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# INVESTIGATION OF SUSTAINABLE URBAN DRAINAGE UTILIZATION IN RESIDENTIAL PLOTS IN AMUWO-ODOFIN, LAGOS, NIGERIA

**Akagwu, M.; Fadamiro, J.A.; & Ayeni, Dorcas A.**
Department of Architecture, Federal University of Technology, Akure.
*majaakagwu@yahoo.com*

## Abstract

The issues of ineffectiveness of most residential plots in terms environmental sustainability are due to the problems of design, planning, regulatory and administrative framework within which physical development takes place. Effective site planning enhances the prospects of a site while addressing issues such as drainage, accessibility and sustainability. The research aims at investigating site planning issues of open spaces within setbacks of residential plots in Satellite town, Amuwo-Odofin local government area in Lagos Nigeria, by assessing utilization of sustainable urban drainage systems, which is a nature driven drainage strategy, with a view of improving the environmental sustainability of the residential plots. The research focused on sustainable urban drainage system infiltration strategies generally occurring as unpaved areas within open spaces in setbacks of residential plots, using questionnaires distributed to elicit data from respondents. Analysis was carried out using Statistical Package for Social Science (SPSS) Version 21. The study revealed that SUDS facilities existed as unpaved areas at different setback spaces within residential plots, though varied with different plots, but is largely dependent on distance observed as setback space, with the level of unpaving predominant within the approach setback space. The study concluded that through Government's implementation of a percentage of the residential site set aside for unpaving during approval and monitoring, with this unpaved area lower in gradient level than the paved area. Governments' building control agencies should also put in more effort as regards compliance to approved setback distances by developers during construction. Furthermore, enlightenment of residents and prospective developers by government environmental agencies and built environment professionals, the significance of unpaved natural areas within residential plots.

**Keywords:** Site Planning**,** Residential Plot, Open Spaces, Setback, Sustainable Urban Drainage Systems

# Introduction

In 2015, the United Nations general assembly adopted sustainable development goals and explained how the goals are integrated and indivisible to achieve sustainable development at global level (Purvis; Mao & Robinson, 2019). **Recent movement pushing to address sustainable development from an urban perspective have taken place throughout the world. Results from this movement can be seen in the inclusion of a stand-alone goal on cities and urban development in the 2030 agenda, sustainable development goal 11, "Make cities and human settlements inclusive, safe, resilient and sustainable (United Nations, 2022).** There is a rising demand to use nature and natural processes to address the different range of urban issues, especially when looking at climate changes and urbanization processes (Daniele & Viviana, 2020). In line with Artmann et al (2017) finding ways to reduce the impact of climate change and urbanization on the environment, includes employing a systematic approach by reflecting the complexity of cities as socio-ecological systems.

According to Frontdesk (2023), the most important aspect of environmental design and development is site planning and it involves the analysis and organization of outdoor spaces to create functional and aesthetically pleasing environments. Site planning begins with assessing a potential site for development through site analysis (Ajay & Anil, 2022). Drainage systems can contribute to sustainable development and improve the spaces where people live, work and play by balancing different opportunities and challenges that influence urban design and development of communities (Susdrain, 2024).

## THE CONCEPT OF SUSTAINABLE URBAN DRAINAGE SYSTEMS

In the natural environment, rain falls on permeable surfaces, moving into the ground through the process of infiltration, but in urban areas where many surfaces are sealed by buildings and paving, infiltration is limited with water flowing through installed channels, hence resulting to flooding when these channels are over loaded (British Geological Survey, 2024). Sustainable urban drainage systems are a sequence of water management practices and facilities designed to drain surface water in a manner that will provide a more sustainable approach than the conventional practice through pipes and water courses (Muhammad, 2022). Many countries, most notably the United Kingdom, United States and Australia have adopted the use of SUDS (Boluwatife, 2021). SUDS methods of urban design include the introduction of natural elements (Bridget, Berit & Kuande, 2022), designed to reduce impervious areas through different ecological means, ultimately improving the water environment and generally propelling environmental sustainability in the urban sector.

