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Review Paper

Urban planning and vegetation in Togo: what approaches for the mitigation of global warming in the city of Lomé in a context of climate change?

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Abstract

Urban planning must take into account the preservation of the balance of the ecosystem by prioritizing vegetation for sustainable development. The city of Lomé, inseparable from the green spaces in the colonial time is today in rapid urbanization. The purpose of this research is to analyze the evolution of the temperature and the mismatch between urban planning and the gradual disappearance of the vegetation cover in the prospect to seek an approach to sustainable urban planning. The methodology relied on the use of the technique of Visual (image-interpretation) and digital analysis of images by remote sensing at 30 m resolution. The resulting vector file has been used to extract the study area on satellite images of the years 1986-2000-2013-2016.The process took into account classes of Vegetation-built occupation, compared with the rise in the temperature average of the same years. It appears clear that the mineralization of the soil at the expense of the canopy is the raison of the rise of temperatures in Lomé. Only the urban planning of the vegetation cover can mitigate warming in Lomé.

Keywords: Vegetation, temperature, land use and climate change.

Introduction

Nowadays, the world knows with the rampant urbanization of towns, a spectacular population growth. People living in cities with important dimensions are estimated at more than half of the world's total population[1]. If the situation is under control in developed countries, it is almost not controlled in African cities that know annual demographic growth above 4%[2]. This rapid growth degrades the environment to which special attention must be given[3-4]. The establishment of a city necessarily leads to the disappearance of natural forest for the benefit of buildings, but the rehabilitation of vegetation cover is a necessity. In order to maintain balance of the ecosystem, wood Parks and green spaces must be created to compensate. Unfortunately, this is not the case because of the competition between different uses of lands[5]. This shows that human being, through its actions and activities, is the main trigger of the transformation which the ecosystem with which he has personal relationships, are currently under[6]. Of cuss, there are natural factors favoring the dynamics of environments like the changes in vegetation cover but these conditions, less favorable to the growth of the trees make often cities look like an islands of mineralized surfaces, full of environmental problems[7].

Anthropic pressure growth that undergo natural resources, lead to malfunction of ecosystems and the loose of the biodiversity[8]. Therefore, it is followed by inappropriate systems of natural resources that have a direct impact on the land use and the configuration of the landscape[9-10]. Shashua-Bar shows through their researches that the presence of the shade of trees can affect and reconcile the geometry and the orientation of the climate of the canyon Street[11].

The warming of urban areas is more pronounced when the ground is partially or totally bared of vegetation[12-14]. Vegetation offers significant freshness that uses prevailing winds as factors of diffusion[15-16]. Asaeda T. studies in Tokyo illustrate well the reductive effect of temperature up to 1.5°C through the creation of a park, with an area of 0.6 km2 placed in the axis of the prevailing winds[17]. It is necessary to establish consistence between urban planning, wilderness and artificial Green frames[18]. Today, like all African cities, Lomé is facing many environmental challenges including the lack of green space and the inadequacy in the consumption of resources and their pace of renewal in a galloping urbanism[19]. However, Lomé had an history with the green spaces during the colonial time and it was estimated that both were inseparable. Nevertheless, today what is the place reserved for urban green heritage in the urban planning in Lomé.

A few sites planned for parks in Lomé are unfortunately squatted by people and the illegal occupants[20]. However, it is always noted in Lomé a persistence of higher temperatures and a rise of areas of bare or built-up soil[21]. More than 85, 05 km of roads are tarred within the last decade according to the Direction of public work (TP) and the General Directorate of infrastructure and urban equipment (DGIEU). Therefore, is there any relationship between the rise in temperature, rapid

urbanization and the disappearance of the vegetation in the urban agglomeration of Lomé?.

The purpose of this study is to show the influence that induced the mismatch between urban planning and vegetation cover on the thermal variation in the perspective of the search for a sustainable urban planning approach. The hypothesis is: the poor urban planning is one of the main causes of the warming of the urban agglomeration of the city of Lomé.

