Journal of Geography and Earth Sciences
June 2014, Vol. 2, No. 1, pp. 55-77
ISSN: 2334-2447 (Print), 2334-2455 (Online)

Published by American Research Institute for Policy Development

Assessment of Urban Heat Island (Uhi) Situation in Douala Metropolis, Cameroon

Enete, I.C,[1] Awuh, M.E[2] and Ikekpeazu, F.O[3]

Abstract

The microclimate variations at several sites in Douala Metropolis were evaluated using paired measurement programme (PMP). The study investigated the spatial extent of urban heat island (UHI) in the city. Temperature varied between land-use and land –cover within the city. Result revealed that a downtown centred heat island was observed at night in both dry and rainy seasons; while there was a mix of cool and heat islands by day especially during rainy seasons. The daytime variations were strongly correlated to the amount of tree shading. During the night, city climate was highly correlated to sky-view factors and thermal properties in Douala Metropolis. It was observed too that temperature gradient was formed at the Central Business District (CBD) in both day and night and progressively lowered to the suburbs.

1.1 Background Of The Study

The urban heat island (UHI) has become one of the largest problems associated with the urbanization and industrialization, as the increased temperatures associated with the UHI tend to exacerbate the threats to human health posed by thermal stress (EEA,2010). UHI has been a central theme among climatologists, and it is well documented in many metropolitan areas around the world (Oke, 1973).

UHI as experienced by many cities is larger at night than during the day, more pronounced in winter than in summer, and is most apparent when winds are weak (Oke, 1982; Adina et al., 2009; Enete et al.,2012).

[1] Dept. of Geography & Meteorology, NAU, Awka, Nigeria.
[2] Dept. of Geography, University of Buea, Cameroon.
[3] Dept. of Architecture, NAU, Awka, Nigeria

UHI effect increases the possibility of the formation of smog created by photochemical reactions of pollutants in the air. The formation of smog that is highly sensitive to temperatures since photochemical reactions are more likely to occur and intensify at higher temperatures (Taha, 1997). Atmospheric pollution can be aggravated due to the accumulation of smog. The UHI effect also increases the hazard of heat stress related injuries which can threaten the health of urban dwellers (Ebi et al., 2004; Hajat et al., 2010; Barredo, 2009; Mathies et al., 2008 ; Enete et al., 2013). Higher temperatures in cities also increase cooling energy consumption and water demand for landscape irrigation. The peak electric demand will be increased as well. As a result, more electrical energy production is needed and this will trigger the release of more greenhouse gas due to the combustion of fossil fuel (EEA, 2012).

Growing concern for the future of cities and for the well-being of city dwellers, stimulated by trends in world urbanization, the increasing number and size of cities, and the deterioration of many urban environments, has focused attention on the problems of living in the city (Enete and Okwu, 2013). Citizens in cities around the world want clean air, clean water, reduced noise, more vegetation and protection of habitat areas, and safety. These are all seen as contributing not only to their health but also to the quality of life. In urban areas, there is an "urban heat island" effect resulting from the production and accumulation of heat in the urban mass. So, how will UHI affect the cities of the future?

Increasing urbanization and industrialization in Douala metropolitan area has in recent decades caused the urban environment to deteriorate. Douala suffers from raised temperatures in the city core, generally known as the heat island effect. Raised temperatures, especially in dry season, turn Douala city centers into unwelcome hot areas. These raised temperatures in Douala city centre derive from the altered thermal balances in urban spaces, mainly due to the materials and activities taking place in cities, by far different to those in rural areas. Therefore the majority of citizens are suffering from outdoor environment discomfort in terms of heat related illnesses and heat related symptoms (Ezezue and Enete, 2013). This study seeks to determine the spatial extent of UHI in Douala city with the following hypothesis:

H_O: There is no significant relationship between land-use and the generation of urban Heat Island in Douala urban space.

