

PASSIVE BIO-CLIMATIC DESIGN FEATURES FOR JUVENILE REFORMATORIES IN SOUTH-EASTERN NIGERIA: LESSONS FROM SOUTH-WESTERN FACILITIES

Stella I. Ufoagbala¹, Nkechi M. Maduka²

^{1,2}Department of Architecture, Chukwuemeka Odumegwu Ojukwu University, Uli Campus, Uli, Anambra State, Nigeria

Email: ¹ ify.ufoagbala@gmail.com (Corresponding Author), ² nm.maduka@coou.edu.ng

Abstract

This study evaluates the integration and efficacy of passive bio-climatic design features within selected juvenile reformatories to foster therapeutic, trauma-informed custodial environments in hot-humid tropical climates. Historically, juvenile facilities in Nigeria have adopted the rigid spatial circulation, punitive layouts, poorly ventilated, and energy-inefficient designs of adult prisons which utilize high-embodied-energy materials like concrete and glass. These induce severe thermal discomfort in hot-humid tropical zones. These restrictive, isolating layouts hinder psychological rehabilitation, exacerbating spatial stress, anxiety, and behavioral aggression. In regions like southeastern Nigeria, high ambient temperatures, elevated humidity, and unreliable municipal grid power render conventional mechanically cooled buildings dysfunctional, resulting in oppressive indoor living conditions. Adopting a comparative case study research design, data were collected through conducting architectural observations, informal interview of facility officials, spatial evaluations across thermal comfort, natural ventilation, day lighting, and spatial flexibility in two state-run facilities: The Special Reformatory Centre for Girls, Idi-Araba, Lagos, and the Special Correctional Centre for Boys, Oregun, Lagos. Findings revealed that while both facilities benefit from significant sustainable design strategies - such as East-West building orientation, deep overhangs, courtyard microclimate, breathable perforated screens, and continuous fenestration to drive cross-ventilation and natural day lighting, their performance is compromised by heavy embodied-energy wall envelopes, non-insulated metal roofing, and basic spatial zoning that induce spatial stress. To address these challenges, this study recommends revising juvenile custodial design standards toward climate-responsive frameworks, adopting low-embodied-energy materials such as Compressed Stabilized Earth Blocks (CSEB), and utilizing courtyard layouts for stack effect cooling. The paper concludes by proposing sustainable and passive design strategies tailored to tropical juvenile reformatories, emphasizing courtyard microclimate, deep overhangs, non-institutional therapeutic spatial zoning, and renewable material choices. Ultimately, synthesizing trauma-informed care with sustainable passive design allows juvenile custodial institutions to balance strict security requirements with humanizing, restorative environments that support rehabilitation and reintegration

Keywords: Bio climatic design, Environmental psychology, Juvenile reformatories, Restorative custodial environments, Trauma-informed architecture

INTRODUCTION

In Nigeria, a juvenile is legally defined under the Child's Right Act (CRA) 2003 as any person under the age of 18, whereas the Children and Young Persons Act (CYPA) differentiates those under 14 years as children and those between 14 and 17 as young persons. Juvenile delinquency encompasses criminal acts or conduct non-conformity exhibited by minors that would otherwise constitute legal offenses if committed by adults. To manage juvenile justice, custodial environments are broadly categorized into temporary remand homes—which temporarily hold youths awaiting judicial trial or background inquiry—and reformatory facilities or Borstal institutions, which provide long-term, post-sentencing rehabilitation, formal education, and vocational training (Anyia, 2014).

Despite the national framework, a severe infrastructure deficit exists in Southeastern Nigeria. Historically, there are no fully operational state-owned borstal reformatories in the region, leaving juvenile offenders at risk of being held in overcrowded temporary spaces or inappropriately confined with adult offenders in federal correctional centers (Obidimma & Obidimma, 2012). Conversely, Southwestern Nigeria houses long-established, functional juvenile reformatory centers, rendering its institutional architecture a valuable empirical benchmark for other geopolitical zones.

Designing juvenile custodial environments presents a delicate balance between security, environmental performance, and psychological well-being. Historically, institutional architecture in Nigeria relied on punitive, prison-like typologies marked by high perimeter walls, security-dominated layouts, and dense concrete structures that trap heat (Nwalusi et al., 2019). Modern penological theory and environmental psychology instead advocate for restorative, trauma-informed physical spaces that reduce stress, improve behavior, and support rehabilitation (Jewkes, 2018; Oostermeijer et al., 2022; Ulrich et al., 2008).

