

Urban Sprawl and Environmental Impacts on the Outskirts of Ouagadougou, Burkina Faso

Pierre Ouedraogo^{1*}, Nadège Compaore¹, Jérémie Rouamba²

¹ Norbert ZONGO University, Department of Geography, Koudougou, Burkina Faso

² Joseph KI-ZERBO University, Department of Geography, Ouagadougou, Burkina Faso

*Email: pierreoued093@gmail.com, Tel: +22672517336

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Abstract

The contemporary period has been mainly characterized by urbanization. Given its growing size, it exacerbates environmental degradation in surrounding cities and towns. This degradation manifests itself in various ways, which are the topic of the study's findings. This study is part of a framework for analyzing the environmental impacts resulting from the sprawl of the city of Ouagadougou. The methodology is based on an approach combining both quantitative and qualitative methods. Work carried out through documentary research, field observation, surveys and diachronic analysis made it possible to identify environmental impacts. ENVI and ARCGIS software were used for diachronic analysis and mapping, SPSS and Excel for data analysis and processing. Thus, it emerges from the study that the sprawl of the city of Ouagadougou has led to an increase in production as well as poor waste management (liquid and solid). These factors cause environmental pollution resulting in air pollution and water retention. Diachronic analysis revealed the degradation of the vegetation cover. The results of the study show that 85.21 % of respondents have noted the degradation of the vegetation cover over the last twenty years. According to 94.10 % of the interviewees, environmental degradation is linked to the urban sprawl of Ouagadougou. Added to this are changes in landforms and flooding. These results of the study provide planning assistance for urban planners, environmentalists, and policymakers.

Keywords: environmental impacts, urban sprawl, degradation of vegetation cover, deforestation, periphery, Ouagadougou, Burkina Faso

Introduction

The world is rapidly urbanizing. In 1950, less than 30 % of the planet's inhabitants lived in cities; today, this is the case for one in two inhabitants; city dwellers will represent more than 70 % of the world's population in 2050 (Véron, 2008). As a spatial issue, the city requires rational management of its expansion, which implies knowledge and understanding of its structures and their evolution. The city is constantly pushing its limits further and further. "The problem of city limits is therefore insoluble" (Allain, 2004). The spatial expansion of cities is not without effects. Indeed, it generates numerous environmental consequences. The extension of peri-urban rings is a characteristic feature of the evolution of cities over the last thirty years. This trend appears detrimental from an environmental point of view because peri-urbanization consumes a lot of space and implies a lifestyle in which the automobile plays a predominant role (Bureau & Thouverez, 2003). In addition, urban expansion modifies land use, leads to significant changes in land use and landscape structures

and causes a weakening and fragmentation of natural spaces. This has environmental consequences, causes disruptions to the ecosystem and is detrimental to biodiversity (Bahanni & al., 2016). On a biological level, studies conducted by Rahim (2009) show both the negative effects of the city on the establishment of wild species and the adaptability of certain populations to spaces transformed by man, through urban planning projects and the behavior of city dwellers. Thus, "the city destroys nature either directly, through the destruction of natural habitats, or indirectly, through the fragmentation and isolation of natural sites" (Clergeau, 2007; Rahim, 2009). The city of Ouagadougou is not on the margins of this reality. The Ouagadougou metropolitan area has exceeded the limits of its administrative territory and extends into the territory of Greater Ouagadougou. (Ouagadougou City Hall, 2019) and thus monopolizes neighboring local authorities such as our study area (rural district of Saaba). The growth that has shaped the urban space of Ouagadougou, the most striking characteristic of which is the peripheral extensions which undoubtedly contribute to massive destruction of the environment (Nikiema & al., 2022).

In view of the above-mentioned problem, we asked ourselves the following question: what are the environmental consequences induced by the urban sprawl of Ouagadougou on the rural district of Saaba? This study is based on the hypothesis that the degradation of vegetation, the modification of the morphology of the relief and the pollution of the environment are the main environmental consequences caused by the sprawl of Ouagadougou. Its objective was to analyze the environmental impacts caused by the urban sprawl of Ouagadougou.

