# Research on Climate Adaptive Design Strategies of Traditional Residential Buildings in Dakar, Senegal

Juan Ren[1,2]*, Mamadou Yacine Diop[2], Lei Zhang[2], Yue Wang[3]

[1]School of Architecture, Xi'an University of Architecture and Technology, Shaanxi, Xi'an, 710055, China
[2]School of Architecture, Chang'an University, Shaanxi, Xi'an, 710061, China
[3]Northwestern Polytechnical University, Shaanxi, Xi'an, 710072, China

*juanren@xauat.edu.cn

**Abstract.** Sustainable development has become a crucial trend in the global construction industry. However, rapid urbanization in Africa presents unprecedented challenges to local ecosystems and living environments, with practical and feasible green building designs still in their nascent stages. The over-reliance on industrial equipment not only exerts negative impacts on the ecological environment but also results in a mismatch between architectural design and regional climate conditions, thereby impeding the advancement of sustainable development. This study is dedicated to exploring climate adaptive design strategies for traditional housing in Dakar, the capital of Senegal. By conducting a comprehensive analysis of local climatic conditions and existing residential buildings, this paper focuses on the climate response strategies employed in traditional housing. Based on a meticulous examination of Senegalese traditional houses, the study proposes a series of design improvement strategies aimed at enhancing the climate adaptability of local residential buildings and improving the comfort of their occupants.

**Keywords:** Senegal; traditional residential buildings; climate adaptive design

## 1 Introduction

In Dakar, Senegal's capital, traditional residential buildings represent a valuable historical heritage with diverse climate adaptation strategies. Modern residential architecture, influenced by traditional and contemporary methods, reflects a rich design diversity, yet its climate adaptability needs further validation. This study examines typical Senegalese traditional houses, assessing their lighting, ventilation, and thermal insulation, and proposes climate-adaptive design strategies for these traditional residences.


Z. Ahmad et al. (eds.), *Proceedings of the 2024 5th International Conference on Urban Construction and Management Engineering (ICUCME 2024)*, Advances in Engineering Research 242,
https://doi.org/10.2991/978-94-6463-516-4_49

## 2 Background

Senegal's tropical climate, influenced by its West African location [1][2], varies from desertification in the north [3] to coastal humidity in the south [4]. With temperatures ranging from 17 to 40°C [5], building designs in Senegal emphasize efficient ventilation and shading systems to manage indoor temperatures. Seasonal changes and regional precipitation patterns further impact building material durability and waterproofing needs, especially in the south receiving up to 1500mm of annual rainfall [4][6]. Dakar, as the capital, exemplifies these climatic and cultural influences in its urban architecture [7].

The architectural history of Senegal reflects its diverse cultural heritage and colonial influences. Traditional styles persisted in Dakar's Serer, Wolof, Peulh, Diola, and Lebou districts, featuring standalone circular or square rooms with thatched roofs and wooden walls, adapted for the tropical climate [8][9][10][11]. During French colonial rule, European styles introduced basic single-story buildings with shell-mixed cement walls and zinc or tile roofs, balancing practicality and cost-effectiveness. Urbanization from the mid-20th century onwards spurred architectural evolution, with a shift to robust colonial designs and subsequent integration of local styles like Beaver balloon houses and SICAP and SNHLM houses [10][11]. Today, Senegal's residential architecture blends modern materials and features like balconies, terraces, and courtyards, reflecting both functional needs and cultural evolution [10].

## 3 Characteristics of Traditional Residential Buildings in Dakar

### 3.1 Traditional Diola Houses

Traditional Diola houses are typically characterized by their single-unit structures, with all functional spaces, except for the public toilet, located indoors. This design promotes the privacy and safety of the inhabitants. Diola houses feature two entrances: a main entrance for daily access and a side entrance leading to the backyard, allowing family members to carry out daily chores or animal husbandry activities without interfering with the activities at the main entrance. This entrance design also maximizes ventilation and natural lighting. A notable feature of Diola houses is the irregularity of the interior space layout, with room doors arranged along a circular path. This design not only enhances the aesthetic appeal of the building but also creates a visually more spacious interior. The central courtyard is another significant feature, with rooms and partition walls arranged around it to form a unique layout that effectively separates rooms from corridors. The courtyard often includes a skylight, which not only introduces natural light and ventilation but also serves as a rainwater collection system, a particularly crucial feature in arid regions. In the exterior design, wooden posts are placed approximately 1.5 meters from the building to support the extended eaves. This not only enhances the structural stability of the building but also protects the exterior walls from rain and direct sunlight. The outer structure typically consists of wood, earth, and slats,

with the roof covered by thatch or slats, reflecting the utilization of local resources and adaptation to the environment. Although the windows are small and arranged horizontally, they provide sufficient lighting and ventilation to maintain indoor comfort (see Figure 1).

