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The Influence of Rainfall on Hausa Traditional Architecture

[1]Anselm E.O. Eneh and [2]Ojonigu Friday Ati
[1]Department of Architecture, Faculty of Environmental Design,
Ahmadu Bello University, Zaria, Nigeria
[2]Geography Department, Ahmadu Bello University, Zaria, Nigeria

Abstract: The present-day traditional architecture of a place usually results from solutions to climatic problems through reasoning, countless experiments, experiences and accidents as well. This usually takes the efforts and perseverance of generations of builders who make use of whatever works for them while discarding what did not. The purpose of this study is to discuss the influence of climate, particularly rainfall, on Hausa Traditional Architecture. The objective is to bring out how the nature of rainfall has influenced the choice of building and roofing material and the architectural design of building in traditional Hausa society. The study examined the extent of the Hausa states in Nigeria and the location of Zaria. This is followed by a discussion on the climatic conditions in Zaria; the influences of rainfall on mud construction of foundations, walls and roofs. The study concludes with an overview of the resultant effect of this element of climate on the future of Hausa Traditional Architecture, with recommendations aimed at salvaging the situation.

Key words: Architecture, hausa, influence, rainfall, traditional

INTRODUCTION

The idea of traditional or vernacular architecture is not a simplistic approach to architecture. Porphyrios (2006) holds that it is rather the 'ideas and technologies' of a particular group's manner of constructing shelter under the conditions of scarcity of materials and operative constructional techniques: an Adhocist's approach to Architecture (Attoe, 1979). Traditional architecture is always evolving while absorbing new materials and methods of construction (Fatty, 2006). It therefore holds that the introduction of new materials and techniques which will safeguard the traditional architecture of a group should not be viewed as an adulteration, provided that it exhibits a straightforward approach, reasoning, efficiency, durability and comfort to its users.

The present-day traditional architecture of a place usually results from solutions to climatic problems through reasoning, countless experiments, experiences and accidents as well. This usually takes the efforts and perseverance of generations of builders who make use of whatever works for them while discarding what did not. In the Tropics only scientific evaluation of new ideas will save its traditional architecture (Fatty, 2006). Any approach to restore traditional architecture should therefore investigate and apply concepts that will add value and meaning to the environment.

THE extent of hausaland in Nigeria: The Hausa in West Africa form a large group linked by a common lifestyle. In Nigeria, they comprise much of Northern Nigeria apart from the 'Middle Belt' and Bornu (Dmochowski, 1990). They are principally found in the present-day States of Nigeria such as Bauchi, Gombe, Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara.

The location of Zaria: Zaria is a Hausaland located at a height of about 670 m above mean sea level, 640 km from the Atlantic shores of Nigeria in the south (Department of Urban and Regional Planning-DURP, 1979). It is located on Latitude of 11º10′ N and Longitude 7º38′ E. Zaria is in Kaduna State of Nigeria. It is the second most important town in the state after Kaduna, judging by the amount of educational institutions and other parastatals located within its area of jurisdiction. The city was founded as the capital of the Hausa State in the fifteenth century A.D. (Schwerdtfeger, 1982).

The built up area of Zaria is formed by five distinct urban areas; Zaria City, Tudun Wada, Sabon Gari, Government Reserved Area (GRA) and Samaru, which includes Ahmadu Bello University, Zaria. Nigeria.

The climate of Zaria: Nigeria has six Climatic Zones (Bureau for Public Enterprises, 2003-2007); The Mangrove Swamp, Swamp Forest, Rain Forest, Guinea Savanna, Sudan Savanna and Sahel Savanna. The Sudan Savanna approximates in a belt from Latitude 8º North to Latitude 12º North of the Equator, in Nigeria (Anuforom and Okpara, 2004). This region definitely includes Zaria, which is located on 11º11′ N and 07º38′ E. Climate is an important factor that determines the form of any

Corresponding Author: Anselm E.O. Eneh, Department of Architecture, Faculty of Environmental Design, Ahmadu Bello University, Zaria, Nigeria. Tel: 08057265659, 08133764353

architecture. In Nigeria the Hausa live in northern Savannah type of climate (Moughtin, 1985). The savannah climate type has alternating wet and dry seasons. The rainfall in this region is less than 1000 mm per annum in only about five months in the year, especially between May and October. Rainfall in this zone is highly variable and the onset of the rain is erratic. The rainfall intensity is very high between the months of July and August. As a result though the environment is generally dry, crops are frequently lost through too much rain. It also results in rapid surface run-off, soil erosion and water-logging (Udo, 1970). The region suffers from frequent droughts as particularly witnessed during the 1968-1974 and 1983-1987 periods.