Materials and methods

Geographical and methodological framework of the study

Geographical framework of the study area

Saaba is one of the six rural districts of the Central region. The said commune is crossed by national road n°4 and is located between 12°14'34.8" and 12°30'46.8" north latitude and 1°10'51.6" and 1°27'7.19" west longitude (see map n°1). The rural district of Saaba has twenty-seven (27) villages including its capital. Saaba is bordered to the west by the urban municipality of Ouagadougou, to the south and southeast by the rural district of Koubri, to the East by the rural district of Nagréongo and to the North by the municipalities of Loumbila and Ziniaré (Ouedraogo, 2022).

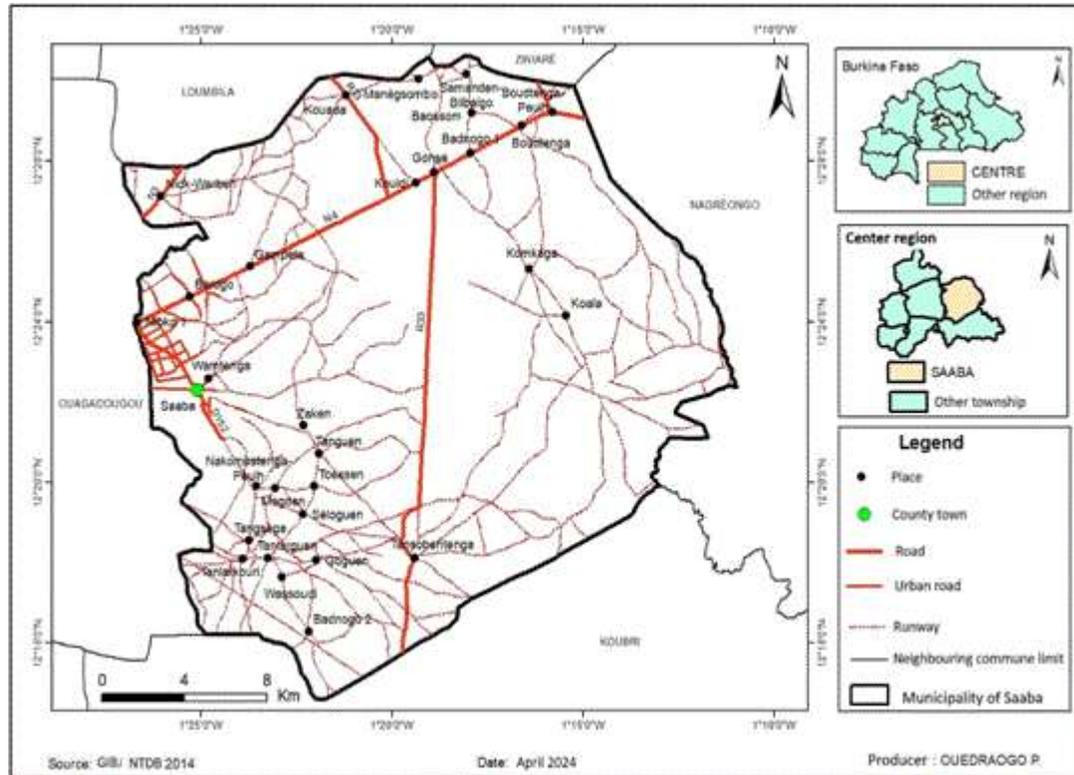
The rural municipality of Saaba was chosen as the study area due to its geographical location. Saaba is contiguous to the urban district of Ouagadougou and is being absorbed by it.

The methodological approach of the research

The methodological approach addresses both the methodological approach, the collection methods and the data processing equipment.

The methodological approach: quantitative and qualitative methods

The study was based on the approach of quantitative and qualitative methods. This approach has a great scientific scope. The main objective of this methodology is the optimization of the strengths of quantitative and qualitative methodologies considered complementary, one compensating for the weaknesses of the other. Indeed, quantitative research does not take into account the context of the study and the opinion of the respondents on the topic studied. Thus, it does not usually allow to explain or interpret the results (Ridde & Dagenais, 2012; Tougma, 2020). By combining the quantitative and qualitative approach, it aims to improve the understanding of the object of study and strengthen the internal validity of the research by improving the collection and processing of data (Avenier & Thomas, 2011). The materialization of the methods approach requires the collection of quantitative and qualitative data.



