

## INTRODUCTION

Natural ventilation is the sustainable means of ventilating spaces in a built environment. This process involves replacing air in any space to provide high indoor air quality and to control temperature.

Office building is a large building with multiple floors holding offices used primarily for the conduct of several businesses relating to administration, clerical services, consulting, and other client services not related to retail sales. Office building can hold single or multiple firms with diverse business activities. In office building, natural ventilation provides the needed amount of good air quality through a natural process of allowing air in and out of the buildings through fenestrations (openings), in order to achieve thermal comfort.

Natural ventilation has experienced a strongly growing interest, relying on wind and thermal buoyancy as the driving forces for natural ventilation is surely not a new phenomenon or invention. Its utilization for the purpose of ventilation has for several millennia provided the desired thermal comfort and air quality for both man and animals (Tommy, 2003).

Therefore, this research highlights those window types, the use of courtyards, orientation of windows, and vegetation that are effective in allowing natural air into office buildings. This research is borne out of the fact that the wrong choice of windows causes poor ventilation in office buildings and in order to solve the poor ventilation problem, window types used in the offices are going to be assessed. Window sizes and types used in the selected offices were analyzed in order to specify effective types for office buildings. Windows play an important role in ventilation of buildings. Its position and type matters allot on the amount of air that comes into the building. In order to get a good air exchange, windows will have to be opened for five to ten minutes in every three hours, (Passive House Resources, 2014). The amount of air that comes in will depend on the openings, verticality and its area, and this is where how the windows open comes to play. Cai Feng & Wai (2010) found out that ventilation performs better with a bigger inlet than with a bigger outlet. It is effective when the inlet is bigger so as to allow enough air into the room. The outlet can be smaller and on the leeward side to let out stale air. Designers tend to understand and provide adequate opening sizes than the types of windows to be used in the openings. This is why there could be big enough opening, but when the wrong window type is used, it impedes the flow of air and poor ventilation is experienced.

## DESIGNING OF WINDOWS TO MAXIMIZE NATURAL VENTILATION

Hazim, (2010) stated that windows should be designed to achieve natural ventilation. But an important issue is whether the windows are single-sided or cross-ventilated to the interior spaces. Windows that are pivoted at the centre have less ventilation capacity, but they can act as wind scoops

Casement windows have the same advantages of the vertical pivot windows but have the likelihood of being by wind. If casement windows must be used to channel wind, they should be opened in the wind direction when they are used as inlets and they should be opened away from the direction of wind when they are used as outlets. (Dutton, 2010).



Kevin, (2006) stated that fins or overhangs can be incorporated, if not part of the design, to create high and low areas of wind pressure and this will channel incoming air. Bay windows can be incorporated for instance, to create localized pressure difference and place windows on the opposite faces of the protuberance of the bay as inlets and outlets.

The windows located on the leeward side. Windows no matter the efficiency in design, if they are not located in consideration to the wind direction, they are not going to maximize natural ventilation.

## **ANALYSING VARYING PRINCIPLES OF NATURAL VENTILATION IN BUILDING**

There are basically three principles of natural ventilation which include:

Cross ventilation

Stack effect

Single sided ventilation.

These principles work very differently from each other with different level of effectiveness. They also have different pattern of air flow in and out of the building

### **Cross ventilation**

In this principle there must be more than one window in a room and on different wall, wind force pushes in air through one window and the contaminated air goes out through the other window. These window can be directly opposite each other or adjacent to each other, having windows on adjacent walls guarantees the circulation of air in the room before it's exist thereby making the room comfortable for guest.

### **Stack effect**

Stack effect work with temperature different in the air. Fresh air from outside enters the building through opening at a lower level; because this air is fresh and cool it is denser it therefore circulates at low level in the room. When the air gets warmed up it then rises because it has become less dense and exist the room through opening at a higher level.

### **Single sided ventilation**

Single sided ventilation occurs where there are one or more window on only one side of the room. The air enters and exist the room through the same window if there is only one window. another way is for the cool air to enter through one window and the hot air exist through a higher window directly above the lower window .of all the principles analyzed above ,cross-ventilation is the most effective followed by the stack effect. The single sided ventilation utilizes stack effect, when cross ventilation and stack effect principle are used with adequate window sizes in combination with proper orientation of the window.



