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Identification of parameters of warming in urban agglomeration of Lomé (Togo), West Africa

Botolisam Polorigni*, Kossi Adjonou, Raoufou A. Radji and Kouami Kokou
Laboratory of forest researches, Faculty of Sciences, University of Lomé, 01BP 1515 Lomé 01-Togo
botolisam@yahoo.fr

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Abstract

Cities are exposed to a microclimate, where temperatures are usually warmer at downtown than outskirts. The intensity of global warming depends on the temperature gap between the downtown and the outskirts of the city known as the urban heat island phenomenon (UHI). Lomé faces intense waves of heat and warming whose temperature gap is 4°C. The purpose of this research is to identify the urban parameters that influence the warming of Lomé. The method is based on the delimitation by remote sensing of one site in hot area and one another in a less hot area using images of the Quick bird satellite with high resolution (0.6m) dating from the month of January 2016. The data collection is relative to a group of 4 main urban parameters namely the area of vegetation on the floor, the naked or built soil, urban traffic and the size of the population. Comparison of values of these parameters on the sites has proven that the vegetation cover only is not in favor of urban warming. Therefore, the city of Lomé is warming by intensive mineralization.

Keywords: Urban settings, climate change, urban heat island.

Introduction

Meteorological data, in particular temperature, show that the global climate is increasingly warming. The entire world faces temperatures increasing, which occurs at two levels: globally with warming (RC), and locally through the urban heat island (ICU). With awareness of the negative consequences of the RC, attention is paid on the phenomena that occur in urban areas. It is in this way that[1] showed that the consequences of the RC are as important as the effects of the UHI.

In urban areas, the extension of built-up surfaces is made at the expense of green spaces like gardens and rural areas, whose thermal and radiative properties are different from those of urbanized areas[2]. This phenomenon, called 'urban heat island', appears with the human activities in the city including the construction of buildings and waterproof coatings that store heat in materials with high thermal inertia, reinforced by human activities that produce heat such as the CO_2 emission[3-5]. A study of Heat Island Group found that the installation of pavers to high albedos combined with a strategy of revegetation could reduce the temperature of the city of Los Angeles to 0.6°C[6]. The works of Akbari H. on the greater area of Toronto, suggested that the costs of air conditioning could be reduce to approximately 11 M$ (150 GW) if the city was installing white roofs and used a strategy of strategic greening[7]. It is in this way that USEPA recommends that planners of the integrative design of cities take into account different parameters of thermal comfort such as vegetation, materials of construction, the architecture of houses, according to the climate and the existing morphology of cities[8]. The contribution of these parameters is vital in the fight against the heat island[9-14]. The phenomenon affects all corners of the world including Africa. Indeed, African cities in their dynamics of fast urbanization bring with them huge problems that are felt on the urbanmicroclimate[15]. This urbanization affects much more capitals such as the city of Lome, capital of Togo. Lomé, border town, experiencing an increasing warming noted by many authors. Through analysis of Guezere the Horizontal sprawl that affect the city is one of the consequences of the obsession to live “chez-soi”[16]. According to him, the limits of Lomé are now, on the limits of the prefecture of Golf. Government has failed to bring citizens to social housing. Of cuss, a housing policy has eventually been adopted in 2010, but unfortunately could not be implemented for various reasons among which the land problem. In this regard, Margueratargued that because the land is in the hands of communities, habitat is turned into a matter of first importance, but strictly private[16]. That prove that Lomé has not ceased to expand excessively since the independence[17]. The spatial growth takes the form of various erections that come with mineralization of the city.

Today, the city heats up under the weight of climate change with a difference of temperature sensitive between downtown and the outskirts of Lomé. However, good urban planning, recommends, a subdivision then a concession by the Government as it is done elsewhere. Therefore, we can say with the conclusions of Badameli that Lomé knows a temperature rising that continues every day[18]. He said that the littoral in Lomé faces high temperatures. In the same way, Adjoussi P. talks about passage of wave of heat by the time in Lomé[19]. Ringenbach concludes that all factors of urban development generate a change in heat transfer[20]. He goes further in stating that the fight against this phenomenon is through the control of these factors. From the perspective of controlling warming and redo the balance of the ecosystem, it is necessary to ask what are the parameters that influence the rising of temperatures in the city of Lomé?