In tropical hot-humid climates like Southeastern Nigeria, achieving thermal and psychological comfort in institutional settings is particularly challenging. High ambient temperatures, elevated relative humidity, and erratic municipal power supplies often render mechanical HVAC reliance impractical, resulting in dark, poorly ventilated, and oppressive living spaces (Okafor et al., 2022). Passive bio-climatic design strategies - such as natural cross-ventilation, optimized building orientation, solar shading, high-thermal-mass earth construction, microclimate courtyards, and biophilic integration - offer a sustainable solution (Browning et al., 2015). By evaluating operational juvenile reformatories in Southwestern Nigeria as comparative precedents, this study extracts practical passive bio-climatic architectural lessons to establish a framework for developing sustainable, human-centered reformatory infrastructure in Southeastern Nigeria.

Area of Study

The primary geographical context for this study is Southeastern Nigeria, which spans Abia, Anambra, Ebonyi, Enugu, and Imo States, with an estimated population exceeding 21.6

million people (see Figure 1). Despite this significant population base and growing urban youth demographic, the region lacks functional, standalone juvenile reformatory infrastructure. Consequently, empirical data was gathered from established reformatory facilities in Southwestern Nigeria - the Special Correctional Centre for Girls, Idi-Araba, Lagos State and Special Correctional Centre for Boys, Oregun. These Southwestern facilities operate with defined architectural capacities - 88 girls in a dormitory in Idi-Araba and 100 boys in a dormitory for Oregun facility. These frequently experience spatial pressure and over-capacity lockups. Quantifying resident density and spatial allocation in these precedent facilities provides critical architectural baseline data needed to size indoor spaces, calculate required fenestration for ventilation, and optimize passive micro climatic strategies for future developments in Southeastern Nigeria.

While the proposed design framework is tailored to the bio-climatic and sociocultural parameters of southeastern Nigeria, empirical case studies were selected from Lagos State in southwestern Nigeria. This selection is necessary because southeastern Nigeria lacks operational, standalone state-owned Borstal or juvenile reformatory facilities. The selected Lagos facilities represent functional contemporary models in southern Nigeria, providing operational, structural, and spatial data. The architectural strategies and passive cooling performance derived from these Southwestern precedents serve as comparative benchmarks to establish viable bio-climatic design guidelines for the Southeastern context

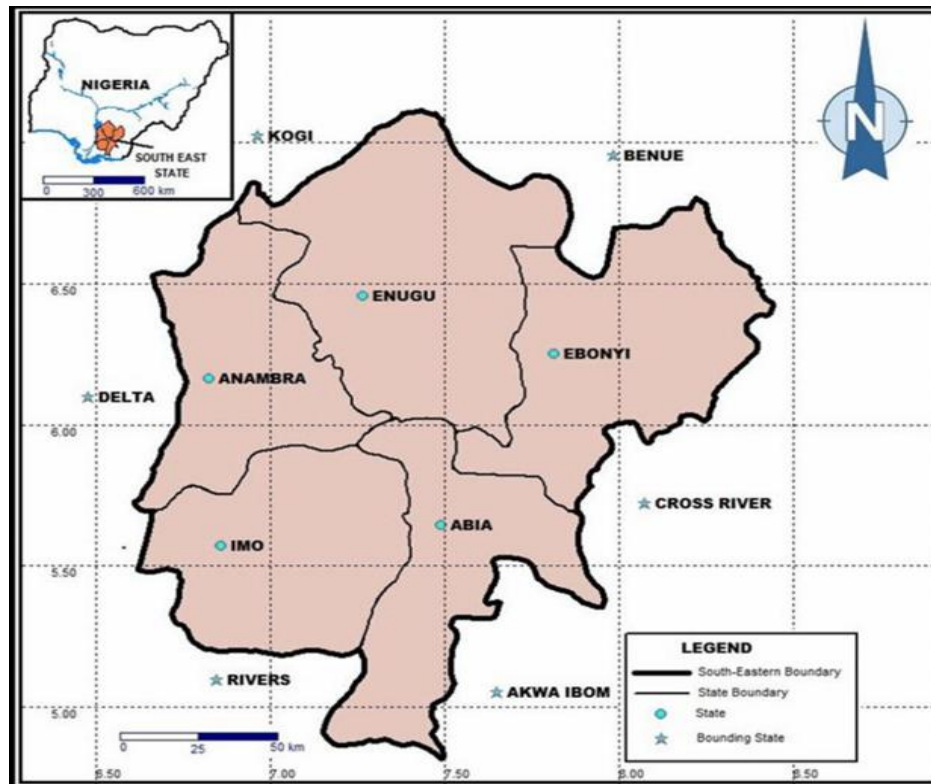


Figure 1: Map of southeastern Nigeria States.