## **ANALYSES OF VARIOUS TYPES OF WINDOWS**

The types of windows analyzed are based on the common window types used in the study. Which are casement windows, sliding windows, projected windows, fixed light, and Louvre window.

### **Casement Window**

According to Breezeway Technical Bulletin (2012), the sashes of casement windows can only minimally reduce air flow when the window is opened with the sash in a perpendicular position. Casement windows are hung on the vertical sides of the frames, that is, if the window has double leaves. It can have single leaf and be hung on one side. The leaves can open 90-180 degrees allowing maximum air flow in the room.

### **Sliding Window**

Sliding windows usually have panels or sashes that slide along tracks on the window sill. The sash that slides, sits directly behind the fixed pane when the window is completely opened. The amount of air that is offered by this type of window is half of the entire window size. Very big window sizes will be needed if sliding window is the specification. This is to achieve maximum air flow when the panel slides.

### **Projected Window**

This type of window is hung on the top and can open at different angles up to 90 degrees, depending on the amount of air that is to be allowed in. In any case it allows for maximum air inflow when opened.

### **Fixed light window**

These types of windows are not meant for ventilation because they are not made up of operable partitions (panels) or sashes. They are permanently fixed just to allow light into a space in the building.

### **Louvre Window**

This type of window has horizontal blades that open perpendicular to the window when completely opened. The blades to an extent impede the air flow, but a great amount of air still gets into the room.

## **COURTYARDS IN OFFICE BUILDINGS**

Courtyard in office building serves the main purpose of creating an air and light inlet to building beside of the courtyard condition, the effect of air movement on human thermal comfort is important and also, is different. It depends on environmental temperature and humidity, as well as on the clothing and metabolic rate.

When air temperature is above the skin temperature (like sub-Sahara condition, but daytime), the effect of air movement will be the same as other climatic factors and the increase of air movement will raise the skin temperature. Air movement is more noticeable when the air is cool and the difference between skin and air temperature is large (like sub-Sahara condition, but night-time). Conversely, if the air is only slightly below skin temperature, very large



Increases in air speed are needed to achieve an increase in convective cooling. However, variation in air velocity is important. The air movement, in combination with air temperature, will affect the rate at which warm air or vapor. The courtyard can also be utilized for other purpose such as recreational, green areas and relaxation during and after work.

## **AIM AND OBJECTIVES:**

### **AIM**

This research is aimed at assessing the level of natural ventilation in the selected public office buildings in Niger state.

### **TO ACHIEVE THE AFOREMENTIONED AIM, THE FOLLOWING OBJECTIVES ARE SET:**

- Identifying public office buildings in Niger state.
- By determining the position, number, size and type of fenestration provided in the selected public office building.
- By identifying public office buildings with court yards
- By identifying the effectiveness of various passive cooling strategies to achieve an efficient interior cooling.

## **RESEARCH METHODOLOGY**

The research was carried out by using a practical observation field work which depended on data extraction of public office buildings in Niger state through observation schedules, structured interview, and photograph. Secondary source of data was extracted from published and unpublished materials. The research was carried out in order to check the types of window used, to determine the position, number, size and type of fenestration provided in some selected public office buildings in Niger state. These studies were conducted in ten different public office buildings by the use of random selection. The areas were studied using observation schedule to analyses the window size and types, after that, the data was analyzed using Statistical Package for Social Sciences (SPSS), and was represented in figures showing bar, and pie charts:

## **STRUCTURED OBSERVATION SCHEDULES**

For the purpose of this research this instrument is the back bone of this work because of the size of the data that was obtained by this source. This instrument was designed based on some pre-conceived information on the physical appearance of office buildings and their courtyard in the study area. This was done after a detailed review of related literature, which helps in informing the research questions to ask and what to look out for while in the field. For the purpose of this study, observation schedule was carried out for each study area.

## **STUDY AREA**

Niger state is the preferred location for the research Niger state is located in north central geopolitical zone of Nigeria. Minna; is a city in west central Nigeria. It is the capital of Niger State, one of Nigeria's 36 federal states, and is the headquarters of Chanchaga Local Government Area.

Niger state is connected to neighboring cities by road. Abuja, the capital of the country. Niger state is also connected by railroad to both Kano in the north and Ibadan and Lagos in the south which is also border by Ilorin city.

For the Purpose of this research, ten (10) public office buildings were selected randomly in order to assess the level of natural ventilation. Ten observation schedules were produced for the ten buildings, and at the end of the field work the ten was properly observed and analyzed.



