

Assessment of Thermal Comfort Perceptions of Low Impact Strategies Within Residential Plots in Satellite Town, Lagos, Nigeria

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Abstract: The emphasis on thermal comfort experience and subjective perceptions with respect to different open spaces is paramount for achieving outdoor functionality and environmental sustenance. The research aims at appraising resident' perception of the thermal enhancement capabilities of Low impact development strategies within their residential plots with a view of proposing strategies for outdoor thermal comfort enhancement within the urban residential development. The research focused on the thermal comfort effect of low impact development strategies, which is a nature based water management strategy utilizing natural processes, generally occurring as unpaved areas within open spaces in setbacks of residential plots in Satellite town, Amuwo-Odofin, Lagos, Nigeria. Questionnaires were distributed strategically to elicit information on resident's social status, residential site status, low impact development status and perceptions as regards Thermal comfort enhancement of LID. Analysis at three levels, which involved descriptive statistics and chi square test and multiple regression analysis, using Statistical Package for Social Science (SPSS) Version 21 was carried out. The results of the chi square test reveals positive perception relationship setback open space distance and thermal comfort, while the regression analysis reveals that an increase in setback distances and decrease in paving will improve thermal comfort on residential plots . The study concluded that thermal comfort within open spaces in residential plots are largely dependent on the availability of setback distance and the state of setback ground. It further reveals from its multivariate analysis that the more the provision of spaces for setback and lesser the areas paved, the more the thermal comfort within the residential site.

Keywords: Thermal Comfort, Low Impact Development Strategies, Urban Area.

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I. INTRODUCTION

In recent times, climate change has led to irregularities in rainfall patterns, increased droughts and rising temperatures. Global warming is likely to cause a sharp rise in overall world temperature, resulting to an increase in evapotranspiration and atmospheric moisture content with associated changes in rainfall pattern (Wang et al, 2016). Urban areas are usually affected by extreme climatic conditions with urban expansion and changes in the ground surface properties leading to urban heat island effects (Chen et al, 2015). He et al (2019) reported that 346.4 thousand kmsq of the world land surface was urbanized between 1992 and 2016. Extreme rainfall events as reported by Shahid et al (2016) is likely to be more intense and recurrent under the influence of a warmer climate, with effects

more severe in urban areas. Affected by global and urban climate change, urban heat islands become aggravated over time. In these areas, higher temperatures resulting from urban heat island impacts affects the micro-climate, amplifying the climate variability resulting from global warming (Liu & Niyogi, 2019, Simsek & Odul, 2019), hence adversely affecting thermal comfort.

Thermal comfort is the state of mind indicating contentment with the thermal conditions, which is subjectively evaluated (ASHRAE Standard 55, 2017, Eddy et al, 2017) .Hensen (2021) presented thermal dissatisfaction as situation where an individual's mental state no longer reflects contentment with the surrounding thermal condition. Several factors that strongly impact thermal comfort include air

temperature, radiant temperature, air velocity, humidity, metabolic rate, clothing, insulation, gender differences and psychological factors (Hensen, 2021). According to Karimi et al (2020) building design should not only focus on providing a space, but also consider the health and safety of the occupants with thermal comfort being a primary consideration. According to Mustafa et al (2026), instead of intervening only during disasters, an approach that reduces risks during the planning process should be adopted in cities.

➤ *Low Impact Development*

Globally, the increase in impervious surfaces due to urban development has resulted to significant water circle issues such as ground water depletion, urban heat islands and flooding. To address these issues, Low Impact Development (LID) techniques are increasingly being applied in storm water management. Low impact development (LID) is an environmentally sustainable planning and site development approach that integrates landscaping and storm water management design strategies to preserve or enhance natural hydrology of a site, mimicking water shed patterns of pre-existing site (State of Hawaii, 2026). Implementing LID offers substantial environmental, economic and community benefits to the developer, municipality and the wider community through environmental through environmental protection, life circle cost reduction, increased property value, aesthetically pleasing urban areas and improved public health (State of Hawaii, 2026).

