SPSBIC 2017

4 - 5 May, Minna Nigeria

SCHOOL OF PHYSCIAL SCENCES
1ST BIENNIAL INTERNATIONAL CONFERENCE

PROCEEDINGS

Theme:
Science Technology and Innovation (STI):
The Vision for Poverty Reduction and Sustainable Development

FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA, NIGER STATE, NIGERIA

EFFECT OF SOME WEATHER ELEMENTS ON HUMAN THERMAL COMFORT IN BIDA, NIGER STATE, NIGERIA

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Abstract

Atmospheric conditions such as relative humidity, temperature, wind, solar radiation, air pollution and precipitation greatly affect living creatures. There is always a certain limit beyond which these conditions are no longer tolerable by them. Whenever the limit is exceeded, stress, discomfort and disaster, are inevitable. Proper study on the evaluation of human comfort is yet to be given much needed attention in many parts of Nigeria in general and Niger state in particular. The effect of climatic variables on human comfort has become a major concern affecting the well-being of people of the people of Bida. This study examined the trend in temperature and relative humidity in relation with human comfort in Bida. The objectives of the study includes; examination of the trend and variation of temperature and relative humidity in the study area; assessment of the effect of temperature and relative humidity on human comfort and examination of the proportions of stressed and unstressed peoples. To achieve these, Monthly data of Temperature, Relative Humidity and Vapour pressure for eleven years (2004-2014) was obtained from Nigerian Meteorological Agency (NiMET) office, Bida which was used to calculate the Relative Strain Index(*RSI*) and Discomfort Index (DI). The results showed that there is an increase in temperature and relative humidity over the years under study with the values reaching its peak in 2011 and the variation was well marked. The discomfort levelwas well pronounced in the months of March, April, and May while the heat stress becomes moderate in the months of January, July, August, September and December. At all these months, 80% of humans and animals are not comfortable due to hot and humid weather condition. Tree planting is encouraged as it helps in the absorption of Carbon-dioxide and lessen ozone emanations from vehicles. The review of the master plan of Bida is recommended to cater for well-defined environment through adequate spacing of structures that will allow free flow of low level winds that support atmospheric thermal reduction. It was also recommended that education and awareness of daily weather conditions in the area be given utmost priority.

1.0 Introduction

Bida is found in the tropics, where the climate is seasonally damp and very humid. The town experiences consistently high temperatures all year round. Since temperature varies only slightly, rainfall distribution over space and time becomes the single most important factor in differentiating the seasons and climatic regions. Nigeria in general and Bida town in particular have two major seasons, the dry and wet season, the lengths of which vary from north to south.(NFC 2003).The extent to which the thermal environment challenges the body's thermo-regulatory mechanisms is referred to as the environment heat or thermal stress (Ojoye and Yahaya, 2008).

The concept of the heat stress index as well as heat exposure assessment plays a fundamental role in integrating knowledge of human responses to the heat in a way which can be used to specify safe working conditions (Pourmahabadian *et.al.,* 2008). The physiological sensation of human and animal comfort is influenced by heat stress. In hot regions and seasons, discomfort level is raised by heat stress as well as increase in mortality rate among the aged and those who constantly suffer from malnutrition (Okpara, 2007).

There is no particular temperature and humidity condition at which everyone is comfortable. People are comfortable at a range of temperatures and humidity. American Society of Heating, Refrigeration, and Air Conditioning Engineers(ASHRAE, 2015) concluded that there is a range of combined temperatures and humidity that provides comfort to most people, hence most people are comfortable at higher temperatures if there is a lower humidity, as the temperature drops, higher humidity levels are still within the comfort zone..

Atmospheric conditions which include relative humidity, temperature, wind, solar radiation, air pollution and precipitation greatly affect living creatures including human beings. There is always a certain limit beyond which these conditions are no longer tolerable by them. Pauli and Rizzi, (2005) found that whenever this limit is exceeded, disaster and stress is inevitable as hospitals record showed an increase in the number of people admitted during days with high temperature (Pauli and Rizzi, 2006).

According to Ojoye and Yahaya (2008) which affirm that proper study on the evaluation of human comfort is yet to be given much needed attention in many parts of this country. Hence, Bida, Niger state in particular has been so much vulnerable to thermal stress due to prolong and intense daylight heating of the surfaces experienced over the years, longer dry seasons and thermally built up environment that affects peoples comfort.The effect of climatic variables on human comfort has become a major concern affecting the living standards in Bida. This however has made it difficult for people moving from one part of the country to another to acclimatize. It is obvious, that people want to live in thermal environments in which they feel comfortable. If the temperature drops due to changes in diurnal weather variations or season, people want to stay in warmer environments and if it rises, they want to stay in cooler environments accordingly.

