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Original Research Article

Impact of Climate on the Environment: Effect of Driving Rain on Buildings and Monuments in Port Harcourt, South-South Nigeria

Alexander BC[1*], Irimiagha Gibson Francis[2]

[1]Department of Transportation Planning and Logistics, School of Environmental Sciences, Port Harcourt Polytechnic, Rumuola, Port Harcourt, Nigeria
[2]Department of Architectural Technology, School of Environmental Sciences, Port Harcourt Polytechnic, Rumuola, Port Harcourt, Nigeria

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***Corresponding author:** Alexander BC
Department of Transportation Planning and Logistics, School of Environmental Sciences, Port Harcourt Polytechnic, Rumuola, Port Harcourt, Nigeria

Abstract

This work is an attempt to understand the effect of climate in an environment, therefore the effect of driving rain on buildings and on monuments is considered a case study. The study area is Port Harcourt Metropolis, a subequatorial climate environment, located in southern part of Nigeria. The study made use of questionnaire, and response were analyse using a descriptive statistical tool (simple percentage and pie chart). The study observed among other things that driving rain defaces buildings and monuments. Furthermore majority of those interviewed are of the opinion that driving rain has made them spend more money in building and monument maintenance as the case may be. It was also observed that driving rain contributes to rill erosion within and around buildings and monuments. The study also finds out that driving rain affects the strength of buildings negatively, and that electrical appliance can also be affected. This work suggests among other things, that water resistance paints and material should be used on buildings and monuments. The windward side of buildings should be designed in a way that the effect of driving rain should be minimal on the wall or windows. Furthermore, materials like books, cloths and other weather sensitive materials should be kept away from the damp windward side of the rooms. This implies that wardrobes should not be fixed or constructed in the windward side of the building. The study suggested that strong materials and standard specification of concrete mixture and standard original materials should be used in building construction especially in a humid environment like Port Harcourt metropolis. Finally, geographical factors need to be considered before building construction and professionals should be engaged in the business of building of houses and monuments construction to avoid collapse and damages.

Keywords: Buildings, Dampness, Driving rain, Windward side, Monuments.

1. INTRODUCTION

Climate is an end product of the day to day weather. Lot of scholar and political figures has concerned themselves on the issue of climate change, but the problem rages on. It is not the scope of this work to talk on climate change; however this paper is concerned on the effect of driving rain on building and monuments in Port Harcourt.

The environment is the summation of conditions in which an organism lives. It includes all the external conditions influencing the development of any living organism (Aloni and Alexander, 2020). Buildings, monuments and other manmade structures are part of human environment.

The earth physical environment is divided into biotic and abiotic environment. The earth physical environment is the frame or platform in which man organize or form his society and carry out his activities. It is the skeleton on which human and other organisms manifest their existence and achievements. It includes other things that enhance the life of living organisms and human on earth. Dearden and Mitchell (2009) used the word Ecosystem in describing community of organism co-habiting or occupying a given region within a biome. In an ecosystem or an environment the interaction of organisms and their environment and even within the organisms is unavoidable.

In this work the type of environmental resource of interest is the atmospheric resources, which includes wind, sunlight and rainfall. The effect atmospheric resource varies from one place to another. The climate of an area or an environment is a function of many factors; therefore the effect of climatic element on the environment also varies.

Buildings and monuments are human designs within an environment with specific reasons. Some buildings are constructed for residence; others could be for business or just for shelter and conveniences, while monuments could be for serene beauty, historical, cultural, educational, etc. Whatever maybe the reason, observation have shown that climate affect this manmade structures a great deal. It is important that we understand the rate to which climatic element like rainfall and wind can affect manmade structures like buildings and monuments within the sub equatorial climate environment.

Driving rain is the type of rainfall that is falling very fast and being blown by the wind (Cambridge Dictionary, 2022). When the wind change the direction of descending drop of water to angles outside 180 it form a driving rain. The drops of such rain are faster than those descending under the force of gravity. It is rain that is given a horizontal velocity component by the wind and that fall obliquely. Driving rain or Wind-driven rain (WDR) is important in a number of research areas including Earth Science, Climatology, Architecture, Metrology and Building Science (Blocken and Carmeliet, 2004). Driving rain is important in building science, because it is the modt important moisture source affecting the hydrothermal performance and durability of building facades (Eldridge, 1976). The impact of driving rain among other things include discolouration by efflorescence, structure cracking due to thermal and moisture gradients (Erpul, 2001; Franke *et al*., 1998).

