Assessment of the Satisfaction of Residents in the Barrack Houses with the Natural Ventilation Design of Military Barrack in the Context of Climate of Plateau State

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Abstract
Natural ventilation is the main means by which military barrack houses in Nigeria are expected to provide thermal comfort and acceptable indoor air quality, yet little is known about how residents experience it. This study assessed residents' satisfaction with the natural ventilation design of two barracks in Plateau State, Nigeria: Maxwell Khobe Cantonment Barracks (MKCB), a cold highland site in Bassa, and 332 Artillery Regiment Barracks (ARB), a warm lowland site in Shendam. A convergent mixed-methods design was used. A structured questionnaire based on ASHRAE Standard 55 was administered per household (250 distributed; 245 retrieved, 98%) and complemented by field observation and spot measurements of air temperature and velocity. Descriptive statistics, correlation and multiple regression were applied. Satisfaction was moderate overall (mean = 3.5 out of 5) but uneven. MKCB residents rated air quality (4.0 vs. 3.0) and the airflow–comfort relationship (4.5 vs. 3.5) higher than ARB residents, who expressed a stronger wish for additional ventilation features (4.5 vs. 3.5). Occupant comfort correlated strongly with ventilation performance ($r = .868$, $p < .001$) and was the strongest predictor in the regression model ($B = 1.008$, $p = .013$). Enclosed rooms recorded air velocities of only 0.000–0.044 m/s. The study establishes that natural ventilation satisfaction is an attribute-specific outcome governed by physical features, user behavior, and microclimate. Dissatisfaction was linked to poor maintenance, stagnant air in hot periods, security-driven window closure, noise and odours. Barrack ventilation design should be climate-specific, maintainable and compatible with security requirements.

Keywords: *Natural Ventilation; Occupant Satisfaction; Military Barracks; Thermal Comfort; Microclimate; Plateau State*

1. Introduction

Housing is a basic human need within Maslow's (1943) hierarchy of needs. For serving military personnel, the barrack house is the place where soldiers and their families rest and recover between duties, so its indoor conditions bear directly on comfort and wellbeing. Among the factors that determine those conditions, natural ventilation is central. It uses wind and buoyancy to supply fresh air and to remove heat and pollutants without mechanical energy, but its success depends on climate, building form and the behaviour of occupants who open and close windows (Brager & de Dear, 2000; de Dear & Brager, 2002). Plateau State offers an unusual setting for studying this relationship. Although it lies in the tropical wet-and-dry (Aw) climatic belt, its elevation, which ranges from about 1,200 m to 1,829 m above sea level, gives it a semi-

temperate character that differs from most of Nigeria (Gontul et al., 2007). Within this one state, barracks occupy sites at sharply different elevations. Maxwell Khobe Cantonment Barracks (MKCB) in Bassa Local Government Area (LGA) is a cold highland site, whereas 332 Artillery Regiment Barracks (ARB) in Shendam LGA is a warm lowland site. The two barracks share a prototype design, so differences in how residents experience ventilation are more likely to reflect climate than variation in building type. Preliminary field observation in both barracks showed that new and renovated houses still depend on mechanical cooling or heating, depending on the prevailing climate, which raises energy demand and signals that the passive ventilation provision is not meeting residents' needs. Existing Nigerian barrack studies have mostly examined the physical condition of buildings and the adequacy of facilities (Milala et al., 2021; Oyeleke et al., 2021), but little is known about how residents judge the ventilation their houses provide especially across contrasting microclimates within the same state.

In addressing the gap, the research aims to assess residents' satisfaction with the natural ventilation design of military barrack houses in Plateau State. It answers how satisfied residents are with the natural ventilation of their houses. Does satisfaction differ between the cold highland barracks (MKCB) and the warm lowland barracks (ARB)? How strongly is occupant comfort associated with the perceived performance of natural ventilation?