Bida town is so vulnerable to stress as a result of variation in climatic elements such as temperature, relative humidity, vapour pressure and so on which has resulted to human discomfort due to prolong

and intense daylight heating of the surface over a long period of time. Exposure to hot and cold conditions can result in a spectrum of outcomes that range from mild discomfort to life-threatening medical conditions. Thermal discomfort is at the mild end of the spectrum and is distinguished from the more severe effects of heat and cold stress by the absence of significant potential for adverse medical outcomes. Most of the people living in this place experience several thermally related difficulties such as skin cancer and diseases outbreak, continuous aridity and small and large scale changes in climate as a result of excessive or insufficient heat received from the Sun. The aim of this study is therefore to assess the effects of some weather elements on the human comfort of the people of Bida town in Niger state. The aim was achieved through the following objectives; examination of the trend and variation in temperature and relative humidity in the area; to assess the effect of temperature and relative humidity on human comfort and to examine the proportion of stressed and unstressed people.

2.0 Review of Literature

The relationship between man and climate is reciprocal in the sense that man responds to variation in climate by insulating buildings, heating and air-conditioning. Man's aim is to be comfortable despite the climate, and this gives rise to the notion of thermal comfort. Thermal comfort has been studied since the start of 20th century, and improvements in building techniques, as well as discoveries in central heating and air conditioning systems have led to improved comfort in indoors, even in the hottest and coldest climates (Brager and de Dear, 1998).

According to ASHRAE, 2004 thermal comfort is a subjective response, and is defined as the 'state of mind that expresses satisfaction with existing environment, making it difficult to assign it a specific numerical value. The state of mind is widely driven by perception and expectation of the occupants. So, the same thermal environment may be perceived differently by different occupants, or different occupants may perceive the same thermal comfort sensation for different thermal environments (de Dear, Brager, 2002). Bangladesh is widely recognized as one of the most climate vulnerable countries in the world (United National Development Programme, 2007). This growing concern about climate change is imposing additional future threat to the

functionality of existing built environment and design of future buildings. Studies shows that, 85% of the rural dwelling units in Bangladesh are very basic shelters, and do not provide adequate protection from wind, rain, flood, and other climatic forces (Hassan, Ullah, Gomes, 2000). There has been no thermal comfort study in rural areas. Previous research has all concentrated on the urban situations. Numerous recent studies on vernacular buildings conclude that bioclimatism is an integral part of vernacular rural architecture and a deciding parameter towards achieving sustainability of modern architecture (Plemenka, 1982).

In Nigeria, recent studies have shown that heat induced mortality resulting from meningitis has increased in the north and middle belt of Nigeria (Greenwood, 1999; Mohammed *et al.*, 2000; Greenwood, 2006). Sawa and Buhari (2011) also predicted that meningitis and measles would increase by 6 and 19 persons per thousand, respectively, for every 1 ◦C increase in temperature in their study on Zaria, in northern Nigeria. Although records of mortality and hospital treatments are fraught with uncertainties in many developing countries (Kwast *et al.*, 1986; Williams and Boren, 2008), we know that urbanization in Nigeria, as in most developing countries, is rapid, and the explosion of urban population has not been matched by a change in social, economic and technological development (United Nations population Fund, 2007; WHO, 2011). Public infrastructure, social and health services have been neglected, and urban planning and zoning have been slow or stagnant in many cases. Consequently, there is the preponderance of large proportion of urban dwellers living and working under conditions that make them vulnerable to effects of climate. These are often poor people, and a sizeable proportion of the Nigerian population is in this category (Adepoju, 1982). Certain urban characteristics, including structure and geometry can affect the pattern of movement and distribution of the air and solar radiation, with important implications for thermal comfort (Jonsson, 2004; Candido *et al.*, 2010; Krueger *et al.*, 2011). Thus, the research attempted to analyse the thermal sensation, and perception of occupants living in naturally ventilated typical rural houses in Bida region of Niger State, Nigeria.

3.0 The Study Area

Bida is an ancient Nupe town, the headquarters of Nupe ethnic group in North -central Nigeria with a population of about 188,181 persons (NPC,2006, 2010). The town lies within latitude 09^0 0380”N to 09^0 06’40”N and longitude 06^0 0’0”E to 06^0 02’42”E. It is about 20km away from tributary of River Kaduna called River Wuya along Mokwa-Bida road and 84km south–east of Minna, Niger state capital (Adebunmi, 2002).

It is located in middle Niger Basin that can also be referred to as Bida basin, also known as the Nupe sandstone formation, which consist of plains with ironstone capped hills or mesas. The scenery is fairly uniform since lithology and dock structure are not greatly variable. An important feature of thescenery is the existence of large areas of Fadama. The northern edge of the town consists of a broken off Plateau. The town is drained by Chiken and Musa rivers, with Landzun which flows right across the heart of the town. The importance of these rivers is that they provide good irrigation opportunities for the inhabitants. Thus they are of both economic and social importance (Abubakar, 2003).

Being an ancient town one could still see the remnant of its former glory (City wall) here and there embracing the wide expanse of Bida. This ancient city wall estimated to measure more than 19 kilometers in circumference. Before it was demolished this wall had ten gates. Bida a traditional once walled city is situated on a gentle slope of the river Landzun which runs through its heart in a given swath of Fadama (Abubakar, 2003).Bida has a mean annual rainfall of 1227mm with the highest mean monthly rainfall in September with 248mm. The rainy season starts on average between the 5th and 15th April and last just over 200 days. The mean monthly temperature is highest in March at 31 and lowest in August (Abubakar, 2003).