Material and methods

Study area: The city of Lomé, economic and political capital of Togo, is located in the extreme south of the country, on the coast of the Golf of Guinea, between 6°8" and 6°11" latitude North and 1°11" and 1°18 longitude East (Figure-1). Subject to a climate anomaly, the city of Lomé undergoes a subequatorial climate.

Data collection: In the context of the data collection, we got from the management services of the city of Lomé, a topographic map at 1/200,000th of Lomé commune, geo-referenced from the WGS 84 ellipsoid and the zone 31 north.

Lands at images of 30 m resolution of the study area of the years 1986, 2000, 2013 and 2016 were downloaded by digitization of the outline on Google. A step of 14 years allowed selecting the first three years. However, the fourth year (2016) has been selected by the fact that we think that with the profound change in development known this last term, important information of the evolution of classes can be obtained. Targeted classes of occupation on maps are: vegetation - bare / built soil - water. Finally, data on the annual thermal average of selected years was obtained from the national meteorology branch.

Processing and analysis of data: pre-processing: Preprocessing has objectives to improve the quality of images and to facilitate interpretation of the results. Then it proceeded to a Visual analysis and the technique of supervised classification of images based on the algorithm of the maximum likelihood[22,23]. The assessment of the quality of the classifications is done by the calculation of the matrix of confusion and Kappa Index K. The Kappa index is expressed as probability of correct classification on a scale of 0 to 1. The Visual analysis of the images by colorful compositions (RGB: 4-3-2) led at first to issue a provisional map of land occupation.

Verification on the soil: For the purpose of correcting this map, it was taken to the validation of the classification by sampling points. To do this, a sample of thirty (30) points of soil control has been selected, which's coordinates are recorded by the placement of mesh on the map of occupation. Thirty points were divided in group of 10 points per class of occupation including vegetation, buildings, water.

Using a GPS, positioning on the ground of the points corresponding to those identified on the map to check the conformity of the class of occupation identified on the map. A type of land use is attributed to the coordinates. Once the classification has been validated, we step to the edition of maps of land use.

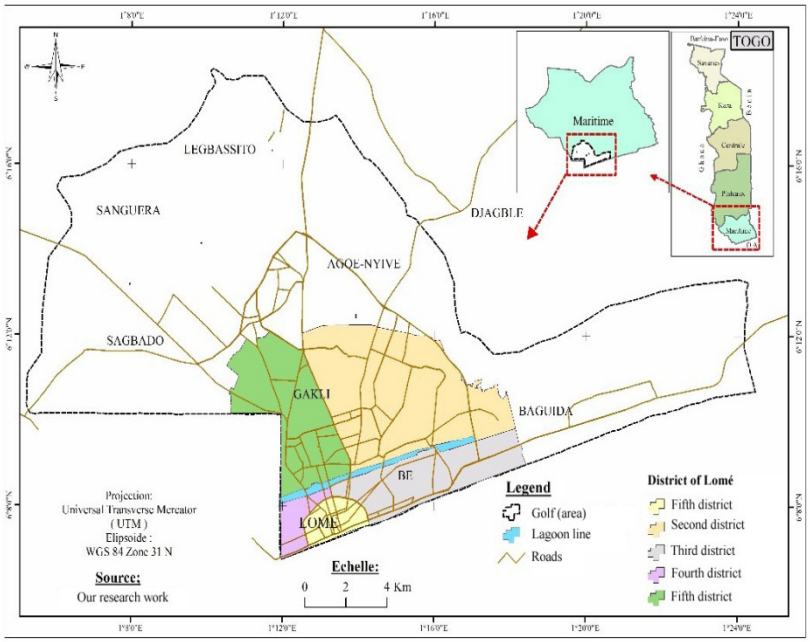

Figure-1: Location of the study area.

The edition of the map: It was made by importing results of classifications in the Arc Gis version 10.2.1 software. Maps of land of the years 1986, 2000, 2013 and 2016 are thus produced and different surfaces are calculated. These different surfaces allowed seeing dynamics of the occupation within years. Secondly, we got from the national meteorology, data of temperature from 1986 to 2016. These data were used to draw the curve of temperature changes and compare it with those of the dynamics of the occupation of the soil and bring out different correlations between vegetation cover loose and the rise of temperature. In order to confirm the existence of a link between the three parameters including temperature, bare and built-up surfaces and vegetation cover, we proceed to a correlation analysis using the R software.