This research is intended to identify the parameters that enhance the temperature in the city of Lomé based on previous studies. These ones have pointed some major urban parameters including population, urban traffic, and the occupation of the land that includes vegetation, the bare or built soil, as elements influencing the warming of cities[21]. It is specifically to make a comparison of the values of these parameters on two separate sites. A first site selected at the downtown and a second site located in the peripheral area of the city. Thus, the value of the population is obtained by census, vegetation cover by superficies, the value of the bare or builds soil obtained by its size and the nature of the materials. As for urban traffic, three elements are used to determine its value: the number of activities, the length of paved roads and the average number of vehicles in daily use.

Methodology

Presentation of the area of studies: Lomé is located in Togo on the Abidjan - Lagos corridor between 6°8" and 6°11" North latitude and between 1°11" and (1) 18 longitude. This territory of a size of 280 km^2, with a population of 1 477 660 inhabitants concentrates the majority of market, economic and social infrastructure[16].

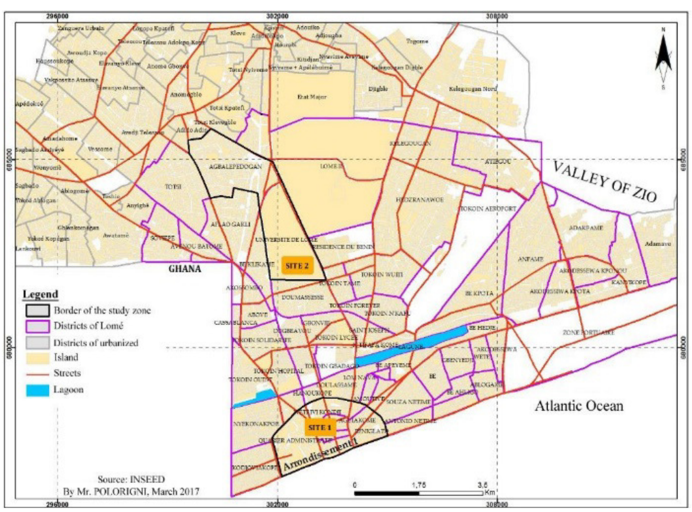


Figure-1: Location of the study area.

The study focused on two sites in Lomé (Figure-1) determined by three criteria. It's the i. positive gap in temperature between the two sites; ii. availability of geographic, economic and social data and information; iii. accessibility of the sites. The first site S1 is delimited in the lower town on the coast (downtown), the second S2 on the outskirts of the city. Downtown is generally warmer than the outskirts[21]. Considering these guidelines, two sites meet these criteria. It is the S1 site that covers the space between the Ocean coast to the Boulevard Circulaire, with the size of 4 km². The second site (S2) with a size of 5.62 km2 is located on the outskirts of Lomé city, composed of the location of the University of Lomé and the District of Agbalepedogan.

Data collection: The collection of data is relative to the urban parameters among which the size of the vegetation on the ground, that of the bare or built soil (size of the bare or built soil, nature of the building materials), urban traffic (major activities, daily amount of vehicles on the road, length of bituminized roads) and the size of the population. For this, satellite images are used.

S1 (first District) and S2 (University-Agbalepedogan) had been delimited according to the areas administratively defined by the Government while exploiting the Quick bird satellite image of very high spatial resolution (0, 6 m) of January 2016. Geographic data is composed of a geo-referenced digital layer of "Greater Lomé", with geographic and economic information, elaborate and update by the national Institute of statistics and economic and demographic studies (INSEED). The area within the administrative boundaries has been extracted using the Arc GIS Desktop 10.4 software. This device has been used to extract from each site, the classes of occupation related to vegetation cover and the bare or built soil.

