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Ameliorating the Effects of Climate Change of Building Occupants in Nbawsi Isiala Ngwa North Local Government Area, Abia State – Nigeria

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Abstract

The term global warming and climate change in our contemporary world, has become a mantras, which is understood or at least partially by most literate and non – literate individuals in our rural and urban environments. This is so because all have without reference to literature or records concluded that there is evidenced shift in seasonal climatic periods, and felt increase in body temperature. Increase in water levels and death of aquatic lives quickly lead to a conclusion of change. All these are resultants of global warming. The most felt of these shifts resulting from global warming that affects buildings and comforts level of inmates is climate change and increase in temperature, a situation that is even getting worse. This have resulted in increased demand for air conditioners for space cooling due to indoor discomfort in buildings. Air conditioners consume much energy and energy is scarce, especially in the study area. The investigation of the effects climate change in buildings exert on occupants in Nbawsi sub – urban environment of Abia State Nigeria has the major objectives to gather and spread information on expected effects climatic change could exert on buildings and the environment. The study which was conducted mainly by literature reviews and interviews revealed noticeable increase in temperature, rainfall and relative humidity in the study area. The rise in temperature and humidity created very possible health risk. Energy was noted to be in greater demand and scarce. The study noted that the time for architects and other building professionals to come out with ideas in building designs and development that will ameliorate discomfort in buildings and then recommended that architects and other professionals involve developers beginning from design inception to completion letting them understand the need to save energy in buildings.

Keywords:
Ameliorate, Climate change, Greenhouse effect, Themal comfort, Comfort zone

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Background the Study
Climate Change
According to Oberthur et al. (1999), research has proved that concentration of certain 'heat – trapping' gases in the atmosphere popularly known as the Green House Gases (GHG), are on the increase. The emission of GHG, mainly carbon dioxide (CO_2), into the atmosphere results in green house effect. Natural green house effect increases the global atmosphere temperature to about 15°C, a temperature warm enough to sustain life on earth (Oberthur et al., 1999).

Nevertheless more Carbon dioxide (CO_2) and other Green House Gases are emitted into the atmosphere by human activities like burning,fossil fuels which may be used in the generation of electricity, in industrial activities and in the transport sector. These gases build up and cause an increase in the temperature of the atmosphere.By so doing the basic mechanism of natural green house effect is altered and leads to additional induced green house effect. This phenomenon of human induced green house effect is popularly known as "global warming". Oberthur et al; (1999) however concluded that in international discussions the term "climate change" has been used to cover green house effects and all its varied impacts.

According to Botkin and Keller (1998), there has been a lot of effort by the United Nations Framework Convention on Climate Change (UNFCCC) towards reducing the emissions of greenhouse GHG into the atmosphere. However, there are concentrations of greenhouse gases already emitted into the atmosphere. For instance, carbon dioxide, which is the main GHG, has an effective lifespan of around 100 years in the atmosphere (EPSRC, 2003). That means even if GHG emissions into the atmosphere were reduced it would take decades for any atmospheric concentrations to reduce. This implies that the effects of climate change would continue to develop (EPSCR, 2003).

The impact of climate change is likely to become more evident in the coming decades. Since buildings generally are designed and constructed for use over a long period of time. People are living in and will continue living in buildings designed on the basis of past climates rather than the warmer conditions experienced today and the more extreme climates that are expected in the future as a result of climate change. This should inform building professional and policy makers that provision for future condition is essential in present day building design, if not it could present severe consequences. Resilience of existing buildings would also have to be improved. Currently, atmospheric conditions, especially in the dry season, are getting hotter and drier with increased heat waves. There has been an increased demand of air-conditioning for space cooling as a result of internal discomfort of buildings. Non- physical effects such as increased energy demand for space cooling by air-conditioning, mostly in hotels and administrative buildings, are already manifesting. This could put an additional stress on the already over-burdened energy capacity. (Alozie 2014).

Thermal Comfort in Buildings

Literature on the concept of thermal comfort in buildings as developed in Alozie, et al; (2015) and Alozie (2014) are relevant to this study, especially as the area of study have near similar climatic conditions. According to Gut et al., (1993) the optimum thermal comfort condition in buildings can be defined as the situation in which the least effort is required to maintain the human body's thermal balance. The greater the effort that is needed the less comfortable the climatic condition. In normal design practice, maximum comfort condition can usually not be achieved. However, the designer's aim will be to design a house and build it to provide an indoor climate close to the optimum.

