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Original Research Article

Assessment of heatwave ıntensity and associated human responses in Kano Metropolis Northwestern Nigeria (2001-2020)

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ABSTRACT

There is an increasing concerned upon the increase in annual mean surface temperature over the years. The high increases in temperature brings about the occurrence of heatwaves especially in the tropical cities of the world including Kano. A research was conducted to assess the prevalence of heatwaves and associated human responses concerning its occurences between 2001-2020 in Kano metropolis, Northwestern Nigeria. Multi-stage sampling technique was applied from the eight local government areas of the metropolis while data concerning heatwaves occurrences were obtained from International Institute for Tropical Agriculture (IITA) data base. Self-designed questionaire was used as tool for collecting data on human responses to heatwaves in the area. The year 2020 experienced high intensity of heatwaves (consecutive 30days) with temperature of 41.7°C. The heatwaves occur mostly in April and May. The human responses to heatwaves in Kano metropolis showed that during heat wave period people experienced mental tiredness, uncomfortability for working, increased in heat related diseases, decreased in work productivity and increased spate of social upheavals. These therefore implied that, heat waves can be regarded as one of the factors that affect socio-econmic settings of the area negatively. Thus, there is the need of orienting people on the inherent dangers of heatwaves on human well being in the area.

Keywords: Heatwave; Human response; Kano metropolis; Nigeria

1. Introduction

Despite heat waves being one of the most common natural hazards experienced across the globe including African community, they remain imprecisely defined events with little understood varied impacts across different community sectors. The increasing availability of high-quality climate and weather-forecast temperature datasets offers an opportunity to build a shared understanding of the hazard posed by sequences of high temperature days.

Heat wave is a period of marked unusual hot weather (Max, Min and daily average) over a region persisting at least two consecutive days during the hot period of the year based on local climatological conditions, with thermal conditions recorded above given thresholds. It is a situation when the daily max temperature of more than five consecutive days exceeds the average maximum temperature by 5°C. Heatwaves cause severe damage to society and the environment [1,2] with impacts on human health, air quality, and Vegetation [3]. In 2003 European countries faced an unprecedented heatwave, which in turn caused unusually high ozone concentrations [4] and severe health problems, particularly in France, where 15,000 extra deaths occurred [5]. United Nations Environment Programme considers the European heatwave the world's most costly weather-related disaster in 2003. Impacts were exacerbated because the region was in a drought [6]. Heatwaves have a variety of direct, indirect, immediate, and delayed impacts, including

higher water loss via evapotranspiration, lower yields of grains and other agricultural products [7], increased energy consumption, a decrease in efficiency of power plants air pollution, and adverse effects on human health. Heatwaves have also contributed to an increase in the duration, size, and intensity of wildfires, causing economic losses and catastrophic environmental impacts [8].

Increased in heatwaves intensity may also cause lowering of water tables leading to emergence of recurrent droughts in the area, frequent bush fires, desertification, decreased in soil fertility which leads to the loss of agricultural products and subsequently increase the risk of death and serious illness especially in younger and older age groups and the urban poor who constituted a large sector of the population [7]. This means that, metropolitan Kano is at risk of heatwaves due to high population density of the area, rapid urbanization and it is the most growing urban center in Nigeria. This study therefore aimed at assessing the intensity of heatwave and related human responses in the study area.

2. Material and Methods

2.1. Study area

Metropolitan Kano encompasses eight Local Governments of Dala, Fagge, Gwale, Municipal, Nassarawa, Tarauni, Kumbotso and Ungogo. It lies from Latitudes 11º52`N to 12º7`N and Longitudes 8º 22.5`E to 8º 47`E and is 500 metres above sea level