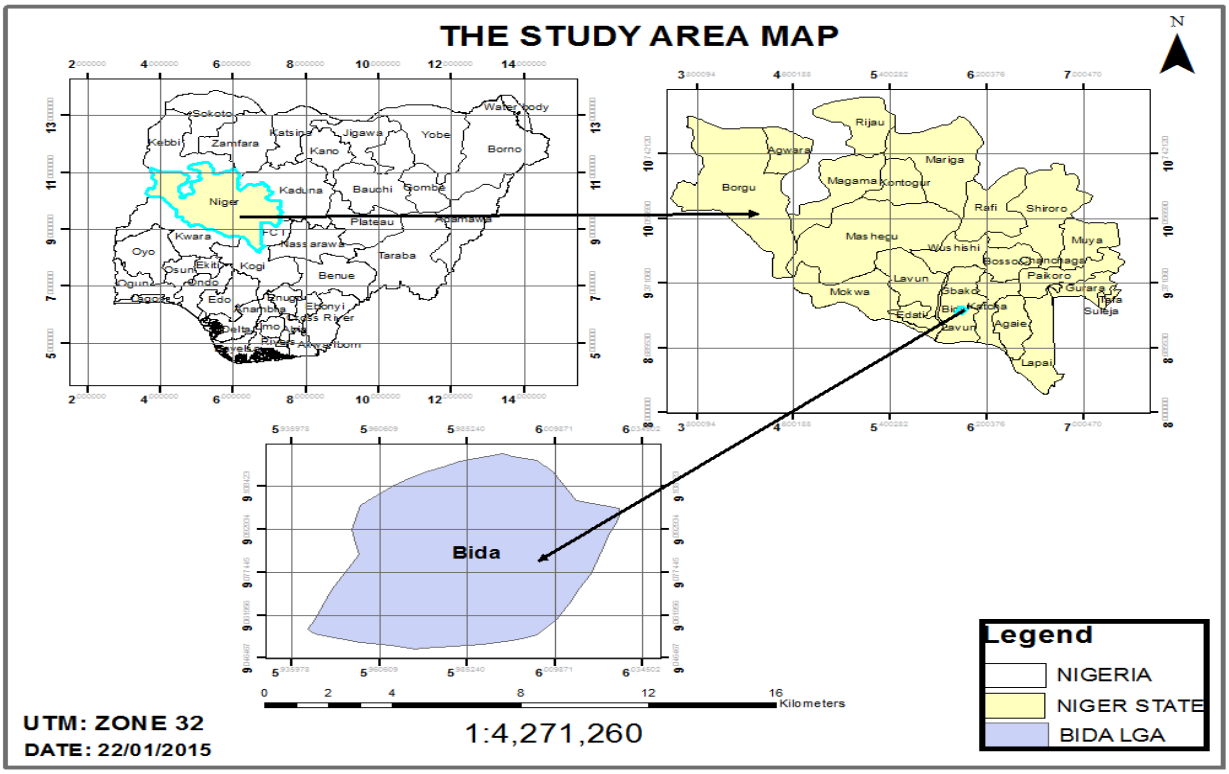

Figure 1, Bida **Source:** Author's work (2015)

4.0 Materials and Methods

The data used for this work were obtained from crucial primary and secondary sources. The primary data used was in form of an extensive personal field work carried out with a view to obtain a clear picture of an inventory condition and present thermal perception and identifying their ways of combating its negative effects.The secondary data used while embarking on this research work include; Weather data, journals, maps, past project works and relevant literatures, thesis etc.The dry and wet bulb temperature, vapour pressure and relative humidity data for a period of eleven years (2004-2014) were obtained from the Nigerian Meteorological Agency, (NiMET) Bida. The mean annual values were computed for the period under consideration.

Methods

Trend analysis and some indices were employed in analyzing the results using suitable charts in order to provide thoroughmonthly mean variations in human comfort of climatic conditions of Bida over the past eleven years (2004 to 2014). Temperature, relative humidity and vapour pressure data were fitted into the various analysis and indices.

Relative Strain Index: was used to examine the proportion of stressed and unstressed people. Relative Strain Index (RSI) is used to determine proportion of persons unstressed or distressed. RSI have been found to be readily suitable for Nigeria(Unger, 1999, Alessandro and de Garin, 2003) RSI take into account the effects of clothing insulation and net radiation. RSI for a "standard man" (i.e. healthy 25-year old male, un-acclimatized to heat, in business clothing) under specified conditions (i.e. internal heat production = 100Wm-^{2}, wind speed = 1ms-^{1} and no direct solar radiation) is given by the following

$$RSI = (t - 21) / (58 - e)1 \ldots\ldots 1$$

Where:

't' is the air temperature (°C)

'e' is the vapour pressure (kPa)

Table 1: The Relative Strain Index (RSI) classification

RSI	Proportion of Persons unstressed/distressed (%)

0.10	100 unstressed
0.20	75 unstressed
0.30	0 unstressed
0.40	75 distressed
0.50	100 distressed

