



# IMPLICATIONS OF POPULATION GROWTH ON URBAN ECOLOGY: A STUDY OF THE YAOUNDE METROPOLITAN AREA, CAMEROON

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## ABSTRACT

Urban areas around the world especially in the developing countries are experiencing unprecedented increases in their population and the impact of this population growth on the urban environment has become obvious. This study examines population growth in the Yaounde metropolitan area from the year 2000 to 2020 and the implications on the population-environment nexus with particular focus on those aspects where human activities have the greatest impacts. The study makes use of a mixed method design where questionnaires, semi-structured interviews and field observations were used to collect primary data from the sampled population.

The results of the study revealed that the population of Yaounde has increased rapidly over the last two decades with over a million people adding to the population every ten years between 2000 and 2020. Biodiversity loss, Land use and land cover (LULC) change, poor waste management, air pollution, and micro-climate change are among the biggest and visible indicators of the ecological implications of population growth in the Yaounde metropolitan area.

**KEYWORDS:** Implications, Population, Ecology, Urban Growth, Yaounde

## 1. INTRODUCTION

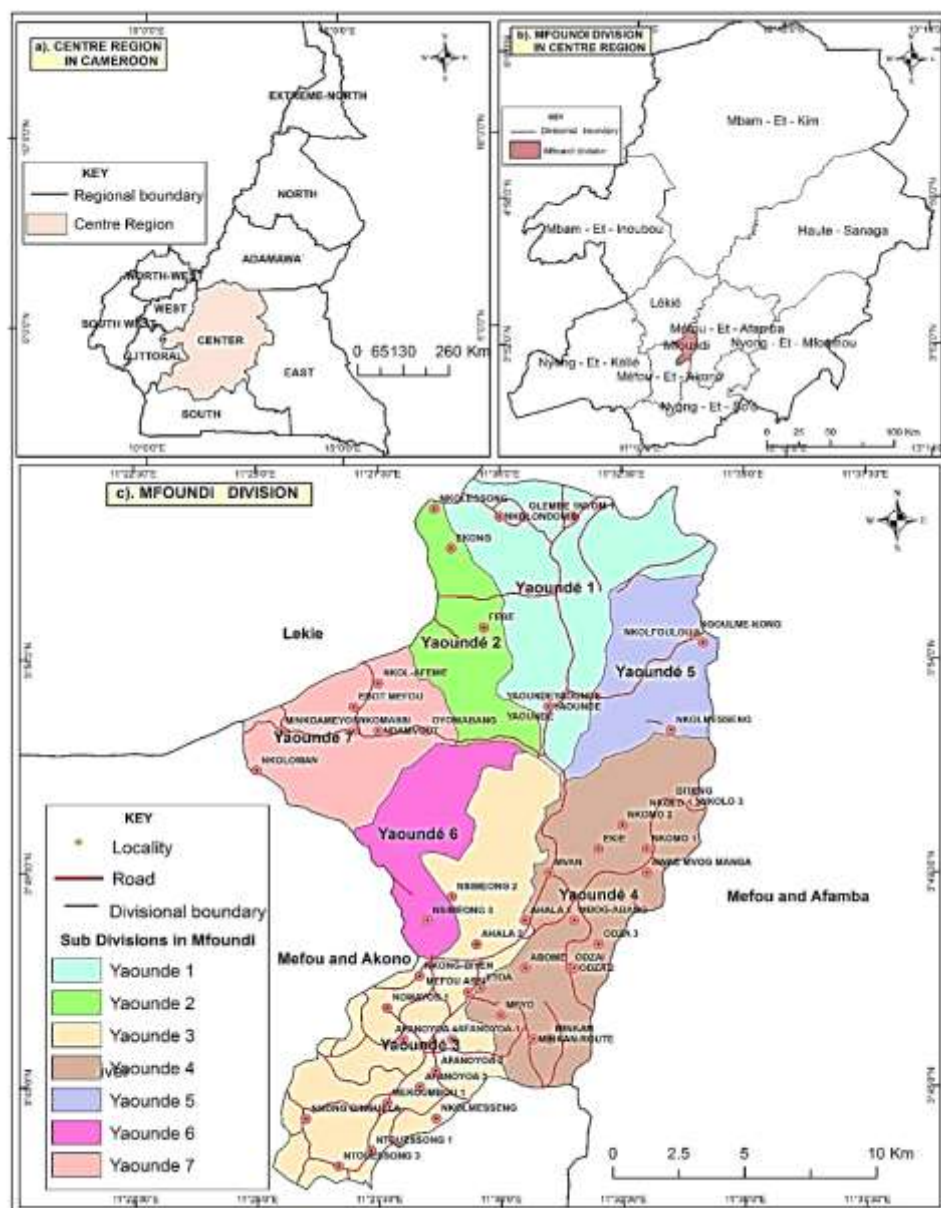
Projections based on the on-going global urbanisation and population increase show that about 2.5 billion people will be added to the world's population by 2050 and this will occur mainly in Asia and Africa (UN, 2018). Until the 1960s, a majority of the African population lived in rural areas and Africa was the least urbanised continent with an urban population of 18.8% (United Nations Environment Programme, 2011). However, from the mid-1990s, the urban trend changed and about 43% of the African population was living in the urban areas (United Nations Population Division, 2009) and Sub-Saharan Africa had one of the highest rates of urbanisation with an annual growth rate of 4.87%. The UN (2012) suggested based on the 2011 predictions that, between 2030 and 2050, another 1.3 billion people will be added to the global urban population and more than 90% of this growth will be in the cities of the developing countries.

In the same way as global situation and developing countries, the urbanisation phenomenon in Cameroon is not so different (Akoko *et al.* 2019). Current urbanisation rate in Cameroon stands at 52 percent and the urban population is expected to grow by 8 million by 2030 (UN, 2018). This makes Cameroon one of the fastest urbanising countries in Sub-Saharan Africa. Yaounde and Douala for example which are the two major cities in Cameroon have been expanding exponentially. A study carried out by Gwan and Kimengsi (2020), indicated that the city of Yaounde is growing rapidly resulting in overcrowding in neighbourhoods such as Simbock, Nkolbisson and Emombo which in some few years back were very underdeveloped and less urbanised. Past trends indicate continuous expansion in terms of size, structure and density. The population has significantly increased from 1.3 million in 2000 to 3.2 million in 2015 and 3.9 million in 2020.

The urbanisation of most of Cameroonian cities has been rapid, uncontrolled and unplanned and has been eating up much of their fringes (Kimengsi and Fogwe, 2017). Rapid increase in the number of people living in the urban areas has been accompanied by more drastic changes of land use types, and in most developing countries including Cameroon, this has been in a more disorderly manner resulting in haphazard, and fragile ecological environment (Zhou *et al.* 2014). Urban land-cover and land-use changes as a result of increased population and human activities cause significant ecological changes in climatic regimes, changes in biological life cycles, reduced wildlife habitat and resource availability to wild animals (Chyb *et al.*, 2021, Seto *et al.*, 2013 and Grimm *et al.*, 2008). This paper examines the implications of population growth on the ecology of the Yaounde metropolitan area.

## 2. THE STUDY AREA

Yaounde which corresponds to Mfoundi Division, is the part of the western sector of the Southern Cameroon Plateau. It is bounded to the North East by Mefou and Afamba Division, to the North West by Léké Division and to the South by Mefou and Akono Division. Yaounde is located between latitudes  $3^{\circ} 45' 50''$  and  $3^{\circ} 59' 55''$  North of the equator and between longitudes  $11^{\circ} 22' 40''$  and  $11^{\circ} 30' 25''$  East of Greenwich meridian. Yaounde is the administrative and political capital of Cameroon and also doubles as the regional capital of the Centre Region. It is divided into seven subdivisions; Yaounde 1, 2, 3, 4, 5, 6 and 7. The city of Yaounde (nicknamed the city of seven hills), is located on a network of hills dominated by the Mbam Minkom mountains (1295m) and Mount Nkolodom (1221m) in the northwest sector of Yaounde, and Mount Eloumden (1159m) to the southwest. It also comprises of other set of hills ranging from 600 to 700 m above sea level. Plateaus and valleys are also major relief features in Yaounde. With this altitude, the climate of Yaounde is normally humid and mild with moderate and constant temperatures throughout the year and temperatures are believed not to be as quite hot as one would expect for a city located near the equator with average temperatures of 24oc.