In contrast to traditional and highly centralized grey infrastructure, SUDS controls and manages runoff at its source through the process of evapotranspiration, infiltration and detention, synergizing with

the hydrological circle in its natural conditions (Fletcher et al 2015; Sletts et al; 2019). SUDS system involves an integrated network of engineered vegetated areas and open spaces used to protect natural ecosystem principles and functions and to offer a wide variety of benefits to people and wildlife (Tang et al 2021). SUDS are known for providing multiple environmental benefits including climate change impacts reduction (Coutts and Haihn 2015, Ghods et al, 2020; Roseboro et al, 2021), along with ecological and social benefits and other potential monetizable benefits in the long term (Hamann et al 2020).

SUDS is of great international importance as a useful tool for the environmental improvement of urban spaces, reducing flooding and in recent years has become widespread as a new management strategy for sustainable cities (Rodriguez-Rojas, Huertas-Fernandez, Martinez, & Moreno, 2017). Urban master plans developed by the Lagos state government call for ecosystem-based measures in the Lagos mainland, central areas including vegetated banks capable of absorbing flood water, use of porous paving materials such as sea-binding gravel to allow rain and flood water to infiltrate into the soil and adopting green roof technology to reduce the burden on the storm water and sewerage systems (Adelekan, 2016). According to Boluwatife (2021), massive sacrifices and planning must be made in order to transform Lagos state drainage systems into SUDS so as to safeguard the environment from future floods and other severe environmental situations.

**SUSTAINABLE URBAN DRAINAGE SYSTEMS IN SITE PLANNING**

Sustainable urban drainage systems play a crucial role in creating eco-friendly urban spaces and as developers embark on projects that integrate SUDS, a well thought-out plan and collaboration with local authorities, specifiers and contractors become paramount (Bluegreen Urban, 2024). SUDS should be considered during the site selection process, where different management strategies may be required for different parts of a site, with flows from the roofs also considered (Designing Building, 2024). According to the Construction Industry Research Information Association (2023), SUDS can improve quality of life in developments and urban spaces by making them more vibrant, visually attractive, sustainable and resilient to change by improving urban air quality, building temperature, reducing noise and delivering recreation and education opportunities.

Site development as an urbanization occurrence, affects the natural drainage process by creating impervious surfaces and therefore decreasing the soils natural drainage process, which is a critical issue according to the drainage regulating services delivered by ecosystems in the urban landscape (La Rosa & Pappalarado, 2020), Hence it is crucial to incorporate permeable unpaved surfaces into the design and development of residential plots to compliment overall drainage systems and enhance ecosystem of urban developments. Planning SUDS should consider not only the number of potential beneficiaries but also where beneficiaries are located in the city.

Site Design specifications for residential plots according to the Nigerian Federal Ministry of Works and Housing, URDD (2015) include: Minimum set back from plot boundary line to building line from minor road to be not less than 6m, minimum set back / air space on either side of building to plot boundary line to be not less than 3m and minimum set back/ air space

at the rear of building to plot boundary line to be not less than 3m. The only clause relating to site setbacks in the guideline, is the approved distances to be left around residential buildings, with no clause relating to achieving sustainable development goals through environmental sustenance of space within setbacks in guidelines. It is crucial to implement facilities and systems that are sustainable, multifunctional and flexible, with the planning process involving the use of planning and costing approaches that include flood mitigation and co-benefits in the long and short term simultaneously (Madeleine, 2020).