## Data Analysis

**Table 1: Fenestrations (Window)**

S/ N	Study Samples	Type Of Windows Used	Sizes Of Window	Type Of Glazing	Are The Windows Properly Oriented		Cooling Method Employed	
					Yes	No	Active	Passive
1	Post-Graduate School Bosso, Minna	Sliding	1200x1200 1200x1800 900x1200	Transparent	✗	✓	✓	✗
2	Senate Building Gidan Kwano	Fixed, Sliding, Casement	900x3000 1200x3000 1000x1200	Transparent	✗	✓	✓	✗
3	Neco Building, Bida Road Minna.	Sliding	1800x2400 1200x1800 1200x6000	Transparent	✓	✗	✗	✓
4	State Secretariat Complex Tunga, Minna	Sliding	600x600 1200x1200 1200x2700	Transparent	✗	✓	✓	✗
5	Local Govt. Secretariat Suleja	Sliding, Fixed And Louvres	1200x1400 400x1200 700x1200	Transparent	✗	✓	✓	✗
6	Administrative Block C.O.E. Minna	Sliding And Louvres	1200x1200 600x1200	Transparent	✗	✓	✓	✗
7	I.N.E.C. Office Kwamba Suleja	Louvres	1500x1500 700x800, 1200x1400	Transparent	✗	✓	✓	✗
8	Phen Office Kwamba Suleja	Sliding	600x600 1200x1200	Transparent	✗	✓	✓	✗
9	Ministry Of Education Bahago Drive, Minna	Sliding	600x600 1200x1200	Transparent	✗	✓	✓	✗
10	Ministry Of Tertiary Institution Old Sec. Minna	Awning	800x800 800x1200	Transparent	✗	✓	✓	✗

Table 1 above shows the various sizes and types of windows used in the study areas.

It shows that casement window can give 80% ventilation as the most effective in the table. Louvre window is a type of window can offer 75% ventilation. Projected window can offer 50-80% ventilation depending on the winder or the opening angle. The least percentage is sliding window with 40% ventilation, and it is the most used type in the selected study areas.



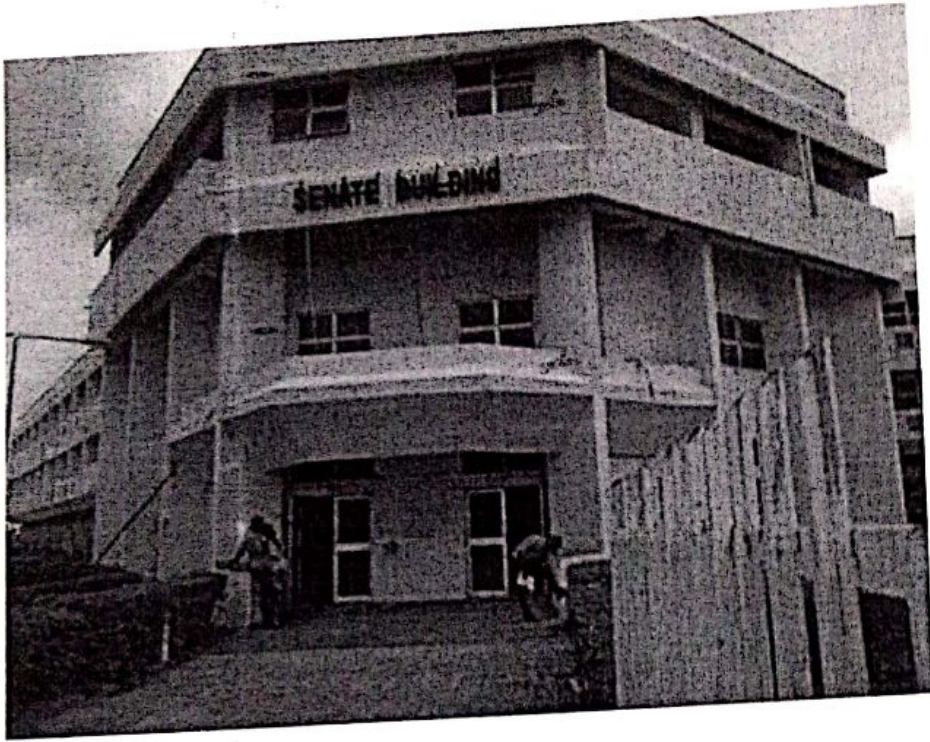


PLATE 1: showing the façade of the senate building Gidan Kwano, Niger state.  
Source: Researcher's field work (2015).