Driving rain occurs when the wind pushes water droplet with intense force to a horizontal direction. It is similar to the effect of jet dream water on raw rock material to remove the ore from the original products. It can also be described as the type of rain that passes through a vertical plane in the atmosphere. All but the largest drops will reach their terminal velocity within about 20m of beginning their fall (Beard, 1979). It is also on record that the horizontal velocity of driving rain drops, will equal that of the wind within a short distance (Straube and Burnett, 2000). As the wind encounters a building, streamlines and pressure gradients form around the building; while it is clear that driving rain is re-directed by these streams of air, accounting for the effect is difficult and beyond the scope of this study.

Building and monuments are man-made structures that are static in a place for a long time, while all the buildings has roof and walls (Egenhofer, (2002) not all monuments has roof over them. Driving rain is one of the most crucial sources of moisture for building in the sub-equatorial climate.

A study by Alexander (2022) shows that the intensity of RF in Port Harcourt in greater than it was years past. He also opined that RF duration has increased, that implies that rain splash on buildings and monuments will be greater than the previous.

The impact of driving rain on building and monuments is shown on its defacing or discoloration, it can also affect the strength due to reaction of water and the chemical contents of the house or the monuments.

The impact of driving rain on building over the years, despite the experiences acquired by builders and designers remain a huge task. Avoiding rain-related building damage is still one of the most difficult tasks architectures and builders face. This work seeks to identify the extent this menace has worried residence in Rivers State and Port Harcourt metropolis in particular. The concern is more of facial and not structural.

Driving rain brings water to the surface of the building. Once water is on the wall it will form a film and flowing downward under the force of gravity. Wind flowing over the surface will tend to deflect the flow from this path and, in extreme cases, may even push water upward. According to BSD-013, (2011) Surface features like trim, texture of the surface and openings on the wall can greatly affect the flow paths of this surface drainage, either concentrating or dispersing surface flows. This tendency can wash paints, thereby defacing the house, it in some cases allow water to enter into the building through weak points and may also weaken the building.

2. THE AREA OF STUDY

Port Harcourt is the capital of rivers state and has rapidly grown in the last 16 years. The word Port Harcourt metropolis is often used than Port Harcourt city.

It is a sub equatorial climate with an annual rainfall of over 2600mm. on the months of December and January had rainfall humidity is on average of 67% (Chinago (2019)

The prevailing winds us the south west trade wind (maritime air mass) which is rain bearing wind as it enters into Port Harcourt from the Atlantic Ocean.

The monthly rainfall in Port Harcourt is almost predictable and follows a temporal sequence of increase towards July – August before decreasing in the dry season months of November to February. Port Harcourt rainfall exhibits a double maxima regime. Rainfall is at its peak in July and September with a little dry season

occurs in August. The highest monthly rainfall in July and September are 3496.1mm and 3578.4mm respectively. Port Harcourt experiences the July/August break otherwise known as the little dry season.

The little dry season, even though the actual time of occurrence varies. Many reasons have been advanced for the occurrence of the July/August break in the literature. These are the following among others: (1) the existence of well-marked anti-cyclonic flow coupled with marked in inversion; (2) coldness of the sea in mind summer, derived from eddies of cold water from the cold Benguela current; and (3) speed, direction and moisture divergence stemming from the high pressure belt in the southern hemisphere moving towards the equator. These three factors they argued, act to reinforce each other in producing the July/August break.

It needs to be stated that the factor, which controls the temporal pattern of rainfall in Port Harcourt is the position of the Inter Tropical Discontinuity (ITD) at various locations during the course of the year. For example, the ITD is in its maximum location of 22^0N during July – August, and Port Harcourt during this period is completely under the strong influence of the ITD. During the months of January and February, the ITD is right inside the Atlantic Ocean with the dominance of the North East trades. Though there might be rain during the months of December, January and February, most of the rains received are unreliable and spotty due to the convective overturning of the southwest wind. Generally speaking, rainfall starts early in Port Harcourt and ends late. The mean onset date for Port Harcourt is 27th February. This temporal situation falls in line with the situation of the rain belt at this period.