2. Literature Review

2.1 Satisfaction with barrack housing in Nigeria

Studies of Nigerian military housing show that satisfaction is attribute-specific rather than uniform. Milala et al. (2021) surveyed 194 respondents in Coral Barracks and found that bedrooms, walls and floors were rated fair, while roofs, kitchens, toilets, laundry and drainage were rated poor. Oyeleke et al. (2021) surveyed 160 respondents at Shadawanka Barrack, Bauchi, and found that security, walls and floors were viewed positively, whereas sewage systems and road networks were rated low. Both studies concluded that rehabilitation and better auxiliary services were needed, but neither examined ventilation or thermal comfort directly.

2.2 Ventilation, orientation and occupant priorities

Evidence from other Nigerian building types shows that design decisions measurably change ventilation outcomes. Mba et al. (2022) measured 60 primary school classrooms in Enugu and reported higher ventilation coefficients for north–south orientation (mean = 0.9) than for east–west orientation (mean = 0.8). On the occupant side, Mokhtariyan Sorkhan et al. (2024) compared 30 building experts with 102 occupants of commercial buildings in Iran and found that engineers and occupants gave the highest priority to thermal comfort among indoor environmental quality factors. Studies of residential natural ventilation have also drawn attention to occupants' perceptions, usage patterns and motivations (Buonocore et al., 2024). Because these perceptions are subjective, questionnaire-based evaluation remains an important complement to physical measurement in thermal comfort research (Yang et al., 2024).

2.3 Climate-responsive design

The bioclimatic approach holds that buildings should be shaped by the climate in which they stand (Olgyay, 2015). The adaptive comfort literature adds that people in naturally ventilated buildings accept a wider range of indoor conditions when they can adapt through behaviour and control of openings (Brager & de Dear, 2000; de Dear & Brager, 2002). Together these ideas imply that barrack ventilation should be judged against local climate and against residents' ability to operate their houses, which is the perspective adopted in this study.

3. Methodology

3.1 Study area

The study was conducted at MKCB in Bassa LGA and ARB in Shendam LGA, both in Plateau State, Nigeria. The state's hot season lasts about three months, from late January to April, with average daily highs above 30 °C and March as the hottest month (average maximum 32 °C). The cold season runs from early July to early October, with average daily maxima below 25 °C, and the dry, cool and dusty Harmattan wind dominates from November to March (Gontul et al., 2007). Geographic Information System (GIS) analysis recorded elevations of 1,169–1,295 m at MKCB and 200–237 m at ARB, which explains the contrast between a cold highland and a warm lowland microclimate. The housing types studied were Corporals Below Quarters (CBQ), Senior Non-Commissioned Officers Quarters (SNCOQ), Single Officers Quarters (SOQ) and Married Officers Quarters (MOQ).

3.2 Research design

A pragmatist, convergent mixed-methods design was adopted. Questionnaire data on residents' satisfaction were collected alongside field observation, photographic documentation and spot measurements of indoor air temperature and air velocity, so that perceptions could be compared with measured conditions. Local weather data were drawn from the University of Jos weather station and a site-specific meteorological weather file for Jos.

3.3 Population and sampling

The population comprised 638 housing units supplied by the Army Engineers unit (449 at MKCB and 189 at ARB). Sample size was determined with Yamane's (1967) formula at a 5% margin of error, which gave 245.8, rounded up to 250 housing units. The sample was allocated first between the two barracks and then across housing types in proportion to the number of units in each category. One questionnaire was distributed per household. Of 250 questionnaires distributed, 245 were retrieved and used for analysis (98% response rate): 170 from MKCB and 75 from ARB.

3.4 Instruments, validity and reliability

The questionnaire used closed-ended and Likert-scale items drawn from ASHRAE Standard 55 sample questions for naturally ventilated buildings (ASHRAE, 2020). It had a demographic section and four schedules covering design parameters, occupant satisfaction, integration of microclimate and occupancy patterns. Satisfaction items addressed air quality, the effect of airflow on comfort and the wish for additional ventilation features. Content and face validity were established through review by the researcher's supervisors and a pilot administration to 54 respondents outside the main sample. Construct validity was examined with principal component analysis with Varimax rotation, which produced a human-centric component (occupant comfort, occupancy pattern, ventilation performance) and a technical-architectural component (design parameters, integration of microclimate). Internal consistency, measured with Cronbach's alpha, was .707, above the commonly accepted threshold of .70. Digital thermometers and anemometers were calibrated before fieldwork and cross-checked against weather station data.