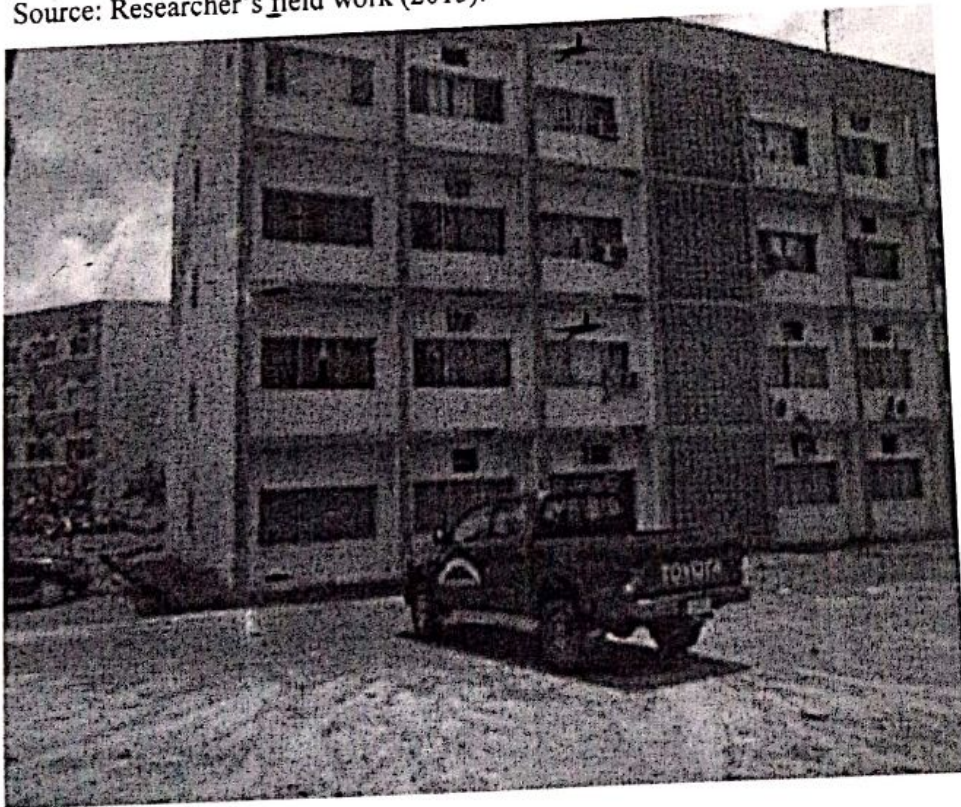


PLATE 2: showing the side view of the state secretariat Minna, Niger state.  
Source: Researcher's field work (2015).

The use of courtyards as a design element is common to residential, office, commercial/retail, and even manufacturing buildings. Courtyards are typically defined as an open space with a building or walls on all four sides. Spaces surrounded on three sides by a building or walls with an open end can also be classified as courtyards. Courtyards