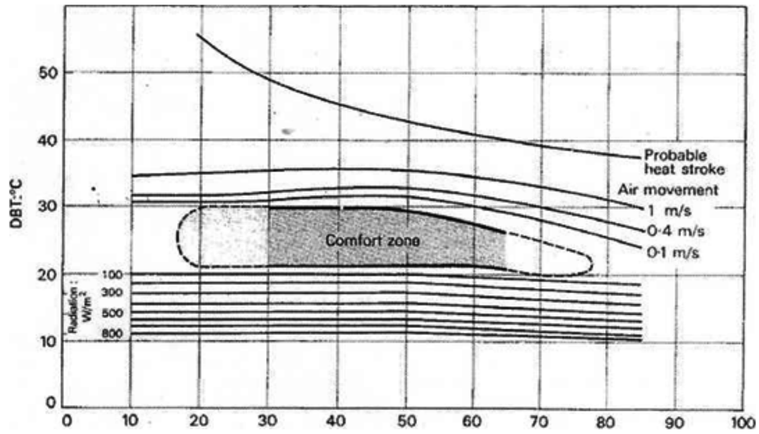
This is a range in which thermal comfort is experienced. This range is called the human comfort zone (Szokolay, 1981). The comfort condition differs with individuals within the range and depend on the clothing worn, the physical activity, age and health condition. Although ethnic differences are very important, the geographical location plays a role because, of living habits and the acclimatization capacity of individuals. Four major factors, outside psychological and physiological factors,that may determine the comfort zone, include air temperature, temperature of the surrounding surfaces (radiant heat), relative humidity and air velocity (Gut ***et al.,*** 1993). The relationship of the four factors that determine the comfort zone is illustrated on the Bioclimatic chart, which was developed by Olgyay (Szokolay, 1981). It provides a method of establishing an environmental comfort condition through the interaction of the four climatic variables on the bioclimatic chart. The chart has relative humidity as the abscissa and temperature as the ordinate as indicated in Figure 1. The comfort range is plotted on the chart. The chart indicates the zone where comfort is felt in moderate climate zones, wearing indoor clothing and doing light work.

A comfort zone is first defined in terms of dry bulb temperature and relative humidity, with the assumption that the air is still and there is no radiant heat gain or loss.

Monthly hourly diurnal “loops” of temperature and humidity conditions for each month, in any given location, can be plotted on the chart. This provides a “diagnosis” of the extension of under heated, comfortable, and overheated conditions in that place (Szokolay, 1981). In the overheated situation the chart specifies the air speed of evaporation rate that may restore comfort. This can be achieved through cooling and dehumidification by an air conditioner and/or a dehumidifier. This scenario applies in the hot climates.

Figure 1: The Bioclimatic Chart

BH: %



Source: Ogunsote (1990)

Methodology

The study is similar to Alozie(2014) and followed near same method. The study reviewed literature from authors on like subjects, in order to pin down contemporary and developing concepts relating to the study.

Primary data was generated from interviews conducted with residents in Nbawsi the study area. The interview centered on how knowledgeable the residents are on the trending issue of climate change and its impact on their thermal comfort level. The interview also recorded on how the residents have adapted to changes and what they do to ward off more challenges. Like in Alozie (2014), this study collected climatic information for thirty (30) years from Nigerian Metrological Institute Abuja (NIMET). The data was from 1985 to 2014. This is in-line with World Metrological Service for any study on climate variations. (Fenestrate et al; 1998).

The climatic variables of temperature, precipitation and relative humidity in the area of study were analyzed to determine the climatic trends in thirty years. Microsoft excel was similarly employed for data analysis. The trends of temperature precipitation and relative humidity were calculated as a slope of linear trend line of the observed values. Mean temperature values for every decade and relative humidity were calculated from the climatic data for the thirty years period and plotted on the Bioclimatic chart.

Thermal Behaviour of Buildings in Nbawsi Sub – Urban Environment.

Nbawsi sub-urban environment is located on a plain terrain, which covers a land area with about 1200 buildings. The basic building forms are rectangular and square. Walls are either constructed of sandcrete blocks or adobe, with sandcrete blocks forming about 95% of the total building type, as the adobe types have continue to be replaced with more modern buildings over the last 30 years. Some of the walls generally have cement-sand mortar screeding finish while many do not.This condition of not being screeded exposes the blocks to so much moisture and influences the thermal condition inside the buildings.

