleifera (Drumstick Tree / Sohanjna)	Moringa oleifera (Drumstick Tree / Sohanjna)

**Table 2.2 Ten (10) Climate-Resilient Shrubs with Social and Therapeutic Benefits**

S.No	Plant Species	Climate Resilience	Social / Therapeutic benefits	Suitability for Peshawar
<b>Shrubs</b>				
01	Lagerstroemia indica (Crape Myrtle)	Lagerstroemia indica (Crape Myrtle)	Lagerstroemia indica (Crape Myrtle)	Lagerstroemia indica (Crape Myrtle)
02	Euonymus japonicus	Euonymus japonicus	Euonymus japonicus	Euonymus japonicus
03	Rosa spp. (Roses)	Rosa spp. (Roses)	Rosa spp. (Roses)	Rosa spp. (Roses)
04	Nerium oleander (Kaner)	Nerium oleander (Kaner)	Nerium oleander (Kaner)	Nerium oleander (Kaner)
05	Pittosporum tobira	Pittosporum tobira	Pittosporum tobira	Pittosporum tobira
06	Jatropha integerrima (Peregrina)	Jatropha integerrima (Peregrina)	Jatropha integerrima (Peregrina)	Jatropha integerrima (Peregrina)
07	<b>Hibiscus rosa-sinensis</b>	<b>Hibiscus rosa-sinensis</b>	<b>Hibiscus rosa-sinensis</b>	<b>Hibiscus rosa-sinensis</b>
08	Murraya paniculata (Orange Jasmine / Kamini)	Murraya paniculata (Orange Jasmine / Kamini)	Murraya paniculata (Orange Jasmine / Kamini)	Murraya paniculata (Orange Jasmine / Kamini)
09	Alstonia scholaris (Devil Tree / Blackboard Tree)	Alstonia scholaris (Devil Tree / Blackboard Tree)	Alstonia scholaris (Devil Tree / Blackboard Tree)	Alstonia scholaris (Devil Tree / Blackboard Tree)
10	Dodonaea viscosa (Sanata / Hopbush)	Dodonaea viscosa (Sanata / Hopbush)	Dodonaea viscosa (Sanata / Hopbush)	Dodonaea viscosa (Sanata / Hopbush)



Integration of Climate-resilient plant traits with social and therapeutic benefits.

### 3. Materials and Methods

#### Study Area

The study focuses on Peshawar, Pakistan, a major urban center located in the northwestern region of the country. The city experiences a subtropical climate characterized by extreme seasonal variations, including hot summers where temperatures frequently exceed 40 °C and cool winters during which temperatures may approach 0°C. Such climatic variability poses considerable challenges for the sustainability of urban landscapes.

Rapid urban expansion in Peshawar has also contributed to reduced vegetation cover, increasing urban heat island effects, and declining environmental quality. These conditions highlight the importance of selecting landscape plant species that can withstand climatic extremes while supporting sustainable and health-promoting urban green spaces.

#### Plant Selection Criteria

Plant species considered in this study were identified based on their suitability for climate-resilient urban landscapes and their potential to contribute to social and therapeutic horticulture.

The main criteria used for plant selection included:

1. Climate Resilience
  - Tolerance to high summer temperatures
  - Ability to withstand moderate winter cold
  - Drought tolerance and reduced irrigation requirements
2. Landscape Suitability
  - Ornamental value including attractive flowers, foliage, or plant form
  - Adaptability to urban soils and environmental conditions

- Low maintenance requirements for urban landscape management
- 3. Social and Therapeutic Value
  - Visual and sensory characteristics that promote psychological well-being
  - Fragrance, color, and aesthetic appeal that enhance relaxation and stress reduction
  - Cultural or traditional importance in community spaces

### **Sources of Information**

Information regarding plant adaptability and landscape value was obtained from multiple sources, including:

- Published scientific literature on urban landscaping and climate-resilient plants
- Horticultural manuals and landscape design guides
- Observations from urban parks, institutional landscapes, and residential gardens in Peshawar
- Expert consultation with horticulture and landscape professionals

These sources provided comprehensive insights into the performance and suitability of various ornamental plants under local climatic conditions.

### **Evaluation Framework**

The selected plant species were evaluated using an integrated framework combining environmental adaptability and human-centered landscape benefits.