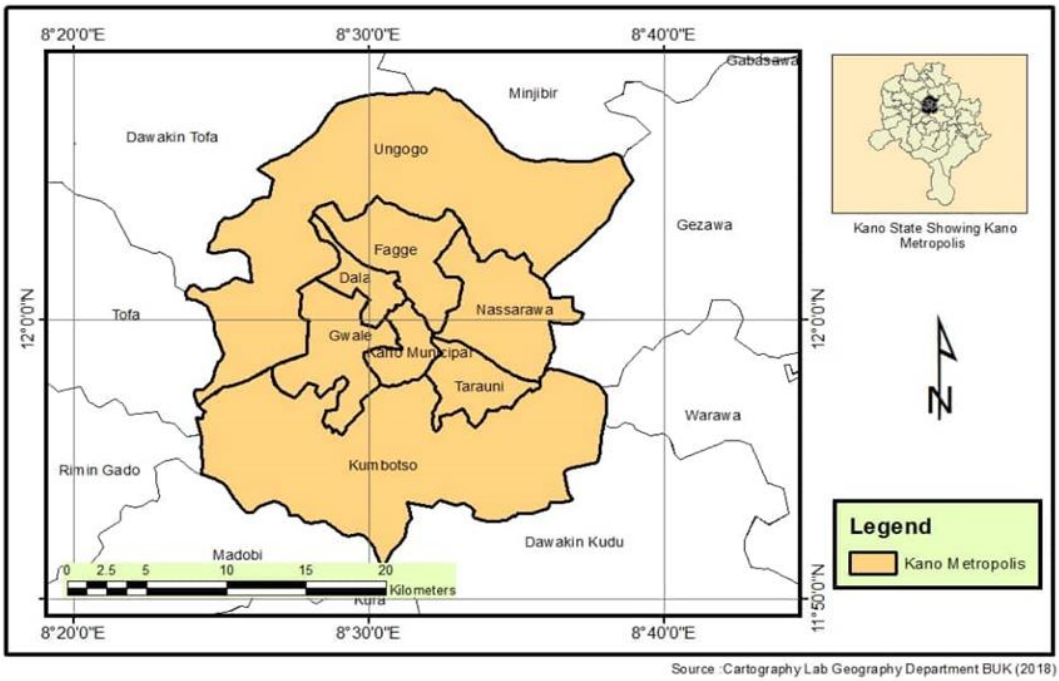

Figure 1. Map of study area

2.2. Research design

Both quantitative and qualitative data were used as described by [9]. The primary source of data was obtained through the use of structured questionnaire, while the secondary data was sourced from Nigeria International Institute of Tropical Agriculture Data base.

For these reasons, this work had analyzed 20 years of daily maximum temperatures and mean monthly maximum temperatures data as the climate base period. The data obtained in this study was split into four seasons in order to determine the high heatwave intensity, duration and frequency in the study area. Percentiles were used in favor of maximum temperature values as stated by [10]. A heatwave event occurred if it satisfied these criteria: maximum temperature ≥ 95th percentile of the maximum temperature for the month in which the heat wave begins for a minimum of 3 consecutive days.

Data from human responses were collected using self-designed questionnaires. The questionnaires were distributed within the metropolis.400 respondents as required by Research Advisers Table (RAT) for determining sample size. Multi-stage sampling technique was applied from the eight local government areas of the metropolis. Five local governments areas were selected in the first stage using random sampling these includes Dala, Gwale, KMC, Ungoggo and Kumbotso. Then smaller unit or wards were also selected in the second stage using systematic sampling. Four wards were selected from each of the core Local government areas (Dala, Gwale, Kano municipal) and three other wards from each of the sub-urban metropolitan (Ungoggo and Kumbotso) as shown in Table 1.