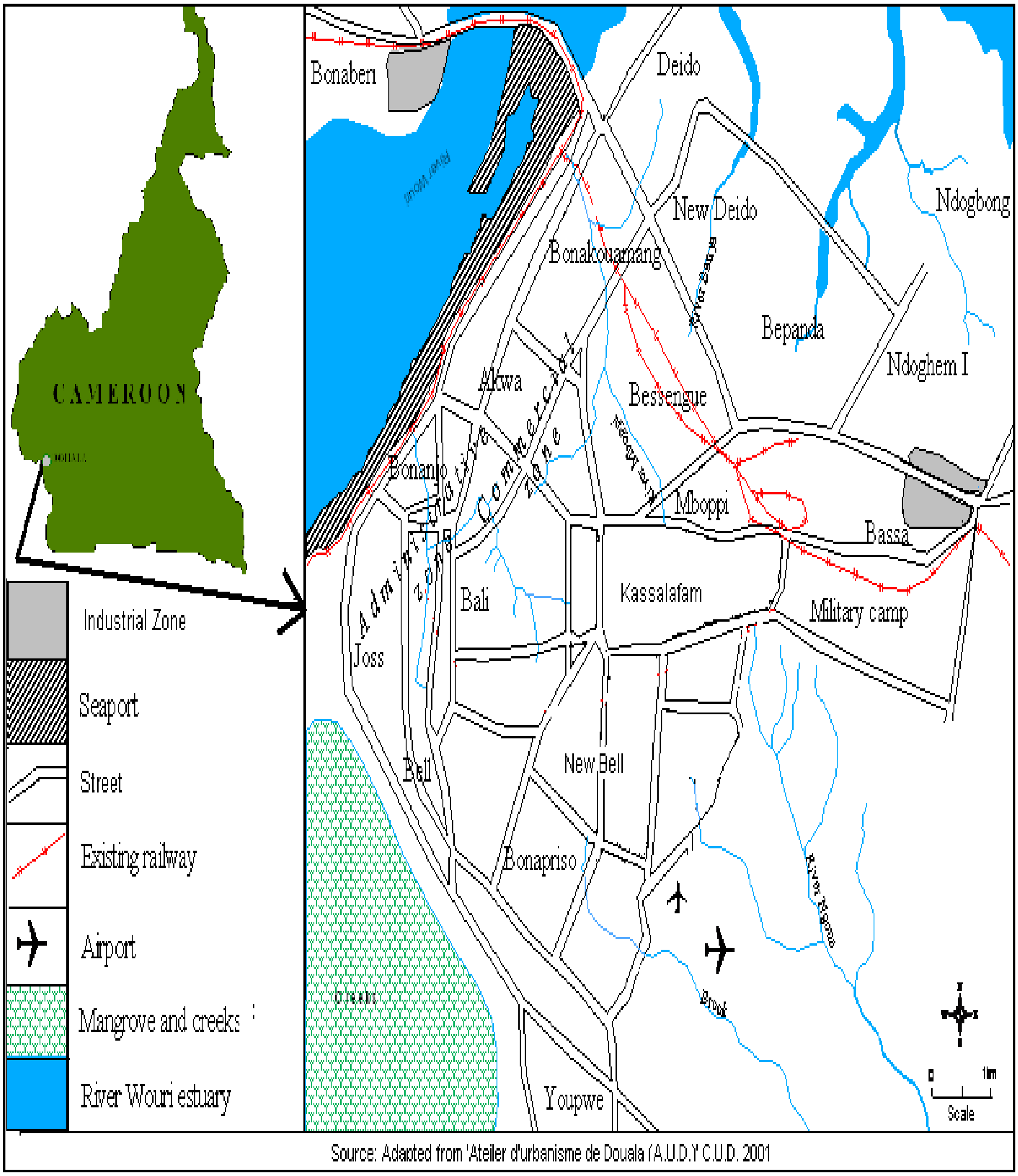
H_O: There is no significant difference between UHI in the inner city area and the outskirt area of Douala.

2.0 The Study Area

Douala Metropolis is located on the south west coast of Cameroon at an altitude of about one meter and lies on 4.05°N latitude, 9.71°E longitude. Douala is a tropical city that have grown to engulf the River Wouri, delta ,a terrain of several sandy, low-lying landscape dissected with several dust, butaries and small streams. It is one of the well-known cities in Cameroon and its home to the largest port and the city's largest international airport.

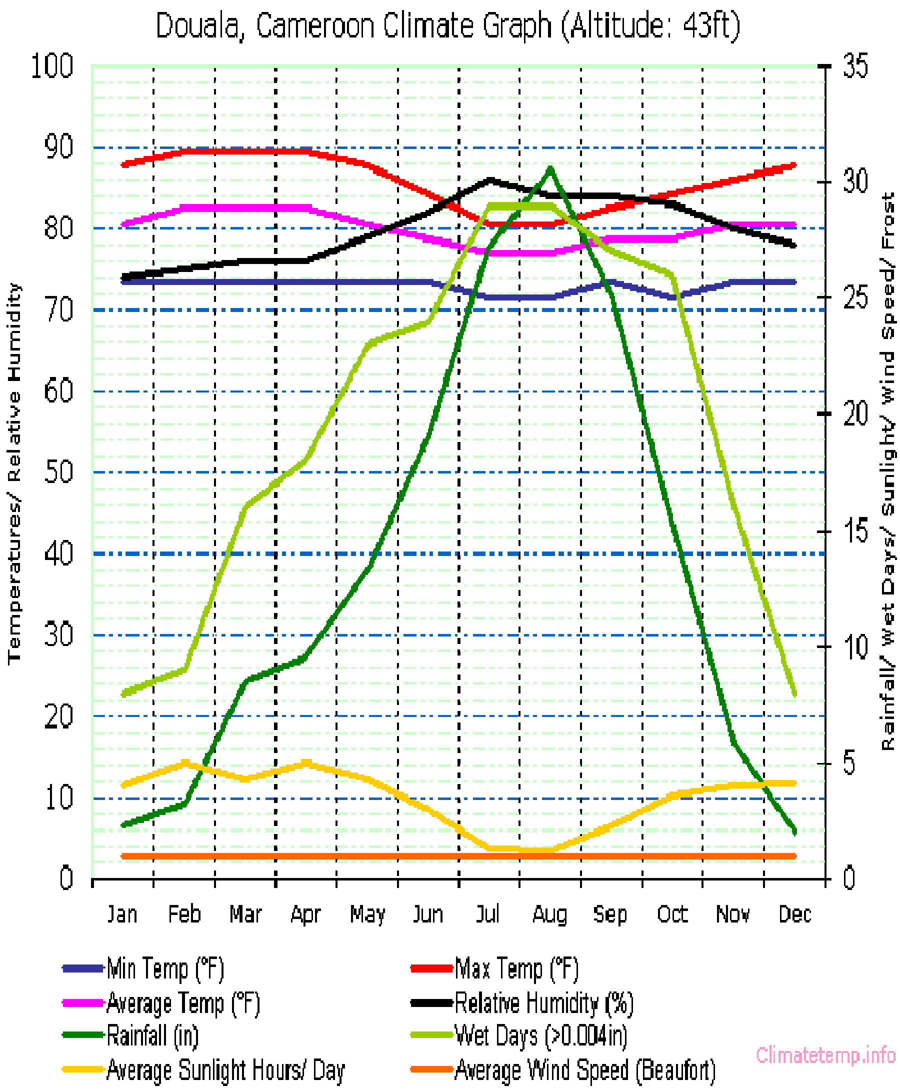
Douala has evolved through a dual colonial process whose imprints are reflected on its present layout and land use. The urban legacy has been highly mirrored by the presence of the Germans (up to 1945) and later by the French (up to 1960). The forces of nature such as climate and soils and the evolving rhythm of urbanization have also equally determined the present land use.