The retreat of the rains begins generally from the middle of November. By this time, the maximum location of the ITD is about 16^0N at which time, most of the northern and middle belt parts of the country are already under the influence of the dry subsiding north – east trade winds. It should be noted that the southward retreat of the rains is faster than their northward advance. The mean decadal end of the rains in Port Harcourt is 26th November. In terms of the length of the rainy season which is also taken as the length of the period (in days) between the date of onset and date of end of the rainy season, the literature shows that there is no year when the length of the rainy season falls below 250 days. The mean length of the rainy season in the Port Harcourt region is 272 days.

Temperature rises gradually and peaks around 2pm; between 4pm and 5pm, it becomes warm and peters to a cold situation again at night. The months of February, March and April record the highest temperatures. This gradually slopes down through May, June and more deeply in July and August. Consequently, July and August record the lowest mean monthly temperatures. Again, temperature rises through September, October and November. These months are periods of weather instability, with November marking the end of the rainy season. At this period cloud cover also reduces. The value of temperature is considerably reduced in the months of November and December (26.5^0C – 26.2^0C) because of the influence of the hamattarn. The seasonal variations in relative humidity are mainly due to the seasonal variation in the amount of insolation received at any given location on the globe. The apparent movement of the sun through the region creates two periods of low relative humidity separated by a period of high relative humidity. Generally, relative humidity is high over the entire region with mean annual figures at 85%. The rainy season months of June, July, August, September and October record the highest values. These months are very cloudy due to the strong presence of the south-westerly wind. Comparatively, the more northerly town of Onne, taking lower values both in annual amounts and seasonal march, revealing spatial variation even within short distances because of the nearness of the region to the sea. Like temperatures, monthly and annual relative humidity variations are very low.

Hamattarn, which is a dry cold wind, embedded in the North East trade wind blows over the Port Harcourt region from December to February. A study of hamattarn characteristics by Bob-Manuel (1998), revealed that February has the highest intensity (5.68%) followed by January and December with (5.50%). Generally speaking, these intensities are very low, mainly due to the nearness of the area to the moderating influence of the sea. Another plausible reason is the fact that after its long trajectory, the hamattarn weakens as it reaches Port Harcourt. Its persistence, duration and reliability are very low with values at 12.48% for the month of January (Ede, 1999). It is erroneous to believe that the hamattarn has a moderating and soothing effect on the sultry weather conditions of Port Harcourt as per human comfort. Ede (1999), calculated the effective temperature index (ET) and wind chill index for the hamattarn months. No month had less than 27^0C (mean ET). Consequently, Port Harcourt is uncomfortable and stressful during the hamattarn months. The mean wind chill figures viz: (20.29k, 33.45k, 63.21k and 68.94k) in January, February, November and December respectively, reveal relatively low wind chill which has a small soothing effect on the high ET., of December to February which show slightly higher variations. This low temporal variation is consistent with the low seasonality and low variability in most climatic elements of the humid tropics. Figure 1 shows the study area.