Source: Adapted fromKyle (2008)

Human Thermal Comfort Index (HTCI): was used to assess the effect of temperature and relative humidity on human comfort**.** Bio-climatological indices are standard models used in determining heat stress quality within few kilometers of a given area. The microclimate of any area using human thermal comfort index (HTCI) is characterized with the levels of comfort to which it occurs at a particular time. Models develop for this often provides Physiological Equivalent Temperature (PET) in degrees centigrade. However through several applications, the Discomfort Index (DI) or scale has been successfully long time in use and observed to be one of the most suitable indices for Tropical Climate Zones among the known ones. Thom from the US weather Bureau development (2006) made use of such index in the study of heat stress within confines. The index is based only on two major weather parameters as expressed mathematically in the following equation:

$$DI = 0.4(Td + Tw) + 4.8 \quad \text{.....2}$$

Where $\boldsymbol{DI} = DiscomfortIndex in ℃$ $\boldsymbol{Td} = drybulbtemperature in ℃$

$$\boldsymbol{Tw} = Wetbulbtemperature in ℃$$

Thus, the levels of risk correspond to given heat stress were classified according to the temperature discomfort index ($\boldsymbol{DI}$) values as in Table 2.

Table 2: Classification of thermal environment according to ranges of discomfort Index

S/n	Di classification	Temperature discomfort index (di) in °c	Heat stress indications

1	No discomfort	DI<23	Safe
2	Under 50% population feels discomfort	23 ≤DI < 25	Heat fatigue is possible with prolonged exposure and activity
3	Over 50% population feels discomfort	25 ≤ DI < 27	Sunstroke and exhaustion are possible with prolonged exposure and activity
4	Most of population suffers discomfort	27 ≤ DI < 29	Sunstroke and exhaustion are at high-risk
5	Everyone feels severe stress	29 ≤ DI > 31	Sunstroke and heat Cramps are possible
6	State of medical emergency	DI ≥ 31	Sunstroke, heatstroke and heat confusion, or delirium is possible

Source: Adapted from Thom (2006)

5.0 Results and Discussion

Trend and Variation in Temperature and Relative Humidity in the Area

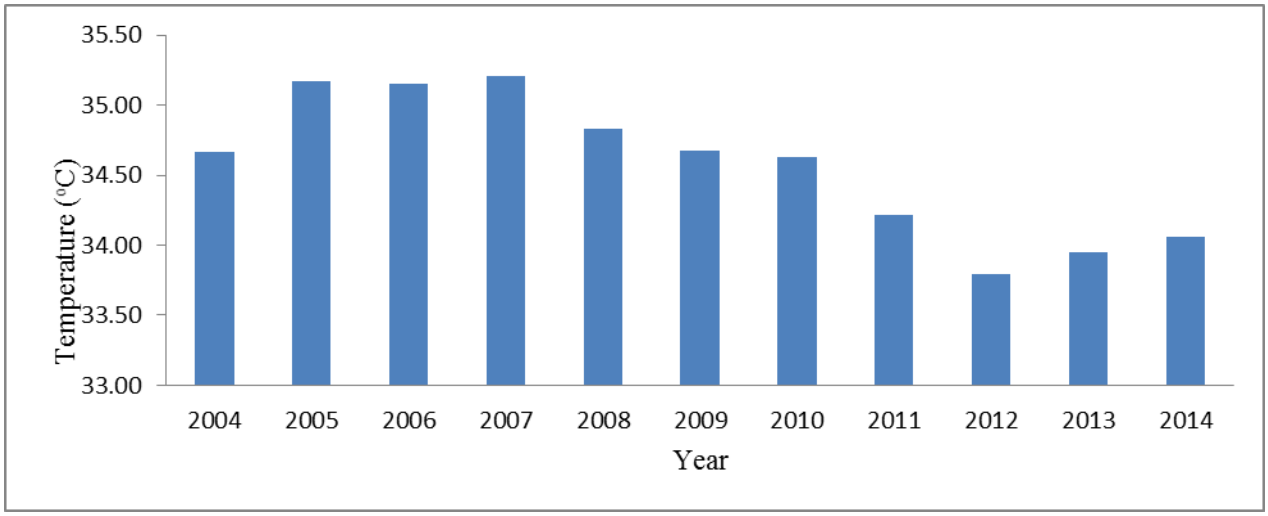

Figure 2: Mean Annual Temperature Distributions in Bida **Source:** NiMET Bida (2015)

Figure 2 indicate the pattern of average annual temperature between the periods of study 2004-2014 the lowest temperature observed was in the year 2012, while the highest temperature observed was in 2007. It is seen that temperature decreased between 2007 and 2012 and later started increasing.