The gross features of rainfall patterns in this region, as in other parts of the country are usually in association with what is often called the Inter Tropical Discontinuity (ITD) (Nicholson 1981; Kanote, 1984; Hayward and Oguntoyinbo, 1987; Oladipo, 1993). The movement of the ITD northwards across the country between January and August, and its retreat from the southern fringe of the Sahara desert, after August, cause much of Nigeria to experience seasonal rainfall (Olaniran and Summer, 1989). The ITD itself is the boundary at the ground between the dry Tropical Continental (cT) air of northern origin and the moist Tropical Maritime (mT) air of southern origin.

The seasons: Table 1 show that two major seasons are dominant in Zaria; the Hot Season and the Wet Season. In-between, however, two climatic conditions exist which cannot be ignored, bringing the total to four seasons, these being initiated by the action of the Intertropical Discontinuity.

The dry season: This is the period of Harmattan: a transition period between the Wet and the Hot Seasons. It is a period when there is little or no rainfall (Ati, 2002). Daytime temperatures fluctuate between 16 and 32ºC in November with clear sky of sunshine hours of between 8.9 and 9.5 (DURP, 1979). December to January in Zaria is characterized by the suspension of fine dust particles in the air, due to Harmattan winds which cause surface turbulence. Visibility is poor, disrupting air navigation while sun's rays barely reach ground surface. This action reduces night temperatures to 14ºC, with sunshine hours between 8.7 and 9.5. Daytime temperature may drop to 31ºC, giving a variation of 17ºC, the highest in the year. This extreme diurnal temperature range is another characteristic of the Savanna type of climate (Areola *et al.,* 2006).

Relative Humidity, Fig. 1, falls from 68 percent in October to 36% in November and 35% in January. This is usually the season of maintenance, repair and erection of new buildings in Zaria.

Table 1: The seasons of Zaria and their periods

S. No.	Seasons	Period
1	Dry season	November to February
2	Hot season	March to April
3	Thunderstorm and Squalls	May to June
4	Wet season	July to October

Source: (DURP, 1979)

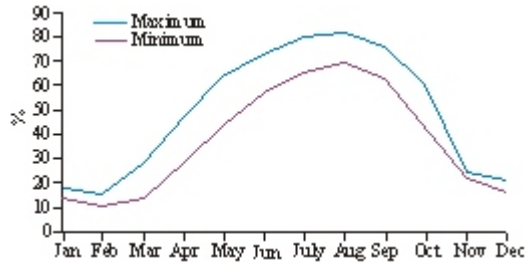

Fig. 1: Relative Humidity in Zaria, Source: Scwerdtfeger (1982)

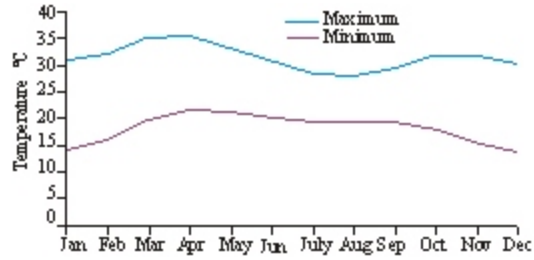

Fig. 2: Temperature in Zaria, Source: Schwerdtfeger (1982)

The hot season: The season commences the movement of Intertropical Convergence Zone northwards, crossing the latitude of Zaria late in March or early April (DURP, 1979).

The Relative Humidity, which was 20% in February, leaps up to 31% in April, Fig. 2, which is considered to be the hottest month in the year as dry bulb thermometer records up to 36ºC. At night the clear sky which promotes intense heating during the day causes rapid evaporation (Areola *et al.*, 2006).

Thunderstorms and Squall: This is the period of highest number of squally winds with associated heavy showers of short duration, gusty winds and consequently low air temperature of 33ºC in May and 31ºC in June, due to presence of clouds.