In order to validate the processing of the images, we have moved to the field. Then, a laying of mesh on the image helped to identified GPS location of five (5) points related to the canopy and five (5) others, related to the bare or built soil. The obtained provisional map was validate after verification of identified points.

Concerning the identification of materials of the construction, the choice of islands to be take in account has been done randomly at first and dispersed geographically. On a subdivision plan of these sites, a sample of five (5) is lands has been taken by site. Then we perform a Visual check on the ground, the nature of materials used in the construction of existing buildings. It should be noted that, by definition, an island in a subdivision is a plot bored by four (4) streets; it may contain an average of six to twelve houses in Lomé. A systematic census of houses was made on the Islands according to the nature of the materials.

In order to quantify the number of vehicles (all gear rolling) that cross each site, two 'round-trip' of urban traffic count stations were installed. A 'go' post and a 'back' post were installed in front of the SGI after the crossroads of GTA when going downtown for site 2 (Figure-3). Two others "go and back" have been installed at the level of the intersection of Decon near Boulevard Circulairein, at the South; for the site 1 (Figure-2). The accounting has been done during 24 hours without interruption; and that, during three days: 16, 24, 29 March 2017. The number of vehicles has been got by the average of the accounting of these three days.

Figure-2: Accounting of the traffic Décon/Lomé (Site1).

Figure-3: Accounting of the trafic at GTA/Lomé(Site 2).

For activities, we proceeded by the systematic counting of targeted activities and grouped into shops, industries, trades and administrative/private services across both sites. In the comparison of both sites, a percentage was established for each activity according to the counts.

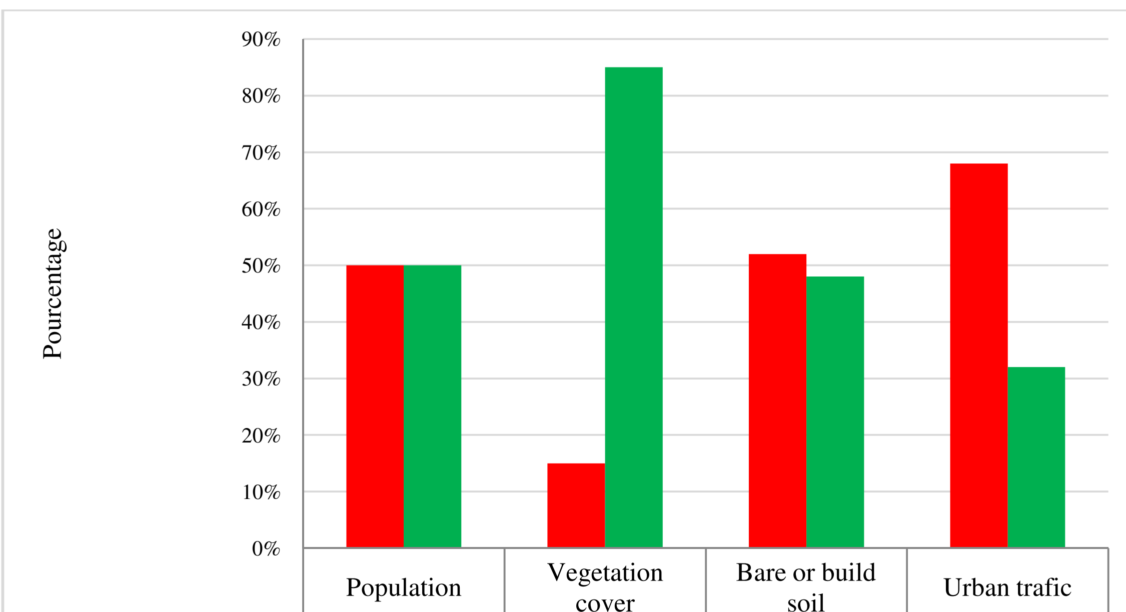
The population estimation comes from the last general census of population and habitat held by INSEED in 2010.

Analysis and data processing: The data were process by Excel tables. The integration of data on maps extracted from satellite images was made by Arc GIS Desktop software 10.4. Using curves, we did the interpretations and analyses of data.