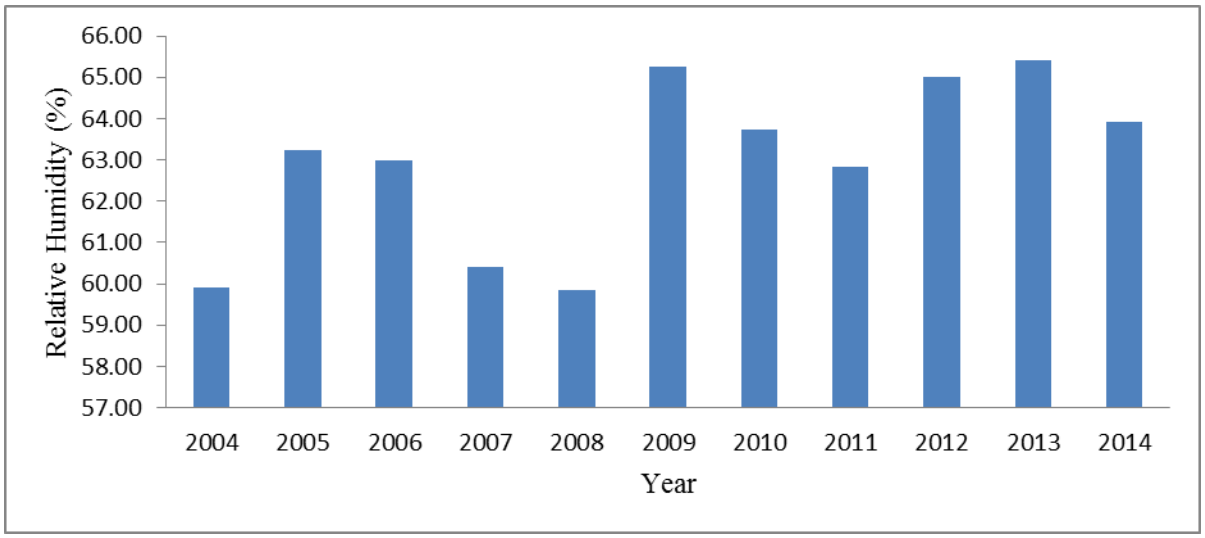

Figure 3: Average Annual Relative humidity in Bida **Source:** NiMET Bida (2015)

Figure 3 reflects the pattern of average annual relative humidity between the periods of study (2004-2014) the lowest relative humidity observed was in the year 2008, while the highest relative humidity observed was in 2013. It is seen that relative humidity decreased between 2005 and 2008 and later increased sharply till 2009 when it started decreasing till the year 2011, before it started increasing again till 2013 when it began to decrease till 2014.

Effect of temperature and relative humidity on human comfort

Table 3: Discomfort Index (DI) January to December (2004 -2014) in Bida

	Discomfort Index $(DI) = 0.4(Td + Tw) + 4.8$											
Years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	**DEC**
2004	27.60	29.60	31.04	30.48	28.00	27.04	26.60	26.00	26.48	27.60	29.88	**27.60**
2005	27.40	31.40	31.88	30.80	28.80	27.28	26.72	26.60	26.96	27.36	28.04	**27.60**
2006	29.08	30.80	31.04	31.24	28.28	27.64	27.16	26.24	26.68	27.80	27.52	**26.84**
2007	27.00	30.08	31.12	30.20	28.84	27.04	26.96	26.32	26.72	27.60	28.24	**27.84**
2008	26.76	29.20	31.36	30.28	29.04	27.52	26.40	26.20	26.44	27.36	27.92	**27.80**
2009	28.12	30.20	31.56	29.60	28.76	27.12	26.96	26.44	26.48	26.88	27.48	**27.32**
2010	27.96	30.48	31.32	31.20	29.20	27.60	26.32	26.28	26.56	27.16	29.40	**26.60**
2011	26.68	29.96	30.92	30.20	28.44	27.16	26.76	26.28	26.48	26.88	27.32	**26.44**
2012	28.16	29.92	30.92	29.60	27.16	26.72	25.84	25.84	25.92	26.92	28.16	**27.44**
2013	28.24	29.68	31.16	29.56	27.72	26.56	25.76	25.84	26.00	27.20	28.20	**27.48**
2014	28.00	29.64	30.68	29.28	27.96	27.20	26.80	26.04	26.20	27.08	28.00	**27.32**
Mean($\bar{x}$)	27.73	30.09	31.18	30.22	28.38	27.17	26.57	26.19	26.45	27.26	28.20	**27.30**

Source: Author's Computation (2015)

The mean monthly analysis of Discomfort Index (DI) for eleven years (2004 - 2014) obtained in Bida is presented in figure 4