Source: (Kayode et al, 2019)

Table 1. The Distribution of Population in the South East

Sn	States	Population
1	Abia	3,727,300
2	Anambra	5,271,800
3	Ebonyi	2,800,400
4	Enugu	4,411,100
5	Imo	5,408,800
6	Total	21,619,400

Source: Merem, et al., (2019)

LITERATURE REVIEW

Bio climatic design highlights human reliance on connections with nature for stress recovery and cognitive restoration. In custodial settings, integrating direct nature through courtyard, gardens, native plants and indirect nature by use of natural daylight, timber finishes, natural breezes, lowers cortisol levels, reduces spatial tension, and interrupts environmental trauma triggers. Sustainable design in hot-humid tropical climates centres on passive cooling mechanisms, solar radiation avoidance, and maximum airflow utilization (Hyde, 2015). Research indicates that indoor operational comfort in non-conditioned tropical buildings depends heavily on building orientation relative to prevailing south-west monsoon winds, optimized window-to-wall ratios, and effective thermal shading (Obamoh, Udeala, & Obamoh, 2026). High solar heat gain through non insulated roof envelopes and unshaded fenestration elevates indoor operative temperatures, inducing heat stress and spatial irritation among occupants (Ufoagbala & Maduka, 2026).

Environmental psychology demonstrates that physical spatial configuration directly impacts human behaviour, stress levels, and emotional self-regulation (Evans, 2003). In custodial facilities, oppressive architectural elements - such as claustrophobic and doubled loaded corridors, dark dormitories, excessive noise reverberation, and lack of visual access to nature - exacerbate trauma, anxiety, and aggression among detained youth (Ulrich, et al., 2008).

Trauma-informed architecture seeks to counteract these triggers by prioritizing clear spatial legibility, passive visual connectivity to nature, soft natural lighting, controlled acoustics, and non-institutional material palette (Wener, 2012). Trauma-informed design aims are to create environments that emphasize both physical and emotional safety, while ensuring spatial clarity, predictability, and opportunities for personal autonomy. The core goal of trauma-informed design (TID) is to create built environments that influences emotional safety, promote a sense of safety, agency, and dignity for individuals who have experienced trauma. When these psychological goals are translated into physical space, it radically changes how spatial planning, lighting, circulation, and material selection are approached. (Jewkes, Yvonne, Melanie, & Serena, 2019). Its architectural implication includes creating calm environments such as courtyards that offer refuge and reduce emotional outbursts and the potential for spatial related aggression. By applying its principles, spatial configuration

becomes an active tool for rehabilitation. Integrating sustainable, passive design features directly reinforces therapeutic goals: natural breeze and daylight lower spatial tension, while internal courtyards provide secure, restorative outdoor spaces (Nwalusi et al., 2019).

METHODOLOGY

This study adopts a comparative case study research design incorporating spatial audits, architectural observation, and comparative environmental evaluation. Two juvenile reformatories were purposely selected based on operational capacity, institutional age, and representation of state-run custodial architecture.

Case Study 1 - Special Reformatory Centre for Girls

This facility is located at 11/13 Ojerinde street, Idi-Araba, Lagos State. It lies adjacent to the Lagos University Teaching Hospital (LUTH), which provides potential access to healthcare and outreach services. Figure 2 shows the study area delineated on google earth imagery.

Background: This centre was begun by the Red Cross society for its humanitarian activities in the 1960s. Different views of the centre are seen in plates 1 and 2. It was later taken over by the Lagos State government for housing and rehabilitating young girls who conflict with the law, or vulnerable girls due to abuse, neglect, or abandonment.

The goal of the centre is to reform, empower and reintegrate the girls into society. One of the empowerment scheme in the centre is recycling of waste (see plate 3), while plate 4 shows a primary school building where academic courses are taught. The age group include girls between the ages of 11 to 17 with various cases - child offenders, girls beyond parental control, victims of abuse or neglect. They are admitted to the centre through Ministry of Youth and Social Development or police extracts by court injunctions. It is a haven for vulnerable girls. Here they receive vocational training and basic education for empowerment. The layout of buildings and structures in the special reformatory centre is seen in Figure 3.