## MATERIALS AND METHODS

The research population to gather quantitative data for this study is all the residential plots in the selected estate categories in satellite town. Satellite town has three (3) categories of estates. Category one comprises of estates in which land areas (plots) were allocated by the Federal Ministry of Lands and Housing with buildings designed and developed by the owners. There are ten (10) estates in this type and site E comprising of 133 residential plots was selected as type one study population because it has the highest number of residential plots compared to the other sites (estates) in this type. Category two comprises of estates in which buildings were designed and developed by the Federal Ministry of Lands and Housing before the plots allocation process. There are seventy seven (77) closes, grouped into 3 sectors. Sector 2 comprising of 496 residential plots was selected as type two study population because it has the highest number of residential plots compared to the other sectors. Category three comprises of land areas under the jurisdiction of the Federal Ministry Lands and Housing but in the custody of the traditional royal families (Agbojo-Alagbo Chieftancy Family), with the allocation of plots done the family representatives. New-site residential estate was randomly selected in this category and comprises of 714 residential plots.Hence, the research population to gather quantitative data is the combination of residential plots from the selected categories, which is a total of 1,343 residential plots as presented in table 4, whose house heads were respondents for the questionnaires.

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. The total sample size after adding the individual sample sizes generated by the sample size calculator for administered questionnaires is 567.A set of questionnaire was designed to elicit quantitative data from respondents. The questionnaire is divided into Four (4) subsections. The first is designed to gather information on social status of respondents, while the second and third sections are to gather information on residential site plan and SUDS statuses respectively. The final section involves subjective information on effects and perceptions of SUDS on residential site plan users and environment.

Data collected from the field was sorted and then analyzed. The analysis was carried out using the statistical package for social sciences (SPSS) version 21.

**Table 1:** *Research Population for Residential Plots*

| | ESTATE | Research Population | Research Sample |
|---|---|---|---|
| **1** | CATEGORY 1 **(Site E)** | 133 | 99 |

| | | | |
|---|---|---|---|
| **2** | CATEGORY 2 **(Close 17-Close 55)** | 496 | 217 |
| **3** | CATEGORY 3 **(New site Estate)** | 714 | 251 |
| | **Total** | **1343** | **567** |