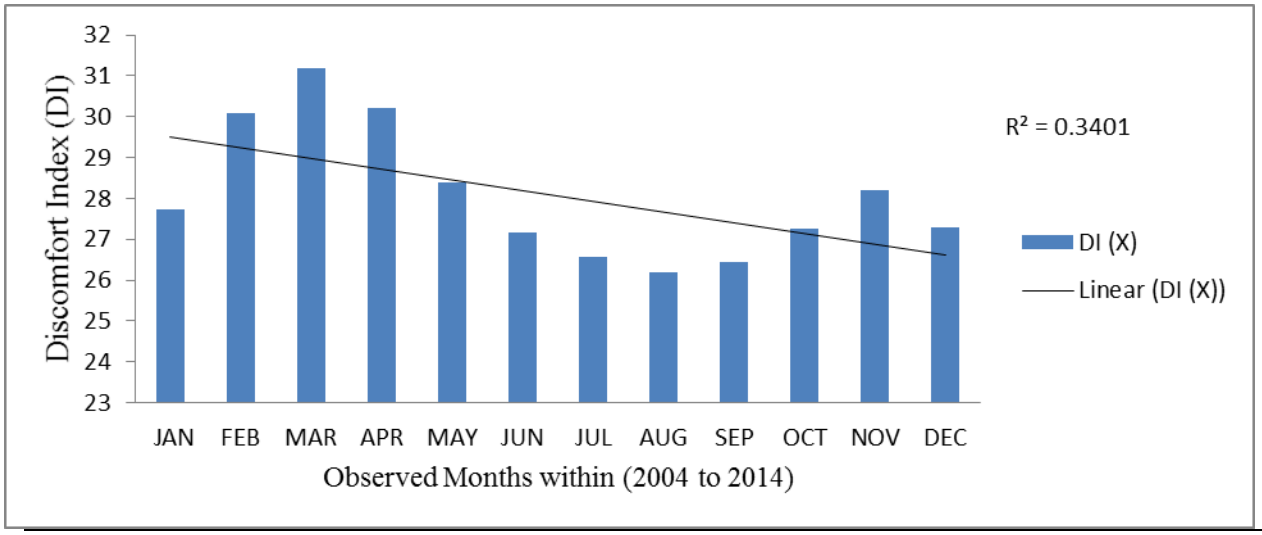

Figure 4: Monthly Mean Variations of Discomfort Index in Bida for the period (2004 - 2014)

Figure 4 shows that generally the environment of Bida, Niger State, human thermal stress increases from January to April and begins to attain maximum comfort through the months of June, July, August, and September, respectively while October, November and December are a little bit environmental harsh. There is a level of significance between the monthly mean of Discomfort Index and the months of the years observed($R^2 = 0.34$). However, the chart reveals what is likely to experience in Bida at any month of staying. Over 50% of population are likely to feel discomfort in the months of August, September and July respectively as their indexes fall between the range ($25 \leq DI < 27$) such that the environment could exposed them to the effects of sunstroke and heat exhaustions with prolong activity resulting into illness with fever, rheumatism, Eczema and often loss of consciousness among other risks are attached While the environmental level of exposure in the

months of June, October, December, January, November, and May (27 ≤ DI < 29) could to be a little bit at high risk compared to the aforementioned months and most of population suffers discomfort. Lastly, the months of February, and April produce the highest environmental discomfort respectively in Bida with Discomfort index of ranges (29 ≤ DI < 31) such that everyone feels severe stress; and the health implications which could be Sunstroke and heat cramps (painful involuntary muscular contraction, mental bar with bent ends for holding masonry). However, the month of March in Bida has discomfort index exceeding (DI ≥ 31) resulting into state of medical emergency for the period of eleven years of case study (2004 to 2014).

The proportion of stressed and unstressed people

The result in table 4 provides the monthly mean variation in proportions to the human thermal percentage of persons unstressed and distressed for the periods of eleven years (2004 to 2014) in Bida.

Table 4: Showing the Relative Strain Index (RSI) result for the months of January to December within (2004 to 2014) in Bida

Relative Strain Index$(RSI) = (t-21) / (58-e)$												
Years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	**DEC**
2004	0.33	0.37	0.42	0.50	0.44	0.39	0.34	0.31	0.35	0.42	0.45	**0.38**
2005	0.30	0.46	0.52	0.52	0.48	0.39	0.36	0.33	0.38	0.41	0.42	**0.37**
2006	0.42	0.46	0.47	0.51	0.45	0.42	0.38	0.32	0.37	0.45	0.37	**0.32**
2007	0.29	0.40	0.44	0.53	0.50	0.39	0.37	0.34	0.38	0.44	0.46	**0.38**
2008	0.28	0.35	0.49	0.50	0.48	0.40	0.34	0.33	0.34	0.41	0.40	**0.37**
2009	0.36	0.45	0.48	0.51	0.48	0.40	0.37	0.35	0.35	0.38	0.39	**0.36**
2010	0.36	0.45	0.45	0.53	0.50	0.41	0.33	0.33	0.34	0.38	0.44	**0.34**
2011	0.30	0.43	0.48	0.47	0.47	0.38	0.35	0.32	0.35	0.38	0.39	**0.31**
2012	0.37	0.43	0.42	0.48	0.39	0.36	0.29	0.28	0.32	0.46	0.45	**0.35**
2013	0.35	0.41	0.51	0.48	0.42	0.35	0.29	0.29	0.33	0.40	0.45	**0.35**
2014	0.36	0.38	0.47	0.48	0.43	0.39	0.35	0.30	0.33	0.40	0.42	**0.35**
Mean($\bar{x}$)	0.34	0.42	0.47	0.50	0.46	0.39	0.34	0.32	0.35	0.41	0.42	**0.35**

Source: Author's computation (2015)

The monthly mean analysis of eleven years RSI obtained through the result for the months of January to December are presented in figure 5 in graphical representation.