Results and discussion

Characterization of different land-use classes: The municipality of Lomé is occupied from 1986 to 2016 by vegetation, the bare and built soil and water surfaces. The vegetation includes community forests, green spaces, and plantations. The bare and built soils include lands without vegetation or with low vegetation cover (Figure-2); these lands include the bare soil, rock outcrops, roads, constructions, and infrastructure. The class of water includes lagoons, pools, the stored seawater and the sea. The comparison of the four maps shown the difference of land use between the four dates. This allows seeing clearly how vegetation changes within time.

Dynamics of the occupations of the soil of the municipality of Lomé: The results of the analysis of the satellite images of the different dates show generally that vegetation, occupied a large proportion of the total area of Lomé in 1986: 71% (Figure-3). By this year, this surface has significantly declined in favor of bare and built soil up to 16% of the total surface in 2016. Indeed, bare and built soilat lower proportion in 1986 (28%) experienced a rise of 53%: from 28 to 81%.

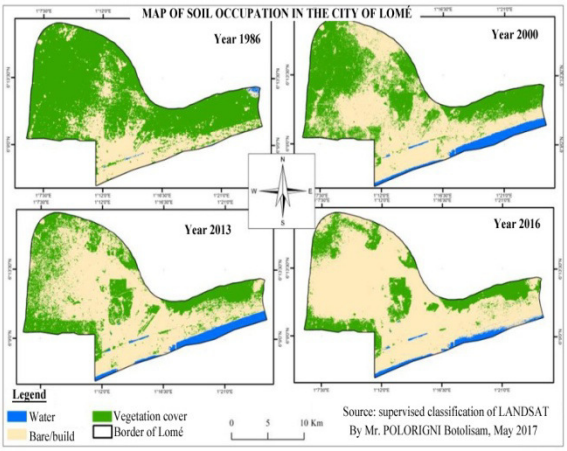

Figure-2: Current Occupations of the soil in 1986, 2000, 2013 and 2016 in the municipality of Lomé.

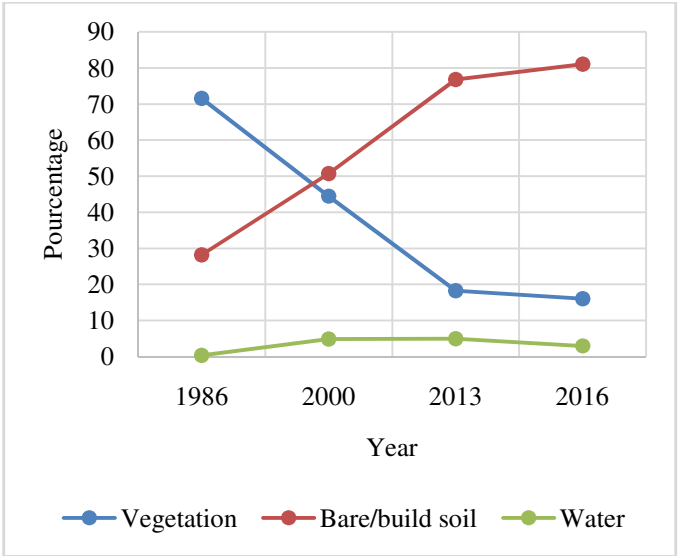

Figure-3: Trends of the rise of land use in the municipality of Lomé (1986, 2000, 2013 and 2016).

Canopy, bare or built soil and temperature, three strongly bound parameters: The city of Lomé takes a very remarkable spatial scale by the proliferation of the constructions of massive buildings that occupy the soil. This situation forces various facilities including the construction of socio-economic infrastructure to follow the horizontal extended of the development. This led to the removal, without fair replacement of the vegetation. All this happens when it is noted through meteorological data, a gradual rise in temperature over the years in Lomé (Figure-4).

Curves Representing the evolution of bare/built soil and the temperature within the years 1986, 2000, 2013 and 2016 rise while it is observed a dramatic decrease in the curve of the evolution of the vegetation. This antagonism between the curve of the vegetation and the curves of the bared/built soil and temperature portends a strong correlation.