3.5 Data collection, ethics and analysis

Ethical approval for fieldwork in the restricted barrack environment was granted by the Nigerian Army Engineers Unit of the 3rd Division, Maxwell Khobe Cantonment. Questionnaires were administered with research assistants, and follow-up reminders were used to secure retrieval. Observation notes, photographs and sketches recorded the condition of

ventilation components. Data were analysed using descriptive statistics, Pearson correlation and multiple regression, with significance judged at the .05 level. The dependent variable was the perceived performance of the natural ventilation design, a 16-item composite. The predictors were occupant comfort (five items), occupancy pattern (five items), integration of microclimate (four items) and design parameters.

4. Results

4.1 Respondent profile

Table 1 summarises the 245 respondents. Most lived in MKCB (69.4%), in old buildings (64.9%) and in Corporals Below Quarters (53.1%). More than half (53.9%) had lived in the barracks for 6–10 years, so most had experienced at least several seasons in their houses. Respondents ranged in rank from lance corporal to warrant officer.

Table 1

Characteristics of Respondents (N = 245)

Characteristic	Frequency	Percentage
Barrack		
MKCB (Bassa)	170	69.4
ARB (Shendam)	75	30.6
Gender		
Male	198	80.8
Female	47	19.2
Marital status		
Single	200	81.6
Married	45	18.4
Housing unit type		
CBQ	130	53.1
SNCOQ	68	27.8
MOQ	34	13.9
SOQ	13	5.3
Duration of stay		
1–5 years	54	22.0
6–10 years	132	53.9
11–15 years	36	14.7
16–20 years	23	9.4
Status of accommodation		
Old building	159	64.9
New building	45	18.4
Renovated building	41	16.7

Note. MKCB = Maxwell Khobe Cantonment Barracks; ARB = 332 Artillery Regiment Barracks; CBQ = Corporals Below Quarters; SNCOQ = Senior Non-Commissioned Officers Quarters; MOQ = Married Officers Quarters; SOQ = Single Officers Quarters. Percentages were computed from the frequencies and may not sum exactly to 100 because of rounding.

4.2 Satisfaction with natural ventilation by barrack

Overall satisfaction across the three satisfaction items was moderate (mean = 3.5 out of 5) but differed between the barracks (Table 2; Figure 1). MKCB residents rated air quality (4.0 vs. 3.0) and the impact of airflow on comfort (4.5 vs. 3.5) higher than ARB residents. ARB residents showed a stronger preference for additional ventilation features (4.5 vs. 3.5), indicating a group that is less satisfied and actively seeking improvement.

Contextual items pointed the same way. Window condition was rated 4.5 at MKCB and 2.5 at ARB, obstacles to airflow scored 4.0 at ARB against 2.0 at MKCB, and MKCB residents opened their windows more often (4.0 vs. 3.0).

Table 2

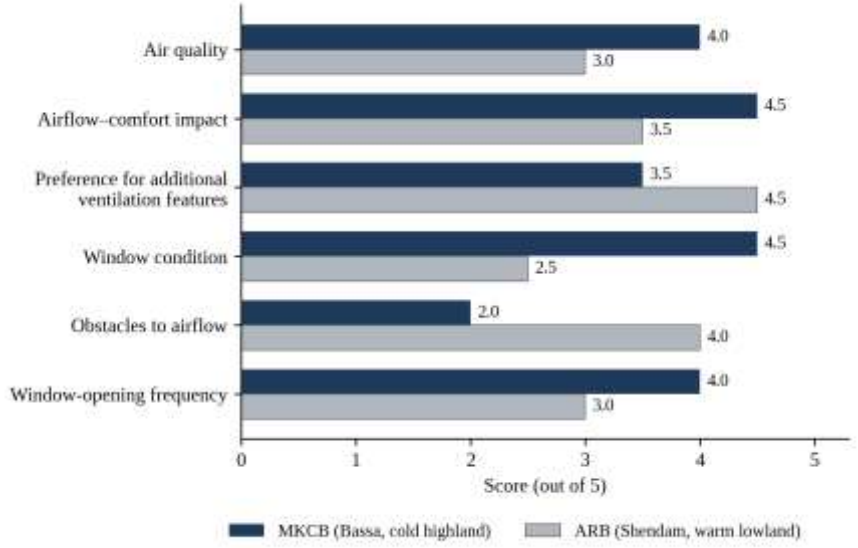
Satisfaction-Related and Contextual Item Scores by Barrack