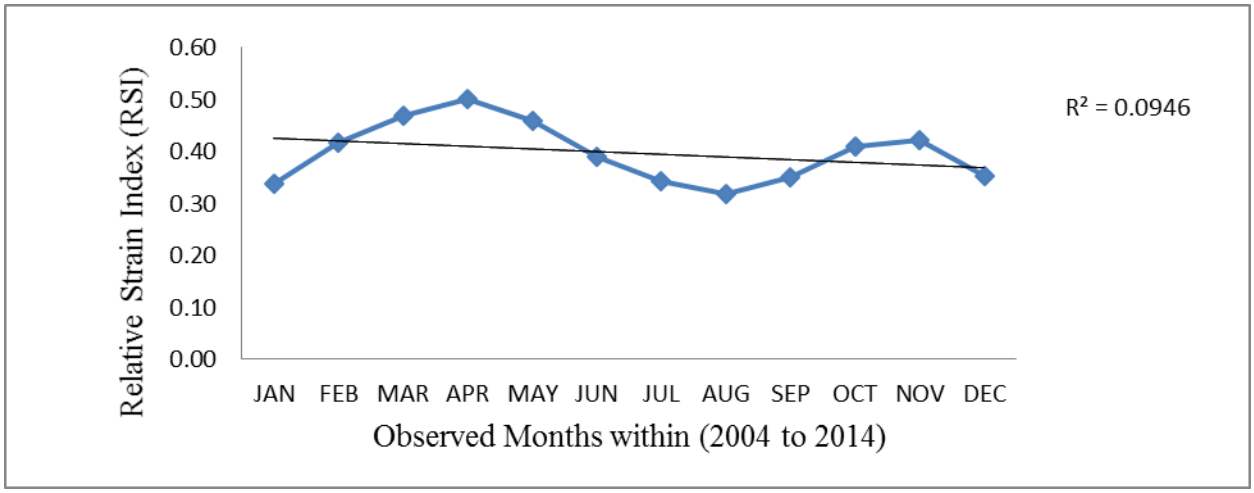

Figure 5: Monthly mean variations of Relative Strain Index (RSI) in Bida (2004 - 2014).

Figure 5 depicts an outcome of the mean monthly variation in human thermal discomfort. The Relative Strain Index (RSI) is proportional to the percentage of person(s) unstressed and distressed for the period of eleven years (2004 - 2014) in Bida Niger State. The chart however, shows a regression between the monthly mean variations in human thermal perception and the Relative Strain Index (RSI) with a high level of significance$R^2 = 0.09$.

The result obtained through the chart is interpreted as follows; note that value above 0.30 stress has started, but since the months of January, July, August, September and December falls within the RSI indication of about 0.34 where value less than 20% of the entire populations in Bida are stressed such could be as a result of decreases in the amount of vapour pressure moderate air temperature. In the months of February, June, October and November there is a greater increase in the degree of human discomfort since the RSI is about 0.40 in which almost 75% of persons were distressed, correlating with an increase in the amount of vapour pressure and air temperature. Furthermore, the months of March, April and May further increase in discomfort proportion to 100% while the months of produced the highest thermal discomfort with a very strong RSI of about 0.50 to which 100% of population in Bida were distressed. It also marks the months with the highest amount of vapour pressure and air temperature over the past eleven years of case study.

6.0 Conclusion and Recommendations

Thermal stress is known to reduce mental and physical efficiency of man. It therefore deserves more close study. Having achieved the aim of this work by adopting suitable Human Thermal Model (HTM) which include the Relative Strain Index (RSI) and Discomfort Index (DI) for heat stress evaluation in an attempt to keep environmental alertness and to offer use in regulating the needed measures to our thermally build up society. The main conclusion is that proportions of human thermal stress/comfort and related diseases in an environment are largely influenced by the degrees of air temperature, relative humidity and the vapour pressure amount at any particular time.

Finally, the bio-meteorological studies of this type are invaluable for societal concerned and support environmental health practitioners. Such studies are prerequisites to analysis both spatial and temporal pattern of diseases that are associated with human thermal comfort such as cerebral spinal meningitis and measles. This type of study will assist in timely intervention to avert and manage the consequence of the outbreaks of such diseases so as to achieve health Sustainable Development Goal (SDG) in the country.

Thermal human comfort can be characterized as a state of mental which communicates fulfillment with the thermal environment. Because of extensive varieties from individual to individual, it is hard to fulfill everybody thermal conditions within the same thermal environment. An average satisfying temperature that is needed to sustain human comfort is between $25 - 32℃$ as per the National Standard given by the Department of Occupational Safety and Health. However, to keep our environment Thermally Disaster Risk Free (TDRF) or reduction, the following recommendations are offered

I. Also education of migrants to new environment example if someone travelling from Lagos State going to Bida, Niger State needs to be educated of the experiences to encounter before going there. This will thus give such a person a psychological boost to face the strange experience with not much shock. Hence impress this productivity, since he has achieved a psychological thermal comfort even before entering a new place; (know the layer of cloth to wear and type of food to take).