The evaluation included the following indicators:

#### Climate Adaptability Indicators

- Heat tolerance
- Cold tolerance
- Drought resistance

#### Landscape Functionality Indicators

- Shade provision
- Ornamental and aesthetic value
- Maintenance requirements

#### Therapeutic and Social Indicators

- Visual qualities associated with stress reduction
- Sensory attributes such as fragrance and color
- Cultural significance and community engagement potential

Plants demonstrating favorable performance across these indicators were considered suitable candidates for climate-resilient and therapeutic urban landscapes in Peshawar.

### **Data Analysis**

The collected information was synthesized using qualitative comparative analysis to identify plant species that best fulfill the combined criteria of climate resilience and social–therapeutic benefits. The findings were organized into tables and conceptual frameworks to support practical recommendations for urban planners, landscape architects, and municipal authorities.

## **4. Results and Discussion**

### **Climate Resilience of Selected Landscape Plants**

The evaluation of selected landscape plant species revealed that several ornamental trees, shrubs, and flowering plants possess strong adaptability to the climatic extremes of Peshawar. The city experiences hot summers with temperatures exceeding 40 °C and relatively cold winters where temperatures may approach freezing. Plants that demonstrated tolerance to both temperature extremes and water scarcity were considered highly suitable for climate-resilient urban landscaping.

Among the evaluated species, *Melia azedarach*, *Moringa oleifera* and *Lagestroemia indica*, exhibited strong tolerance to high temperature and drought conditions. These plants are already widely observed in urban landscapes of Peshawar and have shown consistent performance under limited irrigation and poor soil conditions. Their resilience makes them valuable components of sustainable landscaping, particularly in areas where water availability is limited.

Similarly, species such as *Ficus religiosa*, *Hibiscus rosa-sinensis*, and *Rosa* spp. demonstrated moderate tolerance to both heat and cold conditions. Although these species may require slightly higher maintenance compared to highly drought-tolerant plants, they provide significant ornamental and ecological value in urban landscapes.

The results suggest that integrating hardy trees with flowering shrubs and ornamental plants can create resilient urban landscapes capable of withstanding climatic variability while maintaining aesthetic value.

### **Landscape Functionality and Environmental Benefits**

Beyond their climatic adaptability, the selected plant species contribute significantly to the environmental functionality of urban landscapes. Trees such as *Melia Azedarach* and *Ficus religiosa* provide dense canopy cover that helps reduce surface temperatures and mitigate urban heat island effects. Shade-providing trees also improve outdoor comfort for pedestrians and recreational users of urban green spaces.

Flowering shrubs and ornamental plants such as *Hibiscus*, *Murayya* and *Roses* contribute to visual attractiveness and seasonal color diversity. Such aesthetic qualities play an important role in improving the visual identity of urban spaces, parks, and institutional landscapes.

Furthermore, several species evaluated in this study also contribute to ecological sustainability. For example, *Lantana camara* attracts pollinators such as butterflies and bees, thereby supporting urban biodiversity. Similarly, *Moringa oleifera* offers multiple ecosystem services including soil improvement, nutritional benefits, and shade provision.

These findings support earlier studies suggesting that climate-resilient landscaping should integrate ecological functionality with ornamental value to maximize the benefits of urban green infrastructure.

### **Social and Therapeutic Benefits of Urban Green Spaces**

The social and therapeutic value of plants emerged as an important component of climate-resilient landscaping. Exposure to green spaces has been widely associated with psychological relaxation, stress reduction, and improved mental health. In the context of rapidly urbanizing cities such as Peshawar, accessible green spaces can serve as essential areas for recreation, social interaction, and emotional well-being.

Flowering plants such as *Rosa* spp., *Hibiscus rosa-sinensis*, and *Lagerstroemia indica* provide visual stimulation through vibrant colors and seasonal blooms, which have been linked with positive emotional responses and reduced stress levels. Fragrant flowers, particularly roses, further enhance sensory engagement and are commonly used in therapeutic garden designs.

Large shade trees such as *Peepal* (*Ficus religiosa*) and *Bakain* (*Melia Azadirach*) also hold cultural and social significance in South Asian communities. These trees often serve as gathering points in parks, streets, and community spaces where people meet, rest, and interact. Such spaces contribute to social cohesion and community engagement.

Additionally, plants like *Moringa oleifera* offer opportunities for community gardening initiatives due to their nutritional and medicinal value. Community involvement in planting and maintaining such species can strengthen social bonds and encourage environmental stewardship.