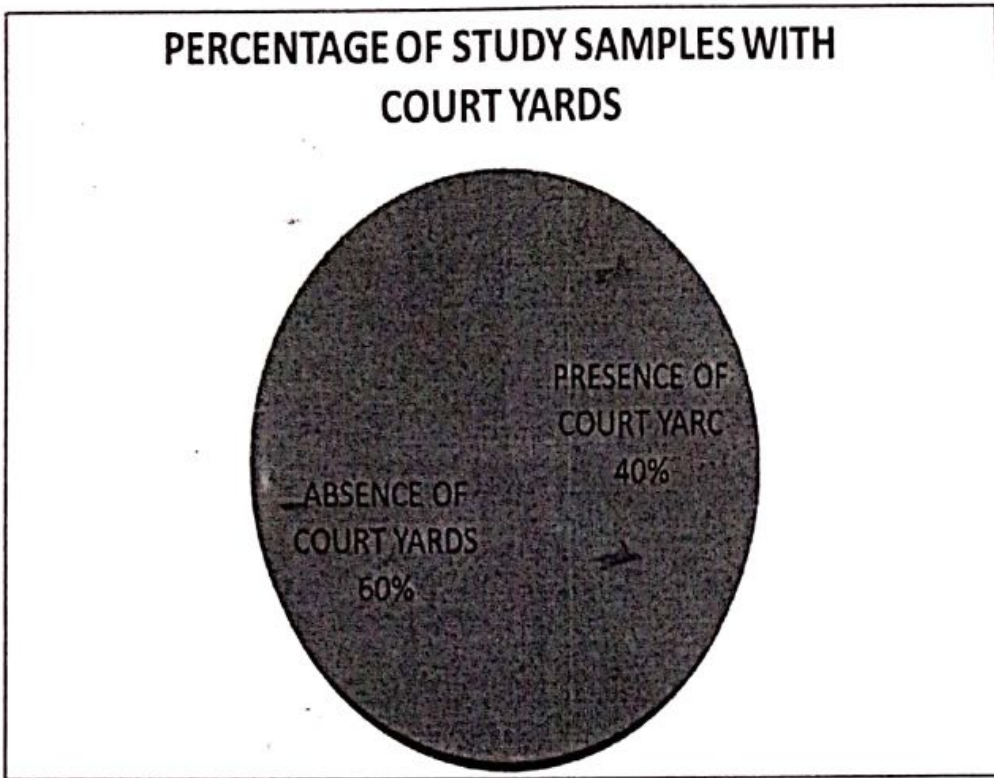
were once a viable way to create large school buildings while still providing natural ventilation and light to all classrooms. In the early 20th century, schools were designed as low-slung courtyard buildings to give students light, air and access to open space.

**Table 2: Courtyards**

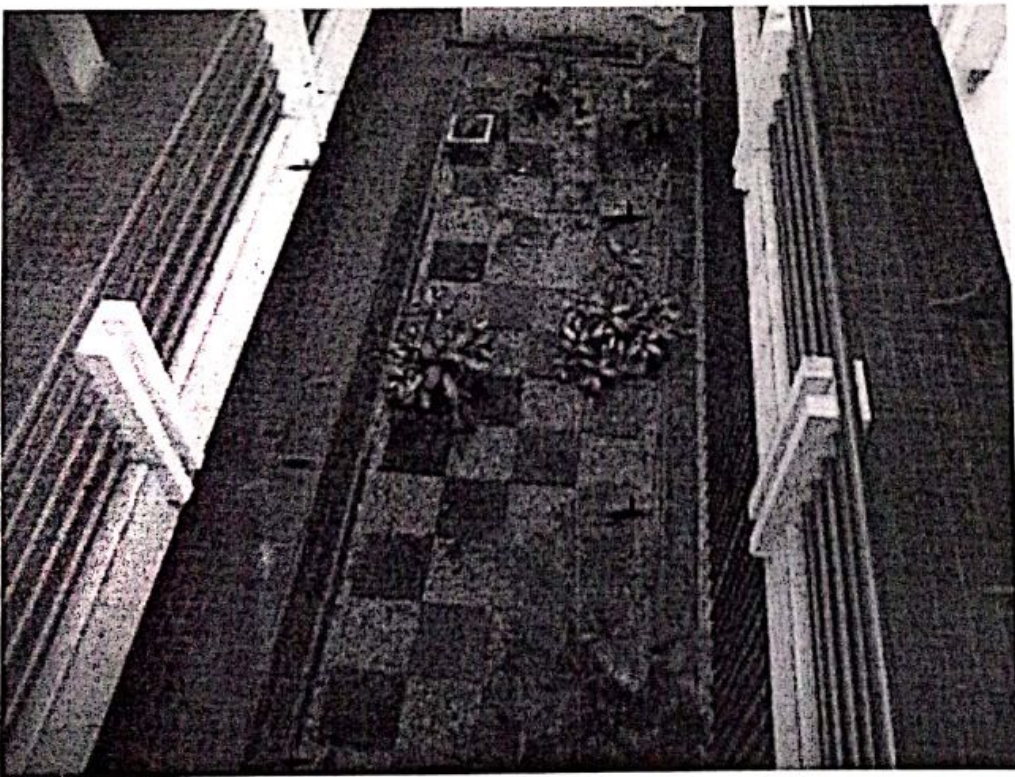
S/N	Study Samples	Presence Of Courtyrd		Shape Of Courtyard	
		Yes	No	Squared	Rectangular
1	Post-Graduate School Bosso, Minna	✓	✗	✗	✓
2	Senate Building Gidan Kwano	✓	✗	✗	✗ /Parallelogram
3	Neco Building, Bida Road Minna.	✓	✗	✗	✓
4	State Secretariat Complex Tunga, Minna	✓	✗	✗	✓
5	Local Govt. Secretariat Suleja	✗	✓	✓	✗
6	Administrative Block C.O.E. Minna	✗	✓	✓	✗
7	I.N.E.C. Office Kwamba Suleja	✗	✓	✓	✗
8	Phcn Office Kwamba Suleja	✗	✓	✓	✗
9	Ministry Of Education Bahago Drive	✗	✓	✓	✗
10	Ministry Of Tertiary Institution Old Sec. Minna	✗	✓	✓	✗