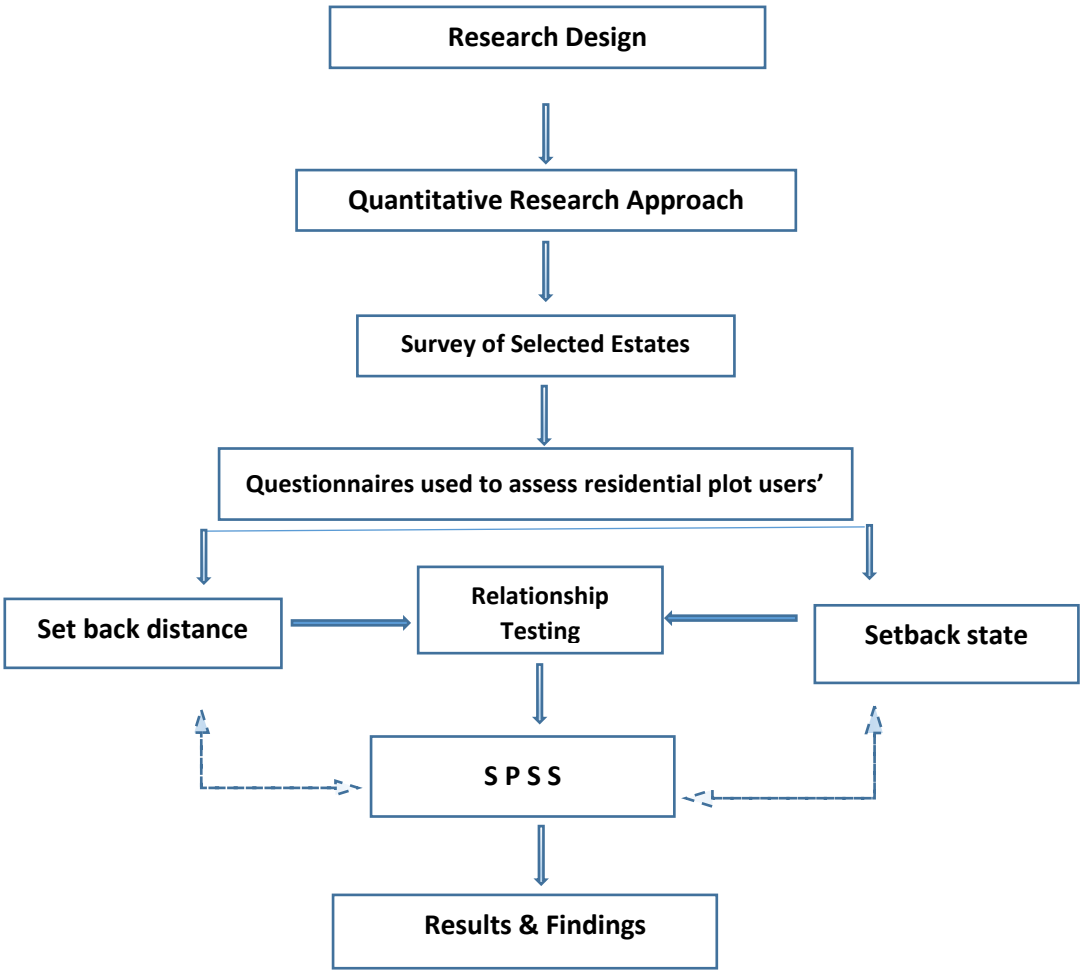



**Fig 1.0**: *Research Work flow*

**RESULT**

From Category 1 estate (Site E), it can be seen that about 25.9% of the developed residential plots have approach setback distance well above 6m which is within the approved standard, with 41.90% of the residential plots having side setback distances within 3m and above which is of standard. The analysis also showed that 74.2% of the residential plots have their rear setback distance falling below 3m, which is below standard and 77.4% with setback above 0.5m between their approach fence and external drainage. The analysis further revealed that 58.6% of the approach setback space are totally paved, 13.1% were unpaved and 32.3% are partially paved which is an indication that there are more approach paved areas within the estate. It also showed that 51.5% of the side setback spaces are paved, 10.1% are unpaved and

38.4% are partially paved, which is an indication that a larger percentage of side setback spaces within the estate are paved, having 67.7% of the occupied residential plot in the estate with rear setback spaces paved, 22.2% unpaved and 10.1% are partially paved which indicates that most of the rear setback spaces of developed sites within the estate are paved.

From Category 2 estate (Closes 17-58), it can be seen that about 100% of the developed residential plots have approach setback distance well below 6m which is below the approved standard. It further revealed that 100% of the residential plots have their side setback distances within 3m and above which is of standard and 100% having their rear setback falling below 3m, which is below standard, with 40.6% having setback of above 0.5m between their approach fence and external drainage. Also from Category 2 estate, the analysis revealed that 41.1% of the approach setback space are paved, 3.8% are unpaved and 55.3% are partially paved which means that there are more approach partially paved areas within the estate. It further showed that 57.6% of the side setback spaces are paved, 33.6% are partially paved and 8.8% are unpaved, which is an indication that a larger percentage of side setback spaces within the estate are paved. Finally it revealed that 61.8% of the occupied residential plot in the estate have their rear setback space paved, 23.5% partially paved and 14.7% unpaved.

From Category 3 estate (Newsite estate), it can be seen that about 54.1% of the developed residential plots have approach setback distance well above 6m which is within the approved standard. The Table further revealed that 39.9% of the residential plots have their side setback distances within 3m and above which is within standard, with 91.7% of the residential plots having rear setback falling below 3m, which is below standard. The analysis further revealed that 62% have setback above 0.5m between their approach fence and external drainage. The analysis also revealed that 44.2% of the approach setback space are paved, 4.4% are unpaved and 51.4% are partially paved which means that there is more approach paved areas within the estate. It further revealed that 56.6% of the side setback spaces are paved, 37.8% are partially paved and 5.6% are unpaved, which is an indication that a larger percentage of side setback spaces within the estate are paved. Finally the analysis revealed that 64.5% of the occupied residential plot in the estate have their rear setback space paved, 16.8% partially paved and 18.7% unpaved