Table 1. Sampled local governments and wards

LGA	Selected Wards	Number of Questionnaires Administered	Percentage
Dala	Dandinshe	27	8.3
	Madigawa	27	8.3
	K/Mazugal	27	8.3
	Yalwa	27	8.3
Gwale	Diso	27	8.3
	Dorayi	27	8.3
	Goron Dutse	27	8.3
	K/Na`isa	27	8.3
Kano Municipal	Sharada	27	8.3
	Yakasai	27	8.3
	Alfindiki	27	8.3
	Gandun Albasa	27	8.3
Ungoggo	Rijiyar Zaki	29	16.7
	Rangaza	29	16.7
	Zango	29	16.7
Kumbotso	Mariri	29	16.7
	Guringawa	29	16.7
	Panshekara	29	16.7
Total	**18**	**498**	**200**

Source: Field Work, 2020

The respondents were selected from the diversity of occupations and classified according to age; sex and educational background to assess the responses of the inhabitants to the heatwave menace.

3. Results and Discussion

3.1. Mean monthly maximum temperature and heat wave occurrences from 2001-2010

Table 2 indicates that the highest number of days with the occurrences of heatwaves were found in April, 2007, 2008 and 2009 with 10 days each. These were followed by March, 2005 and 2006 and May, 2007 with 8 days each. The least number of days in which heatwave occurred during this decade were April, 2001, 2002, 2004 and 2006 then May, 2002, 2003, 2004, 2005, 2006 and 2008. The remaining months did not experience heatwaves. Thus, more heatwaves were experienced in the months of April followed by May and March. The duration of the heatwaves lasted between 5 to 10 days between 2002 to 2009. This is in conformity with the work of [11] who reported that the number of days in which heatwaves occurred in Kano in 2002 were 8 days. This implied that Kano, since 1993, had been experiencing longer heatwave scenarios than past years due to the increasing length of heatwaves duration.

Table 2. Mean monthly maximum temperature and heatwave occurrences in Kano Metropolis 2001-2010 (Threshold at 95th Percentile)

Decade Mean Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2001-2010	28.8	32.2	36.7	39.2	36.7	35.7	32.7	30.8	31.9	34.2	33.5	30.3	No. of Heatwave
2001	Nil	Nil	Nil	5days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	5
2002	Nil	Nil	Nil	5days	5days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	10
2003	Nil	Nil	Nil	7days	5days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	12
2004	Nil	Nil	Nil	5days	5days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	10
2005	Nil	Nil	8days	6days	5days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	19
2006	Nil	Nil	8days	5days	5days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	18
2007	Nil	Nil	Nil	10days	8days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	18
2008	Nil	Nil	Nil	10days	5days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	15
2009	Nil	Nil	Nil	10days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	10
2010	Nil	Nil	Nil	9days	9days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	18
No. of Heatwave days													135

Source: I I T A and Field Work, 2020

Table 3 reveals spectacular out comes and the most highest decade with 22 to 30 days of heat wave occurrences which were found most especially in March 2020, April 2020 and May 2020. This is followed by April 2016 and 2018 with thirteen (13) days and April and May of 2011 with ten (10) days heat wave occurrences. The least number of days to which heat wave occur during this decade are March of 2014 and 2016 then April of 2014 and May of 2012 and 2014 with five (5) days of heat wave occurrences. Whereby no heat waves is experienced in the remaining months. Similarly, more heatwave occurrences were experienced in the months of April followed by May and then March. The occurrence of a maximum of 22-30 consecutive days of heatwaves in Kano in 2020 is in conformity with the finding of [7] who reported 15-20 days of consecutive days of heatwaves in Iran. More so, examining the seasonal frequency of heat waves during the study period indicated that the short-term heatwaves were more frequent than long-term heat waves.

3.2. Socio-demographic characteristics of respondents

The result of the socio-demographic characteristics of the respondents is presented in Table 4. The result showed that the respondents were mostly within the age range of 30-49 years and are mostly males (81.25%). This may be attributed to the fact that these age groups are the most available and the males show high responses to heatwaves than females (Fildwork, 2019). This finding agrees with that of [12] who reported that male members of a household were more likely to adapt to heatwave than the female counterparts in terms of reduced work hours and avoiding work during heatwaves. The socio-economic setting of the respondents in terms of marital status shows 66.7% were married, while educational