The author has observed for ten years that rains at this period are usually preceded by dust storms in the horizon, warning of impending storms, The storms are such ferocious ones that rip off unstable roofs from buildings (Plate 1). It is therefore an annual ritual, immediately before this period, for house dwellers to climb up rooftops to ensure that loose roofing sheets are properly secured or alternatively arrange granite boulders or sandcrete blocks at edges of roofs gables, as counterweights to resist wind pressures.

Plate 1: Wind-blown-off roof of building in Zaria, Source: Author's photo (2007)

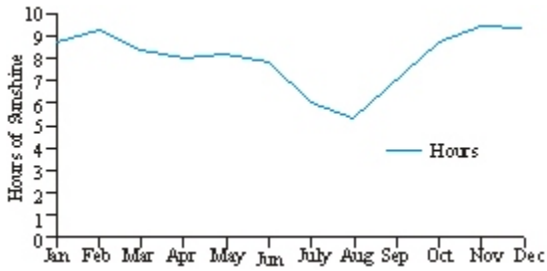

Fig. 3: Sunshine duration in Zaria, Source: Schwedtfeger (1982)

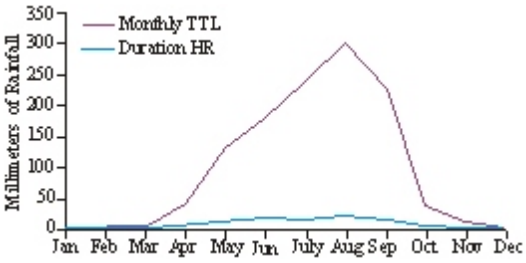

Fig. 4: Rainfall in Zaria, Source: Schwerdtfeger (1982)

The wet season: When the Intertropical Discontinuity moves to the North, cloudiness increases with reduction in sunshine hours of 7.8 in June to about 5.0 in August, Fig. 3. Rainfall however increases from 161.5 mm in June to 295.6 mm in August.

Maximum temperature decreases to 27.7ºC August with an average wind speed of 1.61 m/sec. In October, rainfall drops to 35.8 mm, Fig. 4, while annual total lies within the range of 950 mm and 1150 mm. Relative Humidity continues to decrease from 83% in July to 68% in October; a transitional month when the Intertropical Discontinuity starts to recede southwards with a fall in Relative Humidity and a rise in temperature. On the other hand, from May to September, the South-Westerly wind brings moist, warm air from the Atlantic Ocean

The humidity is high because most of the rain falls at this period. Rainfall in Zaria reaches up to 275 mm/year (Schwerdtfeger, 1982). Because of the two major seasonal patterns in this area, the Hausa builder has to resolve and solve the problems imposed by the hot humid and hot dry climatic conditions. Of much more concern to the structure of the building is the hot humid condition which brings torrential rains, mostly of short duration. The rains wear down the structure of the buildings with dire economic consequences from maintenance and repair.

Natural vegetation: The Sudan Savanna is typified by tall tropical 'savanna' grass (Ati, 2002); the elephant grass (Areola *et al*., 2006). Trees are scattered, typical of wet-dry climate. This vegetation is mixed with scrubs and thorny bushes, adapting itself to the climatic rhythm of longer water-drought and shorter summer rain. They are mostly deciduous, shedding their leaves in the dry season to conserve water which would have been lost by transpiration; lying dormant and searching for ground water.

Observation by the Author reveals that the tallest trees in Zaria are the baobab, 'Gingiya Palm and Cotton trees.

Building materials of the hausa: In Hausaland, the four major building materials are: earth, timber, reeds, grasses and stones (Moughtin, 1985; Dmochowski, 1990). In Zaria less stones are used. Though rock outcrops exist, to use them will involve much labour in breaking. Apart from this mud is more tolerant to climate because of its poor conductivity.

In a survey conducted in 1975, it was discovered that 67% of houses in Zaria were made from mud (DURP, 1979). Table 2 shows the distribution of house types in Zaria.

The earth: The building earth greatly differs in quality from the excellent brown clay to the blackish type with which builders make and adopt the wattle-and-daub constructions. The earth is dug out from borrow pits, carefully chosen by the builder from which bricks, mortar and plaster are made.