Traditional Diola houses feature single-unit structures with most functional spaces indoors, ensuring privacy and safety. They are designed with two entrances: a main entrance for daily access and a side entrance to the backyard, facilitating household chores without disrupting activities at the main entrance. This layout maximizes ventilation and natural lighting. The irregular interior space layout, with rooms arranged along a circular path, enhances aesthetics and creates a spacious feel. The central courtyard, surrounded by rooms and partition walls, serves as a rainwater collection system and introduces natural light and ventilation. Exterior design includes wooden posts supporting extended eaves, enhancing structural stability and protecting walls from rain and sunlight. Built with local materials like wood, earth, and thatch, Diola houses exemplify environmental adaptation and resource utilization.

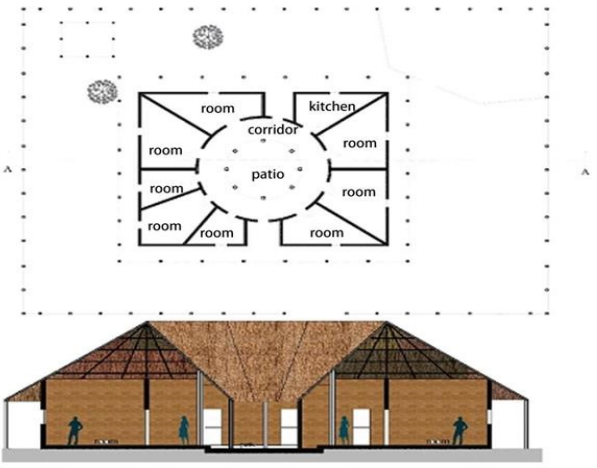


**Fig. 1.** Traditional Diola Residential Building

### 3.2 Traditional Wolof Houses

Traditional Wolof houses feature separate rooms around a central courtyard, creating a circular layout that balances individual privacy with communal family activities. The courtyard, central to social interactions, is shaded by trees, crucial for cooling in the tropical climate. Kitchen and bathroom placement at the rear supports cleanliness and waste management. Built with circular or square bases and conical roofs, these houses efficiently manage rainwater and use local materials like wood and straw for environmental adaptability. Their semi-open design aids ventilation, maintaining comfort in tropical climates. Wolof houses thus embody Senegal's architectural heritage, integrating practicality with cultural significance, serving as hubs for community life and cultural preservation (see Figure 2).

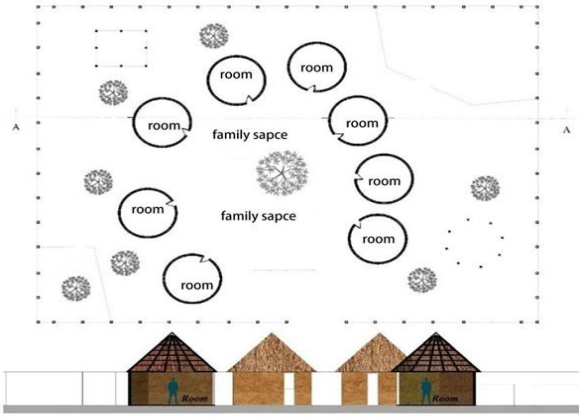


**Fig. 2.** Traditional Wolof Residential Building

### 3.3 Traditional Earth Houses

Traditional earth houses in Senegal are characterized by single-volume structures with square or rectangular interior spaces, featuring thick earthen walls for improved climate control. These houses employ flat roof designs with small windows and strategically placed rectangular doors on opposite walls to enhance air circulation within rooms (see Figure 3).