II. Planting of Trees is exceptionally prescribed in other to offer advantages, for example, absorbing carbon dioxide, and different contamination. Trees additionally give shade and lessen ozone emanations from vehicles by planting numerous trees, we can cool the city thermal by roughly 10 degrees to 20 degrees, which will help diminishing ozone and helping groups that are for the most part influenced by the impacts of environmental change and micro-climatic thermal stress.

III. The government must review the master plan of Bida to cater for well defined environment through adequate spacing of structures that will allow free flow of low level winds that support atmospheric thermal reduction.

Finally, further projects or studies should be done for various locations so as to be able to predict their thermal state of health risk.

References

Abubakar, *et al* (2003).Physical setting of Niger State.

Adebunmi S.O (2002). Spectral Analysis of the Residual Magnetic Anomalies over the Lower Bida Basin, Nigeria Unpublished M.Tech. Thesis Federal University of Technology Minna.

Adepoju A.(1982). Population growth and urbanization. In *Population and Development*

Alessandro A, de Gar´ın A. (2003). A study on predictability of human physiological strain in Buenos Aires City. Meteorol. Appl. 10: 263–271

ASHRAE Standard 55. Energy Build; 34(6):549–61.

ASHRAE Standards 55-1992 (1992) Thermal environmental conditions for human occupancy.American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Brager GS, de Dear RJ (1998). Thermal adaptation in the built environment: a literature review. Build ;5(1):

Contemporary Climatology. *In Proceedings of COC/IGU Meeting*. 15–20 August. Masaryk University, Brno, Czech Republic,

de Dear RJ, Brager GS (2002). Thermal comfort in naturally ventilated buildings: revisions to Energy Build; 27:83–96.

Ethiopia. *Stud. Fam. Plan.* **1**: 288–301.

Gaborone, Botswana. *Int. J. Climatol.* **24**: 1307–1322. Kalkstein L, Smoyer K. 1993. The impact of climate change on human health: some international implications. *Experientia* **49**: 969–979.

Hassan M, Ullah, M. S., Gomes., C. D (2000). Rural housing in Bangladesh: An inquiry into housing typology, construction technology and indigenous practices, Village Infrastructure to cope with environment, S M Seraj, R L P Hodgson & K I Ahmed (eds). Pp.51-60.

in Nigeria, Orubulaye IO, Oyeneye OY (eds). Nigeria Institute of Social and Economic Research: Ibadan, Nigeria; 178.

in Zaria, northern Nigeria. *Res. J. Appl. Sci. Eng. Technol.* **3**(5): 399–402.
Jonsson P. (2004). Vegetation as an urban climate control in the subtropical city of
Kwast EB, Rochat RW, Kidane–Mariam W (1986). Maternal mortality in Addis Ababa,
Kyle (2008).Thermal environmental condition for human occupancy. Atlanta: American Society of Heating

Kyle W. 1994. The human bioclimate of Hong Kong. In Brazdil R, Kolar M.
National Population Commission (2010).2006 Population and Housing Census of the Federal Republic of Nigeria, Cross River State Priority Tables, Volume 1.

NFC (2003) Nigeria's First National Communication under The United Nations Framework Convention on Climate Change. The Ministry of Environment of the Federal Republic of Nigeria Abuja. Retrieved from http://unfccc.int/resource/docs/natc/nignc1.pdf last accessed 15 august 2015

NPC, 2006.National Population Estimates. National Population Commission, Nigeria.

Ojoye S and Yahaya T.I (2008). Micro climate analysis and its effect on human comfort**:** A case study of Minna Niger State**.** *Journal of Science, Education and Technology* (2) 27-32

Okpara, J. N., Kolawole, S. M., Gbuyiro, S. O. &Okwara, M. O. (2002): Investigating the Effects of Weather Parameters onthe Human Comfort and Discomfort of Inhabitants of Urban Environments of Akure, In Nigeria. *Journal of Nigerian Meteorological Society*, 3(3): 12-18.
Pauli, F. &Rizzi, L. (2005).A Statistical Approach to the Relationship between Temperature and Health of Local Population. EEE Working Paper Series, Number 22.
Pauli, F. and Rizzi, L. (2006), Statistical analysis of temperature impact on daily hospital admissions: analysis of data from Udine, Italy. Environmetrics, 17: 47–64. doi:10.1002/env.749

Plemenka S (1982). Vernacular architecture: a lesson of the past for the future. Energy
RCC web bulletin.

Sawa B, Buhari B. (2011). Temperature variability and outbreak of meningitis and measles
Thom, K., *et.al*. (2006). "*Zonal Weather analysis and Computational strategies"* from the US Weather Bureau development.

UNDP (United National Development Programme, 2007). Country-in-focus: Bangladesh. UNDP
Unger J. (1999). Comparisons of urban and rural bioclimatological conditions in the case of a central–European city. Int. J. Biometeorol. 43: 139–144

United Nations Population Fund, UNFPA (2007). The state of world population 2007: unleashing the potential of urban growth. UNFPA, USA.