The design of the roofs as well as the materials used varied throughout the sub – urban. However, hipped and gabled roof types are most common. Most buildings have pitches of between 24° and 36°. With the rafter-purlin system employed in constructing the roof structures. The roof covers are eithercorrugated short or long span aluminumsheets with thickness varying from 0.3mm to 0.55mm. Thatch roofs required frequent maintenance and as such is generally and almost being replace by corrugated or long aluminum roofs. Also most old roofs have been replaced with modern roofing materials, this is because aluminum is more durable and requires little or no maintenance. On the contrary, the aluminum sheets create less tolerable conditions because, lack of insulation causes more heat radiation into the interior space.

The thermal behaviour of a building is basically a function of its form, choice of materials, climate conditions (both macro and micro), and its use (Gut et al., 1999). A typical building structure in the study area consists of many components of different thermal conductance arranged variously in series and parallel. For example, the sides of a house had portions of sandcrete block or sun-dried brick wall into which are inset timber window frames fitted with jalousie or timber battened windows.

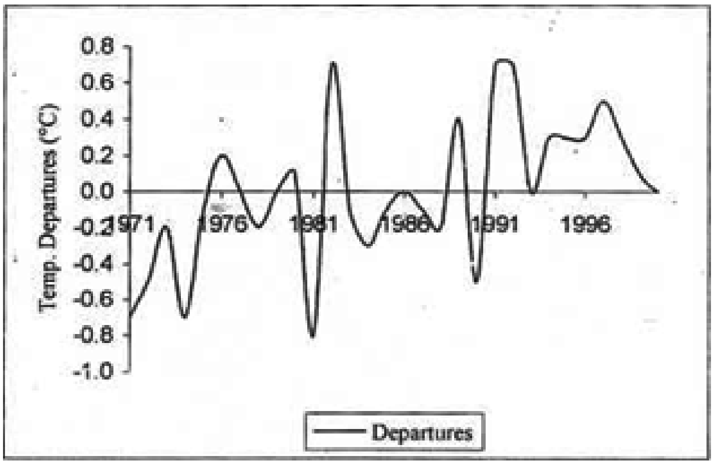
Temperature Values and their Effects on Buildings in Nbawsi Sub – Urban Environment

The average temperature in Nbawsi for the period 1985 to 2014 is 25.8°C. Out of the annual temperature values for the thirty year period that of 10 were below the average, while 6 were above and the rest were of the average value. (Fig. 1) shows the annual mean temperature departures for the period.

A period of considerable warming was identified from 1985 up to the early 1994. During this period the mean annual temperature of Nbawsichanged from a low of 0.7°C below the 1985-2014 mean to about0.2°C above the mean. This presented a mean temperature increase of about 0.9°C over the decade.

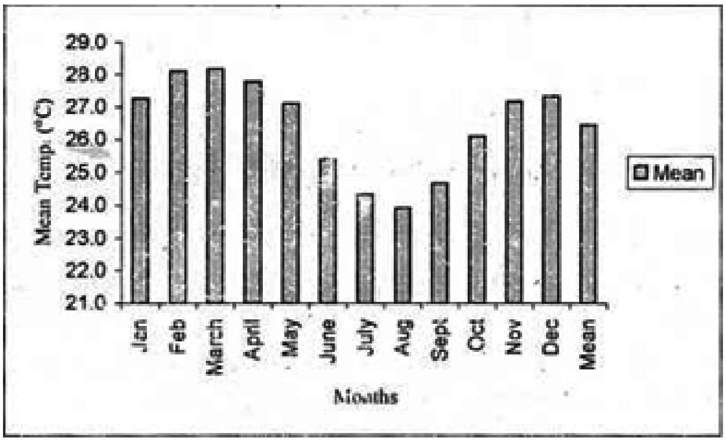
From the early 1990s to the end of the 2000s, there was a steep decline by the end of which the mean for the decade fell below the baseline mean. It is significant to note that the mean temperature in mid 1990s, when the-declining trend stabilized, were much higher than the mean temperatures recorded from the beginning of the study period up to the, earthy 1990s. From the early 2000s, temperature again began to rise, a trend that persisted up to the end of the period. During the whole study period, August was the coolest month for 63 % of the period, while March was the hottest month for 70 % of the period. The average temperature is shown in Fig. 2

Fig.1: Annual Mean Temperature Departures



The average temperature increased at a rate of 0.020 °C annually, which is about 53 % higher than the global warming rate of 0.15°C per decade (Houghton ***et. al.,*** 2001). This means that Nbawsi is approximately 0.69°C warmer now than it was 30 years ago in terms of average temperature. Despite the increasing trend of average temperature, the average temperature of the year 1995 (25.6°C) was even lower than that of the year 1985 by 0.1 °C. All the months of the year 1985 had lower average monthly values than the long-term average monthly values (Table 1).