Map 1. Location of the district of Saaba

Satellite image processing

The diachronic analysis was carried out in order to better analyze the spatial evolution of the city of Ouagadougou and the environmental impacts in the district of Saaba. This operation was carried out as follows:

► data collection

- Landsat satellite images 5, Landsat 7 and Landsat 9;

These images were obtained from the National Observatory for Sustainable Development (ONDD) of the Permanent Secretariat of the National Council for Sustainable Development (SP/CNDD). These Landsat images allowed us to have shape files from different dates (2000, 2010 and 2020), coupled with those from Google Earth for the study.

- Google Earth images.

This search engine was used to locate our research area and to overlay different shape files obtained following Landsat image processing. Google Earth provides high-resolution images, making it easier to delineate the boundaries of the study area and verify land-use entities according to the dates identified for image classification.

► the processing methodology.

To achieve the predefined objectives, a methodology was developed to carry out our study. As a prelude, the preparation of the field work was preceded by the use of satellite images of the study area.

To do this, we first proceeded to the colored composition and then to the display of a scene where our study area is located, which allowed us to obtain the image of our study area.

In our case, the compositions were made based on Landsat images:

- Landsat 7: 5 4 3 color composition for the year 2000;
- Landsat 5: 5 4 3 color composition for the year 2010;
- Landsat 9: 7:5:3 color composition for the year 2020.

Then a 500-meter buffer zone was added to the study area to preserve all pixels along the boundary of our study area. The map format file obtained after adding the buffer zone served as the basis for delineating the study area on Landsat images.

Subsequently, the design of the training sites was carried out after the determination of five (05) land use classes for the district of Ouagadougou: fields; houses; vegetation; water surface; bare soil and seven (07) classes for the district of Saaba: fields; classified forest; habitat; wooded savannah; shrub savannah; bare soil; water surface.

Supervised classification was chosen for the classification of all images with the Maximum Likelihood algorithm which best characterizes the different land use units.

Post-classification operations crown image processing. This involves displaying the confusion matrix to verify whether the classification was successful using overall accuracy and the kappa index. The latter is a measure used to assess the classification; if it is greater than or equal to 0,90 (90 %), the classification is successful. Furthermore, it is determined by the number of drawings during sampling per class. But this index value is not the only indicator that requires good classification.

Data collection methods and processing equipment

The techniques used for data collection are based on literature reviews, household surveys, interviews, and observation. Tools were developed for this purpose. These include a questionnaire for household surveys, interview guides for interviews, and an observation grid for direct observation in the study area. For the interviews, we spoke with two water and forestry officers and two officers from the Saaba town hall. For the household surveys, a total of 398 households were questioned. To determine the sample size of households to be surveyed, the probabilistic method of Marien and Beaud (Marien & Beaud, 2003) was applied to the effective of the 2019 population (General Population and Housing Census (GPHC, 2019).

$$n = \frac{N(\text{total workforcel}) * 400}{N(\text{total workforce}) + 400}$$

With n = sample sizen and N = number of households in the municipality of Saaba according to the 2019 GPHC.

For this study, the acceptable error is 5%. The value 400 (D) is the inverse of the error (E) squared.

$$\mathbf{D=1/E^2 =1/0.05^2= 400}$$

The surveys took place between February and April 2024. They were conducted using the Kobo collect app. Direct field observation was essential, allowing us to gain a firsthand understanding of the reality experienced.

Regarding processing tools, Excel software has used for both frequency calculations and graphing. Arc GIS 10.5 software was used for mapping. A smartphone was used for field photography.

The methodology used allowed us to achieve tangible results specific to the municipality studied.

Results

Presentation and analysis of results

The degradation of vegetation, the modification of the morphology of the relief and the pollution of the environment are the main environmental consequences induced by the urban sprawl of Ouagadougou on the rural district of Saaba.