### **Integrating Climate Resilience with Human-Centered Landscape Design**

The results of this study highlight the importance of adopting an integrated approach in urban landscape planning that combines climate resilience with human-centered benefits. Traditional landscaping approaches often emphasize aesthetics without considering long-term sustainability or

climate adaptability. However, cities facing increasing temperature extremes must prioritize plant species capable of surviving harsh environmental conditions.

The integration of hardy trees, drought-tolerant shrubs, and aesthetically appealing flowering plants can help create landscapes that are both environmentally resilient and socially beneficial. Such landscapes not only reduce environmental stress but also improve quality of life for urban residents.

For cities like Peshawar, climate-resilient landscaping should focus on:

- Increased planting of drought-tolerant trees and shrubs
- Development of therapeutic gardens in parks and healthcare facilities
- Promotion of native and adaptable ornamental plants
- Incorporation of shaded social spaces within urban landscapes

By implementing these strategies, urban planners and municipal authorities can enhance the sustainability and livability of rapidly expanding cities.

### **Implications for Urban Landscape Planning in Peshawar**

The findings of this study provide practical insights for landscape architects, municipal authorities, and urban planners involved in green infrastructure development. Selecting plant species that can tolerate both heat and cold extremes reduces maintenance costs and improves long-term landscape sustainability.

Moreover, incorporating plants with strong aesthetic and therapeutic qualities can transform urban green spaces into environments that support public health and community interaction. In rapidly growing cities where environmental stress and population density are increasing, such integrated landscaping approaches are essential for promoting sustainable urban development.

**Conclusions:** This study identified a diverse range of plant species that demonstrate strong potential for climate-resilient urban landscaping in Peshawar's semi-arid climatic conditions. The selected tree species—including *Ficus religiosa*, *Cassia fistula*, *Bauhinia variegata*, *Melia azedarach*, *Grevillea robusta*, *Delonix regia*, and *Moringa oleifera*—exhibit high tolerance to heat, drought, and urban environmental stress. Similarly, resilient shrub species such as *Lagerstroemia indica*, *Rosa* spp., *Nerium oleander*, *Hibiscus rosa-sinensis*, *Murraya paniculata*, and *Dodonaea viscosa* contribute to landscape sustainability while maintaining strong ornamental and ecological value.

Beyond their environmental adaptability, many of these plant species provide significant social and therapeutic benefits, including shade provision, visual comfort, fragrance, seasonal flowering, and opportunities for nature interaction. Such characteristics are known to enhance psychological well-being, social cohesion, and the restorative quality of urban green spaces.

The integration of climate-resilient vegetation with therapeutic landscape design principles can therefore play an important role in improving the environmental sustainability, ecological resilience, and human well-being of rapidly urbanizing cities like Peshawar. Strategic use of these plant species in parks, institutional campuses, streetscapes, and community green spaces can support both urban climate adaptation and public health objectives.

### **Recommendations**

Based on the findings of this study, the following recommendations are proposed:

#### **1. Climate-Resilient Plant Selection in Urban Planning**

Urban planners and landscape architects should prioritize heat- and drought-tolerant plant species when designing urban green infrastructure. The tree and shrub species identified in this study provide a suitable plant palette for climate-resilient landscaping in Peshawar.

**2. Expansion of Urban Tree Canopy :** Municipal authorities should increase the planting of **shade-providing trees** such as *Ficus religiosa*, *Melia azedarach*, *Grevillea robusta*, and *Moringa oleifera* along streets, parks, and public spaces to mitigate urban heat island effects and improve

microclimatic conditions.

### **3. Integration of Therapeutic Landscape Design**

Urban green spaces should incorporate therapeutic and sensory planting, including flowering and fragrant shrubs such as *Rosa* spp., *Hibiscus rosa-sinensis*, and *Murraya paniculata*, to enhance mental well-being, stress reduction, and social interaction.

### **4. Development of Specialized Green Spaces**

Therapeutic gardens and restorative landscapes should be developed in hospitals, universities, schools, and community parks to support public health, environmental education, and social engagement.

### **5. Promotion of Climate-Responsive Landscape Policies**

Local government agencies should incorporate climate-resilient landscaping strategies into urban development policies, master plans, and green infrastructure programs to ensure long-term environmental sustainability.

### **6. Future Research and Monitoring**

Further research should focus on long-term monitoring and experimental evaluation of plant performance under urban climate stress conditions, including drought tolerance, carbon sequestration potential, and their measurable effects on human health and psychological well-being.

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