LID employs a variety of natural and built features that reduces the rate of runoff, filters pollutants and facilitate infiltration of water into the ground by employing a set of overall site design strategies as well as highly localized small scale decentralized source control techniques known as integrated management practices (IMP) (Paul, 2023). LID have emerged as an essential strategy to mitigate urban storm water quantity and quality challenges caused by rapid urbanization. Recent surveys according to Shangjun (2025) revealed that in highly impervious catchments, LID practices can reduce annual runoff volume by 30-70%, peak discharges by 20-60%, total suspended solids removal by 70-95% and 40-80% of metals from storm water. Outcomes of low impact development varies, hence the question of when and how public participation affects performance arises (Mingwei & Jin-oh, 2025)

➤ *Thermal Comfort Through LID*

Thermal comfort is a complex and multifaceted concept that has been extensively researched (Modeste et al, 2018). The

American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) defines thermal comfort as the psychological satisfaction individuals experience about their thermal environment (Terence & Lyrian, 2020). Although this definition is not a universal standard, rather highly subjective and influenced by numerous physical, physiological and psychological factors. According to Ge et al (2022), personal factors such as clothing, activity level, age, gender, mood and cultural norms significantly influence and individual's thermal comfort. The influence of pavement on outdoor thermal comfort differs when under conditions with and without shades (Jiahao et al, 2022). A comfortable outdoor environment benefits cities in various ways, involving physical, economic and social aspects, further encouraging outdoor stay and relaxation (Karimimoshaver et al, 2022; Garcia-Lopez & Heard, 2015; Dong et al, 2023). Thermal conditions represents one of the most important factors in creating a satisfying outdoor environment (Lin et al, 2013; Fang et al, 2018; Xie et al, 2022)

The characteristics of the outdoor thermal environment vary with different climatic zones and over the years, different mitigation approaches involving a number of optimizations for outdoor thermal environments have been carried out, employing various landscape and urban design strategies (Rahman et al, 2020; Jamie et al 2016). Some of these mitigation approaches involved employing tree species and layouts (Liu et al 2018; Wang et al, 2020; Yin et al, 2022), urban layouts (Zang et al, 2018; Li et al, 2020) and pavements (Yang et al, 2013). The results from a study by Jaemoon et al (2024) demonstrates that the introduction of LID techniques in public spaces can significantly enhance water management, providing insights into effective water circle management, specific urban land uses, foundation for future planning and sustainable development.. Outcomes of low impact development varies, hence the question of when and how public participation affects performance arises (Mingwei & Jin-oh, 2025).

II. METHODOLOGY

The research is designed to assess resident's perception with respect to thermal comfort capabilities of Low impact development infiltration strategies. Survey approach was employed which involved administering to selected residents, a questionnaire designed with comprised close ended questions with the aim of gathering subjective LID thermal comfort perception data from residential plot users. Details of the variables studied are as summarized in table 1.

Table 1: List of Quantitative Research Variables

Component	Variables	No. of Variables
Socio-Economic Characteristics of responden	Plot ownership, plot size, Age of respondent, Education status and employment status	5
Residential Site plan status	Site design, parking space, open natural space, set back distances, site plan approval and development monitoring	6
Low impact development status	Nature preservation, nature introduction, site setback state, nature of paved area, nature of unpaved area	5

The research population for this study is all the residential plots in New-site residential estate in Satellite town that are accommodated. A total of 342 residential plots are accommodated either as personal ownership or rental ownership as at the time of this study. For the purpose of this research, the study area was divided into three (3) sectors according to the residential plot development pattern. These sectors include community road sector with a research population of seventy-one (71), David West sector with a research population of one hundred and forty-one (141) and David East sector with a research population of one hundred and twenty-eight (128).

The research sample size was calculated using a sample size calculator according to Creative Research System (2012) at a confidence level of 95% and confidence interval of 5 with a population size of 342. A sample size of 181 was generated by the sample size calculator which was compared with the sample size figure according to Krejcie & Morgan (1970). For the purpose of this research, a sample size of 182 was used. The samples were proportionally selected from each of the research sectors to make up a total of 182. This gives 21% from sector one with a total of 38 samples, 41% from sector two with a total of 75 samples and 38% from sector three with a total of 69 samples

III. RESULT AND DISCUSSION

➤ *Socio-Economic Characteristics of Respondents*

All the 182 questionnaires administered were correctly filled, returned and analysed. The analysis revealed that 55.5% were personally owned residential plots while 44.5% were rental ownership, which means that a larger percentage of the residential plots in the area were accommodated by their owners. About 81.3% of the residential plots were standard plots (18m x 36m) which indicates that there are more standard sized plots still existing after site development in the estate. The analysis further reveals that 79% of the respondents fall within the age interval of 35 – 44 and 71.4% were graduates. This is an indication that most of the accommodated residential plots in the estate were occupied by young adult graduates with first degrees and so are knowledgeable and can express themselves to a large extent. Also from the analysis, 56% of the respondents are self-employed, 22% works with corporate organisations, 17% with the civil service and 9% are retired which is an

indication that virtually all the respondents are economically empowered.