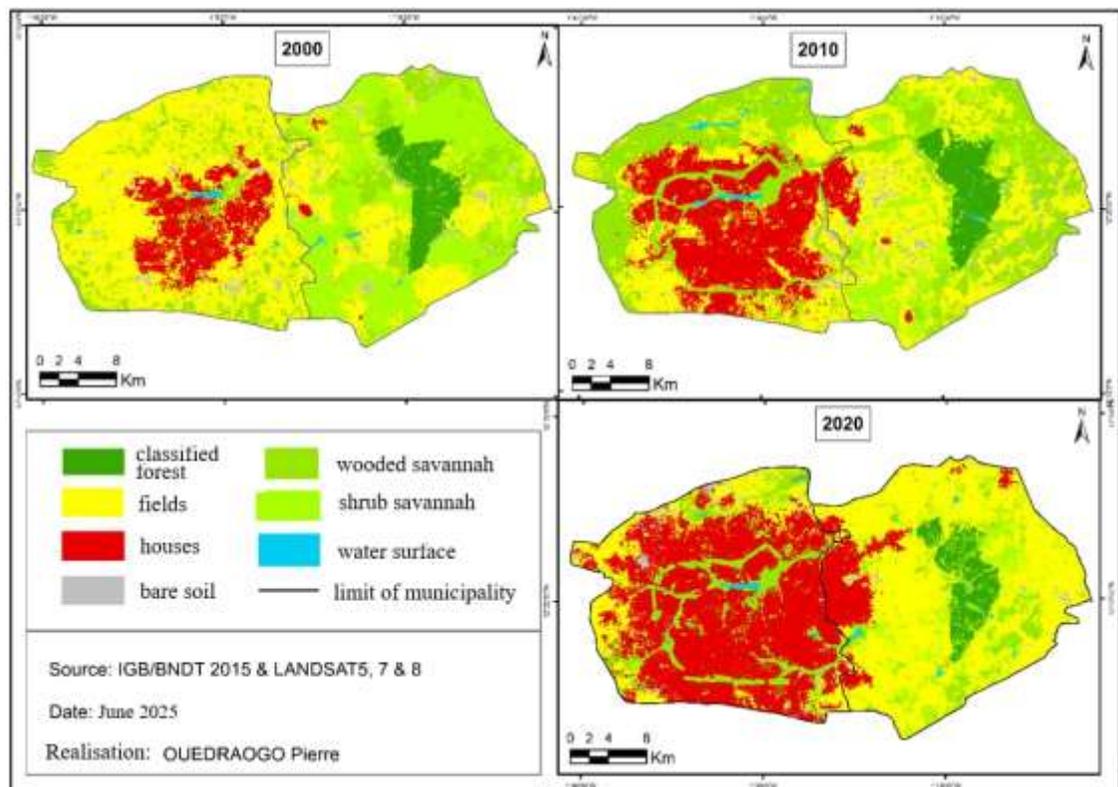
Spatial evolution and land grabbing of the rural district of Saaba

Diachronic analysis (between 2000 and 2020) made it possible to characterize the spatial evolution of the urban commune of Ouagadougou. Map No. 2 reflects the spatial evolution of the city of Ouagadougou.

Analysis of this map reveals that Ouagadougou's spatio-temporal evolution between 2000 and 2020 was dynamic. Indeed, the 2000 map shows that the city was expanding towards Saaba. In 2000, the urban footprint of the rural district of Saaba was very minimal. This means that, at the time, centrifugal movements towards Saaba were less.

In 2010, the map reveals that the city of Ouagadougou expanded to the border of the rural commune of Saaba. The urban area of the rural district of Saaba in 2010 became spacious, reflecting the massive influx of city dwellers into Saaba.

In 2020, the border between the rural district of Saaba and the city of Ouagadougou is no longer recognizable. Confusion is setting in; the city of Ouagadougou has overgrown its boundaries and is in the process of engulfing the urban area of Saaba has become more spacious and is progressing largely toward the center of the municipality.