Results and discussion

Global status of urban parameters: Values of urban parameters including population, urban traffic, bare or built soil and vegetation, are different on each of the two sites of studies as shown in the graphic below.

Socio - demographic features: Population: The population at site 1 is estimated at 25876 inhabitants while on site 2, it is 25583 (Figure-4). At first glance, it is quite clear that the number of residents on the two sites is almost the same. Unlike this visible appearance, the reality is quite different. A daily phenomenon occurs on site 1. As the Center - City is home of most of the economic activities and the majority of administrative and private services, the flow of people coming down every day on this site, represents a third of the population of the urban agglomeration of Lomé. The population in the day on this site exceeds five hundred thousand (500,000) persons. This leads this site to a great anthropogenic heat in the day comparing with site 2.



	Population	Vegetation cover	Bare or build soil	Urban trafic
SITE1 City center	50%	15%	52%	68%
SITE 2 Surounding	50%	85%	48%	32%

Figure-4: Summary of the comparative values of identified parameters.

Urban traffic: Urban traffic (Figure-4) was evaluated through three (3) elements such as the counting of urban traffic, the length of the paved road and the number of activities (industry, trade, handicraft and administrative and private services).

Accounting of the urban traffic: The average number of vehicles on 24 hours on site 1 is 201.655 against 149.037 on site 2. The counting took place on March 16, 24, 29, 2017 at 6 AM and ended March 17, 25, 30, 2017 at 6 AM. This daily urban traffic with an increasing number of rolling engines by day caused the release of a large amount of smoke in the city. These smokes convey several Atomic complex whose carbon dioxide come to increase the amount that naturally exist in the air. These (the existing CO_2) are; natural greenhouse gases that warm the atmosphere and allow the life of bipeds. The environment warms up much more and brings about an unbearable heat for humans. It can form at this time phenomena of heat island (UHI) harmful to public health.

Activities: The measure of the value of activities occurred through the census of the number of industries, shops, craft activities, and administrative and private services in each site. For Industries, the value on the site 1 is 81% against 7% at site 2, trade 67% against 33%; handicrafts 91% at site1 against 9% at site 2. Finally, the site 1 is full of 84% of administrative and private services against 16% at site 2. The general average of activities on site 1 is 83% while on site 2 it is only 17%. This is a danger for Lomé downtown when we know that warming comes from the additional greenhouse effect that comes in part from human activities.

Length of macadamized roads: The paved road has a low albedo. By definition, the albedo is the fraction of solar energy reflected back to space. Its value ranges between 0 and 1. The more a surface is reflective, the more its albedo is. Site 1 contains 15.41 km of linear length of tarred roads while the site 2 has 8.67 Km. Knowing the disadvantages associated with the capacity of absorption of the Sun's rays by tarred roads, site 1stores a large amount of heat in the day that will be rejected during the night. This radiation from the accumulation warms the center of Lomé.

Soil occupation: Bare and built soil: This parameter expresses the level of the mineralization in the area (Figure-4). A strong mineralization expresses itself through the areas built for housing, equipment and infrastructure, which unfortunately absorb large amounts of solar calories during the day. It is decisive on the amount of heat rejected during the night.

The bare and built soil area size: The size of bare or built soil in site 1 is 3.61 km² while in site 2 is 3.08 km². Therefore, there is a strong mineralization of site 1. This site carries enough buildings with absorbent and glass sides. The absorption of the Sun's rays will be larger with intense warming in the night than in site 2. The thorny problem is the compliance with urban planning. Many buildings do not respect land use plans including the blueprint of development and urban planning (SDEAU). So on the field, it was noticed by place, the roads without exits that narrow corridors of wind eroded or having a blocked ventilation. These are conditions which cause easily the rapid formation of the urban heat island.