Figure 2: Study area boundary delineated on Google Earth Imagery (6.5221°N 3.3524°E)

Source: Google Earth (2025)

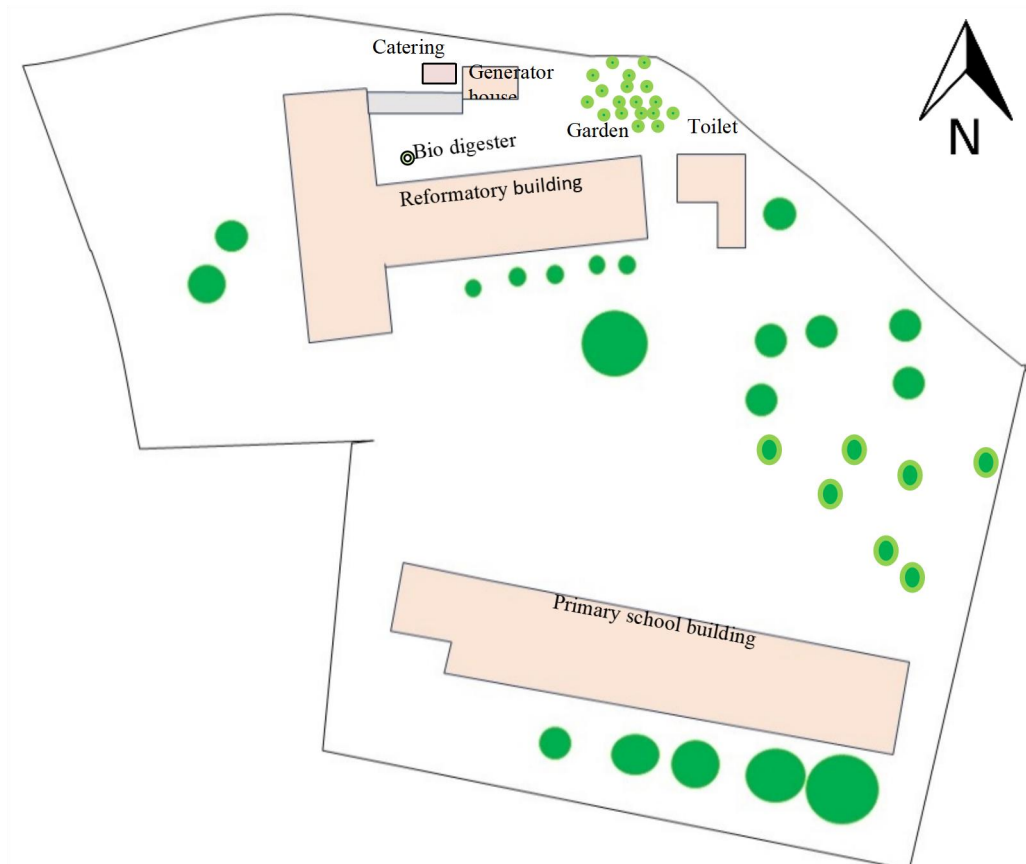


Figure 3: Layout of the of Special Reformatory Centre for Girls, Idi Araba

Source: Fieldwork (2025)



Plate 1: Oblique approach view into the facility compound
Source: Fieldwork (2025)



Plate 2: Right-hand view of the facility showing windows of dormitory on upper floor and workshops for vocational studies on the ground floor
Source: Fieldwork (2025)



Plate 3: Bio digester gas generating scheme.
Source: Fieldwork (2025)



Plate 4: Modern primary school building for the girls
Source: Fieldwork (2025)

Architectural merits regarding sustainable design strategies

Building and solar orientation: The primary building blocks of the reformatory facility and the primary school building are oriented along an East-West axis. This orientation minimizes exposure to harsh eastern and western solar radiation while maximizing north-south cross-ventilation from prevailing tropical trade winds.

Biophilic design, courtyard integration, and green buffer zones: The site layout incorporates natural vegetation, and strategic tree placement distributed across the open spaces. This strategy helps mitigate the urban heat island effect in Lagos state, creates microclimate cooling, and provides therapeutic green views for the occupants. The courtyards act as microclimate modifiers. The green zones help lower ambient temperatures, support natural airflow, and provide therapeutic natural surroundings.