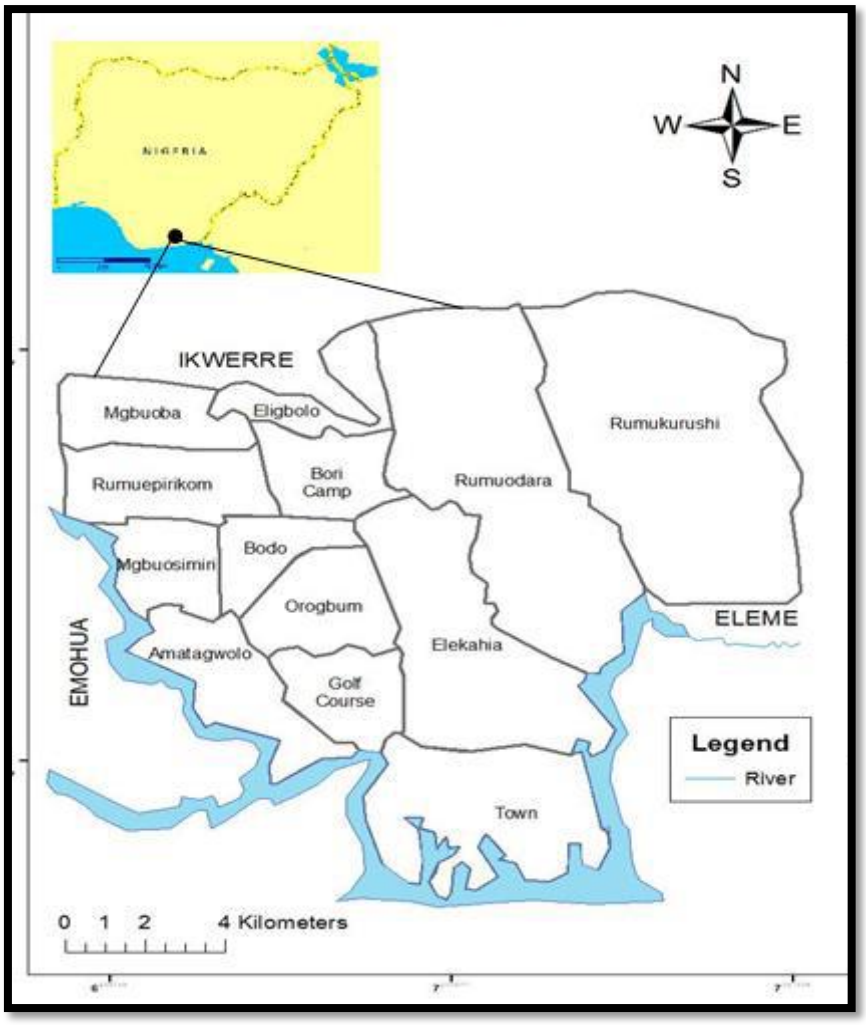

Figure 1: Port Harcourt Metropolis showing study Areas

3. METHODOLOGY

The study used primary data for analysis. The primary data was gathered from questionnaire issued to respondents which was designed in a simple five likert scale of agreed, strongly agreed and disagree, strongly disagreed, and undecided. The questions were very simple and direct as it relate to personal experience of respondents. We also observe the houses and monuments to look at the visible effect of driving rain on the structures for proper analysis. This study used more of descriptive statistics for analysis. Some of the tools used are table, charts and the simple percentage. The results are represented on pie charts for easy understanding.

The sample size is 55 buildings selected within Port Harcourt Metropolis. These buildings were selected based on accessibility and security reasons. 50 questionnaire was retrieved from the respondents representing 90%, while 5(10%) could not return theirs.

Five questions were asked, all on the effect or impact of driving rain on building or architectural designs. The question are shown in Table 1.

4. RESULTS AND DISCUSSION

In response to the first question asked. If driving rain affect or deface the appearance of building and monuments? Of the 50 persons interviewed as shown in Table 1 below.

Table 1: Interview questions

	A	SA	DA	SDA	UD	Total
Does driving rain deface buildings and monuments?	18	27	0	5	0	50
Does driving rain lead to dampness and affect property?	10	30	2	6	2	50
Does driving rain incur extra cost on building occupants?	8	32	4	4	2	50
Does driving rain accentuate soil creep around buildings?	20	10	6	8	6	50
Does driving rain affect strength of a building or structure?	10	15	8	8	9	50

The responses show among other things that 18 persons were strongly agreed that driving rain defaces the appearance of structures and monuments and 27 respondents agreed that driving rain is responsible for defacing building and monuments appearance in Port Harcourt. This implies that 45 respondents representing 90% of those interviewed are of the opinion that driving rain defaces the appearance of buildings and monuments. Of all interviewed none was undecided, which implies that they understand the subject matter very well. Only 5(10%) of the respondents said that driving rain does not deface the appearance of building or monuments. The response is clearly illustrated on Figure 1.1 below.