Nature of materials of building: Constructions of houses and equipment at both sites are dominated to 90% by concrete-cement materials. The remaining 10% are made up of BTC, banco, wood and plate. The cement bricks are dense materials that have a low thermal resistance so quickly store the calories released by the Sun's rays. Heat stored by these materials is easily released into the nature at the sunset and to be cancelled beyond midnight. Warming of ambient air will greatly influence the rise in temperature of site1. That is one of the reasons that keep residents of neighborhoods of site1 out at night. Mainly at Décon where, there are many who remain out of their home until late before joining again their home at the time where the heat declined.

The canopy: It is a very important parameter influencing the urban temperature change. Site 2 has a surface area of 2.29 against 0.39 Km² of vegetation cover. Site 2 has 5 times more vegetation than the site 1, which is completely bare. This situation favors at the level of site 1 the solar rays to come directly on the ground without obstacle. Canopy has the ability to absorb carbon dioxide (CO_2) rejected by human activities for the purpose of photosynthesis. It is in this way that the canopy is designated as a powerful purifying engine that dampens the heat provided by the incident solar rays, thus regulating the warming of nature in a balance of the ecosystem.

Special materialization of the studied urban parameters: The map (Figure-5) shows a very high level of mineralization (construction) at site 1 and a substantially higher level of plant cover at site 2. Mineralization is related to the anthropogenic heat produced in the city under the effect of urban development factors. However refreshment of the town is related mainly to the extent of the vegetation which benefits and the regulatory role of temperature are well known. This confirm that site 1 heats up because devoid of vegetation. Regarding all these analysis, the risk of the UHI in the lower town of Lomé is growing.

Discussion: Warming and the architecture of the city of Lomé: The city of Lomé, despite the development of multiple planning documents and urban plan in past years, is not in a dynamic of consistent and rational occupation of the urban setting[16]. The occupation of the land in the city of Lomé is done in an anarchism, without respect for the master plan for urban development (PDU) of 1981. Referring to the results of the research, all the factors that influence urban warming are strongly represented in Site 1, while the cool factor is located at site 2, which is on the outskirts of the city. The mineralization (various constructions) of the city is explained by a self-build system, an open door to a city that appears in a mosaic form where two concessions, one modern and the other precarious coexist. These realities led[16] said that very few rely on private companies and architect firms for their construction. This system is not likely to focus on the respect of the urbanization plan, safety and ventilation in the building. It had to be taken into account the texture of the soil, the position, the choice of the type of building and the quality of the materials.

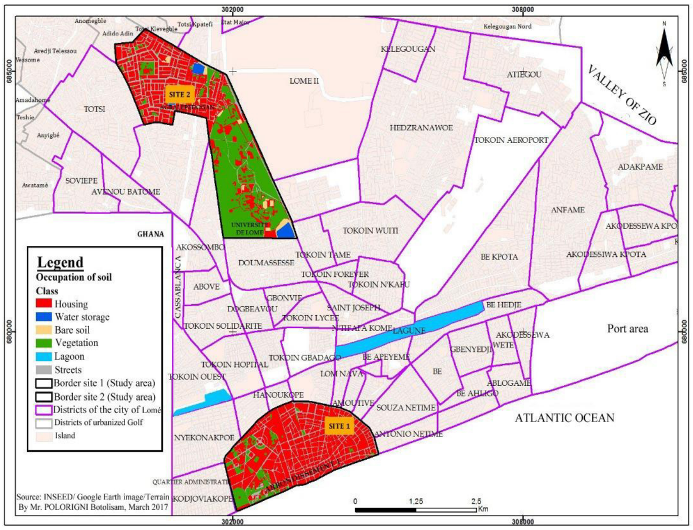


Figure-5: Occupations of soil (bare and built soil and vegetation in both sites).

The study showed that the materials used for construction at both sites are more than 90% brick-cement with low albedo. It is desirable to use a material with high albedo and emissivity, which heat up less quickly when exposed to the Sun and reducing the transfer of heat to the surrounding air[22]. It occurs a high accumulation of heat during the day and an intense restoration of this heat at the sunset. Sidiqui A. found that solar radiation received by the buildings is related to their shape and orientation, and it varies with the latitude of the site[23]. This spirit led the center of construction and housing (CCL) to discover in its researches, a thermal resistant material for the construction needs. It is the compressed soil blocks (BTC) with a minimum coefficient of thermal conductivity of0.81 W/m/h[24].