Fig.2: Annual Mean Temperature'



Local residents interviewed had the same response as regard trend of temperature. Generally, average temperature is seen to have risen over the past years. A rise in temperature can lead to an increase in the rate of reactions and can accelerate many degradation processes. An increase of 10°C doubles the rate of many chemical reactions (Ranson, 1995). High temperatures values lead to high rates of evaporation and volatilisation. High evaporation rates of water from cement mixtures can lead to early weakness; poor adhesion and cracking. Building materials, such as bitumen, can soften or met with high temperatures. Temperature changes can cause dimensional changes in materials, particularly when the coefficient of expansion is high, for example with iron roofing sheets. These changes can cause stresses that, if not accommodated, can exceed the strength of some materials and cause distortion or rupture. Rain falling on a sun-heated surface could lead to a severe quenching shock. Brittle coatings and joints between dissimilar materials can then undergo an initial breakdown, leading to subsequent deterioration. The quality of construction work, especially curing of cement in concrete, could be altered by high temperature conditions.

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean
1985	26.2	27.5	27.5	27.3	26.5	25.2	23.5	22.7	23.3	25.6	26.7	26.9	25.7
1986	21	27.8	27.4	27.4	27.2	24.9	23.1	22.9	23.5	25.4	26.8	26.9	25.9
1987	26.9	27.6	28.3	27.2	26.9	25.4	24.7	23.6	24.4	25.7	26.7	27.3	26.2
1988	26.7	27.5	27.3	27.2	26.6	24.9	23.6	23.1	23.7	25	26.5	26.7	25.7
1989	26.6	33.1	27.3	27.7	27	25.5	23.1	23.4	22.9	25.1	26.9	27.2	26.3
1990	28.3	28.6	28.6	28.2	28.1	25.4	23	22.9	24.7	25.5	27.5	28.1	26.6
1991	27	27.6	28.3	28.1	27.1	25.3	25.4	24	24.3	26.1	28.4	27.1	26.6
1992	27.4	28.1	27.5	27	27	23.7	23.7	23.3	25	28.6	27.7	27.5	26.4
1993	27.6	27.9	27.6	27.3	26.7	28.6	23.4	23.8	28.3	25.2	26.2	26.6	26.6
1994	27.6	28.3	28.4	28.3	26.9	25.8	24.5	24.5	25.3	26.2	27	27.3	26.7
1995	26.6	27.1	27.3	27.4	26	24.3	22.7	22.5	23.6	25.7	27.1	27 2	25.6
1996	28.5	28.6	29.1	28.4	26.7	25.4	24.1	24.9	26	26.4	28.1	28.6	77.1
1997	28.1	27.9	28.1	27.4	26.6	25.2	24.2	23.5	24.3	25.2	27.1	27.4	26.3
1998	27.5	27.7	28.2	27.1	26.6	25.8	24.1	24	23.9	24.2	26.3	27.7	26.1
1999	27.2	27.6	28	27.6	26.5	24.6	23.5	22.9	24.4	28.3	27.5	27.6	26.3
2000	27.7	28	27.6	29.3	26.9	25.5	24.2	23.7	24.3	26.2	26.8	26.9	26.4
2001	26.9	27.5	27.7	28.8	27.6	25.3	24.6	24.3	24.3	26.3	27.6	27	26.5
2002	27.2	27.9	27.6	27.8	27.4	26	23.5	23.3	24.3	25.8	27	26.9	26.2
2003	24.9	29.7	28.1	28.1	27.9	25.9	25.6	24.8	24.8	25.5	27.8	27.9	26.8
2004	27.3	27.8	28.5	27.8	27.3	24.3	23.1	22.5	23.1	25.3	27.1	27	25.9
2005	27.6	28.1	28.2	27.9	27.1	27	26.5	27.2	26.1	26.8	26.1	26.7	27.1
2006	27.4	28.4	29.1	27.8	26.9	24.7	27.9	25.2	27.1	27.4	26.3	27	27.1
2007	27.1	27.9	29.4	27.7	27.1	25.1	23.7	23.4	25.1	26.9	2S.1	27.4	26.6
2008	27.7	27.8	29.3	27.2	27	25.3	26.1	25.3	23.9	25.4	27.3	27.8	76.7
2009	27.7	28	37.7	28.5	27.8	26	24.7	24.1	24.6	25.9	27.2	27.7	76.7
2010	27.9	28.6	29.7	28.7	2.7.6	25.6	24.9	23.7	23.4	25.2	27.5	27.1	76.7
2011	27.9	28.4	27.5	26.9	27.9	25.1	24.8	24.6	26.7	27.6	27.8	27.6	76.9
2012	27.6	28.7	29	28.7	27.5	24.6	24.6	24.2	24.6	25.8	27.8	27.6	76.7
2013	27.1	26.6	29.2	27.4	27.1	26.2	24.9	24.2	23.9	27.5	26.7	27.5	26.5
2014	26.5	26.9	27.7	27.1	27.1	25	23.7	24.7	26.1	26.9	27.3	27.5	16.4
Mean	27.3	28.1	28.2	27.8	27.1	25.4	24.3	23.9	24.7	26.1	27.2	27.3	16.4