Vegetation, built or bare soil and temperature correlation test: The correlation test tie doubts of connections between compared parameters. The following chart (Table-1) presents positive and negative numbers. The negative sign expresses an opposing affair while the positive sign expresses a binding that is moving in the same direction. This binding is weak when the number is around 0.5 but it is strong when the number is closer to 1.

In the case of this study, we realized very strong correlations between the classes of land use and the evolution of the temperature within concerned years. Indeed, over the years, the proportion of vegetation decreased while naked and built-up surfaces (NBS) increase. It is the same for temperature which increases over the time. Naturally, the proportion of the NBS evolves inversely to the one the vegetation. This antagonistic effect is also observed between temperature and vegetation, indicating so that the decline of the vegetation is correlated to the urban temperature increase, and vice versa. Finally, the temperature rises with the rise of the NBS.

This reduction in vegetation cover can then be explained by the urbanization. The urban plan (Le Plan directeurd'urbanisme PDU) of the city of Lomé, a planning tool, developed in 1981, has been implemented partially, though it presents very large insufficiencies in terms of rehabilitation of vegetation cover. Then the city has developed by itself. A Goodurban planning could have merit if protecting a part of existing natural vegetation cover and the renewal of the one destroyed by buildings.

The mineralization of the city took pace over the balance of the ecosystem. The hypothesis is confirmed. The main cause is poor urban planning without taken into account land use plan that include environmental services. It should be noted that strong migration to Lomé during the years 90 and 2000 causes an urgent need in infrastructure such as housing, markets, roads, schools in disfavor of vegetation cover. So, this urbanization was done without respecting the nature.

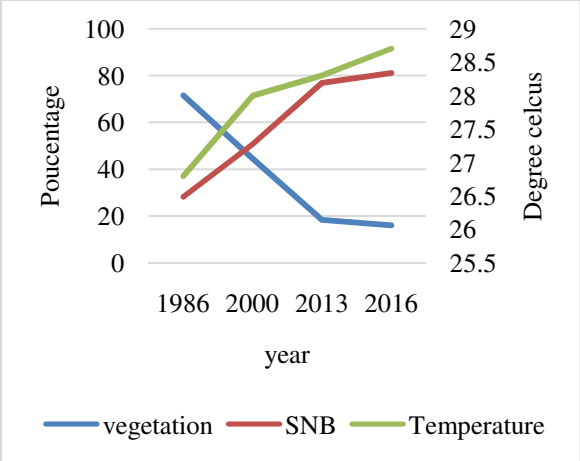

Figure-4: Evolution of temperature based on units of land use in the town of Lomé.

Table-1: Correlation between vegetation, bared and built soil, and temperature.

	Year	Vegetation	NBS	Temperature
Year	1.0000000	-0.9985173	0.9987229	0.9690742
vegetation	-0.9985173	1.0000000	-0.9978797	-0.9631394
NBS	0.9987229	-0.9978797	1.0000000	0.9554408
Temperature	0.9690742	-0.9631394	0.9554408	1.0000000

Discussion: Loss of vegetation cover and warming of Lomé: This approach by remote sensing helped to observe clearly antagonistic evolution of classes of vegetation and classes of bare and built land in the years 1986-2000-2013-2016. Comparison of these results with the annual thermal averages of the relevant years illustrates that the disappearance of vegetation trained a rise of temperatures. These results are similar to those found by Takou P. that show that surfaces of vegetation are decreasing in Lome. Elsewhere the loose of vegetation is confirmed by the national average[24]. The lack of vegetation predisposes urban areas to the birth of warming microclimate in connection with the formation of urban heat island phenomenon. Natural thermal regulators, vegetation reduce the urban heat island by reducing the temperature on the ground and on the surface of the buildings .Through evapotranspiration of trees, based on gas exchange and steam between the plants and the atmosphere, the air is humidified reducing significantly urban heat. In addition, through photosynthesis trees contribute to limit the greenhouse effect by trapping CO2 at the level of its bodies. Also, the effect of shading of vegetation decreases the exposure of areas and buildings in the Sun. Thus, according to the studies of the massive introduction of the vegetation would be the most effective solution to cool the air of cities.