Figure 1.Location of Study area-Douala in Cameroon



The location of Douala puts it firmly within the tropics: as such, solar radiation is high all the year round. Douala has sunshine duration averaging Hours of sunshine range between 1.3 hours per day in August and 5.0 hours per day in April. On balance there are 1274 sunshine hours annually and approximately 3.5 sunlight hours for each day. The climate indicates a region of high temperature and rainfall that are almost evenly, spread throughout the year. Mean daily temperatures drop by about 2°C-3°C. Diurnal temperature variation is however greater than seasonal differences. There are 1274 sunshine hours per year and average temperature ranges between 26.7 °C (80 °F). The warmest average max/ high temperature are 32 °C (90 °F) in February, March, and April. The coolest average min/ low temperature are 22 °C (72 °F) in July, August, and October. Douala receives on average 4114 mm (162.0 in) of precipitation annually or 343 mm (13.5 in) each month. On balance, there are 233 days annually on which greater than 0.1 mm (0.004 in) of precipitation (rain, sleet, snow or hail) occurs or 19 days on an average month. The month with the driest weather is December. The month with the wettest weather is August when on balance 775 mm (30.5 in) of rain, sleet, hail or snow falls across 29 days. Mean relative humidity for an average year is recorded as 79.8% and on a monthly basis; it ranges from 74% in January to 86% in July. Hours of sunshine range between 1.3 hours per day in August and 5.0 hours per day in April. Fig. 1.3

Figure 1.3: Douala Cameroon climate graph



3.0 Research Methods

3.1 Research Design

The study adopted an experimental research design since it seeks to solve existing problem in the environmental management.

In order to assess the urban heat island situation and its possible implication in the Douala municipality, both primary and secondary sources of data collection were used.

3.3 Sample Site Selection

Two land-use classes (resident and commercial) and two land-cover types (paved and green surfaces) were used for the selection of the sample sites. The following land-use/land covers were selected based on purposive sampling (Enete,2009; Emmanuel,1995).

1) High-density, high rise, non residential areas with low greenery.(DTL)
2) Low building density, low-rise, residential areas with high greenery. (HDR)
3) Medium density, mixed residential (some residential, some commercial institutional) area with a greenery extent between (1) and (2) above. (NW2)
4) Areas with similar land-use, building density and greenery, one having more fully developed vegetation canopy than the other. (LVR and LOR) A search for locations with these characteristics resulted in the selection of the following sites:

1. DTL (Downtown location) = Akwa South (CBD), stories accompanied by heavy traffic, high degree of paved areas and little or no greenery.
2. HDR (High-density Residential Site) = Bonapriso. Residential areas with low traffic volume and heavy presence of mature vegetation
3. NW2 (Multi-family Residential/Institutional Site) = Bassa, Bonaberi industrial, residential/ commercial area with substantial parking lots.
4. LVR (Low-density Vegetated Residential Neighborhood) = Bonanjo
5. LOR (Low-density Open-Canopy Residential Neighborhood) = Bonamousadi

3.4 Data Collection

Data was collected using both primary and secondary sources of data collection. During the study, networks of sensors were set up over Douala urban centre to measure air temperature. Temperatures were measured simultaneously in all transects that were superimposed on the study area. The data was collected in two sessions.

The first session covered the months of February, March, representing the dry season while the second session ran from June to July representing the rainy season.

3.5: Measurement Techniques

Air temperature in the Douala urban space were measured simultaneously with the help of a digital thermometer at each experimental site and a reference station was set up at an open area located near a large open grass field on the side of the Douala International Airport. In close proximity to the reference station is a full-featured weather station maintained by the Douala International Airport. The Digital thermometer (KT300) was used as a measurement probe due to its good performance outdoors. (fig3.1) the digital thermometer was placed in a naturally ventilated, insulated plastic box to block direct radiation. Probes used at the reference station and other urban sites were shaded similarly. The shielded probe was sited at an open area approximately 1.5m above ground. Test run was performed by running each shielded probe assembly for three days and comparing the temperature reading against the weather station data at the airport.

Fig 3.1 Digital thermometer KT300 used in obtaining temperature reading from the different transects in the Douala urban space

Data on several climatic parameters including: air temperature, humidity, solar radiation wind speed and global luminance were obtained from the Airport to estimate general climatic characteristics during the study period. The surrounding was classified as low-density institutional land-use with a stretch of plain terrain significant grass cover and some paved (parking lot) areas due to its more or less rural like nature, the difference between a location's air temperature and that at the reference station was considered to be the effect of urbanization at the said station.

Field observation was equally carried out to identify the different land uses in the Douala urban space to correlate their relationship to UHI. The different land uses identified were use as yardstick in the selection of the sample sites.