Item	MKCB (Bassa)	ARB (Shendam)
Air quality	4.0	3.0
Impact of airflow on comfort	4.5	3.5
Preference for additional ventilation features	3.5	4.5
Window condition	4.5	2.5
Obstacles to airflow	2.0	4.0
Window-opening frequency	4.0	3.0

Note. Scores are out of 5. MKCB n = 170; ARB n = 75. Data from field survey (2024).

Figure 1

Satisfaction-Related and Contextual Item Scores at MKCB and ARB



Note. Scores are out of 5. Data from field survey (2024).

4.3 Occupant comfort and ventilation performance

Occupant comfort (M = 12.57, SD = 3.48) correlated more strongly with overall ventilation performance (r = .868, p < .001) than any other predictor. Occupancy pattern, which reflects how residents use windows and arrange their space, correlated very strongly with occupant comfort (r = .921, p < .001) and with ventilation performance (r = .825, p < .001). Integration of microclimate recorded the lowest mean of the composite variables (M = 10.17, SD = 2.34;

Table 3), meaning that residents generally judged the design as weakly responsive to local climate.

Table 3

Descriptive Statistics of Composite Variables (N = 245)

Variable	*M*	*SD*
Natural ventilation design (performance)	40.56	7.87
Design parameters	17.65	3.16
Occupancy pattern	12.44	3.66
Occupant comfort	12.57	3.48
Integration of microclimate	10.17	2.34

Note. Natural ventilation design is the sum of 16 items; occupancy pattern and occupant comfort have five items each; integration of microclimate has four items.

The multiple regression model explained 80.6% of the variance in ventilation performance (R^2 = .806, adjusted R^2 = .790, F = 50.82, p < .001). As Table 4 shows, occupant comfort was the strongest predictor (B = 1.008, β = .445, p = .013), followed by occupancy pattern (B = .871, p = .021) and design parameters (B = .477, p = .015). Integration of microclimate had a significant negative coefficient (B = −.585, p = .021), although its bivariate correlation with performance was not significant (r = −.174, p = .207).

Table 4

Multiple Regression Predicting Perceived Performance of Natural Ventilation

Predictor	*B*	*SE*	β	*t*	*p*
Occupant comfort	1.008	.389	.445	2.590	.013
Occupancy pattern	.871	.364	.405	2.391	.021
Design parameters	.477	.188	.191	2.533	.015
Integration of microclimate	−.585	.245	−.174	−2.389	.021

Note. R^2 = .806; adjusted R^2 = .790; F = 50.82, p < .001.

4.4 Field measurements

Spot measurements supported residents' reports of weak airflow. Enclosed rooms recorded air velocities of only 0.000–0.044 m/s, and the anemometer read 0.00 m/s in a measured bedroom under closed or weakly ventilated conditions. A spot reading of indoor air temperature in a bedroom was about 33.4 °C. By contrast, a corridor with high airflow was not an occupied comfort space and was therefore of little relevance to residents' experience.

4.5 Residents' qualitative comments

Residents valued good airflow and air quality. Dissatisfaction was linked to poorly maintained openings and to stagnant air during very hot periods, especially at ARB, where many respondents felt the existing arrangements could not cope with extreme heat. Shared living spaces produced disagreements over whether windows should be open or closed, often because of security concerns. A subset of respondents also reported noise and odours from refuse dumps near their houses, which reduced the perceived effectiveness of ventilation.