**Table 2:** *Distance between Building and Fence*

| | Variable | Frequency | | |
|---|---|---|---|---|
| | | **Category 1** | **Category 2** | **Category 3** |
| **i** | ***Distance between Building and Approach Fence*** | | | |
| | 1m - 2.9m. | 22 (22.5%) | 217 (100%) | 22 (8.8%) |
| | 3m - 5.9m. | 51 (51.6%) | 0 (0.0%) | 0 93 (37.1%) |
| | 6m - 8.9m. | 13 (12.9%) | (0.0%) | 77 (30.6%) 59 |
| | 9m - Above. | 13 (13.0%) | 0 (0.0%) | (23.3%) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **ii** | ***Distance between Building and Side Fence*** | | | | | | |
| | 0.1m - 2.9m. | 22 (22.2%) | 0 (0.0%) | | 56 (22.3%) | | |
| | 2m - 2.9m. | 35 (35.3%) | 0 | (0.0%) | 105 (41.8%) | | 72 |
| | 3m - 3.9m. | 25 (25.3%) | 217 (100%) | 0 | (28.7%) | | 18 |
| | 4m - Above. | 17 (17.2%) | (0.0%) | | (7.2%) | | |
| **iii** | ***Distance between Building and Rear Fence*** | | | | | | |
| | 0.1m - 2.9m. | 55 (55.6%) | | | | | |
| | 2m - 2.9m. | 21 (21.2%) | 0 (0.0%) | | 145 (57.8%) | | |
| | 3m - 3.9m. | 21 (21.2%) | 217 (100%) | 0 | 85 (33.9%) | | 16 |
| | 4m - Above. | 2 (2.0%) | (0.0%) | 0 | (16.4%) | | 5 |
| | | | (0.0%) | | (1.9%) | | |
| **iv** | ***Distance between Fence and External Drainage*** | | | | | | |
| | 0.0m - 0.5m. | 23 (23.2%) | 129 (59.4%) | | 83 (33.1%) | | |
| | 0.6m - 1.0m. | 59 (59.6%) | 24 (11.1%) | 64 | 137 (54.6%) | | 31 |
| | 1m - 1.5m. | 17 (17.2%) | (29.5%) | 0 | (12.3%) | | 5 |
| | 1.6m - Above. | 0 (0.0%) | (0.0%) | | (1.9%) | | |
| | **Total** | **99** | **217** | | **251** | | |

**Table 3:** *State of Setback Space between Building and Fence*

| | **Variable** | **Frequency** | | |
|---|---|---|---|---|
| | | **Category 1** | **Category 2** | **Category 3** |
| **i** | ***State of Space between Building and Approach Fence*** | | | |
| | Paved | 54 (54.6%) | 89 (41.1%) | 111 (44.2%) |
| | Unpaved | 13 (13.1%) | 120 (55.3%) | 11 (4.4%) |
| | Partially Paved | 32 (32.3%) | | 129 (51.4%) |
| **ii** | ***State of Space between Building and Side Fence*** | | | |
| | Paved | | | |

| | | | | |
|---|---|---|---|---|
| | Unpaved | 51 (51.5%) | 125 (57.6%) | 142 (56.6%) |
| | Partially Paved | 10 (10.1%) | 19 (8.8%) | 14 (5.6%) |
| | | 38 (38.4%) | 73 (33.6%) | 95 (37.8%) |
| **iii** | ***State of Space between Building and Rear Fence*** | | | |
| | Paved | | | |
| | Unpaved | | | |
| | Partially Paved | 67 (67.7%) | 134 (61.8%) | 162 (64.5%) |
| | | 22 (22.5%) | 32 (14.7%) | 47 (18.7%) |
| | | 10 (10.1%) | 51 (23.5%) | 42 (16.8%) |
| **iv** | ***State of Space between Approach Fence and External Drainage*** | | | |
| | Paved | | | |
| | Unpaved | | | |
| | Partially Paved | 22 (22.2%) | 107 (49.3%) | 119 (47.4%) |
| | | 58 (58.6%) | 70 (36.3%) | 61 (24.3%) |
| | | 19 (19.2%) | 40 (18.4%) | 71 (28.3%) |
| | **Total** | **99** | **217** | **251** |