3.6 Data Analysis

The result obtained from the field was analysed using both descriptive and inferential statistical techniques. Descriptive statistic involved the use of multiple and simple bar charts, histograms, tables, graphs as well as measures of central tendency such as running mean. Inferential statistics such as paired measurement program, comfort analysis and spearman rank correlation were also use.

3.5.1 Paired Measurement Programme

Paired measurement programme was used to analysis the data for objective I &II. During the study period, transect and fixed point measurements were taken hourly and average over a month. All temperature differences were calculated as site temperature minus reference temperature. Thus, a negative (-) temperature difference was an indication that the site was cooler than the reference station; and positive (+) was an indication that the site is warmer than the reference station.

3.5.2 Spearman's Rank Correlation

An attempt to provide a Universal affirmation for Douala Metropolis and possibly beyond requires inferential analysis both for the causative factors and for the applicability of the experimental tools. We therefore examined:

1. The relationship between temperature and land use over the sample areas
2. The relationship between temperature at the inner city area and that of the outskirt area of Douala metropolis.

Since the circumstances of the variables in each of the two relationships do not influence each other, a Spearman's rank correlation analysis of the form below was employed to correlate land-use/land-cover and temperature'

$$R = 1 - \frac{6Ed^2}{n(n^2 - 1)} \text{ -- } (3.2)$$

Where: n= number of variables
E= summation

d^2 = square of the difference

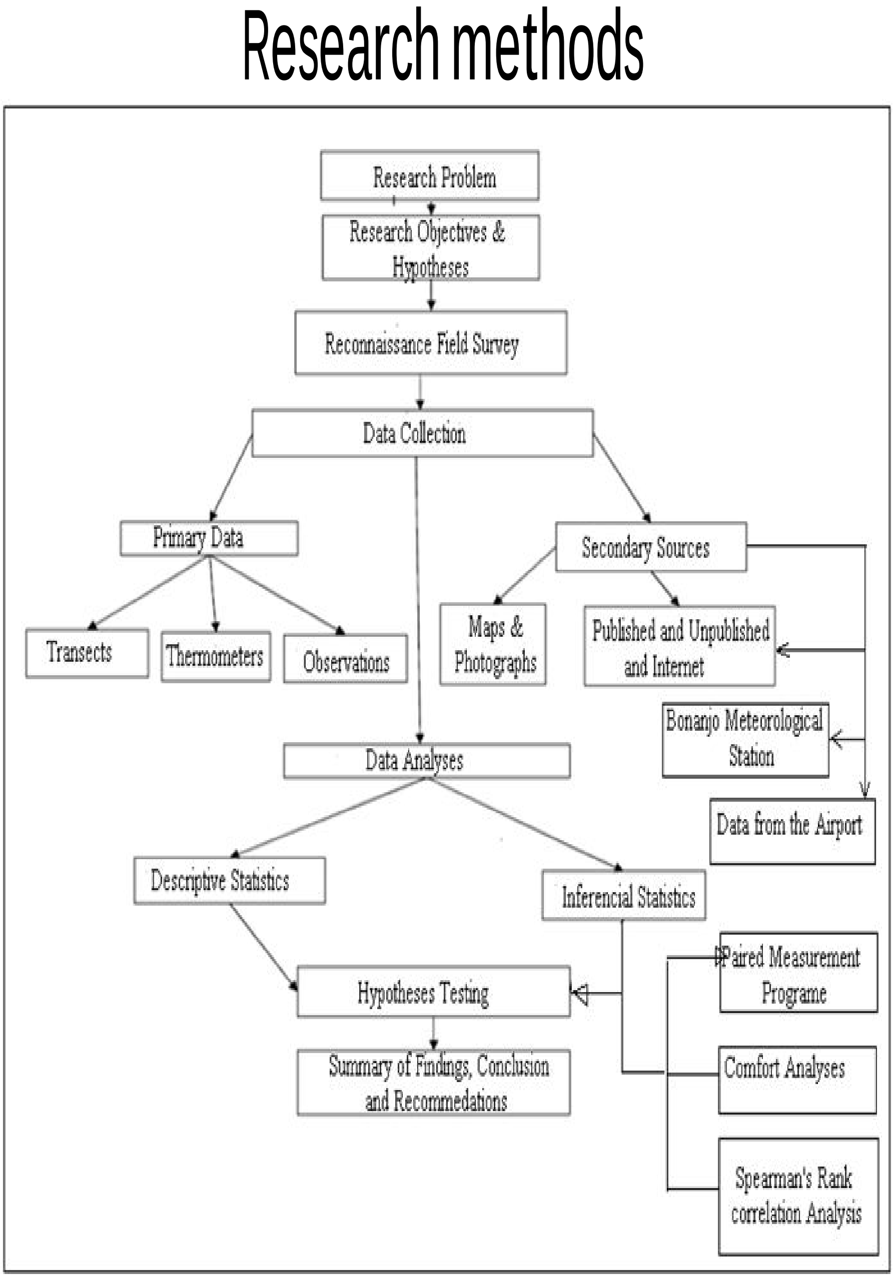
The foregoing assessments produced a convincingly descriptive analysis of the issues of urban heat island in Douala. They affirm the occurrence of UHI in places measured based on the factors identified (cultural and natural factors).

This analysis helped us to not only to determine the level and significance of the relationships using the t- test of significance but also determine the extent to which the variables explained the occurrence of UHI using the co-efficient of determination (CD)

$$CD = (R^2) \quad *100\text{---}3.3$$

If equation 3.1 achieves a pass mark, we assume that the relationship can apply to most urban areas. Otherwise, we restrict our judgement to Douala Metropolis. For these investigations, the following hypotheses were tested.