The bricks: The earth 'birji' is spread on the ground, wetted and trampled by foot until it reaches the consistency of thick paste. This is left for a couple of days to dry before being wetted and trampled on again. If the quality of the broken earth is low, it is mixed with grass 'datsi' (Dmochowski, 1990). The grass and earth form a composite material. While the grass is the reinforcement, the earth serves as the matrix or binder as it surrounds the straw. The straw possesses tensile strength while the earth has compressive strength (Eneh, 2006) The resultant brick 'tubali' (Plate 2) is a composite which has both tensile and compressive strength (Australia Academy of Science, 2006) with better performance than each of the individual components.. The bricks are sun-dried until all the moisture content is

Table 2: Distribution of house types in Zaria

S.No.	Type of structure	Total (%)	Predominant area(s) located
1	Mud walls with pitched thatched roof	9.3	Zaria walled city
2	Mud walls with domed mud roof	15.3	Zaria walled city
3	Mud walls with pitched iron roof	42.3	Tudun Wada and Sabon Gari
4	Cement/Sand block walls with pitched iron sheet roof	33.0	Sabon Gari, Samaru and University
	Total	100	

Source: DURP (1979)

Plate 2: Preparing 'Tubali' Bricks. Source: Dmochowski (1990)

Plate 3: Azara' Beams for Flat Roofs with Source: Dmochowski (1990)

removed from them. By taking these steps the builder is quite aware of the impact and the extent of damage to the structure of the building of the on coming rains and the bricks are prepared to offer the greatest resistance to them.

The mortar: The structural function of the building is much dependent on how the bricks are held together. This task is performed by the mortar which is carefully processed from earth 'kasa' of the highest quality. It forms a shell around each brick, creating a three-dimensional structural network like the complexity

'azara' beams in elevation and section

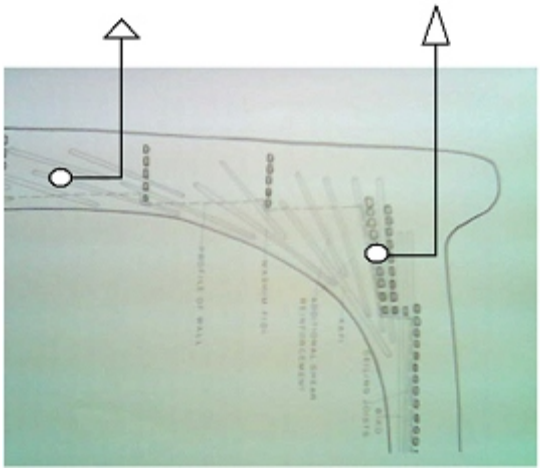

Fig: 5: Strengthening the roof azara' Beams Source: Dmochowski (1990)

of wax cells in a honey comb, forming another composite with the brick. Moughtin (1985), Dmochowski (1990) and Solanke (1990), all noted that it is common practice to cover the wet earth 'birji' with horse manure and be left for about three days with more water poured daily. After being trampled upon, another layer of manure is spread over the composite, watered and trampled on. This process is repeated continuously for about four times over three weeks. Another kind of dark mortar of earth and straw is used while working on the ribs supporting the domes of buildings (Dmochowski, 1990).

The timber and the roof: The best timber used in Hausa traditional buildings are obtained from the trunks of the male palm tree 'deleb' or 'gingiya'. The timbers are commonly called 'azara' beams. They are rigid and heavy, resistant to termite attack and decay for many years. They serve as wooden reinforcement (Plate 3, Fig. 5) to strengthen the structure of walls and pillars. Most specially, Dmochowski (1990), they are used to make frame constructions, beams, brackets and corbels as elements for carrying flat and domed roofs. The ashes of timber are often used as insulating layer, spread on top of flat roofs, treated with infusions from pods or roots to waterproof the top of flat roofs.

The Plaster: Generally, the plaster is the element that is directly exposed to rainfall. It is expected to form a

protective covering to the walls and roofs of mud–building houses. In Zaria, as most applicable in other Hausa cities, plaster for wall covering is made from building earth which is mixed with a fluid 'makuba' from fruit pods of locust bean trees.