achievement reflects 85.5% had finished secondary school. The respondents that finished secondary schools or tertiary institutions, who were married and with a good sources of incomes adapt to heatwaves much better than the other remaining groups. This group of people mostly live in sandcrete buildings, (80.25%) with cooling facilities ranging from local fans, (54.25%); electric fans, (38.0%) to the use of air conditioners (7.75%). This finding corroborates with that of [8] who reported socio-demographic factors as influencing adaptation to heatwaves. The high vulnerability of the agricultural sector to climate change affects women disproportionately as a larger percentage of women are house wives or poor farmers who rely on their husbands income or small-scale and rain-fed agriculture [13]. Women are also more dependent on natural resources, as they are primarily responsible for gathering fuel wood for cooking and heating, collecting the household water supplies, and ensuring food security for the family.

Table 3. Mean monthly maximum temperature and heat wave occurrences from 2011-2020 in Kano (Threshold at 95th percentile)

Decade Mean Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2009-2018	29.7	34.1	37.8	41.7	38.6	35.2	31.9	30.3	32.2	34.8	34.1	30.3	No. of Heatwave
2011	Nil	Nil	Nil	10days	10days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	20
2012	Nil	Nil	Nil	7 days	5 days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	12
2013	Nil	Nil	Nil	8 days	6 days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	14
2014	Nil	Nil	5days	5 days	5 days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	15
2015	Nil	Nil	7days	6 days	6 days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	19
2016	Nil	Nil	5days	13days	8 days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	26
2017	Nil	Nil	Nil	9 days	6 days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	15
2018	Nil	Nil	Nil	13days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	13
2019	Nil	Nil	8days	14days	7days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	27
2020	Nil	Nil	22days	30days	25days	Nil	Nil	Nil	Nil	Nil	Nil	Nil	77
No. of Heatwave days													238 days

Source: I I TA Field work, 2020

Table 4. Socio-Demographic characteristics of respondents

Parameters	Option	Frequency	Percentage	Total
Age	20-29 Years	12	3.0	
	30-39 Years	219	54.75	
	40-49 Years	142	35.50	
	50-59 Years	23	5.75	
	60 Years to Above	4	1.0	400
				100
Gender	Male	325	81.25	
	Female	75	18.75	400
				100
Marital Status	Married	267	66.75	
	Single	125	31.25	
	Divorced	8	2.00	
	Widow/Widower	0	0.00	400
				100
Educational Status	Non Formal	0	0	
	Primary	3	0.75	
	Secondary	342	85.50	
	Tertiary	55	13.75	400
				100
Occupation	Civil Service	228	57	
	Business	70	17.5	
	Unemployed/Student	89	22.25	
	House Wife	13	3.25	400
				100
House Type	Traditional Mud House	79	19.75	
	Modern Bricks House	321	80.25	400
				100
Housing Cooling Facility	Air-conditioners	31	7.75	
	Electric Fans	152	38.0	
	Local Fans	217	54.25	
	Others	0	0	400
				100

Fildwork, 2020

3.2.1. Period of heatwaves severity

The result of the responses pertaining to periods of heatwave occurrences in the study areas is shown in Table 5. The result revealed that heatwaves intensity was more pronounced during the hot and dry season, (89.5%) corresponding to the days in April and May. This finding is in conformity with that of [11] who reported constant heatwave amplitude and mean magnitude condition over the years in Kano in April and May of 1987 and 2005. It was also found that the heatwave, during these periods, were more intense around 3:00pm and 12:00am daily. This may probably be attributed to the tropical nature and position of the area in relation to the sun [14]. Further reported that since 1993 [11], Kano has been experiencing longer heatwave scenario than past years due to the increasing length of heatwave durations.