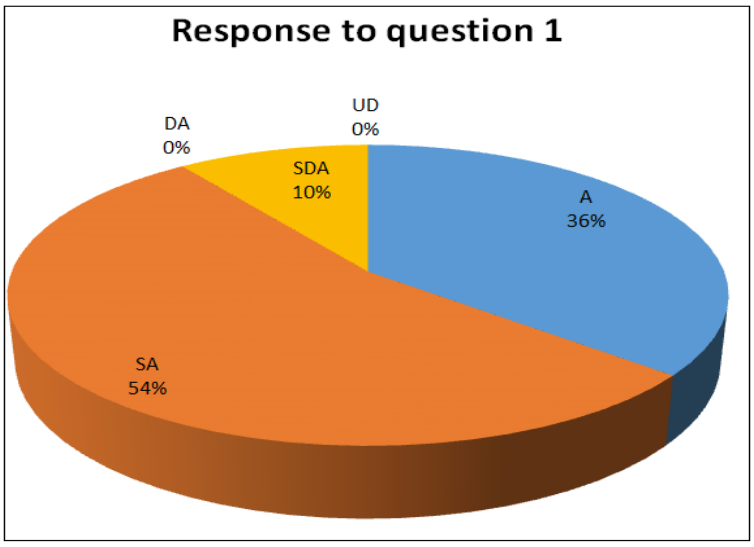

Figure 1.1: Response to question 1

In response to the second question which is "does driving rain lead to dampness and affect property in the house? 10(20%) respondents agreed that it does, and 30(60%) of the respondents strongly agreed that it does. Since these two groups have similar opinions, it implies that both options accepted that driving rain can cause dampness in the house and damage things like cloth, books and can affect the paint on the wall, etc., in the house. However, 4(8%) persons were undecided on the issue of driving rain causing such effect on a building or not. It was observed that 6(12%) of the respondents on the other hand disagreed. They said that driving rain cannot cause dampness and damage property in a building. Similarly, 2(4%) respondents disagree that driving rain can cause dampness or damage property in a building, and 6 respondents (12%) strongly disagreed that driving rain can cause dampness or property damage.

The reason of the majority few could be as a result of their building location or their personal precautions. For instance they lock windows before leaving home; they leave on places where there are wind breakers. The number 2 question was shown in Figure 1.2.

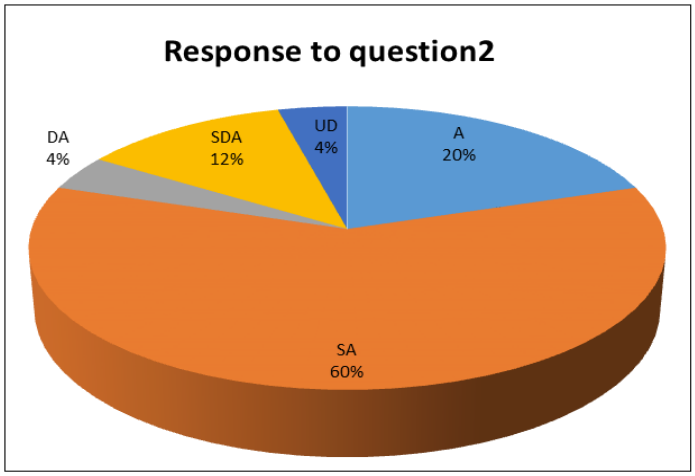

Figure 1.2: Response to question 2

In response to the question 3 "does driving rain increase soil creep around buildings in port Harcourt? The response among other things shows that 8(16%) agreed, 32(64%) strongly agreed, 4(8%) does not known, 4(8%) disagreed and 2(4%) strongly disagreed. The observation using similarity of reason, therefore is that 40 persons (80%) states that driving rain accentuates soil creep around buildings, 12% of the respondents feel otherwise while 8% does not observe anything or undecided in the matter. The analysis is shown in Figure 1.3 below.