Figure 3.2. Summary of research design



4.0 Result Presentation and Discussion

This section presents the result of objective of the study which seeks to determine the spatial extent and magnitude of urban heat Island for Douala urban space The result shows a maximum annual temperature of 28.8 and a minimum of 27.1oc over a 10year period (2001-2011). A monthly temperature range of approximately 7oc was recorded in the dry season and 6oc during the beginning of the rainy season and 3oc during the peak of rainy season. It equally shows that unstable weather condition dominates the study area during the day while stable weather conditions dominate the area at night.

4.1 Atmospheric Situation in Douala

The atmospheric situation in Douala shows a gradual fluctuating from year to year. The variation of climatic elements such as atmospheric stability, temperature and precipitation was attributed mostly to the influence of anthropogenic activities as well as physical factors. The result shows that temperature in the area has been on a considerable increase and such increase, has led to a modification of the other climatic elements and a modification of the heat island situation. The different climatic parameters were analysed below in order to assess the heat island situation.

4.1.1 Temperature Situation

Temperature, which refers to how hot or cool a place is, has been on an increase in the Douala metropolis. The result shows that the annual temperature of the area for over 11 years has not gone below 27^{o}c (table 4.1)

Table 4.1: Temperature Behaviour Over 10year period (2001– 2011) in degree Celsius

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Annual temperature	28.2	28.6	28.8	28.4	27.6	27.1	28.2	27.5	28.8	28.5	27.7
Annual range	-	0.4	0.2	-0.4	-0.8	-0.5	1.1	-0.7	1.3	-0.3	-0.8

Source: Bonanjo meteorological station 2012

The highest annual temperature recorded within this 10years period was 28.8 in the years 2003 and 2009 and the lowest of 27.1 in the years 2006. The drastic drop in temperature in 2006, 2008 and 2011 was attributed mostly to natural phenomena than anthropogenic factor. A graph showing the temperature situation in Douala shows more of a gradual fluctuation (fig 4.1).

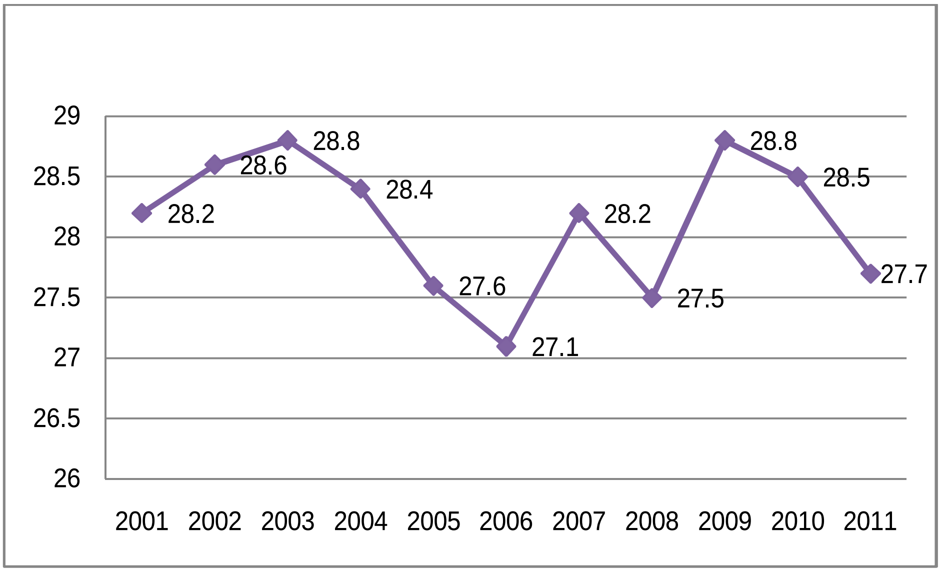


Fig 4.1 Temperature over Douala

A less than one difference in annual temperature from one year to another was recorded. That is the drop or increase in temperature has always been less than the value one. The data collected during the studied period shows that the temperature of the region is considerably high with very slight difference between the rainy season and the dry season (tab.).

Table 4.2: Average Temperature Conditions in Douala during the Study Period

	Temperature Values		
Months	High	Low	Monthly Mean
February	32.6	25	28.8
march	32.3	24.6	28.5
June	30.0	24.0	27. 0
July	28.3	24.4	26.4

The maximum mean monthly temperature recorded was 28.8 and a minimum 26.4. This shows that the Douala metropolis is significantly hot even within the rainy season. The result further elucidated that there is a significant variation in the maximum temperature and the minimum temperature for the months of February and March (representing the dry season) and June July (representing the wet season). During the dry season, the month of February recorded a maximum temperature of 32.6 and minimum temperature of 25 giving a temperature range of 7.6 while the month of March recorded a maximum of 32.3 and a minimum of 24.6 giving a range of 7.7. During the rainy season, the month of June recorded a maximum 30 and a minimum of 24 giving a range of 6 while the month of July recorded a maximum 28.3 and a minimum of 24.4 giving a range of 3.9. The temperature range shows that the Douala metropolis experiences a significant high temperature almost all year round.