Source: NIMET Abuja

High Temperatures with low rainfall conditions leads to longer, drier summers and reduced water supply.This can lead to decreased soil moisture content. Reduced soil moisture content can have consequences on landscaping. Street trees-and materials' used in urban-outdoor spaces could be affected by increased temperature, insulation materials of cables and plastic components of buildings could be affected.

Precipitation and Relative Humidity Patterns and their Effects on Buildings in Nbawsi
The mean annual precipitation for the whole study period (1985 to 2014) is estimated at 1110.5mm. Of all the months the driest was January with a mean precipitation of 20.6mm, while the wettest was June with 270mm mean precipitation. The annual mean, precipitation is shown in fig. 4 and the trend is Fig. 5. The total annual precipitation has been decreasing significantly at a rate of 3.1 mm annually (i.e. 0.3% annually). Almost all the respondents confirmed that there has been a reduction in intensity of rainfall over the past decades**.**

Fig. 4: Mean Precipitation

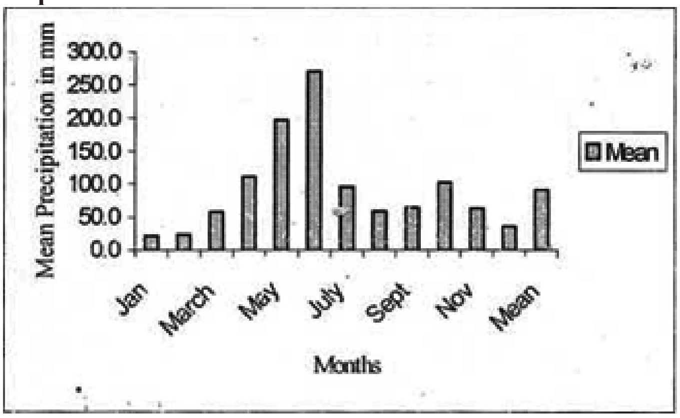


Fig. 5: Annual Trend of Precipitation

Under natural conditions, water and air fill the spaces between the soil particles. When the moisture content within soil particles is reduced or removed, the latter will tend to move closer together. Changes in the movement of soil can influence that of the building foundations in contact with them and this can in turn affect the performance of the superstructure of the building (Ranson, 1995). About 35% of buildings in Nbawsi have suffered from differential settlement with consequent adverse effect on the foundations, and thus affecting the superstructure. On the other hand, when water is absorbed, the soil tends to move apart. Large movement can occur within clay, for it is capable of absorbing and giving off large quantities of moisture. Movement in sand is for the most part negligible, for they have little capacity to hold water (Ranson, 1995).

The mean annual relative humidity was found to be 75.5% (Table 2) and the monthly average relative humidity varied from 60.0 % in January to 82.4% in August (Fig. 6).

