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STRATEGIC URBAN PLANNING AND LANDSCAPE INFRASTRUCTURE INTEGRATION: A THEORETICAL MODEL FOR SUSTAINABLE URBAN DEVELOPMENT IN HOT CLIMATES, CASABLANCA AS A CASE STUDY.

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Abstract. *This article introduces a theoretical model developed specifically for sustainable urban planning in hot climates, where challenges such as extreme temperatures, water scarcity, and rapid urbanization place unique demands on the built environment. The model emphasizes the strategic integration of landscape infrastructure to create urban spaces that are both resilient to climate-related stressors and sensitive to the preservation of cultural heritage. Through the combination of green infrastructure, water-sensitive design, and renewable energy integration, this approach aims to foster urban environments that prioritize both ecological sustainability and human well-being. The model is significant in its ability to address the layered complexities of urban resilience, cultural preservation, and environmental sustainability, providing a structured, adaptable framework for city planners and policymakers. By applying this model, planners can create livable, resilient, and culturally rich urban landscapes, supporting sustainable growth and enhancing the quality of life in hot climate regions. This work underscores the vital role of landscape integration in achieving sustainable urban development and offers insights into practical applications that respond effectively to environmental and cultural imperatives.*

Keywords. *Strategic Urban Planning, Landscape Infrastructure, Sustainable Urban Development, Hot Climates, Urban Resilience, Renewable Energy Integration, Thermal Comfort, Cultural Heritage Preservation, Climate-Adaptive Design, Green Infrastructure.*

Introduction.

Formulation of the Problem. The objective of this research is to develop a theoretical model that enhances sustainable urban planning in hot climates, with a particular focus on the integration of landscape infrastructure. To achieve this goal, the following tasks have been outlined:

- Identify the primary environmental and socio-economic challenges associated with urban planning in hot climates, such as extreme temperatures, water scarcity, and urban sprawl.
- Examine the role of landscape infrastructure, including green spaces and water-sensitive design, in mitigating urban heat, conserving resources, and enhancing ecological resilience.
- Explore methods for preserving cultural heritage in urban planning, ensuring that development respects and integrates historical and cultural sites.
- Analyze current urban planning approaches in hot climate regions, particularly Casablanca, to assess their effectiveness in addressing environmental and cultural challenges.
- Develop a structured model that balances sustainable growth, climate resilience, and cultural preservation, providing practical guidance for urban planners and policymakers.

Materials and Research Methods. To develop this theoretical model, a multidisciplinary approach was adopted, drawing on methods from urban planning, environmental design, and landscape architecture. The research utilized Geographic Information Systems (GIS) for spatial analysis, enabling the mapping of urban zones and the identification of key areas for strategic infrastructure integration [10]. Climate data analysis, using tools such as Climate Consultant 6.0 [9] and Ladybug Tools [11], helped assess thermal comfort, water usage, and solar radiation patterns, providing data-driven insights for sustainable design. Additionally, documents provided by the Urban Agency of Casablanca (AUC) [12] served as foundational sources, offering valuable planning data and strategic insights specific to Casablanca's urban context. This methodological framework allows for a comprehensive understanding of the environmental, social, and cultural dynamics that influence urban planning in hot climates.

Analysis of Recent Research Sources and Publications. Recent studies have highlighted the growing importance of sustainable urban planning, particularly in hot climates where environmental and socio-economic pressures are intensifying. Authors like Beatley (2011) [3] and Gehl (2010) [4] have emphasized the role of green infrastructure in improving urban resilience, while Jacobs (1961) [5] and McHarg (1969) [6] have shown how planning practices can integrate nature and culture to enhance urban environments. Research focused on North Africa, including insights from AUC (Agence Urbaine de Casablanca) planning documents [12], points to the increasing need for adaptive planning strategies that incorporate both climate resilience and cultural preservation. The integration of renewable energy, water conservation techniques, and cultural heritage into planning frameworks has been identified as essential for creating sustainable and livable urban spaces. This article contributes to these ongoing discussions by proposing a practical model that combines landscape infrastructure with strategic urban planning to achieve sustainability, resilience, and cultural preservation.

Main text.

Strategic Urban Zones and Functional Allocations. Urban planning in hot climates demands strategic zoning to address environmental challenges while preserving cultural and social values. The model for Casablanca prioritizes green belts, flood management zones, and high-density areas for crowd management, which collectively contribute to urban resilience and livability [Fig-1].

Green belts surrounding the city are designed to mitigate the urban heat island effect by introducing extensive vegetation. These green spaces not only lower surface and air temperatures but also promote ecological biodiversity and serve as communal areas for recreation and social interaction. By fostering connections between natural and built environments, green belts create multifunctional spaces that enhance both environmental and social resilience.