This imparts a waterproofing property to the plaster. Moughtin (1985) has a reservation for this material because of attack by white ants on the plaster coupled with its life expectancy of two years. However, Dmochowski is of the view that plaster is improved by the addition of 'gashim juna' which consists of goat hair mixed with grease scraped off previously soaked skins. Powdered wild root 'dafara' is soaked to produce gum that binds the plaster, the hair mechanically improves the strength while the grease waterproofs the plaster

This makes the plaster hard weather-resistant cement. Consequently, the plaster adheres strongly to the surface of the wall and lasts for up to five or six years before any maintenance is carried out. The lifespan depends on the orientation of the building where the plaster is applied. This special plaster is strongly recommended for flat or domed roofs and wall parapets. A special wall plaster, 'chafe' is made from black earth to which a glutinous fluid, 'gabaruwa', obtained from acacia tree, is added, while the plaster is still wet on the wall, Dmochowski (1990) reports that sieved gravel is gently pressed into the partly dried plaster with a flat tool. It finally receives two coats of 'makuba' and 'gabaruwa' to make it last for years without maintenance.

The influence of rainfall on the architecture: Protecting the external mud fences, building foundations, walls and roofs from rainfall is a bit complicated because they are all directly exposed to it without overhangs. However, the architecture has been altered in order to mitigate the effects and maintenance costs of repairs due to rainfall.

Foundations: Pre-moulded, sun-dried earth bricks resist moisture better than the monolithic mud wall construction (Solanke, 1990), but it has not entirely eliminated moisture movement from the ground. This has continued to cause swellings and contractions at the lower level of mud buildings. The fact is that most buildings rarely have foundations (Moughtin, 1985). The reason by builders being that one may not get a better stable foundation than the existing grade. Pediments have been constructed in trying to reduce the effect of moisture penetration from the ground. This aspect of mud-wall performance is one of the major causes of plaster instability (Solanke, 1990) and in some cases collapse of buildings.

Remarks: Builders have developed the idea of getting the foundation off the ground by using sandcrete blockwalls or few layers of un-coursed rubble in order to reduce the amount of moisture movement from the foundation upwards this practice is not yet rampant but this is a major influence of rainfall on the traditional method of construction of the foundation.

Plate 4: Plaster failure type 1 Sources: Author's Photo (2007)

Plate 5: Plaster failure type 2, Source: Author' Photo (2007)

Walling and plastering: Un-plastered walls are directly leached away by the impact of driving rain. This is exactly the same on plaster work that are not treated with stabilizing materials. Even the stabilized ones have life spans of from five to seven years (Dmochowski, 1990). This requires constant maintenance. It follows therefore, that mud-walls depend on plaster work to resist the effect of rainfall on them.

It is a common site to see 'adobe' and 'tubali' mud-walled huts directly plastered in cement and sand mixture. Such walls easily soak moisture directly from driving rains, as in Plate 4 and 5, leading to breaking of the loose bonds between the mud and cement planes: hence the plasters peel and fall off the walls.

Solanke (1990) reports that the inhabitants have recognized the need for an effective bond between the background and the plaster-mud. The trial and error

principle has driven builders to understand that there is need for strong bonding between the plaster and the wall. Mud plasters have been pestered with pebbles as key to hold the background and the plaster together. This has improved the life span of plaster work, but has unduly increased the plaster thickness, which led to failures above two centimeters of thickness.

Remarks: Builders have developed a solution to this since it was discovered that cement and sand plaster have longer life spans than treated mud plaster. Instead of the usual 'tubali'bricks, sun-dried, molded mud brick walls are laid in coursed cement and sand mortar joints. The walls are then plastered in cement and sand mixture. A good bond exists between the mortar joints and the plaster, reducing the risk of falling off of the plaster. As long as the plaster is stable on the wall, rainwater penetration is highly minimized.

Roofs: From mud roofs, rainwater needs to be thrown off the walls and foundations. Roofs are traditionally drained by use of hollowed-out trunks of the 'deleb' or 'gingiya' palm (Moughtin, 1985). These projects up to 600 mm beyond wall surfaces and on a rainy day can throw water up to 1200 mm off the bases of walls. Alternatively recesses are made on walls to channel rainwater from the roof to the ground.