4.1.2 Weather Condition During the Study Period

The cloud cover of the area and the wind speed of the region equally show some degree of variation between the rainy season and the dry season (table 4.3)

Table 4.3: Weather Conditions during the Study Period (Feb – March / June – July 2012)

Date	Cloud	Wind
Feb 1 – 10	Overcast	3.3mls
Feb 15 – 28	Clear Sky	3.0mls
March 12 – 30	Overcast	3.3mls
June 1 – 21	Partly Cloudy	2.8mls
July 1 –20	Dust Hazy	3.5mls
	Clear Sky	3.5mls
July 30	Clear Sky	2.8mls

4.1.3 Atmospheric Stability

Based on the MPT classification employed by the present study, stable nighttime and unstable daytime conditions dominated the study period (tab…).

Table 4.4: Distribution of Atmospheric Stability within Study period

Stability Conditions	Day	Night
Stable	10.2	68.4
Neutral	13.2	28.3
Unstable	85.7	00

The result shows that, unstable daytime situation dominates the area leading to an increase in the occurrence of precipitation. The unstable weather condition was attributed to the release of smoke and other atmospheric pollutants, which act as condensation nuclear. The instability of the area was also link to overheating and evaporation from both landmasses and water bodies especially River Wouri. Preponderance of stable and unstable conditions indicates that the urban design suggestions by this study should be particularly applicable to stable nights and unstable days.

4.1.4 Effect of Atmospheric Stability

Sites (DTL, LVR and NW2) experienced stable and unstable day-time conditions on multiple days, among them DTL showed the largest temperature difference. On average, temperature differences at DTL under stable and unstable atmospheric conditions were (01.8^{0}C and 0.15^{0}C). At site LVR, the respective average were (1.7^{0}C and 0.65^{0}C); at NW2, (1.3 C and -0.6^{0}C) was observed.

The variations in air temperature under stable conditions are also worth nothing; at DTL, the mean difference was higher than any of the residential sites. While at LVR and NW2 sites, variations were much smaller. Thus, it is important to comment that the warmest site (DTL) showed wide variations both under stable and unstable conditions, which was not so obvious at residential sites.

Neutral conditions produced temperature patterns similar to those under stable conditions: downtown location was warmest both at day and night; maximum differences occurred during early night-time (2200 – 2300 hours), and the hour-to-hour temperature variations during daytime tend to be relatively low.

4.1.5 The Urban Heat Island Situation in Douala

The urban heat island situation in Douala varies considerable from one area to another due to variation in land use type and pattern and from dry season to rainy season due to change in climatic elements.

4.1.5. 1 Dry Season Situation

A) Dry Season-Daytime

The Dry season months showed strong variability in temperature in the different transects selected for the study. Temperature variability was high especially between day and night.

Table 4.5: DTD Variation during the Day

Site location names	DTD
DTL Akwa south (CBD)	+2.5.
LOR Bonamousadi,	-1.70
LVR GRA(Bonanjo)	+1.5
NW2 Bassa, Bonaberi	+4.0
HDR Bonapriso	-3.0

The result shows that the heavily vegetated urban residential sites (HDR) and suburban sites (LOR) with fully developed vegetation canopy were the coolest with -3.0 and -1.70 respectively. This is because the tree cover act as shade limiting the amount of sunlight that reaches the ground. The hour-to-hour variation in air temperature during daytime was significant. It was also observed that the magnitude of the temperature differences decreased as background climate become hotter.

During the day, very few cool Islands were observed. The thick vegetated areas of GRA record few days of urban cool Islands. The extensive tree canopy of the vegetated sites produced cooling during the day. The peak temperature value was recorded between 1300hrs and 1500hrs.

B) Dry Season-Nighttime

Unlike the daytime (dry season), nighttime temperature showed a clear downtown-cantered heat Island. Table 4.6 clearly depicts this variation.

Table 4.6: Temperature Variation during the Night

Site location names	Temperature Variation
DTLAkwa south (CBD)	+2.3
LOR Bonamousadi,	+0.3
LVR Bonanjo (GRA)	+0.8
NW2Bassa, Bonaberi	-2.2
HDRBonapriso	+0.4

All residential sites were warmer than the reference site (from 0.3 to 0.8 cooler) while the downtown location was up to 2.3^{0}C warmer. This leads to a maximum night-time air temperature heat Island of about 2.3^{0}C during the study period where as the industrial areas where cooler than the reference site (-2.2). The highest night-time intra-urban air temperature difference was observed during early evening period (1500hrs to 2300hrs).

4.1.5.2 Rainy Season Situation

During the rainy season, there was a variation in urban heat island situation during the day and night and there was a clear distinction between temperatures at the different transects that were superimposed on the study area. That is there was a clear variation in temperature between the different land uses, land cover types of the Douala metropolis.

A) Rainy Season Daytime

During the rainy season, temperature varies considerably during stable and unstable weather conditions and within stable/unstable atmospheric conditions. The following were the average air temperature differences under stable conditions.

Table 4.7: Temperature Variation under Stable Conditions

Sites location names	Temperature Difference
DTLAkwa south (CBD)	+ 1.8
LORBonamousadi,	-0.3
LVR Bonanjo (GRA)	-1.7
NW2Bassa, Bonaberi	+0.3
HDRBonapriso	-2.1

The result shows that downtown location site was the warmest (+1.8-) warmer than the residential sites. The heavily vegetated urban residential sites (HDR) – G.R.A, and suburban sites (LVR), with fully developed vegetation canopy were the coolest with -2.1and -1.7 respectively. The low-density residential site (LOR) like Bonamousadi was only -0.3^{0}C cooler than the reference site. Except for sites NW2 where institutions and residential quarters are housed, hour-to-hour variation in air temperature during the day-time was not much. The NW2 sites witnessed higher temperatures during the day than in the night.