Source: Derived from the administrative map of the Centre Region, (2020)

Figure1: Spatial location of study are



### 3. MATERIALS AND METHOD

The study made use of both quantitative and qualitative research approaches. Data was collected from both primary and secondary sources. While secondary data was secured from published, unpublished documents and official archives through content analysis, primary data was collected from the field using quantitative and qualitative tools. Questionnaire was the main tool used to collect quantitative data, while semi-structured interviews and field observations were the main tools used to collect qualitative data.

#### 3.1 Sample size determination

The study made use of Cochran's (1977) formula (with a finite population correction) in order to calculate the sample size, which is suitable for large population size, that is, a population size >10 000 like the case of Yaounde with approximately 721 202 households. Cochran's formula is given as:

$$no = \frac{Z^2 X P X (1 - P)}{e^2}$$

Where:

Z = 1.96 (for 95% confidence)

P = 0.5 (maximum variability)

e = 0.05 (margin of error)

Substituting,

$$no = \frac{(1.96)^2 X 0.5 X (1 - 0.5)}{(0.05)^2}$$

$$no = 384$$

Therefore, the initial sample size before correction is 384.

Applying the finite population correction (FPC) for a known population (N = 721202),

$$n = \frac{no}{1 + \frac{no - 1}{N}}$$

$$n = \frac{384}{1 + \frac{384 - 1}{721202}}$$

$$n = \frac{384}{1.0004788206}$$

$$n = 383.81$$

Using the Cochran's formula and assuming a confidence level of 95% (Z = 1.96) with a 5% margin of error (e = 0.05), a proportion of 0.5 maximum variability and for an estimated household size of 721202, the sample size was calculated as 384 households. The total sample size of 384 households was then redistributed across the 7 municipalities in Yaounde based on their respective population shares. The population shares were calculated as thus:

$$share (\%) = \frac{\text{municipality population}}{\text{total population of Yaounde}} \times 100$$

From the above formula, the shares and number of households sampled in each municipality was calculated and the statistics in table 1 obtained.

**Table 1: Sample size distribution across the different municipalities**

| Municipality | Population | Share of the population (%) | Number of households sampled |
|--------------|------------|-----------------------------|------------------------------|
| Yaounde 1    | 419 347    | 11.6                        | 45                           |
| Yaounde 2    | 389 574    | 10.8                        | 41                           |
| Yaounde 3    | 887 369    | 24.6                        | 94                           |
| Yaounde 4    | 803 401    | 22.2                        | 86                           |
| Yaounde 5    | 357 454    | 9.9                         | 38                           |
| Yaounde 6    | 489 746    | 13.6                        | 52                           |
| Yaounde 7    | 259 119    | 7.2                         | 28                           |
| Total        | 3 606 009  | 100                         | 384                          |

As seen on table 1, the municipality with the largest population received the highest number of questionnaires while the municipality with the smallest population received the lowest number of questionnaires. This was to ensure a fair and representative distribution. A multi-stage sampling technique was used to select the sampled households. First, simple random sampling used to select 15 neighbourhoods from the seven municipalities. Second, simple random sampling was again used to select households to which the questionnaires were administered.

To probe into the quantitative results, some 10 semi-interviews were conducted and field observation also carried out. Three series multispectral and multi-temporal Landsat imageries of Yaounde were obtained from Google earth for the periods– 2000, 2010 and 2020. The aim of using three series image was to show the level and intensity of land use/cover change as a result of urbanisation and the conversion of the vegetated surfaces to other land uses such as roads, and settlements.

The quantitative data was analysed using a descriptive approach where frequency distribution tables and graphs were used to illustrate perceptions on urbanisation process and ecological change in the study area. The main types of graphs used in the study were line graphs, histograms and pie charts. For the qualitative analysis, data collected was constantly reviewed so as to focus on themes and patterns that emerged in subsequent interviews. Audio recordings were transcribed and field notes expanded after each interview. Data was then analysed after transcription and expansion of notes using inductive analysis.

## 4. RESULTS AND ANALYSIS

### 4.1 Population growth in Yaounde

Yaounde is the second largest city in Cameroon and the primate city in the Centre Region. It is one of the fastest urbanising cities in the country and its population has been rapidly increasing since the year 2000. Statistics show that the population of Yaounde has been increasing rapidly since the year 2000 with almost a million people or more added to the population every decade. Table two presents the demographic data of Yaounde every five years over the period 2000 to 2020.

**Table 2: Population evolution and growth rate in Yaounde (2000-2020)**

| Year      | Population | Growth    | Growth rate % |
|-----------|------------|-----------|---------------|
| 2000      | 1.351.047  | -         | -             |
| 2005      | 1.781.264  | 430.217   | 6.34          |
| 2010      | 2.348.656  | 567.392   | 6.37          |
| 2015      | 3.096.728  | 748.072   | 6.37          |
| 2020      | 3.992.411  | 895.683   | 5.78          |
| 2000-2010 | -          | 997.609   | 6.52          |
| 2010-2020 | -          | 1.643.000 | 6.17          |
| 2000-2020 | -          | 2.641.364 | 6.23          |

Source: BUCREP, (2010), Yaounde city council archives (2019) and World's population prospect data, (2020)

From Table 2, about 430 217 people were added to the population of Yaounde between the year 2000 and 2005, representing an annual growth rate of 6.34%. From the year 2005, there was a steady increase in the population from the year 2010 to 2015, recording the highest growth rate. The statistics also show that the populations of Yaounde expanded at least three times between 2000 and 2020. An additional 2641000 people had been added to the population of Yaounde between during this period. In terms of the rate of population growth, Yaounde experienced an average annual rate of population increase of 6.52% during the period 2000-2010. From 2010 to



2020, the average annual growth rate was 6.17% and from the period 2000-2020, the average annual growth rate has been 6.23%, indicating that over the last 20 years the population of Yaounde has grown by about 195%.

The main driving forces behind the rapid increase in the population of Yaounde are natural increase and migration (Tiafack and Mbon, 2017). Rapid increase in the population of Yaounde is mainly attributed to migration from rural areas and from other towns in Cameroon. Field survey revealed that a majority of the people in Yaounde are migrants accounting for more than 70% of the total population. During field survey the respondents were asked to indicate their places of origin. An analysis of the results showed that 70% of the respondents were not indigenes of Yaounde. They were either first generation (those who actually moved from their region of origin to Yaounde) or second generation and third generation migrants (the children of first-generation migrants who did not actually move but descended from the migrants). Just 30% of the respondents were actually indigenes of Yaounde. Statistics showed that the Yaounde has a population of 3 606 009 people unevenly distributed over a surface area of 304 km<sup>2</sup>, with a population Density of 11.86 per/km<sup>2</sup>. Table 3 shows the distribution of the population and density across the seven municipalities of Yaounde.