The courtyard plan is not fixed. Though the basic courtyard form of dwelling is rectangular or cubic in shape, it may be round or curvilinear too.





**FIGURE 1:** Showing the percentage of study samples with courtyards. Source: researcher field work (2015).



**PLATE 3:** showing the courtyard. Source: researcher field work (2015).



**Table 3:** Indoor and Outdoor Temperature of the study areas.

S/N	STUDY SAMPLES	TEMPERATURE		TIME INTERVAL
		INDOOR	OUTDOOR	
1	POST-GRADUATE SCHOOL BOSSO, MINNA	28°C	35.5°C	3:00PM-4:30PM
2	SENATE BUILDING G. KWANO.	30°C	36.5°C	3:00PM-4:30PM
3	NECO BUILDING, BIDA ROAD MINNA.	26°C	35°C	3:00PM-4:30PM
4	STATE SECRETARIAT COMPLEX TUNGA, MINNA	29°C	35°C	3:00PM-4:30PM
5	LOCAL GOVT. SECRETARIAT SULEJA	27°C	33°C	3:00PM-4:30PM
6	ADMINISTRATIVE BLOCK C.O.E. MINNA	30°C	36°C	3:00PM-4:30PM
7	I.N.E.C. OFFICE KWAMBA SULEJA	27.5°C	33°C	3:00PM-4:30PM
8	PHCN OFFICE KWAMBA SULEJA	28°C	33°C	3:00PM-4:30PM
9	MINISTRY OF EDUCATION BAHAGO DRIVE MINNA	29°C	35.5°C	3:00PM-4:30PM
10	MINISTRY OF TERTIARY INSTITUTION OLD SEC. MINNA	27°C	35°C	3:00PM-4:30PM

**PASSIVE COOLING STANDARDS FOR INDOOR TEMPERATURE IS: 24°C - 25°C.**

According to literature, the temperature will actually peak between 3 pm and 4:30pm each afternoon, dependent to some extent on variable cloud cover and wind speed. After that, as the sun gets lower in the sky, the temperature will begin to fall gradually back from its high, and drop in temperature accelerates after sundown.





PLATE 4: Satellite image of Neco building Minna, Source: Google map (2015).