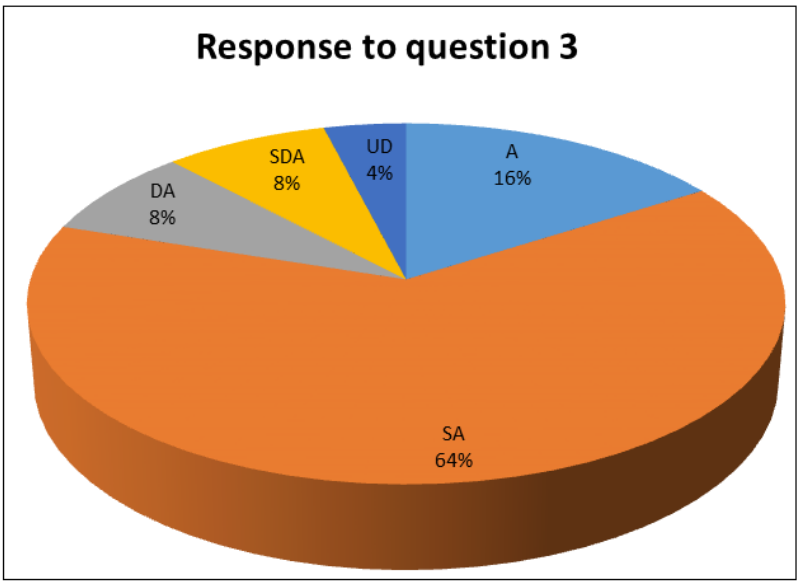

Figure 1.3: Response to question 3

This work base on observations and the field work states that driving rain is responsible to a reasonable extent of soil creeps around major buildings in Port Harcourt.

For question 4, which states "Does driving rain lead to extra cost on the occupant's buildings?"

The respondents' response shows that 20 of the respondents representing 40% agreed that the impact of driving rain results to additional cost to the building occupants. 10(20%) of the respondents strongly agreed that driving rain can enhance extra cost on building occupants. 12% which represents 6 respondents were undecided. While 8 persons (16%) disagreed that driving rain can lead to extra cost on house dwellers, similarly 6(12%) respondents strongly disagreed that driving rain can bring extra cost on building occupants. The analysis shows that driving rain incurred extra cost on building occupants as shown in Figure 1.4.

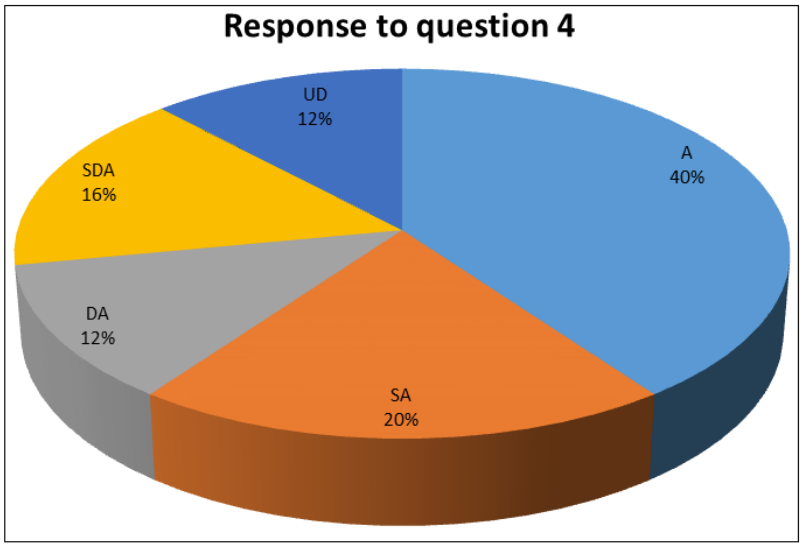

Figure 1.4: Response on question 4

In response to the question 5 **"Does driving rain affect the strength of a building or monument?"**

Of the 50 persons interviewed, 10(20%) agrees that driving rain affects the strength of buildings and monuments. 15(30%) strongly agreed, while 8(16%) are undecided. 8(16) did not agree and 9(18%) strongly disagreed that driving rain affects building and monuments strength.

In taking similar opinions to a said, we observed that 50% (25) of the respondents said that driving rain can weaken the strength of a building. 17(34%) shared the opinion that driving rain cannot weaken the strength of buildings and monuments, while 8(16%) of the respondents are undecided. With the above finding this work agrees that driving rain can weaken buildings and monuments in the study area. However, the percentage that forms this decision is not too strong. This could be as a result of the technicality of the question, which ordinary occupant of a house may not just understand, unless there are evidences like crack on the walls. The explanatory chart for the analysis of question 5 is shown in Figure 1.5.