Flood management zones are another critical component. Casablanca faces seasonal rainfall, which can lead to flooding in vulnerable areas. This model incorporates natural flood barriers, improved drainage systems, and permeable surfaces to absorb and redirect excess water, protecting urban infrastructure and minimizing damage. These flood management strategies seamlessly blend functional design with aesthetic integration, ensuring they align with the broader urban vision.

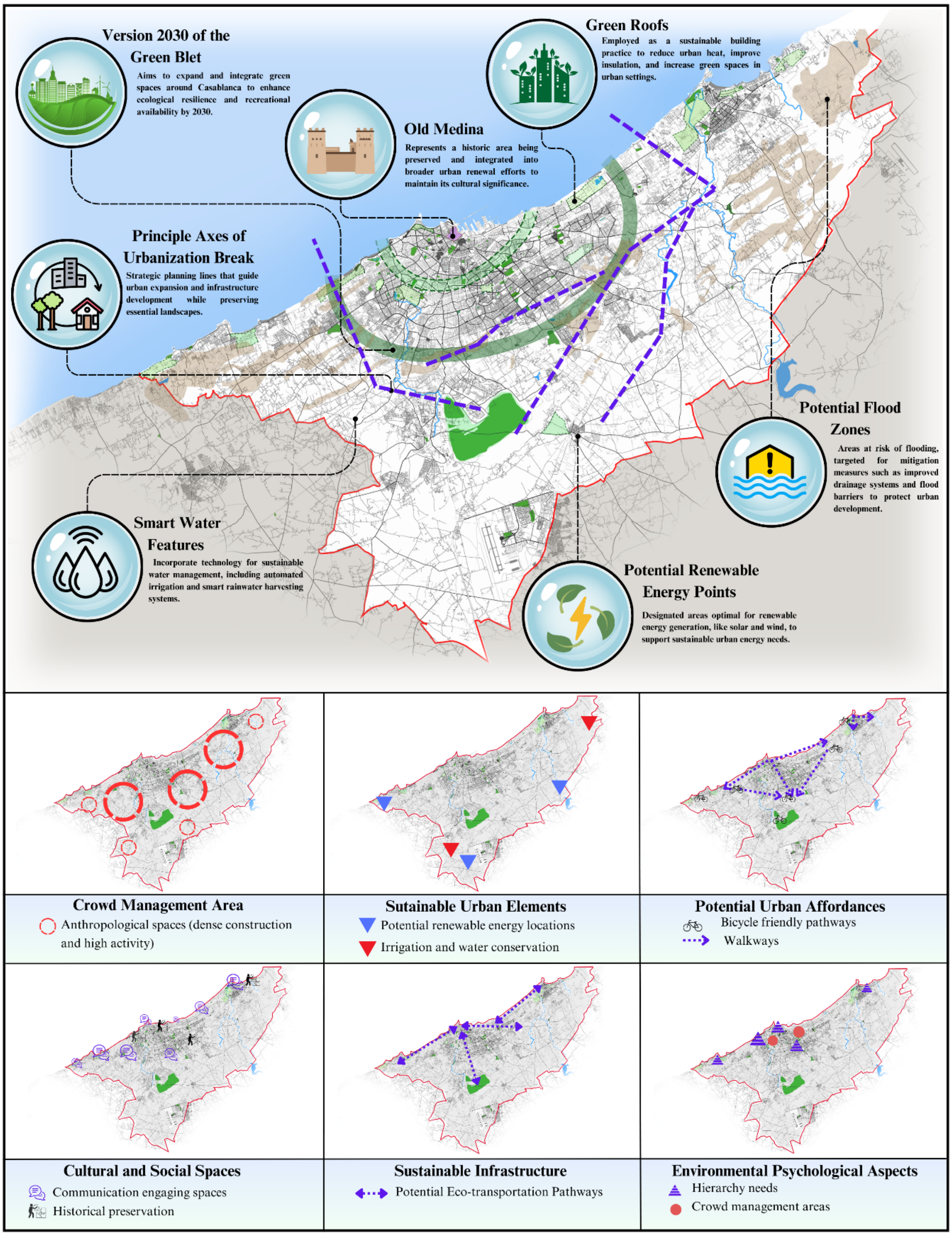

Figure 1- Research Model and the Urban Blueprint: A Strategic Model for Sustainable Growth and Ecological Balance of Grand Casablanca.