3.2.2. Factors contributing to the occurrence of heatwaves

The variation of heatwaves within the three decades (Table 6) may be attributed to increased deforestation activities, (92.75%); air pollution by high consumption of fossil fuel due to power failure, (97.0%); increased rate of urbanization (Land use changes), (75.25%) and industrialization/ automobile emission (100%). This finding corroborates with that of [15] who reported that factors such as soil moisture and aerosols are responsible for extreme temperatures in Nigeria. They suggested that, during day time, heat was supplied by large scaled horizontal advection, warming of an increasingly desiccated land surface and enhanced entrainment of warm air into the atmospheric boundary layer. Overnight, the heat generated during the day was preserved in an anomalous kilometers deep atmospheric layer located several hundred meters above the surface, available to re-

enter the atmospheric boundary layer during the next diurnal cycle. This results in progressive accumulation of heat over several days, which enhance soil desiccation and lead to further escalation in air temperatures. They further stressed that the Sahara Desert, which is associated with atmospheric blocking patterns, is a requirement for the cause of high atmospheric pressure in the the northern part of Nigeria, consequently resulting to high temperatures in the extreme northern part of the country.

Similarly, increased rates of urbanization and high use of fossil energy cause increases in oxides of Carbon and Sulphur as well as other aerosols to accumulate in the atmosphere and reflect some incoming solar radiation (shortwaves) tending to cool the earth surface, but they trapping some heat leaving the earth surface, causing warming of the surface. This effect, known as cloud radiative forcing, play a key role in temperature variations on the surface as reported by [15]. It is a known fact that, temperature increase, with decreasing cloud cover, as a result of evapotranspiration in the atmosphere. Clouds rarely occur in the study area except during rainy seasons. Temperatures go high, since there was no mechanism to prevent the incoming solar radiation from reaching the surface. The situation becomes worst during summer seasons when there were no clouds. The aerosols that do occur in the region are dust, haze, which are drier. As such, they do not reflect the incoming solar radiation, instead, they absorb it, get warmer and release the warm air to the surface. They also trap the outgoing radiation and reflect it back to the surface, acting as greenhouse mechanism making the surface becoming warmer and warmer. Consequently, the surface temperatures rise to the extremes. If the situation last longer, it then becomes heatwaves, especially during summer, as stressed by [15].

Table 5. Period of heatwave severity

Parameters	Seasons	Excessively Hot	Severity Hot	Moderately Warm	Cool	Total
Period in order of severity of heatwave	Hot and Dry (April)	358 (89.5%)	42 (10.5%)	0 (0.0%)	0 (0.0%)	400 100%
	Warm and Wet (August)	0 (0.00%)	310 (77.5%)	86 (21.5%)	4 (1%)	400 100%
	Warm and Dry (October)	0 (0.0%)	276 (69%)	113 (28.25%)	11 (2.75%)	400 100%
	Cool and Dry (December)	0 (0.0%)	0 (0.0%)	17 (4.25%)	383 (95.75%)	400 100%
		6 am	**3 pm**	**6 pm**	**12 am**	
Hours in order of decrease in heat loads	Hot and Dry (April)	0 (0.0%)	302 (75.5%)	0 (0.0%)	98 (24.5%)	400 100%
	Warm and Wet (August)	0 (0.0%)	245 (61.25%)	35 (8.75%)	120 (30%)	400 100%
	Warm and Dry (October)	0 (0.0%)	220 (55%)	87 (21.75%)	93 (23.25%)	400 100%
	Cool and Dry (December)	0 (0.0%)	382 (95.5%)	18 (4.5%)	0 (0.0%)	400 100%

Field work, 2020

Table 6. Factors contributing to the occurrence of heatwaves

Factors	Strongly Agree	Agree	Disagree	Strongly Disagree	Total
Pollution	327 (81.75%)	61 (15.25%)	12 (3%)	0 (0.0%)	400 (100%)
Land-use changes	62 (15.5%)	239 (59.75%)	78 (19.5%)	21 (5.25%)	400 (100%)
Industrialization/Automobile emission	361 (90.25%)	39 (9.75%)	0 (0.0%)	0 (0.0%)	400 (100%)