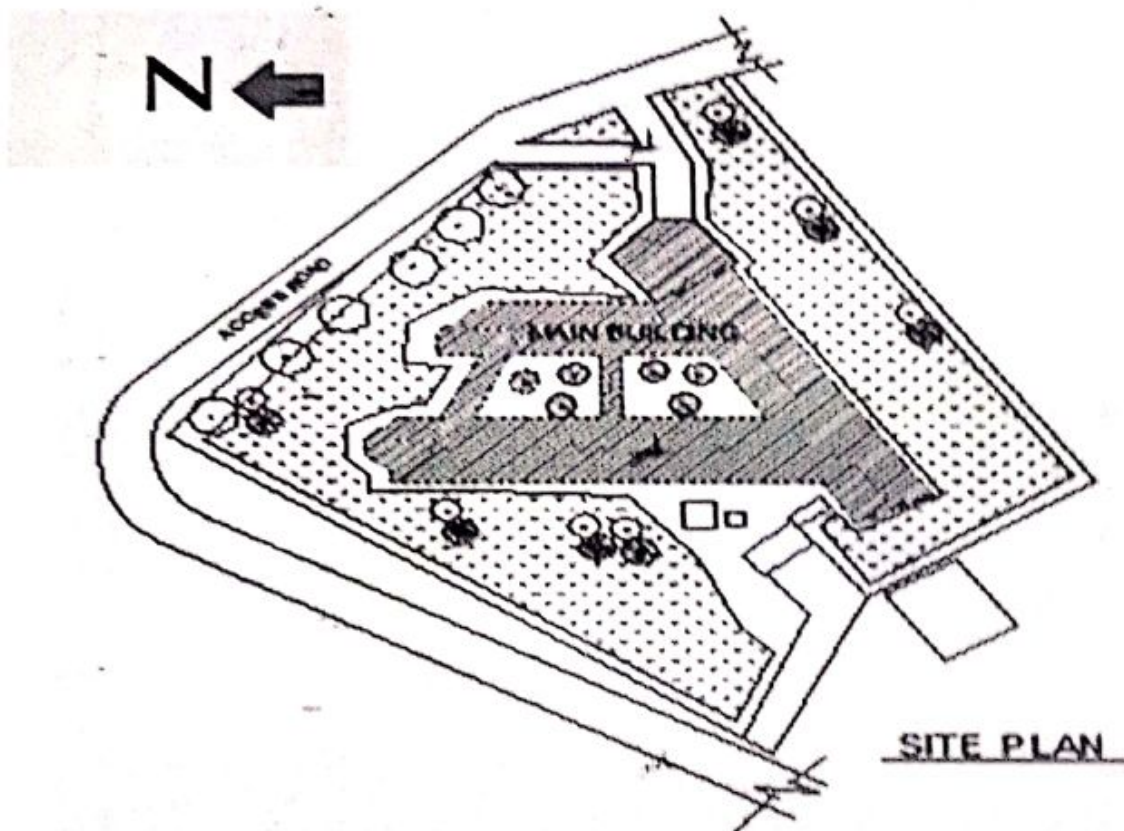


FIGURE 2: 2d sketch of senate building Gidan kwano, Source: Author's field work (2015).



**Table 4: Type of courtyard/Landscape**

S/N	STUDY SAMPLES	TYPE OF COURTYARD		LANDSCAPE	
		OPEN	COVERED	SOFT	HARD
1	POST-GRADUATE SCHOOL BOSSO, MINNA	✗	✓	✓	✓
2	SENATE BUILDING GIDAN KWANO	✓	✗	✓	✓
3	NECO BUILDING, BIDA ROAD MINNA.	✓	✗	✓	✓
4	STATE SECRETARIAT COMPLEX TUNGA, MINNA	✓	✗	✗	✓
5	LOCAL GOVT. SECRETARIAT SULEJA	✗	✗	✗	✗
6	ADMINISTRATIVE BLOCK C.O.E. MINNA	✗	✗	✗	✗
7	I.N.E.C. OFFICE KWAMBA SULEJA	✗	✗	✗	✗
8	PHCN OFFICE KWAMBA SULEJA	✗	✗	✗	✗
9	MINISTRY OF EDUCATION BAHAGO DRIVE	✗	✗	✗	✗
10	MINISTRY OF TERTIARY INSTITUTION OLD SEC. MINNA	✗	✗	✗	✗

Landscape is more than just scenery: it is the interaction between people and place; the bedrock upon which our society is built. The European Landscape Convention defines landscape as 'an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors. Landscape underpins our economy, offering a superb natural and cultural environment that sustains agriculture, attracts inward investment, and supports one of the most vibrant tourism industries in Nigeria.



## CONCLUSION AND RECOMMENDATION

Office building is a large building with multiple floors it was discovered that in order to achieve the amount of natural ventilation required, the use of courtyards has to be considered,

Window types also have great impact in determining the amount of ventilation that windows will provide in tackling poor ventilation. The most effective window types should be used in the ventilation of office spaces. Sliding windows were mostly used because it is considerably cheaper and the prevailing type that is in use, but not because it is good for ventilation. Using window types that provide the least percentage of ventilation in a standard window sizes that should have provided enough ventilation is a serious challenge. This research shows the need to understand the position, types and sizes of fenestration to be used in office building designs so as to achieve a breakthrough in office ventilation. Therefore, it can be recommended that;

Sliding windows should be replaced with casement, louver windows or projected window, and the use of courtyards should also be considered for effective cross ventilation.

If sliding window must be used, its size should be big enough for the slide sash or sashes to offer maximum ventilation, Windows, no matter the size or type should be located to take advantage of the prevailing winds. During the design stage, windows such as casement, louver and projected windows should be specified for maximum and effective ventilation.

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