High-density zones, often the most active parts of the city, require effective crowd management to maintain safety and accessibility. These areas are structured to facilitate pedestrian movement, reduce congestion, and support public transportation. By organizing crowd management systems within high-activity regions, the model ensures that urban expansion remains efficient without compromising safety or cultural accessibility.

Through these interconnected zoning strategies, the model provides a comprehensive framework for sustainable urban growth in Casablanca. Each zone—green belts, flood management areas, and crowd-controlled regions—addresses specific environmental or social needs while contributing to the overall livability of the city.

Sustainable Urban Elements and Infrastructure. In Casablanca's model, sustainable infrastructure addresses key challenges such as resource conservation, energy efficiency, and climate resilience. By integrating renewable energy sources, green roofs, and advanced water management systems, the model ensures a balanced and adaptive urban environment.

Renewable energy systems are a cornerstone of this approach. Solar panels, strategically distributed across rooftops and open spaces, harness Casablanca's high solar potential, significantly reducing the city's dependence on non-renewable energy sources. These installations contribute to lowering greenhouse gas emissions and improving energy efficiency in high-demand regions. Their positioning supports sustainable energy generation and positions Casablanca as a leader in climate-adaptive energy strategies [Fig-1].

Green roofs provide natural insulation, reducing indoor temperatures and lowering the demand for air conditioning. In addition to improving energy efficiency, these installations create additional green spaces in the urban environment, fostering biodiversity and improving air quality. By mitigating the urban heat island effect, green roofs enhance ecological sustainability while improving thermal comfort.

Water scarcity, a critical concern in hot climates, is addressed through advanced water management systems. Automated irrigation technologies monitor soil moisture levels and adjust water distribution, preventing overuse and ensuring resource conservation. Rainwater harvesting systems capture runoff during rainfall events, storing water for later use in dry periods. These systems integrate seamlessly into the urban design, reducing dependence on municipal water supplies and contributing to Casablanca's water resilience [Fig-1].

Collectively, these sustainable urban elements—renewable energy generation, green roofs, and advanced water management—address critical environmental challenges while improving resource efficiency. By combining ecological innovation with practical urban design, the model demonstrates a holistic approach to infrastructure planning, emphasizing sustainability, resilience, and environmental stewardship.

Environmental and Psychological Aspects of Urban Design. Urban design in hot climates must balance environmental challenges with the psychological and social well-being of residents. Casablanca's model integrates features that enhance social interaction, promote mental well-being, and support a sense of community while addressing extreme temperatures. This is achieved through the thoughtful placement of shaded walkways, pedestrian paths, and social spaces that make public areas more inviting and comfortable [Fig-1].

Shaded walkways and green corridors are crucial in providing relief from high temperatures. Tree canopies, pergolas, and other shading devices are strategically distributed along key pedestrian pathways, reducing direct solar exposure and creating comfortable routes for walking or cycling. These green corridors also link parks, plazas, and cultural sites, fostering connectivity and a natural cooling effect that enhances the livability of public spaces.

Social spaces, including plazas, gathering spots, and open areas, are designed to facilitate community interaction and engagement. By integrating historically and culturally significant sites into the urban framework, the model reinforces a sense of identity and continuity. These spaces serve as venues for communal activities, cultural events, and celebrations, strengthening community ties and fostering a shared sense of belonging [Fig-1].

Eco-transportation pathways further improve accessibility and sustainability. Bicycle lanes, pedestrian zones, and shaded resting areas encourage non-motorized movement, reducing reliance on motorized vehicles and contributing to lower air pollution. These pathways not only improve mobility but also enhance social engagement by creating safe, inclusive spaces for residents and visitors alike.

Access to green spaces and well-designed public areas also has significant psychological benefits. These spaces help reduce stress, promote mental well-being, and provide opportunities for relaxation and recreation. By prioritizing environmental and psychological design aspects, Casablanca's model ensures that urban spaces are not only resilient but also socially and emotionally enriching for residents.

Thermal Comfort and Climate Adaptation Strategies. Thermal comfort is a crucial consideration in urban planning for hot climates, where extreme heat can significantly impact livability and energy consumption. The model for Casablanca incorporates design interventions that enhance thermal comfort, improving outdoor environments and reducing heat exposure for residents and visitors.

Key strategies include the use of shading structures, green spaces, and reflective materials to mitigate the urban heat island effect. Tree canopies and pergolas are placed in high-traffic public areas to create shaded zones that lower temperatures and provide relief from intense sunlight. These elements work in combination with reflective materials on building facades and pavements to minimize heat absorption and enhance overall comfort levels [Fig-2].