Domed mud roofs because of their slopes perform better than flat mud roofs and have longer life spans. However, the roof has not been saved from the onslaught of rainfall's constant cycle of erosion and consequent maintenance. One major advantage the mud roof has over iron and thatched roofs is its ability to withstand the gale, rain-bearing winds without collapse. The fact is that it requires constant maintenance to retain its waterproofing properties.

Remarks: Builders and owners enjoy the ability of the mud roof to keep constant temperature in a composite climate in which the Hausaland is situated. But bored by regular maintenance costs, however, the author observed that many of the mud roofs have received corrugated roofing sheets over them. This step will adequately stop rainwater from getting to the domed roof and have an overhang enough to throw rainwater off the building in addition to protecting the walls from driving rains.

CONCLUSION AND RECOMMENDATION

In architecture, people build on the basis of four conditions (Rappoport, 1979):

- Climate
- Technology
- Material
- Economy

The Hausa builder has all along considered these in determining their architecture. The climate of Hausaland has reasonably been constant, but available technology, materials and economy have changed. People have found easier ways of doing things, with the availability of materials that perform better against the rains, with improved economy. In a nutshell, traditionally, here is architecture of mud wall core encased in concrete and steel. The reason? Mud huts provide better comfort zones in a climate which changes from hot-dry to cold-wet situations.

Globalization has however had its toll on Hausa Traditional architecture as it has done on other traditional architecture worldwide. In order to combat the onslaught of climate the traditional features of the architecture are fast disappearing.

Conclusion The skyline of Zaria City, typical of other Hausa cities, has a mixture of mud flat, domed, corrugated metal and concrete outline. Modernity has crept into the very fabric of tradition and is speedily gaining acceptance.

Mud houses built of treated earthen material will be rare sights to be seen for a very long time, even in minute numbers, because of recent innovations in stabilization of earthen materials for buildings. Solanke, (1990), indicates that when well built, mud houses have life spans of up to 100 years.

It is doubtful, however, if many of such houses are still under construction. This is the attitude that will see the extinction of Hausa Traditional Architecture many years to come, unless researches are encouraged to safeguard this noble traditional practice. Plate 6 also shows a completely weathered mud hut amidst modern developments with little hope of replacement or renovation.

In the south-western United States of America, (Sa'ad, 1990), the use of 'adobe' bricks and rammed earth walls are popular. The use does not alter the plasticity, aesthetic, thermal comfort and fire resistance of the material. In the Sahel region of Hausaland which has similar climatic condition as that of south-western United States of America, traditional architecture will survive for a very long time because of reduced amount of rainfall and moisture.

One of the authors had an opportunity of erecting a poultry house using 'adobe' brick walls rendered in fine particle clayey soil stabilized with a little amount of cement. The structure has lasted for twelve years without signs of weathering or peeling out of the plaster.However, the materials for the bricks were excavated in a clay/gravel deposit.

Plate 6: A weathered mud house in Tudun Wada, Zaria, Source: Author's Photo (2007)

Recommendation: There is still hope for the revival of Hausa Traditional Architecture in Zaria. Based on the above discussions, this study recommends as follows:

Innovative Techniques: Researches that incorporate traditional techniques, recognize and apply the qualities of earth as a material should be developed to provide solutions to its shortcomings, by means of stabilization. Information from such researches should be disseminated to reach the local builder.

Foundations: Floors should be placed well above the external grade by forming platforms or rafts of well-rammed lateritic soil at least 300 millimetres thick, to check moisture penetration.

Walls: Instead of the hand-moulded 'tubali' bricks, manually operated presses should be used to produce 'adobe' bricks or rammed earth walls out of the same stabilized earth material, using wooden formwork.

Mortar and Plaster: The mortar and plaster should be stabilized with a little amount of cement to provide greater bonding between mortar and bricks, under compression and between mortar and plaster, since experience has shown that bonding between cement/sand plaster and mud bricks are minimal (Plate 6).

Roofs: The roof is the area that requires much research because it is directly exposed to the rain. Domed earthen roof should be adopted instead of the flat alternative and should be plastered with selected clayey soil stabilized with a little cement with spouts to drain and keep the water off the walls and foundations.

Alternatively, pitched corrugated burnt roofing tiles of up to 22º slope should be used over buildings, t with ceilings done in 'azara' beams and 'zana' or reed mats. In summer months, this will provide a cool interior environment similar to domed roofs: a mutation.

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