Several studies have also demonstrated the role of the refreshing effect of vegetation in urban landscape, such as the studies of which stipulate that urban parks present almost 40% degrees hours of air conditioning than other urban stations nearby. Those by mention that in a park of Viveros with an area of 20 ha, 2.5°C is decrease compared with the maximum measured in urban areas. Therefore, it is important to find a balance between urban planning and management of vegetation cover to avoid the formation of the heat island. It is in this way that, Mansouriproposes the use of greenery as a strategy to mitigate the urban heat island and improve the microclimate[25]. To avoid worsening warming in the city of Lomé, Government must apply a strategy of rehabilitation and preservation of vegetation cover by requiring communities which wish to subdivide their land, a wooded reservation of ten percent 10% of the divided space in compensation to get recording and the processing of the files.

Necessity to promote the establishment of an ecological city in Lomé: In the city of Lomé, the roughness of the city is more established. The lower town is completely mineralized. Apart from few pockets where a few small open spaces are visible, the Middle has experienced its highest level of impermeability with the latest improvements led to the upgrading of almost all of the streets in downtown.

According to Alexsandri, the energetic performance from vegetation is greater when the climate is hot and dry, that corroborates with the results obtained by Jaffall for vegetated roofs[26-27].

Mineralization in this area is reinforced with the sanitation of this part. A few tree plantations have been initiated but still are struggling to develop with the high level of impermeability of the ground. Some streets of the area are lined with trees. About these trees grown along the arteries, Radji A. found that they do not get forest maintenance[28]. They show that these trees grow without follow-up and noted that when it becomes necessary that these trees are pruned, their branches are cut squarely without aesthetic or they are simply cut down. The same observation was made by Polorigni, who notes the negligence at the level of maintenance of some public gardens in lower town including Freau Jardin, Garden of the prefectural direction of environment, the garden of Nyekonakpoe[29]. The conclusions of relative to tree plantations isolated or grouped in wood or urban forests, shows that temperatures under the trees are in the day consistently cooler than above surrounding open spaces, and that the amplitude of this Refresh depends on the species of tree[30]. The size of the trees and their Crown seem to be the factors explaining variations in interspecies[31,32]. The initiation of a program of urban forestry in the rigor of the feasibility as an emergency to protect the city becomes a necessity. In this context, Jack-Scott suggested the inclusion of the needs of populations in urban forestry planning to create the conditions for a sustainable city[33]. Green frames along the thoroughfares of the city must be promoted to mitigate the effect of the Sun's rays in the warming of the city. In order, Molli C. suggests, the promotion of vegetation in the new models of the sustainable city must create green infrastructure, a tool of urban structuration[34]. Thus, Haddad Y. appealed to the notion of urban forestry that allows reporting on the analysis of the characteristics of the landscape[35]. To ensure the likelihood of survival, Cook E. wants an observable indicator usage over the time[36]. Analyzing the shade trees go further and point out that it can help to get savings for seasonal cooling. This must bring leaders of the city of Lomé to an urban forestry program that combines arboriculture, ornamental horticulture and forest management. It is closely related to landscape architecture and urban management[37]. In all cases, the urgent need of the people is to live green, whose main assets are therapeutic and regulator of the ecosystem. In this sense, useful species to be promote may come from highly appreciated work of Radji and Kokourelating to the classification and therapeutic values of the ornamental plants in Togo[38].

Conclusion

The merit of this study is to have proven a correlation between the Status of the city parameters including the rise in temperature, the disappearance of the vegetation cover and the multiplication of built-up and bare surfaces. The method of tele detections based on the use of techniques of Visual (photo-interpretation) and digital analysis images supplemented by a field survey show a correlation between vegetation, bare and built surfaces and the thermal averages studied in the town of Lomé. Today, decision-makers have evidence on the evolution of these urban settings. It belongs to them according to political orientation to know on which parameter to act for a mitigation of global warming in the city of Lomé. The best choice for the

sustainable development of the city of Lomé, is to move to an ecological city, which mitigates global warming.

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