**Table 3: Population distribution and density across the different municipalities in Yaounde**

| Municipality | Population | Surface area (km <sup>2</sup> ) | Density (per/km <sup>2</sup> ) |
|--------------|------------|---------------------------------|--------------------------------|
| Yaounde 1    | 419 347    | 54.64                           | 7.68                           |
| Yaounde 2    | 389 574    | 23.56                           | 16.54                          |
| Yaounde 3    | 887 369    | 68.34                           | 12. 99                         |
| Yaounde 4    | 803 401    | 58.07                           | 13. 84                         |
| Yaounde 5    | 357 454    | 26.52                           | 13. 48                         |
| Yaounde 6    | 489 746    | 28.35                           | 17. 27                         |
| Yaounde 7    | 259 119    | 44.92                           | 5.77                           |
| Total        | 3 606 009  | 304.00                          | 11.86                          |

Source: *Extracted and calculated from Yaounde City Council's archives, (2019)*

Table 3 shows an uneven distribution of the population over the different municipalities. The statistics indicate that, the most populated municipality is Yaounde three while Yaounde seven is the least populated. However, the most populated municipality is not the most densely populated. The most densely populated municipality in Yaounde is Yaounde 6 with a population of 489,746 residing on a surface area of 28.35km<sup>2</sup> giving a density of 17. 27pers/km<sup>2</sup>. This is followed by Yaounde 2 with a population of 389, 574 people occupying a surface area of 23.56km<sup>2</sup> with a density of 16.54pers/km<sup>2</sup>. Yaounde seven is the least populated and the least densely populated municipality with a population of 259 119 residing on a surface area of 44.92km<sup>2</sup> giving a density of 5.77pers/km<sup>2</sup>.

Increase in the number of people living in Yaounde necessitates increase in the number of houses constructed, increase in the number of urban infrastructures and expansion in urban activities. All these activities result in the transformation and occupation of vegetated and permeable surfaces. Most of the houses do not abide to the urban planning regulations and are constructed haphazardly and chucked up. They are also constructed with heat absorbing materials and their surroundings are often paved with concrete materials rather than greened, resulting in the high temperatures experienced in Yaounde municipalities. The rapid population increase in Yaounde is therefore, one of the main reasons behind landscape transformation, increase temperatures and other environmental changes.

#### **Implications of population growth on the urban ecology**

The growth in human population comes with increased utilisation, overuse and misuse of resources and this is bringing lasting implications on the urban ecology. More people mean more space for the construction of houses, more forest cleared, more mouths to feed, more waste generated, more people and goods to be transported, more consumption of fossil fuels, more pollution and change in the local climate. Therefore, the impact of population growth in Yaounde is manifested on biodiversity loss, land use and land cover change, air quality, and waste management.

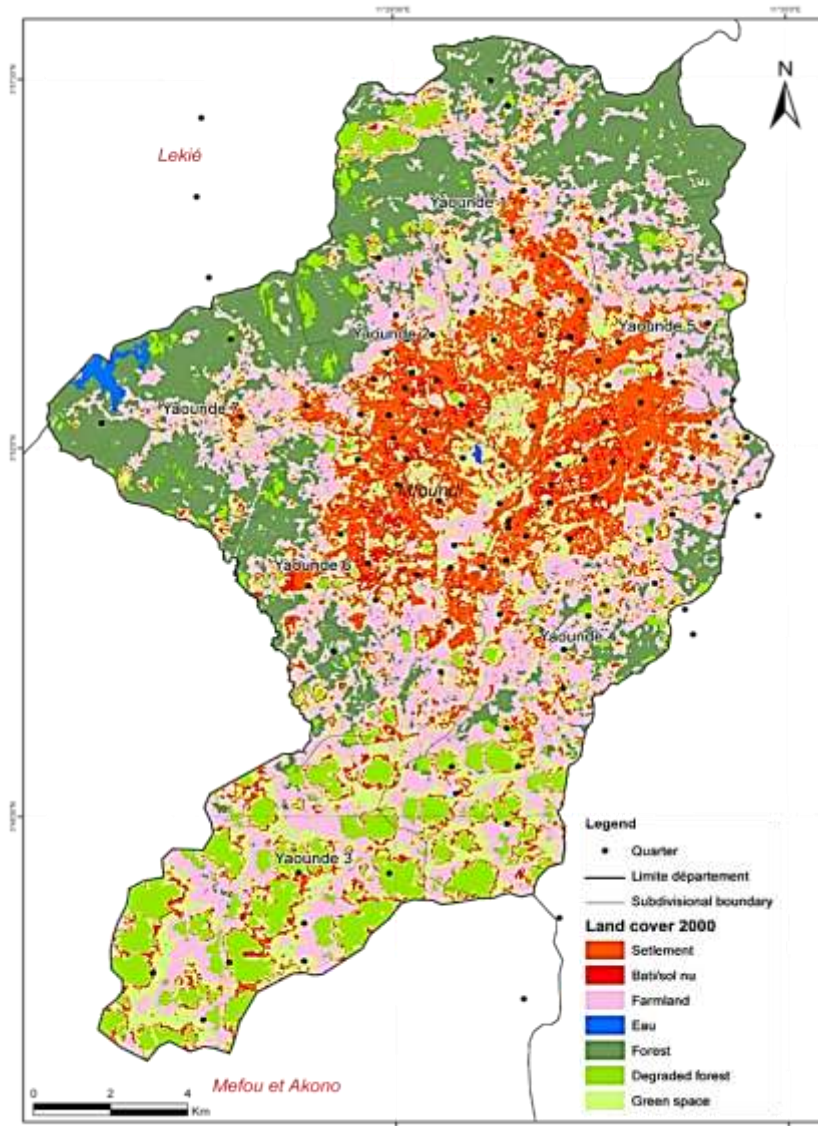
#### **4.2 Population growth and Land cover/land use change in Yaounde**

By the 1950s the surface area of Yaounde was less than 9.000ha. The rapid increase in the population and the development of urban infrastructures especially from the year 2000 has resulted in the expansion of the surface area of Yaounde to 30400 ha (Nkwemoh, 2019). To illustrate landscape transformation, a detail analysis of the spatial evolution of the Yaounde urban space was carried out for the years 2000, 2010 and 2020. The period from

the year 2000 was chosen because this was the period characterised by a remarkable increase in the population of the area and the year also marked an accelerated phase of land use and land cover change.

#### 4.3 Land use and land cover of Yaounde in the year 2000

Though the population of Yaounde reached its first million by the year 2000, most of these people were still concentrated around the city centre. Much of Yaounde was still green with over 60% of its total surface area still occupied by one form of vegetation or the other as depicted on (Figure 2 and Table 4).



Source: LandSat Image 2000, USGS Earth Explorer, Datum: WGS 84 Zone 32N

Figure 2: Land use and land cover map of Yaounde in 2000

Table 4: Land use and land cover statistics of Yaounde in 2000

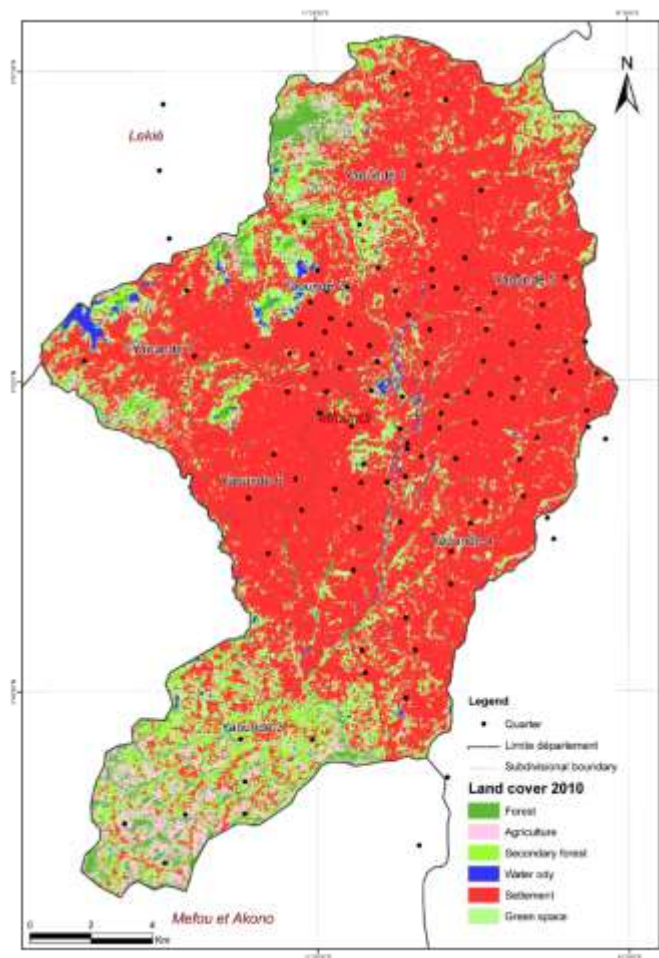
| LU/LC type      | Surface area (ha) | %     |
|-----------------|-------------------|-------|
| Settlement      | 5649,4537         | 20.02 |
| Farmland        | 8073,5212         | 28.61 |
| Water body      | 168,8149          | 0.60  |
| Degraded forest | 1693,5822         | 6.00  |
| Dense forest    | 6567,8397         | 23.28 |
| Green space     | 6061,7067         | 21.48 |
| Total           | 28214,9184        | 100   |