Zoning and spatial separation: Evaluating the built form versus the open space structures were observed to be dispersed along the northern and southern edges of the site boundaries, creating a central green courtyard and open buffer zone that allows for passive visual surveillance without generating an overly restrictive or oppressive physical environment. The many fenestrations allow for visual connection to nature and help to maximize lighting and ventilation.

Integrated extended eaves: Overhanging roof eaves shield external walls and openings from direct tropical solar radiation and heavy rains, acting as a passive shading and envelope protection mechanism.

Circular waste infrastructure: The incorporation of an on-site bio digester recycles human and organic waste into clean cooking gas, reducing environmental impact and promoting operational self-sufficiency. Other service infrastructure such as the garden, generator house, and external toilets is zoned toward the upper northern boundary, keeping utility functions separated from primary educational and residential areas. Incorporating an on-site bio digester reflects a sustainable utility strategy aimed at recycling of waste - generating cooking gas from waste.

Passive ventilation and daylight optimization: The building features abundant, continuous fenestration across its facade along with an East-West main axis orientation. This maximizes natural cross-ventilation and daylight penetration, reducing reliance on artificial lighting and energy-intensive HVAC systems.

Sustainable spatial planning: The inclusion of bunk beds within the dormitory area allows the facility to accommodate up to 88 residents within a compact building footprint. This maximizes floor space utilization.

Architectural demerits regarding sustainable design strategies

Incompatible materials with high embodied carbon: The buildings rely heavily on modern conventional materials such as sandcrete blocks, concrete, and unshaded corrugated metal roofing rather than eco-friendly, low-carbon bio based materials such as compressed stabilized earth bricks or puddled clay. These materials retain heat, lack sufficient thermal mass performance for humid environments, and increase embodied energy.

Lack of deep shading devices and buffer transitions: While long eaves are present, the design lacks deep verandas, continuous shaded corridors, or external louvers/shading screens. This

exposes the outer building walls and fenestration to direct solar radiation and tropical downpours, leading to solar heat gain and rapid material weathering.

Inefficient thermal chimney and microclimate design: The central open courtyard is primarily an unshaded open space without structured microclimate cooling elements such as integrated water features or dense vertical greenery. This fails to optimize the passive stack effect or thermal chimney effect required to draw cool air into surrounding indoor spaces.

Indoor comfort: Hosting a capacity of 88 residents in a single bunk-bed dormitory significantly elevates the indoor heat load and moisture generation. In a hot-humid tropical climate, high occupant density restricts natural airflow paths between elevated bunks, leads to thermal discomfort, accelerates indoor air stagnation, and reduces the efficiency of passive cross-ventilation.

Underutilized renewable energy opportunities: Beyond the standalone bio digester, the facility's roofs and open orientations are not integrated with active solar energy strategies, passive day lighting tubes, or rainwater harvesting networks to achieve true energy and water self-sufficiency.

Dilapidation and poor thermal efficiency: Physical degradation of parts of the building envelope compromises passive environmental performance, leading to localized heat build-up and air stagnation.

Case Study 2: Special Correctional Centre for Boys Oregun

This facility is located at 75A Kudirat Abiola Way, Oregun 101233, Lagos, Nigeria (see figure 4)



Figure 4: Satellite imagery showing the layout of the of Boys Reformatory Centre (6.6022°N, 3.3686°)

Source: Google Earth ()

Background: This correctional home was first as a remand home in 1942 on Lagos Island. It was later moved to Sabo, Yaba and then to Oregun in 1976 where it is still standing and managed by the Lagos State government through the Social Welfare Department. In 2007, the Lagos State government adopted the Child Rights Act and changed its nomenclature from remand home to Special Correctional Centre. Figure 5 shows the spatial layout of the site. Admission into the centre is through family courts in what is called Care Order which is guaranteed under the Child Rights Act. Departure from the centre is also through court order. A diligent and social inquiry is also made before a child is admitted. Plates 5 and 6 show some views from the centre and how passive bio climatic elements were integrated in the layout of buildings on the site.