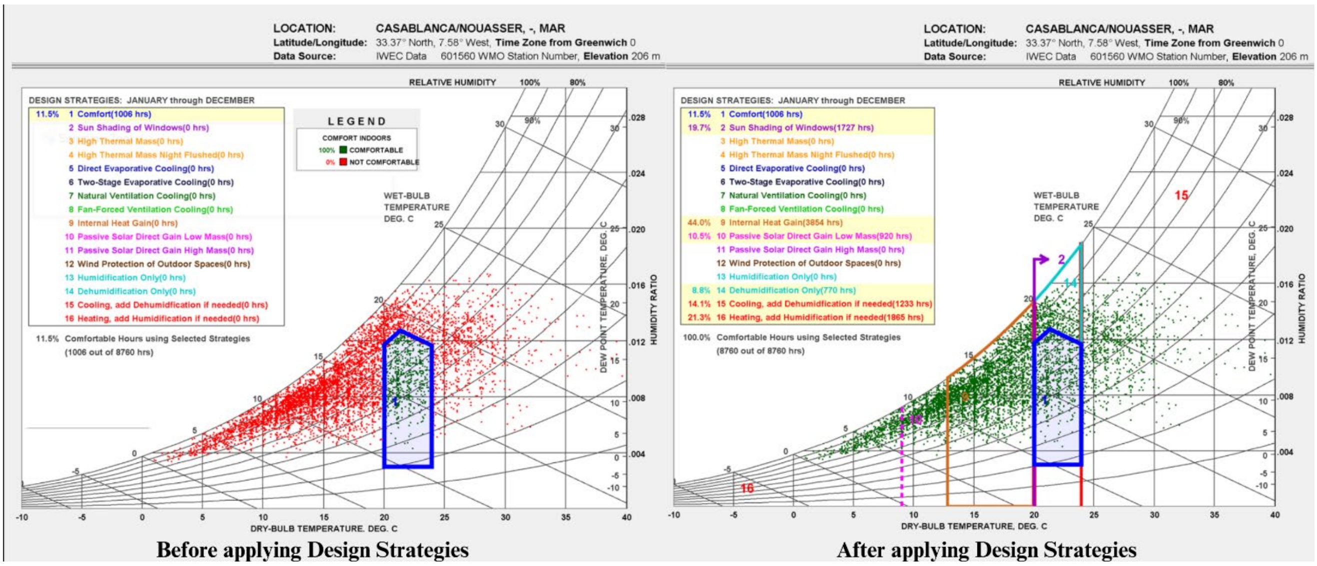

Figure 2 - Psychrometric Analysis: Optimizing Thermal Comfort in Casablanca - Natural Comfort vs. Enhanced Comfort with Design Interventions

The psychrometric analysis presented in Figure 2 compares natural comfort levels with enhanced conditions achieved through these interventions. By reducing direct solar exposure, these strategies help improve outdoor thermal comfort while also reducing the demand for energy-intensive cooling systems.

Seasonal solar dynamics also guide the placement of shading elements. As illustrated in Figure 3, shading structures are positioned to block excessive solar radiation during the summer while allowing sunlight to reach public areas in cooler months. This adaptive design approach ensures year-round functionality, balancing thermal comfort with energy efficiency.