Source: Field Work, 2020

3.2.3. Prevalent diseases during heatwave periods

The result for diseases associated with heatwave is presented in Table 7. The result showed that during the period of heatwave occurrence (Hot and dry season) Meningitis occur more frequently with a prevalent rate of 51.25%, followed by heat cramps, with prevalence rate of 37.5% and heat exhaustion with 6.50%. The result indicated that heat related diseases occur more frequently during April and May. This finding agrees with the previous work of [16] and [17] who individually reported temperature extremes as factor that can affect physiological functioning, mood behavior and workplace productivity, especially amongst outdoor workers. They associated heatwaves to heat cramps, heat syncope, heat exhaustion, heat stroke and possible death. Similarly,

[18] also examined the impacts of prolong extreme heat exposure and high hospital admissions for cardiovascular, respiratory and cerebrovascular diseases. These heatwaves related diseases were also grouped in a single nosologic entity, heat diseases, respiratory diseases and circulatory diseases by [19].

The issue of heatwave related diseases is not popular in Nigeria, even though it exists but due to paucity of information and high cost of radiation measuring equipments is not easily selected as suggested by [20]. Efforts have not been made in Nigeria to geographically examine the frequency, intensity, nature and areal extent of extreme heatwaves and establish a cause and effect relationship between prolonged exposure to heatwaves and hospital admission for cardiovascular, respiratory, cerebrovascular diseases, heat stroke and possible deaths. [21] reported that Nigeria is lagging behind on this vital research. The replacements of natural water channels and path for concrete surfaces have led to urban heat island effects hitting the entire country. Heatwaves are linked to a number of issues that directly affect health. There is the need for more studies on the nexus between heatwaves and health, as it affects the generality of ambient population. There is, therefore, a relationship between heatwaves and mortality in developing countries as reported by [21] and [22].

Several studies have related heatwaves to mortality and heatwave related diseases. The European heatwave of August, 2003 caused total deaths of about 35000 people, with more than 14,800 deaths in France alone [22]. According to a report of Japanese Ministry of Environment, deaths due to heat stroke during the unusually hot summer in 2010 amounted to 1745 people [23]. Deaths were also reported in India due to heatwaves over the years. The heatwaves of 1988 caused an estimated number of 1300 deaths [24]. According to EM-DAT [25] the international disaster database has shown that the heatwave of 2015 caused the death of 2248 people in various parts of India. The heatwaves over India are projected to be more intense and occur more frequently in future [26]. Therefore, the 150 mysterious deaths that occurred in Kano in April, 2020 reported by [1] assumed to be linked with Covid-19 may probably be associated to the heatwave occurrence. Although the authorities concerned related the episode to Hypertension, Diabetes, Meningitis and Acute malaria. [27] have also linked weather to mortality, even though the role of such critical factors as regional variations, susceptible populations and acclimatization remain unresolved. Similarly, [28] ascribed high morbidity and mortality in Adelaide to heatwaves. Unusual high summer temperatures raise power demands for air conditioning, increase heat stress on crops and may create dangerous conditions for human health [29]. Episodes of extremely high temperatures, especially in conjunction with water shortages damage plants [30].

Table 7. Prevalent diseases during heatwave periods

Seasons	Heat cramp	Heat exhaustion	Rashes	Painting	Catarrarh	Meningitis	Total
Hot and Dry (April)	150 (37.5%)	26 (6.5%)	4 (1%)	12 (3%)	3 (0.75%)	205 (51.25%)	400 (100%)
Warm and Wet (August)	125 (31.25%)	42 (10.5%)	2 (0.5%)	7 (1.75%)	26 (6.5%)	198 (49.5%)	400 (100%)
Warm and Dry (October)	92 (23%)	30 (7.5%)	36 (9%)	4 (1%)	84 (21%)	154 (38.5%)	400 (100%)
Cool and Dry (December)	0 (0.0%)	2 (0.5%)	128 (32%)	0 (0.0%)	227 (56.75%)	43 (10.75%)	400 (100%)