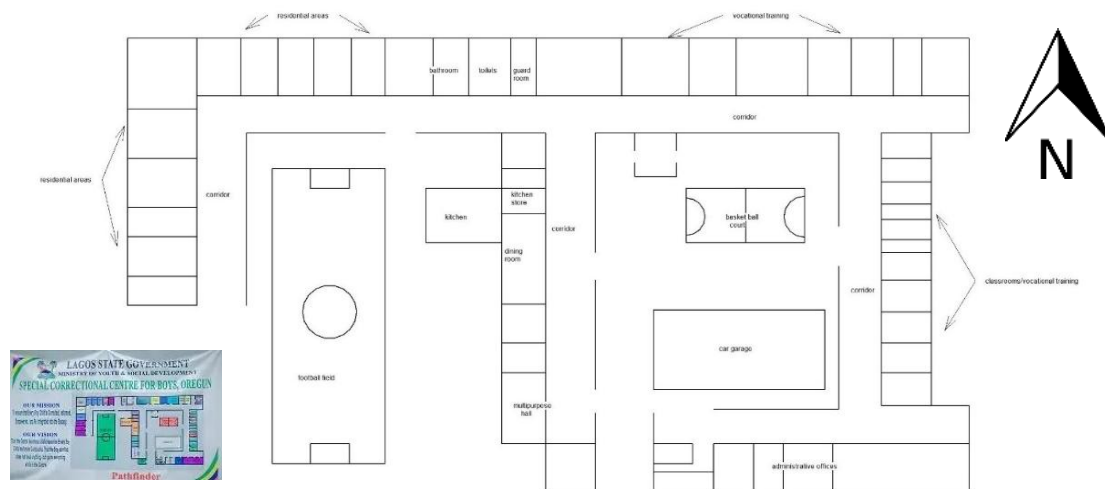


Figure 5: Spatial layout of the site of the Special Correctional Centre for Boys Oregun.
Source: Fieldwork (2025)



Plate 5: Courtyard with basketball court, and car parking. Surrounding it is a screened corridor

Source: (Fieldwork, 2025)



Plate 6: Dormitory area with football playing field.

Source: (Fieldwork, 2025)

Architectural merits regarding sustainable design strategies

East-west orientation: The administration building is oriented in the east-west axis which minimizes the surface area facing east and west, thus significantly reducing heat build-up. The windows on the long facade of the building receive consistent glare-free indirect daylight throughout the day.

Microclimate control and passive ventilation through use of courtyards: The inclusion of central courtyards and open green areas function as thermal lungs and helps regulate the site's microclimate by facilitating passive cooling, enabling stack effect, bringing in cooler air into inner spaces while allowing trapped heat to escape.

Solar radiation control, passive lighting, and ventilation: The single-story, buildings utilize generous, deep roof overhangs and continuous shaded exterior corridors, which shield walls and windows from direct solar heat gain and heavy tropical rains. The layout around open courtyards, maximizes surface area exposure to natural cross-ventilation and day lighting while minimizing the need for artificial cooling and lighting.

Integrated shading and buffer zones: Deep perimeter corridors and extended overhangs act as architectural solar buffers, reducing direct heat gain on interior spaces while allowing natural light.

Permeable ground cover: The expansive grassy sports field and unpaved and semi-paved court areas allow rainwater infiltration, minimizing surface runoff, mitigating urban heat island effects, and promoting natural evaporation and cooling across the site.

Sustainable spatial planning: The dormitory area with bunks for 100 residents allows the facility to maximize floor space utilization.

Architectural demerits regarding sustainable design strategies

East-west solar exposure risks: The residential area building is oriented along the north-south axis without sufficient shading or vegetative buffers. This risk direct exposure to intense morning and afternoon sun angles without sufficient dynamic shading or thermal mass buffering thus causing interior thermal discomfort.

Limited decentralized passive cooling: The structural clustering forms continuous rigid perimeters rather than organic, decentralized pavilions as seen in traditional vernacular compounds. This can obstruct prevailing wind movement across all indoor zones.

High-embodied-energy envelopes: The buildings used modern conventional materials such as concrete masonry, cement renders, and non-insulated corrugated metal roofing, which store and radiate thermal heat into living quarters, counteracting the observed passive cooling strategies.

Lack of vegetative shading: The large central courtyard and parking spaces contain extensive unshaded paving without sufficient tree canopy cover. This increases localized direct sun exposure and solar thermal reflection into surrounding classrooms and workshops.