➤ *Assessment of Residential Site Plan Status*

The analysis revealed that 92.3% claimed to have site designs for their residential plot, 4.9% were uncertain and 2.7% have no site design which indicates that a large portion of the residential estate have plots with site designs. The analysis also reveals that 33% of the residential plots can accommodate 6 – 8 cars after development, 31.3% above 8 cars, 25.8% accommodating 3 – 5 cars and only 9.9% accommodating 1-2 cars. This could mean that most of the occupied residential plots in the estate give more setback space for car parking. Also from the analysis, 78.6% have open natural spaces in their residential plot, 19.8% have none and 3% were uncertain. This could mean that despite the areas developed for car parking most of the residential plots still have open natural area which could either be within the plot fence or between the plot fence and external drainage. About 83.5% of the respondents claimed to have building approval for their residential development. Also 44% of the respondents were uncertain about building control monitoring during their site development, while 26.9% had no building monitoring experience. This indicates that despite the large approval percentage it is likely that most of the residential sites in the estate were not developed in line with what was approved. Finally, in this section, 51.6% claimed to have completed their residential site development, 27.5% are not yet complete and 20.9% were uncertain. This indicates a probability that the nature of setback surfaces of almost 50% of the developed residential plots is likely to change.

➤ *Assessment of Low Impact Development Status*

The analysis reveals that 52.2% claimed to preserve nature during site development, 44.3% did not and 0.5% were uncertain, while 61.5% introduced natural elements after site development and 38.5% did not introduce any. These results indicate that an average proportion of the developed residential plots within the estate have one form of natural surface or the other within its setbacks. Also from the analysis 53.3% used concrete for their paved areas, 44.5% laid interlocking stones with nylon underlay and 2.2% laid interlocking stones without nylon underlay. This indicates that almost all the developed residential sites within the estate have impermeable paved areas. The analysis further reveals that 32.4% had only sand as their unpaved area, 31.3% had sand and shrubs, 8.2% had sand,

shrubs and trees, 8.2% have sand and grass, 6% have sand and trees while 12.1% have no unpaved area. This an indication that most of the accommodated residential plots in the estate had either sand alone or sand and some other element as their unpaved area this is most likely going to drop looking at the percentage of uncompleted accommodated sites if certain measures are now put in place.

Five variables were assessed in 182 residential plots for significant relationship between state of setback space and the

resident’s thermal comfort perception. The variables include the state of the space between the residential building and approach, sides and rear fences and also approach fence and external drainage and thermal comfort perception of respondent. Descriptive summary for the evaluation of respondent’s thermal comfort of the 182 residential plots assessed is presented in chart 1. The chart shows that 58 of the respondents have an average perception to thermal comfort within their residential plot, 17 have a high thermal comfort perception and 107 have a low thermal comfort perception.