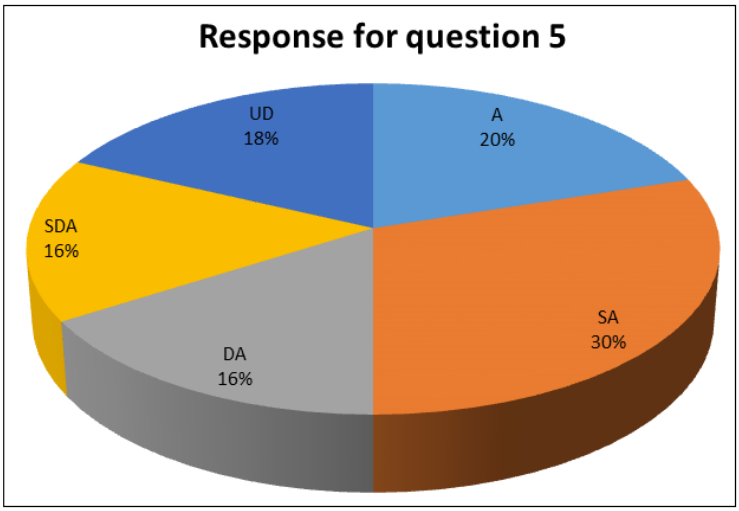

Figure 1.5: Response to question 5

5. FINDINGS OF THE STUDY

The study shows that driving rain is capable of defacing buildings and monuments. 95% of the respondents based on their experiences over the years attested to that. Evidence of defaced buildings and monuments are seen all over Port Harcourt. Face to face interview also shows that driving rain washout paints and particles of the sand, terrazzo from walls and fences etc.

It was also revealed by building occupants that the side of the wall constantly under the influence of driving rain are colder than other side of the building during the rainy season. There was also claims that cloths, materials and paints on the wall side of prevailing wind or on the direction of driving rain are always damp, and thus leads to dampness which can spoil cloths, books etc.

It was also observed that driving rain enhances rill erosion which is a type of erosion common in Port Harcourt Metropolis. 80% of the respondents attested to it. Maintenance cost extra money, therefore driving rain leads to extra expenses on the building occupants and in maintaining monuments.

It was also observed that driving rain can cause the building to be weak, it can affect the workability of electrical insulations in the buildings.

RECOMMENDATIONS AND SUGGESTIONS

Understanding the climatic impact on building and monument is very vital for sustainable construction. Therefore, this study suggests the following among others – Climate and environmental friendly designs suitable for subequatorial (humid) climate should be adopted according to the environment.

Wind breakers in form of flowers should be planted around the windward side of a building to check the effect of driving rain.

Water resistance paints and materials should be used for beautification. Plastics and glasses can be used as substitute to bricks.

Constructions of buildings should be handled by professionals, adequate materials and correct mixture must be used to avoid building collapse and destruction of lives and property.

Legislation should be in place to discourage quackery in the field of construction such legislation should be implemented, under minding who is involved.

Finally, the climate record of an area should be among the first thing to be consulted and well understood before the proper construction. This could

mean engaging the service of a climatologist, so that the architecture, civil engineer, builders and electrician construct and build a durable house or monument.

CONCLUSION

The study the effect of driving rain on buildings and monument in Port Harcourt metropolis reveals that driving rain is responsible to defacing of buildings and monuments especially when they are in the prevailing wind direction. It was also observed that driving rain causes dampness in the house and this is capable of causing a mild dew which lead to damage of cloths and books and other weather sensitive materials. Observation has also shown that driving rain has caused occupant extra money in an attempt to maintain the building to their taste.

Driving rain is capable of causing rill erosion, it can affect the strength of the building or monument, besides it can negatively affect the electrical installation of the house and can lead to real danger like electrocution.

Base on the importance of building as human shelter. The study opined that only professional should engaged in designing, supervision and management of a building site and that appropriate technology should be applied to minimize the effect of driving rain in a humid environment like Port Harcourt metropolis.

Finally, legislation against quackery, use of fake materials and substandard use of material should not only be enacted but enforced and defaulters be punished.

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