5. Discussion

5.1 Moderate but uneven satisfaction

Residents were moderately satisfied overall, but the average conceals a clear climatic divide. MKCB residents were more satisfied than ARB residents on air quality and airflow-related comfort. Three explanations are plausible and consistent with the data: the temperate highland climate of Bassa, the better condition of windows and ventilation provisions in the renovated and new buildings there, and building orientation. ARB residents, living in a hot lowland climate with windows in poorer condition and more obstacles to airflow, reported lower satisfaction and a stronger demand for additional ventilation features. This attribute-specific and site-specific pattern mirrors earlier barrack studies, in which satisfaction depended on the feature assessed rather than being uniform (Milala et al., 2021; Oyeleke et al., 2021). The orientation explanation is supported by Mba et al. (2022), who found measurably different ventilation coefficients for different orientations, although orientation was not tested directly in the present study and should be treated as a plausible contributor rather than a demonstrated cause.

5.2 Comfort as the dominant driver

Occupant comfort carried the largest and most significant regression coefficient, larger than design parameters or integration of microclimate. This accords with Mokhtariyan Sorkhan et al. (2024), who found that occupants consistently prioritised thermal comfort over other indoor environmental quality factors. For barrack designers, the implication is that ventilation should be judged by whether it delivers comfort in occupied rooms rather than by the presence of openings alone. The measured airflow of 0.000–0.044 m/s in enclosed bedrooms and living rooms shows why: openings that exist on plan do not necessarily move air through the spaces where people sleep and rest.

5.3 Behaviour, security and shared living

Occupancy pattern was the second-strongest predictor, and MKCB residents opened windows more often than ARB residents. Residents' qualitative comments show that window use in barracks is shaped by security, shared occupancy and surrounding nuisances such as noise and refuse odours, not only by thermal need. Plans that depend on residents leaving windows open will therefore underperform where security or noise discourages it. This supports the adaptive view that comfort in naturally ventilated buildings depends on occupants' ability to control their environment (Brager & de Dear, 2000; de Dear & Brager, 2002), and it points to the value of ventilation openings that can remain open securely.

5.4 Microclimate integration

Integration of microclimate had the lowest mean score and a negative net coefficient. Read alongside the weak bivariate correlation, this suggests that current designs are not adequately responsive to local climate, although the opposing signs of the bivariate and multivariate results indicate that its effect operates through other variables and calls for a formal mediation analysis before firm conclusions are drawn.

5.5 Implications for design and management

The findings suggest five practical priorities. First, barrack ventilation strategies should differ between highland and lowland sites rather than reuse one prototype unchanged. Second, windows and vents need routine maintenance, especially at ARB, where window condition was rated poorly. Third, airflow paths should be kept clear of fixed and movable obstructions. Fourth, secure ventilation openings, such as protected high-level vents, should allow air

movement when windows must be closed. Fifth, siting and screening decisions should consider noise and refuse odours from nearby sources.

5.6 Limitations

Several limitations should be noted. The data are cross-sectional and perception-based, and the two samples are unequal (170 and 75 respondents). Occupant comfort and ventilation performance were measured in the same survey, so their strong association may partly reflect shared method variance and conceptual overlap. The very high correlation between occupancy pattern and occupant comfort (r = .921) also raises the possibility of multicollinearity, for which diagnostics should be reported in later analysis. Spot measurements of air velocity and temperature cannot represent all seasons, and the simulation of Corporals Below Quarters at MKCB is still outstanding. Finally, only two barracks were studied, which limits generalisation to other Plateau State barracks.

6. Conclusion

This study assessed residents' satisfaction with the natural ventilation design of two military barracks in Plateau State. Satisfaction was moderate overall but uneven: residents of the cold highland barracks (MKCB) were more satisfied with air quality and airflow-related comfort than residents of the warm lowland barracks (ARB), who more strongly wanted additional ventilation features. Occupant comfort was the strongest predictor of perceived ventilation performance, and measured airflow in enclosed rooms was very low. Dissatisfaction was tied to maintenance, stagnant air in hot periods, security-driven window closure, noise and odours. The study recommends that microclimatic data be built into barrack design and retrofitting, with separate strategies for highland and lowland sites, and that ventilation provisions be maintained and made compatible with security needs. Future work should complete the outstanding simulation, test orientation directly, and apply a formal mediation model to clarify how microclimate affects residents' wellbeing through ventilation performance.

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