Soruce: Field Work 2020

3.3. Human responses to heatwaves

Table 8 revealed respondents' perception on what heatwave is all about. The result indicated that 91.0% of the subjects perceived heatwave as a period of severe heat sensation anomaly that causes severe physiological discomfort. This heatwave sensation makes 89.25% of the respondents uncomfortable and mentally tired (10.75%). Majority of the subjects (71.25%) experienced one form of heat related disease or the other. They ascribed infants (57.0%) and old aged (47.75%) as the most vulnerable and heatwave affected groups in the study area. The result also revealed the period of heatwave as non-conducive for work, while respondents' knowledge about heatwave stemmed from the media, academic institutions and the internet. This finding is in conformity with that of [29] who reported that television as the first choice in finding out information about extreme heat advisories in three American cities.

3.3.1. Impacts of heatwaves on socio-economic settings

The result for the impacts of heatwaves on socio-economic setting of respondents is shown in Table 9. The result indicated that densely populated, (69%) and industrial areas (29.25%) of the study area were areas most affected by heatwaves. Majority of the respondents, (91.5%) associated heatwaves to climate change phenomenon and that heatwaves influence work productivity. Moreso, majority of

the subjects, (90.25%) opined that heatwaves were linked to social unrest and, consequently, threaten public health. Heatwaves are associated with high population density, especially in industrial areas, due, probably to the relative formation of greenhouse gases. This finding is in agreement with that of [31].

Table 8. Human responses on heatwaves

	Frequency/Percentage				**Total**
Heatwave perceived as period of severe heat sensation anomaly which causes severe physiological discomfort.	Strongly Agree	Agree	Disagree	Strongly Disagree	
	193 (48.25%)	171 (42.75%)	4 (1%)	32 (8%)	400 (100%)
Feelings during the period of severe heat.	Mentally tired	Uncom-fortable	Happy	Same	
	43 (10.75%)	357 (89.25%)	0	0	400 (100%)
Knowledge about heatwave.	Media	Internet	Academic institution	Personal experience	
	210 (52.5%)	70 (17.5%)	104 (26%)	16 (4%)	400 (100%)
Seasons that are more comfortable for occupations.	Hot and dry	Warm and wet	Warm and dry	Cool and dry	
	15 (3.75%)	20 (5%)	165 (41.25%)	200 (50%)	400 (100%)
Season very uncomfortable for working.	Hot and dry	Warm and wet	Warm and dry	Cool and dry	
	252 (63%)	97 (24.25)	45 (11.25%)	06 (1.5%)	400 (100%)
Seasons experiencing heat related diseases.	Hot and dry	Warm and wet	Warm and dry	Cool and dry	
	285 (71.25%)	75 (18.75%)	40 (10%)	0 (0%)	400 (100%)
Group of people most affected by heatwave.	Infants	Teenagers	Youth	Old-Aged	
	228 (57%)	05 (1.25%)	00 (0%)	167 (41.75%)	400 (100%)

Source: Field work, 2020

Table 9. Impacts of heatwaves on socio-economic settings

Respondents	**Frequency (Percentage)**				**Total**
Area in Kano metropolis affected most by heatwaves.	Densely populated	GRA	Industrial areas	Institutional Land	
	276 (69%)	00 (0%)	117 (29.25%)	07 (1.75%)	400 (100%)
Heatwave linked to climate change phenomenon	Strongly Agreed	Agreed	Strongly Disagreed	Disagreed	
	253 (63.25%)	113 (28.25%)	24 (6%)	10 (2.5%)	400 (100%)
Heatwave influences work productivity.	Strongly Agreed	Agreed	Strongly Disagreed	Disagreed	
	247 (61.75%)	117 (29.25%)	16 (4%)	20 (5%)	400 (100%)
Heatwave linked to social unrest.	Strongly Agreed	Agreed	Strongly Disagreed	Disagreed	
	258 (64.5%)	103 (25.75%)	28 (7%)	11 (2.75%)	400 (100%)
Heatwave linked to public health issues	Strongly Agreed	Agreed	Strongly Disagreed	Disagreed	
	270 (67.5%)	125 (31.25%)	03 (0.75%)	02 (0.5%)	400 (100%)