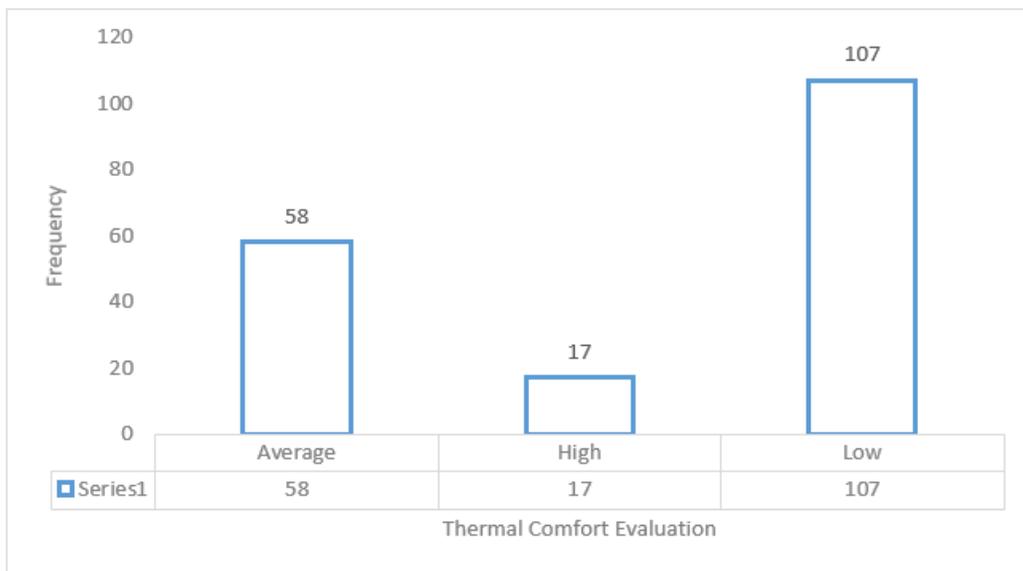


Chart 1: Site Setback Thermal Comfort Evaluation

Chi square test was employed in analysing hypothesis two, which is to check for significant relationship between thermal comfort and the state of setback. The distributions are reported below for the null hypothesis in table 4.4. The test was carried out at an alpha level of 95% confidence and 0.05 significance level. The table 2 shows from the chi square test carried out that an asymptotic significant value of approximately 0.000 is arrived at for significant relationship between the states of approach, side and rear setbacks and the level of thermal comfort within the spaces. While an asymptotic value of approximately 0.005 is arrived at for significant relationship between fence setback state and the thermal comfort within the space. All the chi square values arrived at

are lower than the accepted 0.05 significant level which indicates that there is significant relationship between the state of setback space around a residential building and the level of thermal comfort around the residential building.

Multiple regression analysis was employed to assess the effects of setback distance and state on residential site’s thermal comfort. The analysis revealed that distance of front, fence and side setbacks have positive coefficients while rear setback distance, state of front setback, fence setback, side setback and rear setback have negative coefficients as presented in table 3. This indicates that increase in setback distances and decrease in paving will improve thermal comfort on residential plots.

Table 2: Chi Square Test Between the Different Setback States Around the Residential Building and the Level of Thermal Comfort Around the Residential Building.

CHI-SQUARE TESTS				
Setback State	VALUES		df	Asymptotic Value
	Likelihood Ratio	Pearson Chi-Square		
Approach Setback	23.284	20.563	6	.000
Side Setback	46.004	46.302	6	.000
Rear Setback	32.220	30.880	6	.000
Approach Fence/Drainage	14.919	14.224	6	.005
N of Valid Cases	182			

Table 3: Effects of Site Setback and Setback State on Site's Thermal Comfort

Dependent Variable: SITE_S_THERMAL_COMFORT				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.049223	0.855509	2.395324	0.0166
FRONT_SETBACK	0.545011	0.147567	3.693308	0.0002
FENCE_SETBACK	0.677890	0.188717	3.592104	0.0003
SIDE_SETBACK	0.331870	0.143173	2.317967	0.0205
REAR_SETBACK	-0.226064	0.149000	-1.517212	0.1292
FENCE_SETBK_STATE	-0.304440	0.179127	-1.699576	0.0892
FRONT_SETBK_STATE	-0.724190	0.228584	-3.168159	0.0015
SIDE_SETBK_STATE	-0.524668	0.201837	-2.599461	0.0093
REAR_SETBK_STATE	-0.459493	0.179748	-2.556312	0.0106
Uncensored obs	58	Total Obs	182	

IV. RECOMMENDATION AND CONCLUSION

➤ Recommendations

- The Federal, state and local agencies in charge of building developments should revive their monitoring team to ensure the compliance and adherence to setback standards during site development.
- Government's building control and monitoring agencies should go beyond checking for the compliance with building setback standards alone, but should include compliance with introduction of low impact development practices on site.
- The government through its various housing authorities should periodically organise low impact and sustainable development programmes to constantly enlighten building users, developers and professionals about the strategies and essence to develop sustainably.
- Residential plot owners must ensure that at least a tree is planted within their residential plot to enhance Thermal comfort, reduce the effects of heat islands from inevitable paved areas and generally improve environmental quality.
- Further research on local techniques and natural thermal comfort enhancement strategies recommended

➤ Conclusion

The study through its research methodology and analysis has presented results to show that the thermal comfort are largely dependent on the availability of setback distance and the state of setback ground. It further reveals from its multivariate analysis that the more the provision of spaces for setback and lesser the areas paved, the more the thermal comfort within the residential site. The study therefore concludes that through Government's implementation of the preservation of a certain area for low impact development strategies during residential site approval and monitoring, there is a large likelihood of achieving improved thermal comfort and human wellbeing within residential plots. Complimenting this implementation with public sustainable development enlightenment programmes will enhance low impact development of residential plots in Lagos and Nigeria at large.

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