The site plan status was assessed, employing Spearman correlation analysis to test the significance between site setback and SUDS potential for the three (3) different estate categories as presented in table 4, table 5 and table 6 respectively. Spearman rho correlation analysis was used to test the significance of categorical variables. While the determinant is setback, status of space forms the dependent variable.

**Table 4:** *SITE E – Hypotheses (H1 – Correlation Matrix – Spearman rho)*

| | | | **Dependent Variables** | | | |
|---|---|---|---|---|---|---|
| **Order** | Determinants | | state of the space between building and fence bounding street road | state of the open space between building and side fencing | state of the open space between building and rear fencing | state of the open space between Approach fencing and external |
| **a** | Distance Between Building | & | $r_S = 0.774^{**}$ P<0.001 N=99 | | | |

| | | | | | |
|---|---|---|---|---|---|
| | Fence Bounding Street | | | | |
| **b** | Distance Between Building & Side Fence | $r_s = 0.881^{**}$ P<0.001 N=99 | | | |
| **c** | Distance Between Building & Rear Fence | | $r_s = 0.861^{**}$ P<0.001 N=99 | | |
| **d** | Distance Between Approach Fence & External Drainage | | | $r_s = 0.965^{**}$ P<0.001 N=99 | |

**. Correlation is significant at the 0.01 level (2-tailed)

**Table 5:** *CLOSE 17-58 – Hypotheses (H1 – Correlation Matrix – Spearman rho)*

| | | **Dependent Variables** | | | |
|---|---|---|---|---|---|
| **Order** | **Determinants** | state of the space between building and fence bounding street road | state of the open space between building and side fencing | state of the open space between building and rear fencing | state of the open space between Approach fencing and external |
| **a** | Distance Between Building & Fence Bounding Street | $r_s = 0.713^{**}$ P<0.001 | | | |
| **b** | Distance Between Building & Side Fence | | $r_s = 0.679^{**}$ P<0.001 | | |
| **c** | Distance Between Building & Rear Fence | | | $r_s = 0.867^{**}$ P<0.001 | |
| **d** | Distance Between Approach Fence & External Drainage | | | | $r_s = 0.654^{**}$ P<0.001 |

**. Correlation is significant at the 0.01 level (2-tailed)
N = 217

**Table 6:** *NEW SITE ESTATE ((H1 – Correlation Matrix – Spearman rho)*

| | | **Dependent Variables** | | | |
|---|---|---|---|---|---|
| **Order** | **Determinants** | state of the space | state of the open space | state of the open space | state of the open space |

| | | between building and fence bounding street road | between building and side fencing | between building and rear fencing | between Approach fencing and external |
|---|---|---|---|---|---|
| **a** | Distance Between Building & Fence Bounding Street | $r_s = 0.901^{**}$ P<0.001 | | | |
| **b** | Distance Between Building & Side Fence | | $r_s = 0.855^{**}$ P<0.001 | | |
| **c** | Distance Between Building & Rear Fence | | | $r_s = 0.876^{**}$ P<0.001 | |
| **d** | Distance Between Approach Fence & External Drainage | | | | $r_s = 0.768^{**}$ P<0.001 |