The number of sites that witnessed unstable conditions on multiple days were very few (sites DTL, LVR and NW2), and the patterns were very similar to those produced by stable conditions (tab 4.8).

Table 4.8: temperature variation under unstable conditions

Sites	Temperature Difference
DTLAkwa south (CBD)	+1.52
NW2Bonamousadi,	-3.0
LVRBonanjo	-3.45

The result shows that under unstable weather conditions too, downtown location (DTL) was the warmest followed by NW2 with -30 and LVR GRA were the coolest with -3.45. Maximum daytime UHI was about 3.2^{0}C and hour-to-hour difference was about 3.5^{0}C. Unlike stable conditions, differences between LVR and NW2 under unstable conditions were 0.45^{0}C warmer than the reference site. Green cover alone explained about 40% of microclimate variations. The influences of buildings and vegetations maturity were apparent. The magnitude of the temperature differences decrease as background climate become hotter. However, hotter conditions lead to larger intra-urban thermal comfort difference than the cooler nights.

This finding highlights the need to distinguish between temperature islands and thermal comfort islands. The former peaks at clear calm nights while the latter reaches its maximum under overcast or hazy conditions.

During the day, a mix of cool and heat island was recorded. Under very hot conditions, the low ground cover at the more open residential sites did not significantly improve daytime cooling. This suggests that shading was more central to daytime cooling than ground cover. Extensive tree canopy produced some cooling during the day, but the cooling provided by building shade at the high-density sites also did equally well. However, extensive tree canopy cover resulted in warm microclimate at night.

B) Rainy Season Night-Time

Unlike the daytime temperature differences, night temperature variation (DTN) showed a clear downtown-centred heat island. Table4 .9 clearly depicts this variation.

Table 4.9: Temperature Variation during the Night

Site location names	DTN
DTLAkwa south (CBD)	+1.3
LORBonamousadi,	-0.36
LVRGRA	-0.65
NW2Bonamousadi,	-0.39
HDRBonapriso	-0.57

The result shows that all residential sites were cooler than the reference site (from 0.36^{0}C to -0.65^{0}C cooler) while the downtown location was up to 1.3^{0}C warmer. This leads to a maximum nighttime air temperature heat island of about 2.0^{0}C during the study period. The intra-urban differences among the other sites (LOR, LVR, NW2 and HDR) however, were very small. Air-temperature at site HDR (GRA) in particular was not significantly different from those at any other site. The expected cooling was moderated by tree canopy.

The highest nighttime intra-urban air temperature difference was observed during early night period (1800hrs to 2300hrs). Unlike daytime, the hour-to-hour variation in air temperature during the night was very significant, particularly at the residential sites. Observation has shown that there was a clear downtown-centre heat island at night.

4.1.6 Urban Heat Island Magnitude

Urban Heat Island Magnitude (UHIM) is the temperature difference between the urban (u) and reference (r) station or Tu-r. From the data collected, the difference between the inner city temperature and that of outskates were measured. As an initial step; the average daily temperature and the daily temperature range for each of the sites were compiled using the hourly temperature measurements. These averages were used to determine the site-specific average dry season and rainy season temperatures defined by the months of February/ March and June/July (table 4.12).

Table 4.12: Monthly Mean Temperatures for Reference Station (r) and Urban Sites (u) reported as a Spatial Average (Tm u - r)

Monthly	Urban Sites (u)	Reference Site (r)	Tm u-r
February	31.3^{0}C	28.8^{0}C	2.5^{0}C
March	32.10^{0}C	28.5^{0}C	3.6^{0}C
June	29.87^{0}C	27.0^{0}C	2.87^{0}C
July	28.67^{0}C	26.4^{0}C	2.27^{0}C
Feb – July	30.49^{0}C	27.68^{0}C	2.9^{0}C

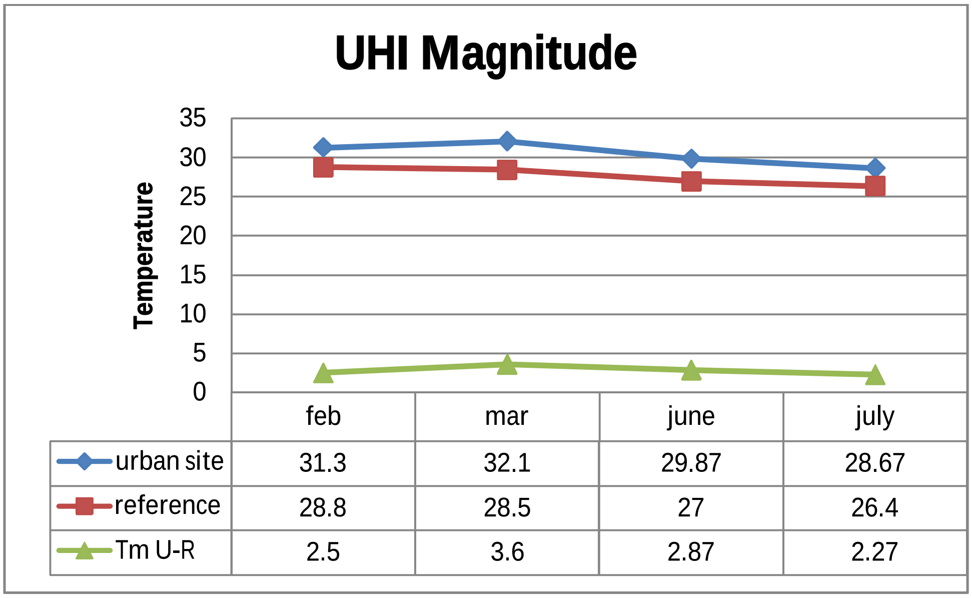


Fig 4.2: UHI Magnitude

Using the reference site as the outskirt and the urban city site as the inner city it is observe that the urban temperature decreases as one move away from the city centre. The result shows that urban heat Island magnitude generally increases with increasing air temperature. On a daily basis, the UHI reach its peak intensity in the late evening and early night. The range of magnitude across the study area (spatial range) is 2.27^{0}C with maximum heating in the urban core and generally busy areas where human activities are concentrated.