The annual average relative humidity values have significantly increased over the last 30 years at a rate of approximately 0.69% per year (Table 3). Over the .entire period chosen for the study-, the minimum and maximum mean values of relative humidity were 71.8% in - 2004 and- 79.8% in 2005-respectively. The trend of relative humidity over the period is given m Fig.7

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1985	68	71	76.3	78.3	75	83.8	85.3	64.5	70	77.5	79	75.8	75.6
1986	53.5	68	71	76.3	77.5	81.3	53.5	85.3	53.5	68	71	76.3	74.6
1987	63.8	71	71	78.3	76.3	64.5	70	77.5	79	76.3	78.3	70.2	73
1988	43	75.3	64.5	37.5	77	79.8	76.5	71.5	83.5	80.5	75.8	74.3	74.5
1989	63.8	64.8	69	77	76.3	78.3	SI.3	83.8	74.5	78	79	82	75.6
1990	22.3	70	64.8	83.5	84.5	83.5	86.5	83.5	80.5	75.8	78.3	81.3	74.5
1991	53.5	71	59.8	71	76.3	78.3	81.3	83.8	85.3	83.5	68.8	76.3	74
1992	63.8	69	75.3	77.5	79	79 3	82.8	83	78.8	74	77.8	76.5	76.4
1993	48	73	60.3	78	77	83	82.5	85.8	83.8	83	81	74.5	75.8
1994	81	77	69.3	70	77.5	59.8	73	95.8	78.8	80.8	79.3	71.5	76.1
1995	75.8	69.5	65	71	76.3	80.5	83.8	81.3	84.3	83.3	71	76.3	76.5
1996	58	67.8	58	69.3	67.8	75.8	79.5	85.8	83.8	86.5	75.3	63.8	72.6
1997	72	64.5	70	77.5	79	65	71	76.3	78.3	81.3	75.5	74.2	74
1998	64.5	70	77.5	79	79.8	80.3	83	81	84.8	83.3	70	77.3	77.5
1999	48	81	75.3	77	78	77	83	82.5	85.8	83.8	71	71	76.1
2000	78.5	77.3	77.5	79	68	71	76.3	78.3	69	77	79.8	64.5	74.7
2001	68	71	76.3	78.3	51.3	83.8	85.3	83.5	83	81	74.5	78	78.6
2002	22.3	64.5	70	77.5	79	76.3	78.3	81.3	83.8	85.3	83.5	61.4	71.9
2003	78.5	77.3	64.5	70	77.5	79	82	86	82.8	83	82.5	71.2	77.9
2004	72	64.5	75.3	77	78	77	67.8	75.8	79.5	82	83.3	75.8	75.7
2005	70.8	69.5	75.5	78	81	82.5	82.8	85.5	83.3	82	78	69.8	78.2
2006	22.3	64.5	70	77.5	79	82	86	82.8	83	78.8	74	77.8	73.1
2007	53.5	68	71	76.3	78.3	81.3	83.8	85.3	83.5	80	78	73.3	76
2008	63.8	64.8	69	77	79.8	80.5	83	81	84.8	83.3	74.5	61.5	75.2
2009	48	59.8	73	95.8	78.8	80.8	83.5	86.5	83.5	80 5	75.8	74.3	76.7
2010	81	75.3	77	78	77	83	82.5	85.8	83.8	81.8	70.5	51.8	79.8
2011	75.5	60.3	69.5	73.8	79.3	84	83.3	87.8	83.5	79.8	76.5	71.5	77.5
2012	58	693	67.5	75.8	79.5	72	83.3	85	83	81	74.5	75.8	76.2
2013	72	65	74.3	78.5	77.3	89.5	53:8	81.3	84.3	83.3	78.3	70.3	77.4
2014	71.8	53	68.8	76.3	77.3	83.5	84.5	84.3	85.3	82.3	78.3	73.3	75.6
M'S! II	60.7	68.9	70.2	77.5	77.7	78.7	81	82.4	SL7	80.6	76.4	73.4	75.7

Data source: NIMET Abuja

Table 2: Monthly Relative Humidity (%) of Nbawsi from 1985 to 2014

Wetness in buildings constitutes potential hazard to health and comfort and is a source of aesthetic and material damage. Thermal resistance of external walls is- reduced by water content and this lowers the internal surface temperature, increases the likelihood of condensation and causes thermal discomfort (Givoni, 1981). Even when under cover, surfaces can become thoroughly wet, and metals may corrode. The situation can be worse when moisture condenses in relatively inaccessible corners, like eaves of building roofs, from which subsequent evaporation is slow.