Source: Derived from the land use/land cover map of Yaounde in 2000

Figure 2 and Table 4 show the LULC statistics of Yaounde for the year 2000 reveal that farmland was the dominant land cover type occupying 8 073.5212ha (28%) of the total surface area. This was followed by forest cover with 6 567.8397ha (23%) and then settlement with 5 649.4537ha (20%). The statistics show that farmland was the dominant land cover type while the least land cover type was settlement.

#### 4.4 Land use/land cover of Yaounde in 2010

By the year 2010, the land cover types of Yaounde had undergone some significant changes. Unlike in the year 2000 when farmland was the dominant land cover type, the built-up area was the dominant land cover type in 2010 as seen in Figure 3 and Table 5.



**Table 5: Land use and land cover statistics of Yaounde in 2010**

| Land use        | Surface area | %     |
|-----------------|--------------|-------|
| Settlements     | 9916,43      | 34,99 |
| Farmland        | 8530,57      | 30,10 |
| Water body      | 148,01       | 0,52  |
| Degraded forest | 2552,74      | 9,01  |
| Dense forest    | 1115,26      | 3,94  |
| Green space     | 6077,84      | 21,45 |
| Total           | 28340,85     | 100   |

Source: Derived from the land use/land cover map of Yaounde in 2010

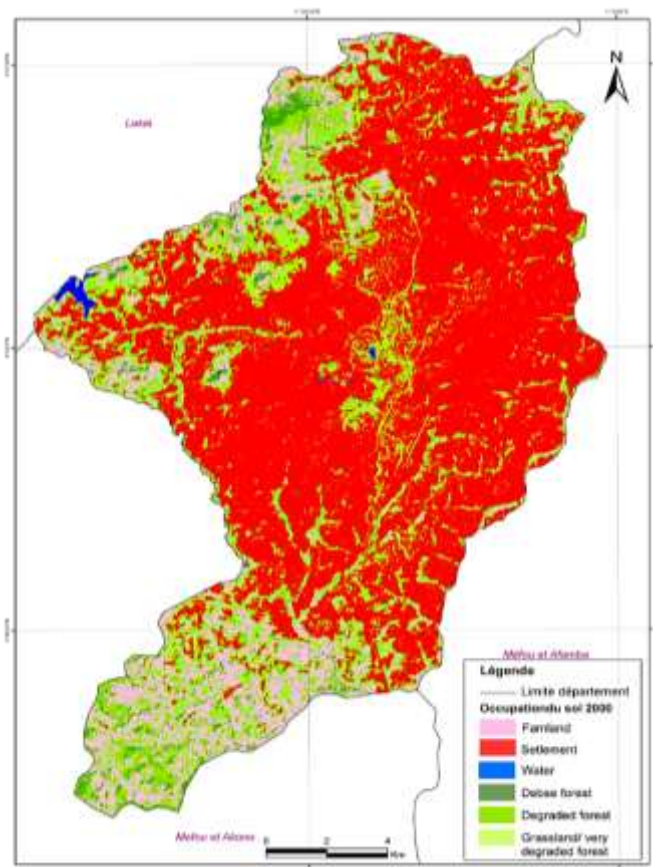
**Figure 3: Land use and land cover of Yaounde in 2010**

By the year 2010 much of the vegetated surface had been lost to the built-up environment. Settlement which occupied 5 649.4537ha (20%) of the total surface area in the year 2000 had increased to 9 916.43 ha representing 34% of the total surface area of Yaounde. The surface area of farmland had also increased to 8 530.57ha covering about 30% of the total surface area. Other land cover types such as the natural forest significantly decreased to 1 115.26ha accounting for just about 3% of the surface. The land use/land cover of Yaounde witnessed remarkable changes over the period 2000 to 2010. Settlement witnessed an increase in surface area from 5 649.4537ha in 2000 to 9 916.43ha in 2010 indicating a significant change of 75% increase in settlement area within a period of 10 years and an annual rate of change of about 7.5%. Farmlands also increase from 8 073.5212ha in 2000 to 8 530.57ha in 2010. That is, farmland increased by 457,0488ha (5.6%) indicating an annual rate of change of 0.56%. While settlement and farmland witnessed an increased forest cover on the other hand witnessed a decrease from 6567.8397ha in 2000 to 1115.26ha in 2010. This means the magnitude of change was -83% and an annual rate of change of -8.3%.

#### 4.5 Land use and land cover of Yaounde in 2020

By the year 2020 settlement land cover had increased tremendously to 18 009.2921ha indicating that 62% of the total surface area was covered by built-up area. Farmlands witnessed a significant decrease to 3 352.6309ha now covering just 11% of the surface area the, natural forest coverage decreased rapidly to 542.1704ha representing

just a minute 1.88% of the total surface area of Yaounde. Table 6 and figure 4 illustrate the land use/land cover of Yaounde in 2020.



**Table 6: Land use and land cover map of Yaounde in 2020**

| Land use             | Surface area | %     |
|----------------------|--------------|-------|
| Settlements          | 18009,2921   | 62,29 |
| Farmland             | 3352,6309    | 11,60 |
| Water body           | 83,9559      | 0,29  |
| Degraded forest      | 1173,21075   | 4,06  |
| Dense forest         | 542,1704     | 1,88  |
| Very degraded forest | 5750,16      | 19,89 |
| Total                | 28911,42005  | 100   |

Source: Landsat image 2020, USGS Earth Explorer, Datum: WGS 84 Zone 32N

**Figure 4: Land use and land cover map of Yaounde in 2020**

The Yaounde urban space continued to witness significant changes in the land use-land cover from 2010 to 2020. The settlement land cover continued to expand at the expense of other land covers. There was an increase in settlement from 9 916.43ha in 2010 to 18 009.3ha in 2020. Meaning that 8 092.8621ha of land was converted to settlement between 2010 and 2020 indicating a magnitude of change of 81.6% and an annual rate of change of 8.16%. Unlike in the decade 2000 to 2010 where farmland witnessed an increase there was a significant decrease in farmland in the decade 2010 to 2020. Farmland decreased from 8 530.57ha in 2010 to 3 352.63ha in 2020 indicating a magnitude of change of -60.7% and a rate of change of 6.07% per annum. Forest cover further reduced from 1 115.26ha in 2010 to 542.17ha in 2020 that is 573.0896ha of forest was lost to other land uses. This indicated a magnitude change of -51.4% and annual rate of change of -5.14%.