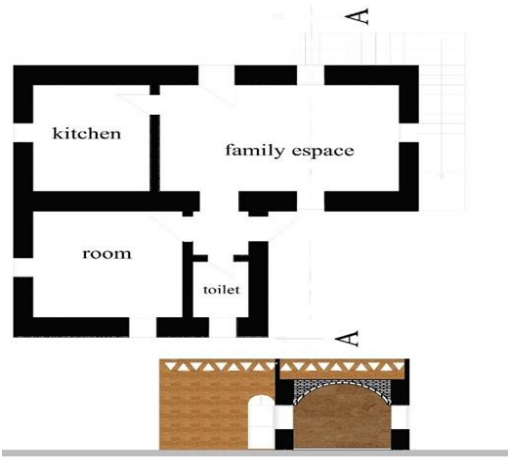


**Fig. 3.** Traditional Earth House

Earth houses are renowned for their environmental adaptability, utilizing locally abundant materials like earth, which offer excellent thermal mass properties. This natural temperature regulation maintains comfortable indoor conditions without relying on modern cooling systems. The simplicity of flat roofs reduces construction complexity and sometimes provides additional usable space for residents in urban settings.

Ventilation is optimized through carefully positioned windows and doors, ensuring efficient airflow and cooling effects throughout the day.

# 4 Analysis and Improvement of Climatic Conditions for Traditional Residential Buildings in Dakar

## 4.1 Shading, Daylighting, and Improvements

Traditional Dakar's residential buildings, like Diola houses, utilizes central courtyards for enhanced daylighting and air circulation. To optimize daylighting, reducing the depth of courtyard roof overhangs while maintaining rain protection and sun shading is crucial. Transparent materials like glass can further enhance lighting. In Wolof houses, increasing window number and size on southern and northern walls improves natural light distribution, reducing electricity dependence and enhancing energy efficiency. Effective shading devices, such as exterior blinds, manage indoor temperatures and glare while preserving traditional aesthetics and integrating modern sustainability practices applicable beyond Dakar in similar climates.

## 4.2 Natural Ventilation and Improvements

Senegalese architectural design must address tropical climate challenges, particularly building overheating. Traditional Wolof houses, with square or circular units and conical roofs, facilitate hot air discharge but often lack sufficient windows for cross-ventilation. Adding more windows or adjusting their positions to enhance airflow, considering prevailing winds, can improve indoor air circulation. Diola houses utilize central courtyards for ventilation and natural light, with roof designs aiding air movement, particularly with sloping or conical roofs that help hot air rise and exit. Adjusting windows opposite courtyard doors along airflow paths can further enhance ventilation efficiency.

To enhance indoor ventilation quality in these traditional houses, the following adjustments are recommended:

- Traditional Wolof houses: Add opposing windows in each independent room or design ventilation openings at the top to promote better air exchange.
- Traditional Diola houses: Add windows around the central courtyard, especially at the top or on walls opposite the courtyard, to enhance natural ventilation.
- Traditional earth houses: Expand or redesign windows, especially on the sides facing the prevailing wind, to improve airflow.

# 5 Conclusions

This study provides a detailed analysis of the climatic conditions in Dakar, Senegal, and their interaction with residential architecture. It proposes targeted design improvements, including enhancing natural ventilation, improving indoor lighting, and optimizing the use of building materials, aimed at enhancing building adaptability to the

environment and energy efficiency. Future research should integrate modern technology with traditional architectural wisdom to develop customized solutions for Senegal's specific climatic conditions, such as incorporating solar panels and green roofs, and utilizing phase change materials and high-performance insulation to achieve more efficient energy use and thermal comfort.

Socio-economic considerations are integral to the cost-effective design of residential improvements, particularly for low-income households. Utilizing local materials, labor, and simplified construction techniques can reduce costs while stimulating local economic growth and enhancing community engagement. Government incentives, such as tax benefits and subsidies, are essential for encouraging energy-efficient and eco-friendly architectural advancements. By integrating technological, cultural, economic, and social elements, the enhancement of traditional buildings in Dakar can lead to more sustainable and resilient urban development.

## Acknowledgment

This work was supported by the International Education and Teaching Reform Project of Chang'an University (No.300108231143), Natural Science Basic Research Program of Shaanxi (Program No.2023-JC-ZD-01).

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