Source: Field work, 2020

3.3.2. Mitigation of Heatwave

Several strategies were device in mitigating the effects and occurrence of heatwaves (Table 10). Several (95.25%) agreed that heatwaves can be mitigated via orientation exercise through print and electronic media, while only 4.75% disagreed. Similarly, 94% of the respondents agreed that interventions by the governmental and non-governmental Organizationsplay a significant role in curbing the effects of heatwaves in the study area. Another 96.25% of the respondents agreed that afforestation programs a vital role in curbing the effects of heatwaves. This finding is in conformity with the report of the National Disaster Management Authority Government of India, (2016) who reported the use of print and electronic media, interventions by the governmental and non-governmental organizations

and afforestation programs as major strategies in combating the occurrences of heatwaves.

Furthermore, 94.5% of the respondents held the view that inculcating the knowledge of the effects of heatwave in schools' curricula may help in its mitigation, while 5.5% of the respondents disagreed. The method of inculcating the knowledge of the effects of heatwaves in schools' curricula may provide firsthand information to the general public on the dangers associated with heatwaves and possible methods of avoiding the effects.

Items	Strongly Agreed	Agreed	Strongly Disagreed	Disagreed	Total
Orientation exercise via print and electronic media can help in reducing effect of heatwave	275 (68.75%)	106 (26.5%)	17 (4.25%)	03 (0.5%)	400 (100%)
Governmental and non-governmental organizations can help in curbing the effect of heatwave	265 (64%)	120 (30%)	17 (4.25%)	07 (0.75%)	400 (100%)
Inculcating the knowledge of the effects of heatwave in schools' curricula can help in its mitigation	258 (64.5%)	120 (30%)	20 (5.0%)	02 (0.5%)	400 (100%)
Relocation of industrial areas away from the metropolis can help to reduce the effect of heatwave.	265 (66.25%)	120 (30%)	10 (2.5%)	07 (1.25%)	400 (100%)
Afforestation programs can also be help as mitigation measures.	265 (66.25%)	120 (30%)	17 (4.25%)	00 (00%)	400 (100%)

Sources: Field work, 2020

4. Conclusion

The aim of this work is to study heatwaves (HWs) in Kano metropolis, because numerous deaths have been reported in this region, which are caused by heatstroke. Heat waves have been a part of extreme weather events, which cause enormous losses in terms of lives, human discomfort and ailments arising out of them. This study describes the heat wave intensity and public responses in Kano metropolis. Because of the loss of life, damage to crops and vegetation in general and the impact on water supplies, these recent heat waves have stimulated much interest in their climatological features whether they are a portent of greenhouse induced climatic change. Over much of the province, there is significant evidence of increases in the intensity of heat waves events between 2007, 2008 up to 2020.

It was concluded that, the two decades extreme temperatures measurement across the seasons from 2001 to 2020 of Kano metropolis showed 19 and 30 days of consecutive heatwaves in 2020 with extreme temperature of 41^{o}C – 41.7^{o}C. The periods (months) of heatwave occurrences across the years in Kano metropolis were March, April and May. The human responses to heatwaves in Kano metropolis showed that during heat wave period people experienced mental tiredness, uncomfortability for working, increased in heat related disease, work productivity and increased spate of social upheavals.

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Authorship contribution statement for Contributor Roles Taxonomy

Aminu Hamisu Auwal: original draft and Investigation.
Nura Isyaku Bello: Methodology and Data Collection.
Muhammad Alhaji: Conceptualization and Supervision.
Kamaluddeen Abubakar Baba: Methodology and Data Analysis.

Conflict of interest

The author(s) declares that he has no conflict of interest.

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