#### 4.6 Population growth and waste management

The analysis of the study results indicates that there is a direct relationship between population growth and solid waste generation in Yaounde. The population statistics for the study area show that from 2010 to 2020, the population of Yaounde increased from 2 482 205 people to 3 992 411 people (Yaounde city council 2020) and projections revealed the population reached 4 337 000 people in 2022. One of the consequences of the rapid population increase had been a corresponding increase in the volume of solid waste generated in the Yaounde metropolis. An increase in the population from 2010 to 2020 resulted in an increase in the amount of solid waste from 1 985.764 tons per day to 3 193.9 tons per day within the same period. Table 7 shows the evolution of population and waste generation in Yaounde between 2010 and 2022.

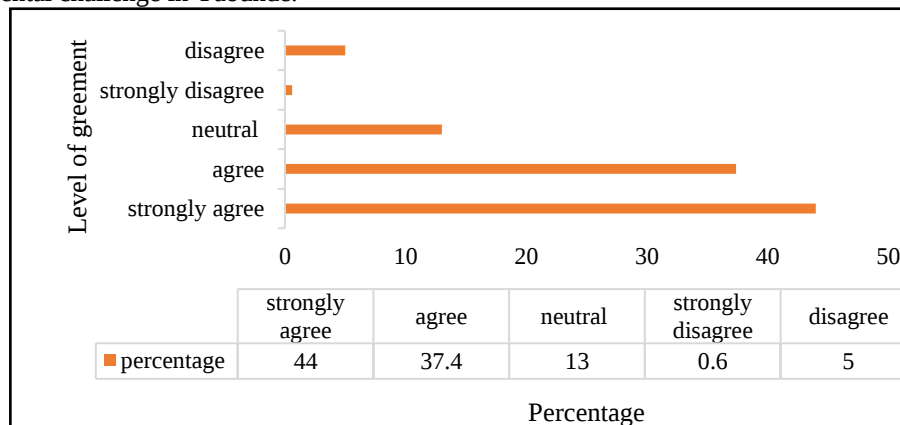
**Table 7: Relationship between population growth and solid waste generated in Yaounde between 2010 and 2022**

| Year | Population | Waste generated (tons/per/day) | Amount collected |
|------|------------|--------------------------------|------------------|
| 2010 | 2,482,205  | 1985.764                       | 297.87           |
| 2011 | 2.582.000  | 2065.6                         | 309.84           |
| 2012 | 2.623.000  | 2098.4                         | 314.76           |
| 2013 | 2.773.000  | 2218.4                         | 332.76           |
| 2014 | 2.930.000  | 2344.0                         | 351.6            |
| 2015 | 3,272,870  | 2618.2                         | 392.73           |
| 2016 | 3.273.000  | 2618.4                         | 392.76           |
| 2017 | 3.459.000  | 2767.2                         | 415.08           |
| 2018 | 3.656.000  | 2924.8                         | 438.72           |
| 2019 | 3.822.000  | 3057.6                         | 458.64           |
| 2020 | 3,992,411  | 3193.9                         | 479.085          |
| 2021 | 4,164,167  | 3331.3                         | 499.695          |
| 2022 | 4,337,000  | 3469.6                         | 520.44           |

Source: Yaounde city council (2020), Barthelémy et al. (2016)

From Table 7, it can be deduced that daily solid waste generated in Yaounde has increased with increase in the population over the years. However, there has not been any substantial increase in the daily amount of waste collected over the years. On an average 3 469.317 tons of municipal solid waste were generated each day by the population from the year 2010 to 2022. Of this daily production only about 15% (520.398 tons) were properly collected and disposed of each day.

To substantiate these statistics, the respondents were asked to indicate if waste disposal was an environmental challenge in Yaounde. Figure 5 shows the respondents' perception as to whether or not waste disposal is an environmental challenge in Yaounde.



Source: Fieldwork, (2020).

**Figure 5: Perceptions of waste as an environmental challenge in Yaounde**

Figure 5 illustrates that 44% of the respondents strongly agreed and 31.4% agreed to the statement 'waste disposal is an environmental challenge in Yaounde'. Only 0.6% strongly disagreed while 5% disagreed with the statement. However, 13% were undecided as to whether or not waste disposal was a challenge in Yaounde. An overwhelming majority of the respondents agreed or strongly agreed to the statement meaning that waste disposal is an issue of concern in Yaounde. Despite the efforts being made by the waste collection bodies, tens of thousands of tons of waste are being discharged into to the environment every day in Yaounde. Plate 1 shows poor waste disposal mechanisms in Biyem-assi and Simbock neighbourhoods in Yaounde.



**Plate 1: Poor waste disposal in some neighbourhoods in Yaounde**

*Photo 1 : waste trapped in a drainage path in Simbock*

*Coordinate: 3°53'34N, 11°30'41"E*

*Height above sea level: 710m Biyem-assi*

*Photo 2: haphazard disposal of refuse in Biyem-Assi.*

*Coordinates: 3°50'55" N, 11°29'7" E*

*Height above sea level: 710m*

*Source: Fieldwork, (2020)*

As seen on the photos, poor waste disposal characterises most neighbourhoods in Yaounde. About 212 illegal dumping sites were counted during field study and this was just a small percentage compared to the overall number of such sites in the Yaounde urban space. Most of the wastes disposed of in the designated trash cans still constitute a nuisance to the environment as the waste is usually left on collected for a very long time (Photo 2). Waste disposal is therefore an obvious and visible problem which affects the physical environment in Yaounde. Poor waste management in Yaounde does not only create an unpleasant image of the city, but also affects water quality and the decomposition of the waste results in air pollution, create health issues as the dumping sites form breeding grounds for disease vectors (for example mosquitoes, rats) and it also generates significant greenhouse gases when burnt or when the waste decomposes.

#### **4.7 Population growth and air pollution**

Like waste generation, there exist a direct relationship between population growth and air pollution. That is, as the population increases, the number of pollutants in the atmosphere also increases. Population growth comes with increased life activities, consumption and burning of fossil fuels. More people mean more resources, more production, more transportation required and more fuel needed. These activities consume energy and emit GHGs which affect the air quality in the city. In 2019, the average annual fine particulate matter in the air with diameter of 2.5 or less (PM<sub>2.5</sub>) concentration in Yaounde was estimated to be 7.5 times higher than WHO recommended concentration level (Siaka et al., 2021). Major contributors to this rising PM<sub>2.5</sub> concentration include: heavy traffic from the high motorised transport and aging vehicle fleet, industries and the use of biomass. Road traffic accounts for approximately 48% of PM<sub>2.5</sub> emissions. Table 8 shows the different types and number of these automobile registered in 2019 and estimates for the years 2020, 2021 and 2022.

**Table 8: Types and number of automobiles registered in Yaounde from 2019 to 2022**

| Type of automobile | No. registered in 2019 | 2020 estimate | 2021 estimate | 2022 estimate |
|--------------------|------------------------|---------------|---------------|---------------|
| Taxis              | 12 000                 | 12057         | 12 116        | 12 178        |
| Motorbikes         | 35 000                 | 35 171        | 35 349        | 35 534        |
| Minibuses          | 600                    | 603           | 606           | 609           |
| Stelcy buses       | 75                     | 79            | 80            | 81            |
| Personal cars      | 110 000                | 110 551       | 111 124       | 111 720       |
| others             | 32 325                 | 32 486        | 32 654        | 32 829        |
| Total              | 190 000                | 197 600       | 205 504       | 213 724       |