Test of Hypothesis 1

Correlation Between Land Use And Temperature In The Generation Of Urban Heat Island In The Douala Metropolis

ND-USE	kwa	onaberi	Bonapriso	Bonanjo	Brazzaville	Bassa	New bell	Youpwe	Congo	Bonamousadi
anking	2	1	6	5	9	3	7	8	4	10

Table 4.14 Rank –order correlation of land –use and Temperature for selected Areas of Douala Metropolis. Temperature values (Y)

Temp	37.1	38.8	36.5	35.4	38.9	38.2	36.4	36.2	37.2	34.9
Ranking	6	9	5	2	10	8	4	3	7	1

$$1 - \frac{6\,\Sigma d^2}{n(n^2-1)}$$

r = -0.46

Significance of the correlation

Let Ho be "there is no significant relationship between land-use/land-cover and temperature. In other to perform this task, the students't' test of the form below was employed. The test was carried out at 95% level of confidence.

$$t = \frac{\sqrt{r \times n-2}}{\sqrt{1-r^2}}$$

Where t = student't' test

r = correlation
n = number of variables.
= -1.3= 6.5
1-0.2 -0.2

Calculated value = 6.5
Table value = 1.86

Calculated value 6.5 is greater than the table value 1.86. Ho is rejected. And H_1 is accepted. H_1 states that there is a significant relationship between land-use / land-cover and temperature variation. Therefore, there is a strong correlation between high browse areas and temperature.

5.4 Conclusion

The present study explored the effects of land-use/land-cover types on intra-urban air temperature variations under different atmospheric stability conditions, using paired measurement programme. Unstable daytimes show the maximum heat Island effect.

Vegetation shade showed title impact on the intra-urban variations in downtown locations. However, shaded sites heated up much more slowly than open ones and this lead to cooler daytime temperatures in LVR areas like LOR. The different transects show some degree of similarities in terms of the implication of urban heat island. It equally shows a strong relationship between the landuse types/cover, and heat related symptoms. Eight heat related symptoms were identified in the area as the major sign or symptoms of urban heat island. The symptoms identified were leg cramp, dry mouth, fatigue, heavy sweating, headache, convulsion, intense thirst, and rapid heartbeat.

In conclusion, there are indeed conflicting design requirements at the city-wide scale. There is therefore, the need to both increase shading as well as increase the sky view of our streets; as a well-designed street is indirectly a well-designed city.

References

Adina, E.N., Enete, I.C and Okolie, T.(2009). Assessment of urban heat island and possible adaptations in Enugu urban using land sat/ ETM. Pakistan Journal of Sopcial Sciences, 6(1):26-31.

Barredo, J.I (2009).'Normalized flood losses in Europe:1970-2006' Natural hazards and Earth system science,9(1):97-145.

Ebi, K., Tisbury,T.J, Kalkstein, L.S, Robinson, L and Weiher, R.F (2004)'Heat watch/Warning System Save Lives, Bulletin American Meteorological Society, 85:1067-1073.

EEA (2010): The European environment – State and Outlook 2010: Thematic Assessment – Urban Environment, European Environment Agency.

EEA (2012): Urban Adaptation to Climate Change in Europe: Challenges and Opportunities for Cities. EEA Technical Report No. 2/2012, European Environment Agency.

Enete, I.C, Awuh, M.E andn Amawa, S (2013): Assessment of Health Related Impacts of Urban Heat Island (UHI) in Douala Metropolis, Cameroon, World Journal of Applied Environmental Chemistry, 2 (2): 54 – 60.

Enete, I.C. and Okwu, V.U. (2013): Mapping Enugu City's Urban Heat Island. International Journal of Environmental Protection and Policy, 1(4): 50 – 58.

Enete, I.C: Officha, M. and Ogbonna, C.E (2012): Urban Heat Island Magnitude and Discomfort in Enugu Urban Area, Nigeria. Journal of Environment and Earth Science 2(7): 77 – 82.

Ezezue, A.M and Enete, I.C. (2013): Evaluation of Indoor Air Quality of Residential Buildings in Enugu, Nigeria. World Journal of Environmental Biosciences, 2(2): 62 – 77.

Hajat, S.O' Connor, M. and Kosatsty, T. (2010): Health effects of hot weather: from awareness of risk factors to effective health protection, Lancet 375 (9717): 856 – 863.

Mathies, F, Bickler, G, Cardenosa Marin, N and Hales, S. (2008): Heat-health action plans – Guidance, WHO regional office Europe, Copenhagen, Renmark.

Taha, H. (1997): Urban Climates and Heat Islands: Albedo, Evapotranspiration, and Anthropogenic Heat. Energy and Buildings, 25(2): 99 – 103.

Oke, T.R (1982): The Energetic Basis of Urban Heat Island. Journal of the Royal Meteorological Society. 108 (455): 1 – 24.

Oke, T.R (1987): Boundary Layer Climates 2nd edition, London: Methuen and Co, p435.