It is proved that if the material is less dense it becomes more insulating and consumes less energy. This could be one of the solutions against global warming in Lomé. An architecture involving the calculation of shadows would be beneficial using economic materials. The works of resulted the fact that the shadow reduces the temperature of outside surfaces and energy used for cooling. Mansouri points out that a low albedo and non-shaded surface of a building exposed to the Sun in the absence of vegetation lead to a very high warming of facades and therefore, increase the temperature of the wind, by the phenomenon of convection[25]. This shows that care must be given to the design and the elevation of buildings in the city. Therefore, regulation and control by the urban planning services becomes a necessity.

Necessity for periodic monitoring of pollution in Lomé: The evaluation of urban traffic showed that 201,655 vehicles pass through the site 1 in 24 hours against 149,037 in site 2. According to the Directorate of road transport, the National fleet is estimated in 2016 at 818,933 vehicles. According to this same direction, the estimation of the Park of Lomé represents 75% of the national fleet, (614199, 75 vehicles). This Park is full at more than 50% with the vehicles acquired in the autonomous port of Lomé (PAL) commonly called "come from Europe". These engines reject enough smoke that contains a large amount of carbon dioxide that comes to increase the amount already present in the air.

Site 1 has large administrative and commercial activities. In detail, there are large hotels, shops, industries, companies, services and informal activities. By returning to the strip of the coastline, the autonomous port of Lomé, economic lung and large industries, emit black smoke open-air in nature. For example, the cement plant, oil mills, SOAP manufacturing, refinery and the artisanal treatment of the skin of the oxen by tires as meat at the abattoir of the port. The consequences of this situation are invaluable. This intensifies the phenomenon of greenhouse effect, that is dangerous for life on Earth. We must know that the initial greenhouse gases are favorable to life. It is in this way that, Achour-Bouakkaz says that it conditions our climates and ecosystems[26]. These concerns are prevailed in the "national communication on climate change" project, with as reference baseline 1995. In this project, the work of national experts helped to identify and retain seven gaz. It is carbon dioxide (CO_2), Methane (CH_4), oxide nitrous (N_2O), nitrogen oxides, carbon monoxide, the Non Methaniques Volatile Compounds (NMVOC) and the dioxide Sulfureux (SO_2)[19]. Adjoussi precise that they showed that most of the emission sources are concentrated in the South of the country, particularly on the coast and the Maritime region[19]. Recently another more alarming assessment was done. According to MERF the third national communication on climate change, with as reference year 2005, estimations of emissions and removals of green house gas at the national level concern the direct gases (CO_2, CH_4, N_2O) and the indirect gases (NOx, CO, NMVOC and SOx)[27]. According to this report, CO_2 emissions stem from the burning of fuels. Like what has been noted in the year 2000, CO2 emissions are estimated at 12569,42 Gg or 70,84 per cent of total emissions, 1764 Gg or 9.94 percent, CH_4 and N_2O to 3 410 Gg or 19.22% (UNFCCC, 2015). Therefore, Lomé faces a danger related to the emissions of greenhouse gases. Therefore, it is necessary to have a policy of intense reforestation. The ability of absorption of carbon dioxide (CO_2) that possess the trees is an inevitable solution to purify the polluted air.

Conclusion

The method of remote sensing combined with field investigations enabled us to identify by comparing the values between the two sites, four (4) parameters of urban growth: the population, urban traffic, the bare or build soil and canopy.

Results showed that all parameters, except the canopy are well represented at site 1 than site 2. The latter is five (5) times more surface area of vegetation cover than site 1. By inference, the parameters involved in the warming of the center of Lomé are those with high values at site 1. Vegetation cover, by its refreshing action, maintains the temperature at site 2. It is important therefore to go toward the greening of cities and the use of insulating materials with high albedo in the construction of buildings. This work must continue towards the definition of a sustainable and adequate urban planning capable to mitigate global warming in Lomé.

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