*Source: PDU (2020); Yaounde City Council (2022)*



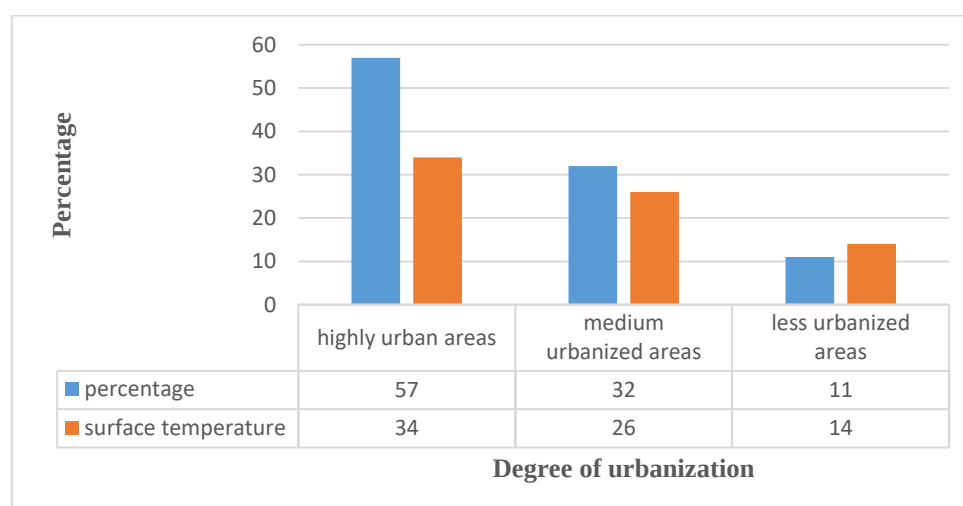
Table 8 shows that there were 190 000 registered automobiles in the city of Yaounde and by the end of 2022 the number had increased to 213 724 indicating an increase of 23 724 automobiles from 2019. This indicates that with increase in the number of people living in the city, the need for mobility is also increasing resulting in more vehicles being purchased. This implies more traffic congestion, the need for auxiliary services, and more pollution. Traffic-related emission is exacerbated by the aging vehicle fleet compounded by the city's poor transport network with frequent traffic bottlenecks especially during rush hours. Statistics revealed that 95% of the vehicles in Yaounde are second-handed, many of which do not meet emission standards. A study carried out by PDU (Plan Directeur d'urbanisme) Yaounde in 2020 indicated that about 74% of the vehicles matriculated in Yaounde are 15 years and even older. This implies more repairs, oil leaks as a result of the wear and tear of the engine. Also, these cars emit dangerous fumes which do not only expose people to high levels of air pollution but have huge impact on the local climate and the overall urban ecological system.

Apart from traffic related emissions, biomass fuel burning for household cooking and heating needs represent another major source of air pollution in Yaounde. More population mean more fuel for cooking and heating. Given that approximately 90% of the population rely fully or partly on biomass fuel, this source of household fuel accounts for approximately 19 % of PM<sub>2.5</sub> concentrations in Yaounde. Other sources of air pollution in the city include: poor waste management and emission from industries. Currently, less than 50 % of the waste generated in the city is collected while the rest is either dumped on vacant lots, drainage paths or burnt. The little amount of waste collected is poorly managed with less than 15% sorted and recycled. The poor methods of waste management used in the city release substances which pollute the air and as such this accounts for approximately 8% of air pollution in the city of Yaounde.

#### 4.8 Population growth and microclimate change

Urban thermal environment dynamics have been associated with land use and land cover (Li *et al.*, 2022). Every addition person increases carbon emission. This is because population growth comes with increased consumption and this tends to increase the emission of climate change GHG. Increase number of houses constructed and other urban infrastructures to meet up with the needs of the growing population reduces the albedo of the urban environment resulting in more heat being retained by the urban infrastructures. In addition, increasing impervious surfaces and decreasing green spaces in the urban areas reduce atmospheric moisture which comes from evaporation and transpiration of latent heat flux of the urban areas.

A Correlation of temperature statistics and population densities in Yaounde revealed that land surface temperatures were very high in densely populated and highly built-up environment. The temperatures tend to reduce as one moved towards the peripheries where the population was less dense, less built-up areas and vegetation was still the major land cover type. Figure 6 shows the percentage of the built-up environment affected by different degrees of temperatures.



Source: Fieldwork, (2020)

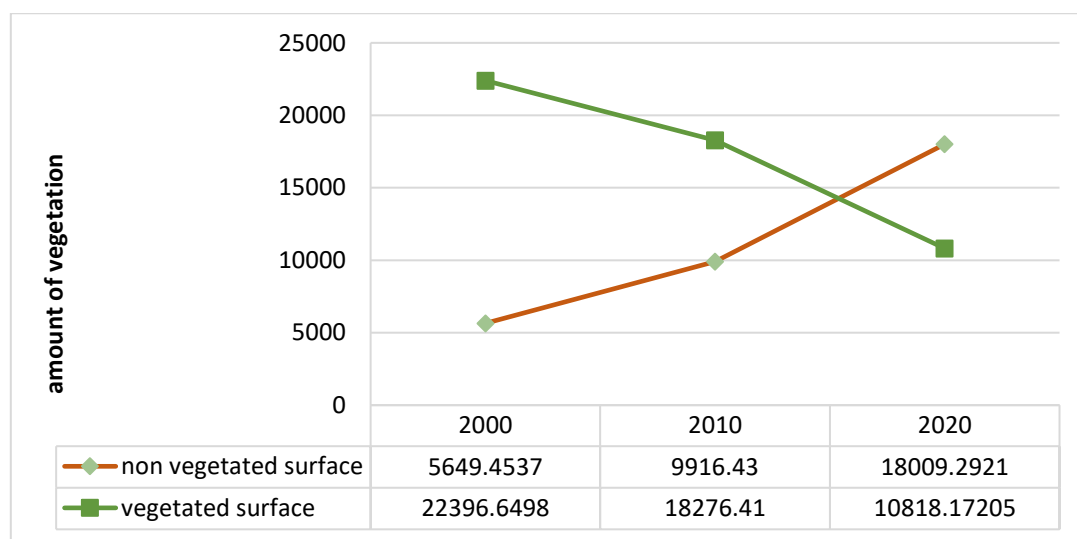
Figure 6: Relationship between built-up environment and temperatures



Figure 6 shows that the highly built-up and congested areas experience high temperatures of about 34oc, moderately built-up environment experience mean temperature of about 26oc while least built-up and less congested environments have low temperatures of about 14oc.

#### 4.9 Population growth and biodiversity loss

Population growth and a corresponding increase in human activity has been consistently found to be one of the dominant contemporary drivers of biodiversity change both at local and global scale (McDonald *et al.*, 2013). As seen in the previous sections, population growth and land expansion lead to land cover change which is mainly characterised by the conversion of natural environment to built-up areas. Similar to the global trend, population growth and urban expansion in Yaounde has been accompanied by the conversion of much of the vegetated surfaces to settlements and other paved surfaces. This results in loss of habitats, habitat fragmentation and loss of food sources. Field observation, survey results, and the analysis of satellite images of Yaounde indicate that much of the vegetated area has been converted to human settlements and other infrastructural development over the past years. Figure 7 shows the evolution of the vegetated and non-vegetated surface in Yaounde from the year 2000 to 2020.