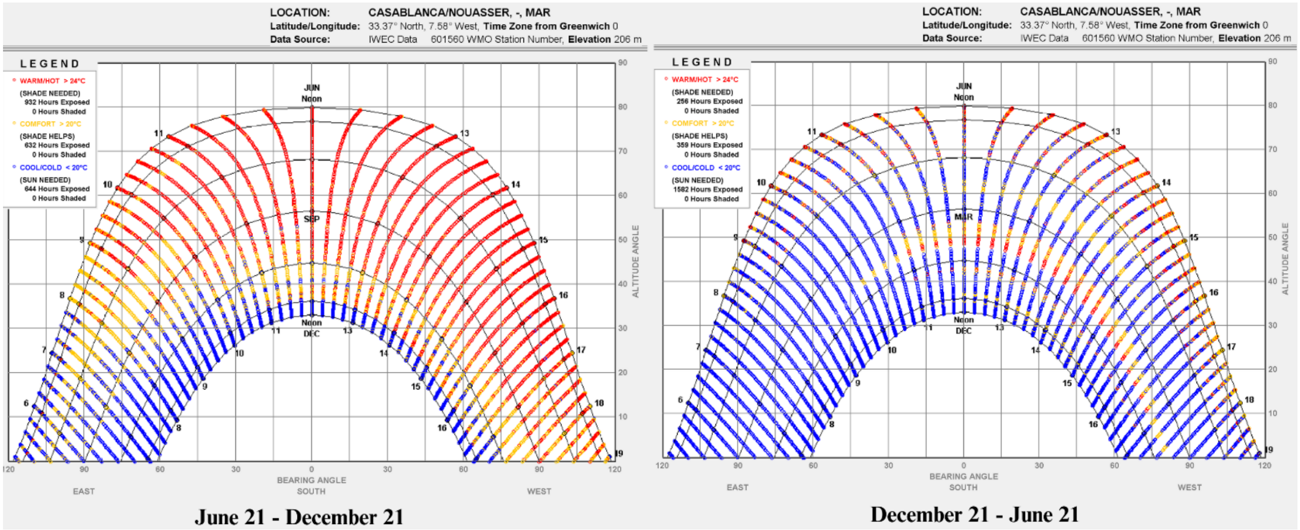

Figure 3 - Sun Shading Dynamics: Evaluating Thermal Discomfort and Comfort Across Seasons in Casablanca

These climate adaptation strategies align with the model's broader goals of creating sustainable and comfortable urban spaces. By addressing the challenges of extreme heat and enhancing thermal comfort, the model supports healthier, more resilient environments that are better suited to the climatic conditions of Casablanca.

Climate Profile and Sustainable Energy Integration. A thorough understanding of Casablanca's climate profile is essential for effective urban planning in a hot climate. The model incorporates climate-responsive strategies, such as renewable energy integration and passive design techniques, to address energy efficiency while reducing environmental impact [Fig-4].

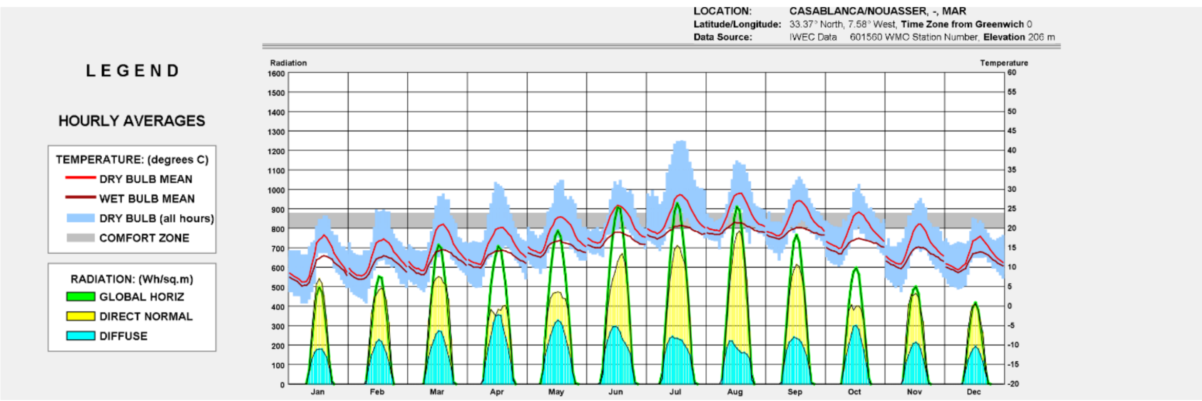

Figure 4 – Seasonal Diurnal Climate Patterns: Monthly Averages of Temperature and Solar Radiation in Casablanca

Casablanca's high solar potential provides a significant opportunity for harnessing renewable energy. Solar panels are strategically positioned across rooftops, open areas, and along key infrastructure to maximize sunlight exposure throughout the year. This ensures a sustainable energy supply that reduces reliance on non-renewable sources and lowers greenhouse gas emissions. These renewable energy installations align with the city's broader goals of sustainable urban growth and energy independence.

In addition to active energy systems, passive design strategies are employed to optimize natural lighting and ventilation. Building orientations and public space layouts are designed to leverage prevailing winds and minimize heat retention, reducing the need for mechanical cooling and lighting systems. These techniques further enhance the energy efficiency of urban infrastructure, contributing to a balanced and adaptive energy profile.

The climate data, including temperature fluctuations and solar radiation levels, are depicted in Figure 4, which provides a detailed overview of Casablanca's seasonal diurnal climate patterns. By analyzing this data, urban planners can tailor renewable energy placements and passive cooling techniques to local conditions, ensuring optimal performance.

Together, these climate-responsive strategies address Casablanca's immediate energy needs while positioning the city as a leader in sustainable urban development. By integrating renewable energy systems and passive design solutions, the model exemplifies how urban planning can balance environmental sustainability with energy efficiency, creating resilient and adaptive urban spaces.

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