Indoor comfort: A single bunk-bed dormitory accommodating 100 juveniles significantly elevates the indoor heat load and moisture generation. This leads to thermal discomfort, accelerated indoor air stagnation, and reduction in the efficiency of passive cross-ventilation

FINDINGS AND DISCUSSIONS

Special Reformatory Centre for Girls: The design successfully leverages bio climate responsive passive strategies. By aligning primary building masses along an East-West axis, solar heat gain is minimized while optimizing North-South cross-ventilation. Extended roof eaves and central courtyard zoning act as passive envelope protections and microclimate modifiers, driving air movement and offering therapeutic biophilic spaces.

Additionally, integrating continuous fenestration enhances indoor day lighting, while an on-site bio digester enables waste management by converting human waste into usable biogas. The building envelope suffers from high-embodied-carbon, heat-retaining conventional materials like concrete and unshaded corrugated metal sheeting. Unshaded central courtyards lead to direct thermal heat gain and material degradation. Furthermore, failure to utilize active renewable systems such as rainwater harvesting and the localized physical dilapidation compromise overall passive cooling performance and long-term environmental self-sufficiency.

Special Correctional Centre for Boys, Oregon: The design successfully utilizes bio climatic passive strategies tailored for tropical climates. Central courtyards, open green spaces, and

permeable ground surfaces act as microclimate modifiers - encouraging natural evaporation and cooling, enabling the stack effect, and promoting runoff infiltration. Deep perimeter overhangs, shaded corridors, and East-West building massing effectively control solar heat gain while optimizing day lighting and North-South cross-ventilation, drastically minimizing reliance on mechanical cooling.

Environmental efficiency is significantly compromised by high-embodied-energy building envelopes - concrete masonry, cement render, non-insulated metal roofing that retain and radiate thermal heat into interior spaces. Structural clustering without organic decentralized layouts disrupts wind paths, while unshaded paved courtyards create severe local heat islands and this will make deep indoor floor plans dependent on artificial lighting during daytime power outages.

Furthermore, the north-south axis orientation of some paths of the building which lack vegetative canopy buffers result in excessive morning and afternoon solar heat gain and localized air stagnation.

Both facilities attempt bio climatic zoning through use of courtyards, and continuous fenestration but undermine these efforts by using high-embodied-energy, high-thermal-retention materials such as concrete masonry, and non-insulated corrugated metal roofing sheets. The East-West building alignment in Idi-Araba case is optimized for cross-ventilation, yet it uses unshaded metal roofing and unshaded courtyards. This presents a design contradiction: passive macro-orientation while neglecting micro-shading details. This will lead to direct thermal heat gain. The study in Oregon notes the use of East-West building orientation to control heat gain in some buildings, yet some other buildings are oriented in the north-south orientation that will result in excessive morning and afternoon solar heat gain. This reveals poor site planning where building axes were improperly rotated or lacked canopy buffers. Modern custodial design demonstrates that security can be maintained through spatial layout and integrated louvered screens without sacrificing natural light or air circulation which is seen in the Special correctional centre in Oregon.

CONCLUSION

Assessing sustainable design strategies in juvenile reformatories highlights the critical need to re-evaluate how custodial institutions are planned and built in the hot-humid climate of southeastern Nigeria. Current facilities heavily emphasize security at the expense of passive cooling, natural day lighting, and therapeutic spatial quality. Incorporating bio climatic architecture - specifically through solar-conscious orientation, courtyard microclimate, breathable security envelopes, and biophilic integration enables juvenile reformatories to maintain safety while providing comfortable, humanizing environments that support youth rehabilitation and reintegration.

Building on these core challenges, this study establishes that passive bio climatic design features directly function as trauma-informed therapeutic tools. Poor material selections, such as non insulated metal roofs and unshaded concrete, cause severe spatial overheating that

actively contradicts psychological rehabilitation by increasing spatial distress. Conversely, decentralized, courtyard layouts generate natural stack-effect cooling while simultaneously creating secure, therapeutic outdoor spaces.

Ultimately, these findings offer significant implications across policy, research, and infrastructure. By establishing a direct link between tropical passive architecture, environmental psychology, and juvenile justice reform, this study provides a baseline framework for revising custodial design standards in hot-humid tropical regions shifting the paradigm away from adult penal designs toward climate-responsive reformatories. Furthermore, integrating passive strategies such as Compressed Stabilized Earth Blocks (CSEB), natural day lighting, and stack ventilation demonstrates a viable path toward economic resilience, significantly reducing long-term operational costs and reliance on unstable municipal power grids.

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