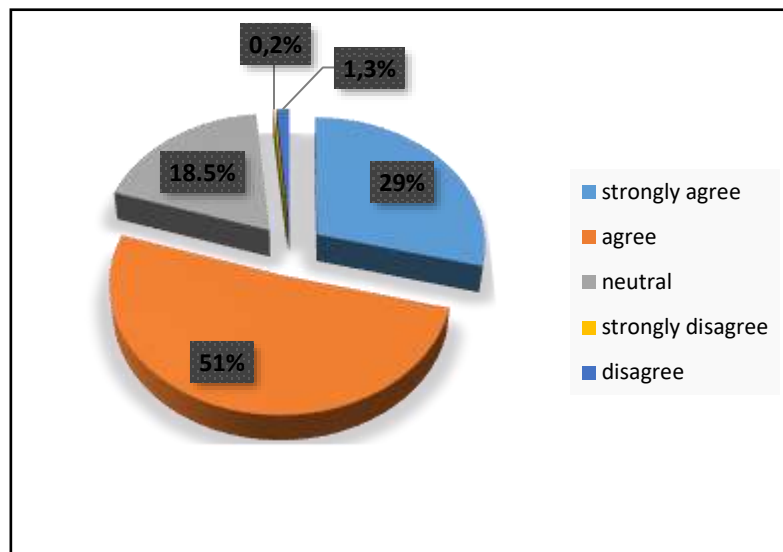


Source: Ntemngweh, (2024)

**Figure 7: Evolution of vegetated and non-vegetated surfaces in Yaounde from 2000-2020**

Figure 7 shows an inverse relationship between the built-up environment (non-vegetated surface) and the vegetated surface over time. That is, over the years, the vegetated surface has gradually given way to the non-vegetated surface. As a result of the expansion of the built-up environment, the vegetated areas decreased from 22 396.7ha in the year 2000 to 18276.4ha in 2010 and from 18 276.4ha in 2010 to 10 818.17205ha in the year 2020. This indicates a 218.8% increase in non-vegetated surfaces from the year 2000 to the year 2020 and a 51.7% decrease in vegetated areas from the year 2000 to the year 2020.

The respondents were asked to state their views regarding the relationship between urbanisation and biodiversity as depicted on Figure 8



Source: Fieldwork, (2020)

**Figure 8: The Perceptions of respondents on the relationship between urbanisation and biodiversity loss**

During field survey, the respondents were asked to state their level of agreement with the statement ‘urbanisation results in biodiversity loss. Figure 8 shows that the majority of the respondents hold a positive view that urbanisation has resulted in loss of biodiversity in the study area with about 80% either strongly agreeing (29%) or agreeing (51%) to the statement. About 18% had a neutral view regarding the relationship between urbanisation and biodiversity loss while a negligible (1.5%) of the respondents mentioned that urbanisation has no negative impact on biodiversity. The results indicate that urbanisation has greatly affected the plant and animal species in the study area.

The quantitative results were fleshed out with the results from the semi-structured interviews. During an interview with a 75-year-old resident of the Mendong neighbourhood who had been in Yaounde for the past 40 years he gave the view that:

*“When I came to Yaounde in the early 1980s, the town then ended at Obili and the rest of the area beyond that was thick forest. It was common to see wild animals crossing the roads at nights. What we bought as plots then were dense natural forest with huge trees in them. But today, all that is gone, you have to be very lucky to even see a live rat mole in this town. Everywhere now are houses and few available plots now are just relics of agricultural lands”*

The view of this respondent indicates that population growth and rapid urbanisation has eroded the Yaounde metropolitan area of its rich biodiversity. The abundant flora and fauna which had earlier occupied a greater part of the city of Yaounde some 30 years ago has been lost to other land uses as a result of population growth.

## 5. DISCUSSIONS

By the year 2010, the population of Yaounde had more than doubled. The population which was 1 351 047 inhabitants in the year 2000 had increased to 2 482 205 in the year 2010. Yaounde witnessed a further increase in its population from 2 482 205 inhabitants in 2010 to 3 992 411 inhabitants in 2020. This implies that within this period about 1 510 206 people had been added to the population of Yaounde which is more than the total population of this area in the year 2000. This additional one and a half million people need houses to live in, demand additional services and infrastructures and it has accounted for the rapid expansion of the city towards the periphery and a change in the land cover with built-up area occupying much of the space.

Land use and land cover change is one of the inevitable consequences of population growth. The study analysed the land use and land cover change in Yaounde between 2000 and 2020 using satellite images. The results indicated that significant changes have been observed in the land use and the land cover over the studied period. It was observed that the forest cover and other green areas witnessed a significant decrease while the built-up areas observed a substantial increase. By the year 2000 much of Yaounde was still covered by vegetation with the dense forest occupying about 23% of the total land area and degraded forest, farmlands and other permeable surfaces occupied about 56% of the total surface while the built-up area occupied just about 20% of the total



surface. However, by the year 2020 the reverse was true for the Yaounde urban space. While the built-up areas had taken up more than 62% of the land surface, the vegetated surface including farmlands, forest and other green areas represented less than 34% of the total surface. As the population increased and the urban area expanded the vegetated areas gradually gave way to built-up areas. It was observed that the natural forests zone which represented about 23.2% of the land in 2000 had reduced to about 1.8% in 2020. This implies that over the last 20 years there has been conversion of about 21.4% of the natural forest land to other land uses especially settlement. The results are consistent with those of a prior study carried out by Oben *et al.* (2015). They carried out a study on 'Urbanisation, Wetland Retreat and Heat Island Development in Yaounde' and found out that within a period of 26 years, that is, from 1989 to 2015, the built-up area in Yaounde has increased by 140%. The urbanised surface of the city had moved from 86.79km<sup>2</sup> in 1989 to 183.61km<sup>2</sup> in 2015. Similar results were found out elsewhere in Cameroon by Nguh and Maluh, (2018). They carried out a study in Tubah Sub-division and found out that the Sub-division whose physical environment knew little or no stress before the 1980s had witness a significant change in its land use and land cover between 1983 and 2013. Their study indicated that in the year 1983 settlements occupied just about 5.4% of the surface area while the rest 94.6% were occupied by vegetation including forests, farmlands and rangeland. However, by 2013 the area occupied by settlements had increased to 11% while that occupied by vegetated surfaces had reduced to 89%. A notable observation was that though the results of the present study and those of Nguh and Maluh showed significant changes in the land uses and the land covers of Yaounde and Tubah respectively, the analysis of both results indicated that there was a difference in the rate of change. In both areas the vegetated surfaces gave way to the built-up area. However, the rate of change was more rapid in Yaounde than in Tubah. This could be explained by the size and the rate of urbanisation in the two areas.

The findings of the study revealed that, a large amount of the solid waste produced in Yaounde remains uncollected as evidenced by the rampant illegal dumping sites in the city. This is not only unpleasant to the eyes but has numerous environmental impacts including air pollution, pungent smell of garbage, and its multiplier effects. Prior studies carried out by a World Bank group found out that solid waste management is a serious problem in most African countries including Cameroon (World Bank, 2017). In line with this, the Green Africa City Index (2011) found out that waste management strategies and environmental qualities related to waste landfills are lacking in most African cities. Both studies noted that solid waste collection is low in most African resulting in much of the waste piling up on the roads, along walkways, in the gutters and waterways.

Rapid increase in the number of people living in Yaounde and the spatial expansion of the urban area has increased vehicule ownership. This was obvious given the nature of traffic congestion experienced in the area. Increase in the number of cars and long-distance driving increased the amount of greenhouse gases emitted to the atmosphere and the resulting poor quality of air in the study area. Also, a surge in the number of people living in Yaounde had resulted in the increase in domestic fuel use. About 60% of the individuals surveyed made use of charcoal, sawdust and firewood which emit smoke that pollution the air in the study area. Other obvious causes of air pollution in Yaounde were poor waste management, and increase in the number of unpaved roads. All these had resulted in the increase in the amount of air pollutants in the atmosphere. The results corroborate with those of Rafaj *et al.* (2018) who carried out a study on the 'Outlook for clean air in the context of sustainable development goals' and found out that energy consumption as a result of human activities is the largest source of air pollution. They cited transportation, industrial activities, charcoal production and combustion, and domestic energy consumption as some of the major activities which necessitated high energy consumption and the resulting air pollution.

It was evident from the research results that the local climate of the Yaounde urban space has been greatly influenced by urbanisation. Temperatures around the highly built-up areas were higher than those in the less congested and vegetated areas. The study results are consistent with those of (Aretouyap *et al.*, 2021) who carried out a study on the 'Appraisal of environmental quality in the capital district of Cameroon using Landsat-8 images. Their study found out that temperatures were about 14oc or less in the vegetated and the less developed southern part of Yaounde and about 34oc in the overpopulated and highly built-up area. This indicated that the highly built-up and populated areas are about 20°C warmer than the less populated and vegetated surfaces.