Fig. 6: Mean Relative

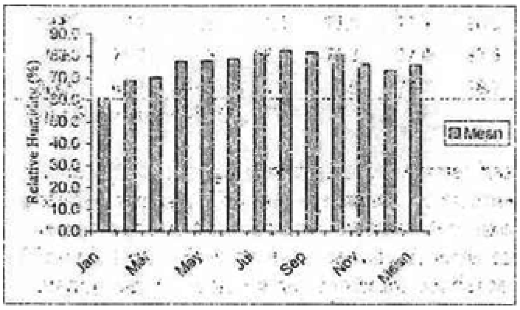
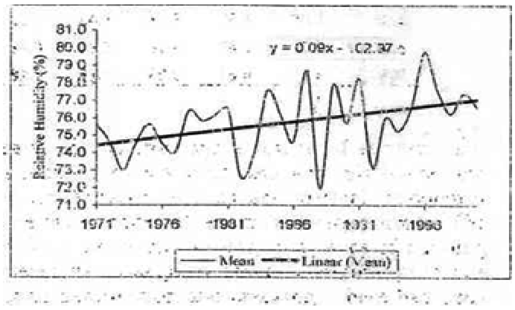


Fig. 7: Trend of Relative Humidity



Source: Data from NIMET Abuja

Table 3: Summary of Calculated Annual Weather Parameters for Nbawsi: Average of 1984-2014

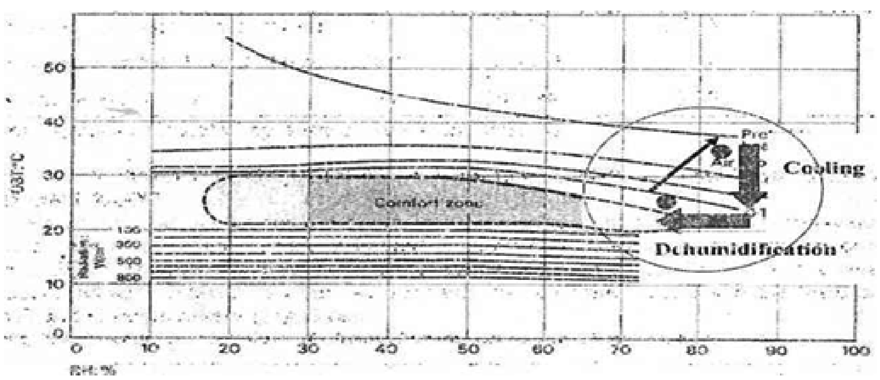
Description	Unit	Values	Change per year	% Change
1 Annual Average Temperature	°C	26.4 °C	0.023	0.08
2 Annual Ave rage Precipitation	*mm*	1111.3	-3.2	-0.3
3 Relative ***Humidity***	%	75.7 %	0.09	0.13

Source: *Data from NIMET Abuja*

Shift in Climatic Conditions at Nbawsi from the Human Comfort Zone

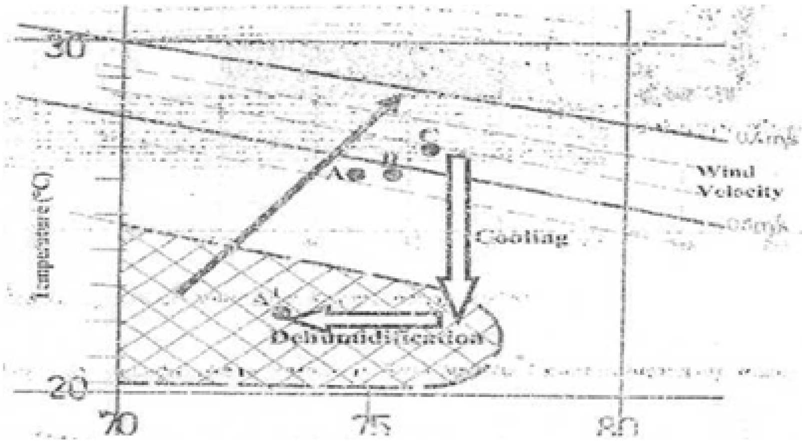
Three sets of decadal means for temperature and relative humidity for the thirty-year period computed and plotted on the Bioclimatic Chart indicated a significant shift from the human comfort zone. These are shown in Fig. 8a and 8b. For the first decade, a temperature of 26.3°C and a relative humidity of 75% were observed as indicated by point A. Similarly those of the second and the third decades were plotted as points B and C respectively (Fig. 8a).

Fig. 8a: Mean Values of Climate Parameters for decades on Bio-Climatic Chart



(Source of chart from Ogunsote, 1991)

Fig. 8b: Mean Values for decades on Bio-Climatic Chart



In all three cases the points are out and above .the comfort zone. At point, A if temperature can be controlled but not humidity, a cooling of 3.9°C would be needed to ensure comfort at point Al. Alternatively, if relative humidity call up controlled but not temperature, a dehumidification of 2.0% would be needed to ensure comfort condition at point A I.