**. Correlation is significant at the 0.01 level (2-tailed)
N= 251

**FINDINGS AND DISCUSSION**

For category one (Site E estate) ,test result on the relationship of setback distance and setback state between building and fence bounding street showed a strong positive correlation coefficient $r_s$ of 0.774. This implies that a 77.4% variation and distance between building and fence bounding street influence respondents' state of open space from paved to partially paved. On the relationship between setback distance and setback state between building and side fence, the test showed a strong positive correlation coefficient $r_s$ of 0.881. This implies an 88.1% variation and distance between building and side fence influence respondents' state of open space from paved to partially paved. On the relationship setback distance and setback state between building and distance rear fence, the test shows a strong positive correlation coefficient $r_s$ of 0.861. This implies an 86.1% variation and distance between building and rear fence influence respondents' state of open space from paved to partially paved. On the relationship between setback distance and setback state of approach fence and external drainage, the test showed a strong positive correlation coefficient $r_s$ of 0.965. This implies that a 96.5% variation and distance between approach fence and external drainage influence respondents' state of open space from paved to partially paved.

For category two (Closes 17 -58 estate) ,test result on the relationship of setback distance and setback state, between building and fence bounding street, showed a strong positive correlation coefficient $r_s$ of 0.713. This implies a 71.3% variation and distance between building and fence bounding street influence respondents' state of open space from paved to partially paved. On the relationship between setback distance and setback state between building and side fence,

the test showed a strong positive correlation coefficient $r_S$ of 0.679. This implies a 67.9% variation and distance between building and side fence influence respondents' state of open space from paved to partially paved. On the relationship between setback distance and setback state between building and rear fence, the test showed a strong positive correlation coefficient $r_S$ of 0.867. This implies that an 86.7% variation and distance between building and rear fence influence respondents' state of open space from paved to partially paved. On the relationship between setback distance and setback state, the test showed a strong positive correlation coefficient $r_S$ of 0.654. This implies a 65.4% variation and distance between approach fence and external drainage influence respondents' state of open space from paved to partially paved. For category three (New site estate) ,test result on the relationship between setback distance and setback state between building and fence bounding street showed a strong positive correlation coefficient $r_S$ of 0.901. This implies a 90.1% variation and distance between building and fence bounding street influence respondents' state of open space from paved to partially paved. On the relationship between setback distance and setback state between building and side fence, the test showed a strong positive correlation coefficient $r_S$ of 0.855. This implies an 85.5% variation and distance between building and side fence influence respondents' state of open space from paved to partially paved. On the relationship between setback distance and setback state between building and rear fence, the test showed a strong positive correlation coefficient $r_S$ of 0.876. This implies an 87.6% variation and distance between building and rear fence influence respondents' state of open space from paved to partially paved. On the relationship setback distance and setback state of approach fence and external drainage, the test showed a strong positive correlation coefficient $r_S$ of 0.768. This implies a 76.8% variation and distance between approach fence and external drainage influence respondents' state of open space from paved to partially paved.

## RECOMMENDATIONS AND CONCLUSION

### Recommendations

The following are the recommendations evolving from results of the study

1. A certain percentage of the residential plot area must be unpaved to serve as human and environmental sustaining area of residential plots during plot development, which must be shown and presented as part of the details of the site analysis on the site plan drawing.
2. It should be ensured that natural elements are introduced into unpaved areas to reduce the monotony of paved areas, improve landscape variety and generally enhance environmental attributes of the residential plot.
3. The government through its various housing authorities should improve of enforcement during development and periodically organise sustainable development programmes to enlighten stakeholders in building development on the strategies and significance of unpaved natural areas within residential plots.

## Conclusion

The study through its research methodology and analysis has shown that most of the residential plots though have site designs but most do not follow approved design setbacks during plot development, hence having limited open spaces after plot development usually covered impervious floor materials. The study further presented that an increase in the setback distance within residential plots will increase the area of unpaved open spaces, hence creating more opportunities for SUDS implementation. Therefore the need for intensified enforcement from building control agencies to ensure setback compliance during plot development.

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