The research results also revealed an inverse relationship between urbanisation and biodiversity. The most visible impact of urbanisation in the study area was land cover change. The change of the land cover from a more natural landscape to the built-up environment resulted in loss of both plants and animal species. The respondents reported that it was very difficult to see a live animal in Yaounde, as the animals had no home to accommodate them. Most of their homes have been transformed to human habitat. As the city grows, the forests and other natural habitats are destroyed or fragmented into patches. Many endemic and native species are extinct and replaced with non-



native, exogenous, and cosmopolitan species. This result supports the views of Lepczyk *et al.* (2017), who investigated the ecology of urban green spaces for biodiversity conservation and concluded that population growth negatively affects the biodiversity composition of urban areas. A study carried out by (Anguh and Louis, 2021) indicated that urban expansion has degraded the dense forest that served as home for many wildlife species in Yaounde and the biodiversity population is also affected by toxic substances emitted in the urban environment.

## 6. CONCLUSION

The Yaounde metropolitan area has witnessed a significant increase in its population over the last two decades. Increase in the number of people living in the urban area and expansion of the area is placing pressure on the natural environment. More of the population living in the city implies that much of the resources are being consumed and increase demand on resources is altering the land use system and distorting the urban ecology. This is manifested in the negative environmental impacts such as poor waste management, air pollution, biodiversity loss and local climate change. The study suggests a move to a more nature-adaptive urban planning and advocates for the enhancement pro-policies for waste selection, transformation, and recycling, as well as the creation of more green spaces in the city to help mitigate the negative effects of population growth on the urban natural environment.

## BIBLIOGRAPHY

1. AKOKO, R., MONONO, E., & PČOLINSKÁ, L. (2019). Urbanisation and food security in Buea: an appraisal of household food security situation and resilience in Bolifamba Buea Cameroon. *International Journal of Modern Anthropology*, 2(12), 173. doi: 10.4314/ijma.v2i12.8
2. ANGUH, N., & LOUIS, D. (2021). Urban Sprawl and the Effects on the Zoogeography of the Yaounde Metropolis, Cameroon. *The International Journal of Science & Technoledge*, 9(2). doi: 10.24940/theijst/2021/v9/i2/st2102-004
3. ARETOUYAP, Z., DOMRA KANA, J., & KEMGANG GHOMSI, F. (2021). Appraisal of environment quality in the capital district of Cameroon using Landsat-8 images. *Sustainable Cities and Society*, 67, 102734. doi: 10.1016/j.scs.2021.102734
4. CHYB, A., JEDLIKOWSKI, J., WŁODARCZYK, R., & MINIAS, P. (2021). Consistent choice of landscape urbanisation level across the annual cycle in a migratory waterbird species. *Scientific Reports*, 11(1). doi: 10.1038/s41598-020-80872-3
5. GRIMM, N., FAETH, S., GOLUBIEWSKI, N., REDMAN, C., WU, J., BAI, X., & BRIGGS, J. (2008). Global Change and the Ecology of Cities. *Science*, 319(5864), 756- 760. doi: 10.1126/science.1150195
6. GWAN, A., & KIMENGSI, J. (2020). Urban Expansion and the Dynamics of Farmers' Livelihoods: Evidence from Bamenda, Cameroon. *Sustainability*, 12(14), 5788. doi: 10.3390/su12145788
7. KIMENGSI, J., & FOGWE, Z. (2017). Urban Green Development Planning Opportunities and Challenges in Sub-Saharan Africa: Lessons from Bamenda City, Cameroon. *International Journal of Global Sustainability*, 1(1), 1. doi: 10.5296/ijgs.v1i1.11440
8. LEPCZYK, C. A., ARONSON, M. F., EVANS, K. L., GODDARD, M. A., LERMAN, S. B., & MACIVOR, J. S. (2017). Biodiversity in the city: Fundamental questions for understanding the ecology of urban green spaces for biodiversity conservation. *BioScience*, 67(9), 799–807. <https://doi.org/10.1093/biosci/bix079>
9. LI, S., ZHAO, Y., XIAO, W., YELLISHETTY, M., & YANG, D. (2022). Identifying Ecosystem Service Bundles and the spatiotemporal characteristics of trade-offs and synergies in coal mining areas with a high groundwater table. *Science of the Total Environment*, 807, 151036. <https://doi.org/10.1016/j.scitotenv.2021.151036>
10. MCDONALD, R. I., MARCOTULLIO, P. J., & GÜNERALP, B. (2013). Urbanisation and global trends in Biodiversity and Ecosystem Services. *Urbanisation, Biodiversity and Ecosystem Services: Challenges and Opportunities*, 31–52. [https://doi.org/10.1007/978-94-007-7088-1\\_3](https://doi.org/10.1007/978-94-007-7088-1_3)
11. MESJASZ-LECH, A. (2014). Municipal Waste Management in Context of Sustainable Urban Development. *Procedia - Social and Behavioural Sciences*, 151, 244- 256. doi: 10.1016/j.sbspro.2014.10.023
12. NGUH, B., & MALUH, N. (2018). The implications of land use/cover dynamics on resources development in Tubah sub-division, Cameroon. *Journal of the Cameroon Academy of Sciences*, 14(1), 71. doi: 10.4314/jcas. v14i1.6
13. NKWEMOH, C. (2019). Urban Expansion and Implications on the Exploitation of a Non Metallic Mineral (Rock) in the Yaounde Metropolis, Cameroon. *The International Journal of Science & Technoledge*, 7(12). doi: 10.24940/theijst/2019/v7/i12/st1912-022
14. NTEMNGWEH, P. (2024). The Fate of Sustainable Development Goal 11 Amidst Growing Environmental Challenges In Developing World Cities: Insights from the Yaounde Metropolis. *International. Journal of Research and Innovation in Social Sciences*, 4514-4528
15. OBEN, E. E., & NDI, H. N. (2014). Urbanisation and market growth trends in the Yaounde Metropolis. *Journal of Geography and Geology*, 6(3). <https://doi.org/10.5539/jgg.v6n3p203>
16. RAFAJ, P., KLESEWETTER, G., GUL, T., SCHOPP, W., COFALA, J., KLIMONT, Z., PUROHIT, P., HEYES, C., AMANN, M., BORKEN-KLEEFELD, J., AND COZZL, L. (2018). Outlook for clean air in the context of Sustainable Development Goals. *Global environmental change*, 53, 1-11



17. SIAKA, F., NDAM NGOUPAYOU, J.R., NOLA, M., DJUIKOM, E., TONFACK, L., & EKODECK, G. (2021). *Preliminary study of black carbon content in airborne particulate matters from open site in the city of Yaounde, Cameroon. Environmental Monitoring and Assessment*, 193(11), 773. <https://doi.org/10.1007/s10661-021-08924-3>
18. SETO, K.C., PARNELL, S., & ELMQUIST, T. (2013). *A global outlook on urbanisation*. Springer, Dordrecht Heidelberg New York 1-13.
19. TIAFACK, O. & MBON, A.M. (2017). *Urban Growth and Front Development on Risk Zones: GIS Application for Mapping of Impacts on Yaounde North Western Highlands, Cameroon. Current Urban Studies*, 5: 217- 235.
20. UNITED NATIONS, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS, POPULATION DIVISION. (2018). *World Urbanisation Prospects: The 2018 Revision*. United Nations. <https://population.un.org/wup/>
21. ZHOU, D., SHI, P., WU, X., MA, J., & YU, J. (2014). *Effects of Urbanisation Expansion on Landscape Pattern and Region Ecological Risk in Chinese Coastal City: A Case Study of Yantai City. The Scientific World Journal*, 2014, 1-9. doi: 10.1155/2014/821781