On the other hand, if both temperature and humidity are uncontrollable, wind velocity can be provided to ensure comfort condition. From the Bio climatic Chart, an induced air velocity of 0.04m/s would be needed to ensure comfort.

Similarly at point C, at uncontrollable relative humidity, a cooling of 4.2°C would be needed for comfort at point Al. Uncontrollable temperature, a dehumidification of 3.7% would be needed for comfort at point Al. If both temperature and humidity were uncontrollable, an air velocity of 0.2m/s would be needed to ensure comfort. It can be deduced from the above that as the decadal mean values increase more cooling and dehumidification would be needed to ensure human comfort condition. This implies that the energy needed to ensure human comfort conditions also keep increasing over the years with increasing temperature.

Climate change issues or impacts are of concern to the key informants, however, very little or no response is shown towards evolving adaptive measures in design of the buildings. Generally, all the key informants interviewed have some knowledge on some of the impacts of climate change. The increasing ambient temperature was of most concern to a majority of them.

Conclusion

The study revealed that climatic conditions in Nbawsi have changed over the past three decades. Atmospheric conditions are getting warmer with increased temperature and reduced rainfall level. On the other hand, humidity levels have rather risen over the years.

The combined effect of these changes in the climatic elements has led to a shift of atmospheric condition towards an uncomfortable level. There have been associated environmental and physical defects of building elements that have also contributed in diverse ways towards uncomfortable conditions in buildings. More critical study needs to be carried out and appropriate responses evolved to ensure that the thermal performance of buildings is improved accordingly.

Recommendation
Based on the findings of the study, the following recommendations were made.
Suitable design techniques should be applied to reduce cooling demand in buildings. The Ministry Public Utilities, Works and Housing should formulate guidelines, for the building industry to produce quality homes that will ensure its terminal comfort conditions. Design of building envelopes should make room for adaptive measures that can effectively ensure indoor comfort conditions.

There is the need for practicing architects and other related professionals and policy makers to, consider seriously building technology and thermal properties of building materials in order to achieve human, comfort conditions in buildings. This will help to produce buildings that are naturally climatically comfortable for tropical conditions like that of Nbawsi and other settlements in Nigeria.

Replacement schedules for existing building stock also presents an advantage. Components such as roofing systems, doors and windows, wet cladding; ceilings are replaced several times in the course of a few decades. This could offer a considerable opportunity for adaptation during the implementation, by selecting appropriate, materials that can withstand the gradually changing climatic conditions. It is therefore, imperative that developers should be effectively guided by qualified professionals within the framework of policy guidelines based on sound research. The Ministry of Public Utilities, Works and Housing, Universities and Research Institutions should collaborate in this regard. Energy efficiency should be developed in the curriculum of all tertiary institutes offering architecture, building and engineering.

References

Alozie, C. (2014). *Sustainable Environment: Assessing Thermal Comfort in Residential Buildings in Abia State Nigeria*. Unpublished Ph.D thesis submitted to Department of Architecture, Faculty of Environmental Studies, Abia State University Uturu.

Alozie G. C, Odim O. O & Alozie E.N (2015). Impact of Air Temperature in Thermal Comfort of Indoors of Residential Buildings in Umuahia Urban, Abia State, Nigeria. *International Journal of Scientific and Engineering Research. 6* (10)1531-1541.

EPSRC (2003). *Building Knowledge for a Changing Climate.* United Kingdom Climate Impact Programme, UK.

Givoni, B. (1981). *Man, Climate and Architecture.* New York: Van Nostrand Reinhold Company

Gut, P. & Ackerknecht, D. (1993). *Climate Responsive Building; Appropriate Building Construction in Tropical and Subtropical Regions, SKAT, Switzerland.*

Houghton, J.T., Ding. Y., Griggs, D.J., & N-oguer, M. (2001). *Climate Change 2001: The-Scientific Basis.* IPCC, Cambridge University Press.

Oberthur, S., & Ott, H.E. (1999). The Kyoto Protocol, International Climate Policy for the 21st Century, 'Spinger-Verlag,' Berlin.

Ogunsote, O. O. (1990). *Introduction to Building Climatology: A Basic Course for Architecture Students.* Zaria. Ahmadu Bello University Press Ltd.

Ranson, W. H. (1995). *Building Failures; Diagnosis and Avoidance*, 2nd Edition, E & FN Spun, London.

Szokolay, S.V. (1980). *Environmental Science Handbook for Architects/Builders*. The Construction Press