Map 2. Spatio-temporal evolution of Ouagadougou

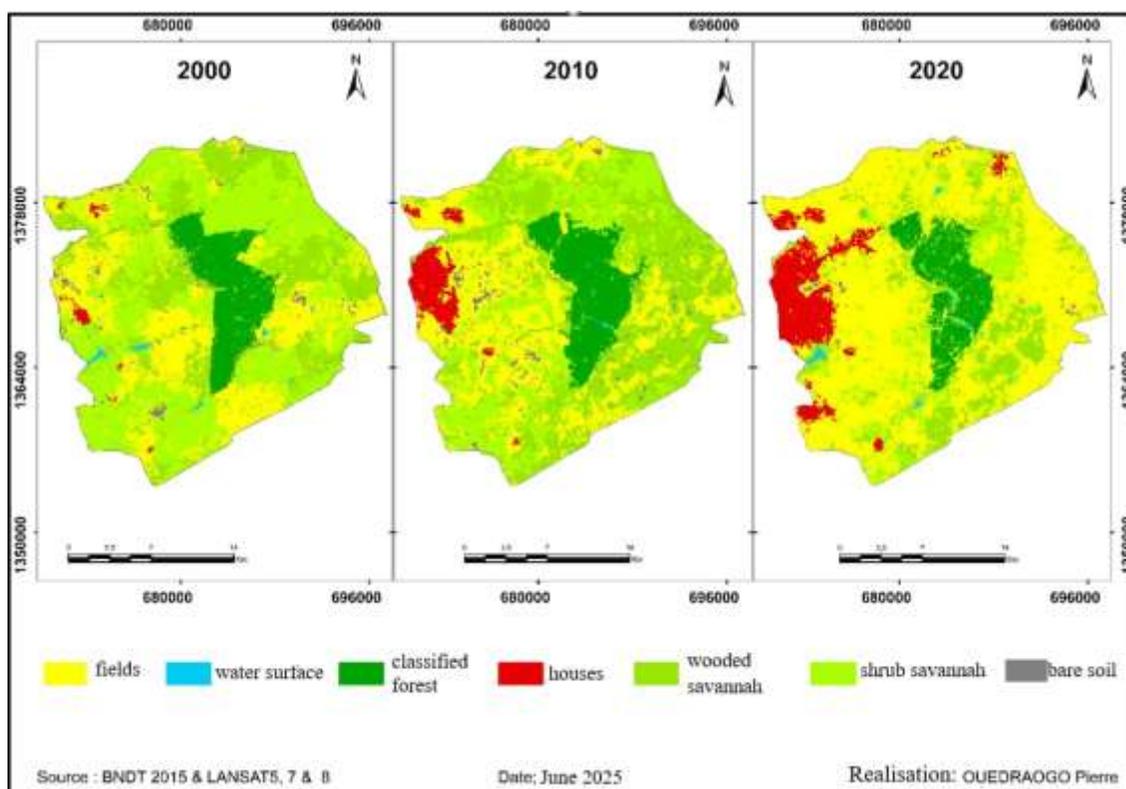
The land of Saaba is increasingly being taken over by city dwellers. In recent years, Saaba has been receiving a large number of foreigners. This is linked to the spatial evolution of Ouagadougou but also to the intervention of real estate companies. Thus, we see that between 2000 and 2020, the surface area of housing increased at the expense of that of other land use units. The takeover of the rural commune of Saaba by the city of Ouagadougou has had enormous environmental consequences, which are illustrated below.

Degradation of vegetation or forest

To analyze the impact of sprawl of Ouagadougou on vegetation, a diachronic analysis was conducted. Map 3 shows the impact of Ouagadougou's spatio-temporal expansion on the vegetation of the rural district of Saaba.

Analysis of this map reveals the impact of human activities on the vegetation of Saaba. In the 2000s, the shrub savannah was denser and more extensive. The forest of Gonsé was also degraded and the urban area of Saaba was small.

In 2010, the restoration of the wooded savannah and the Gonsé forest was observed, while the shrub savannah was deteriorating. The urban area of Saaba is spacious, reflecting the quick extension of the city of Ouagadougou on Saaba. The deterioration of the shrub savannah is due to the extension of the city and the increase in the area of fields (clearing). The restoration of the Gonsé forest and the wooded savannah after a decade is explained by reforestation and nature conservation policies implemented by the country's authorities.



Map 3. The degradation of the vegetation of Saaba between 2000 and 2020

Ten years later (in 2020), the results are alarming. Indeed, the level of degradation of the Gonsé forest is very evolved. The shrub savannah is endangered and the wooded savannah has almost disappeared. The urban area has become very large. With the massive influx of people due to centrifugal movements, landowners have sold off land around the district of Saaba. This has led farmers to go beyond and clear new fields, resulting in the degradation of the vegetation. Among those interviewed, 85.21 % said they had noticed the degradation of the vegetation cover in the rural district of Saaba over the past twenty years.

The deforestation

In the context of urban expansion, deforestation is reflected in energy consumption and the construction of housing (see photo plate no. 1)

The sprawl of the city of Ouagadougou is leading to deforestation in the rural district of Saaba. As a result, people moving from downtown Ouagadougou to settle in Saaba are cutting down trees to build their homes. Among the households surveyed, 94.10 % said that deforestation is linked to the urban sprawl of Ouagadougou. Picture a and b illustrate the felling of the shea tree (*Vitellaria paradoxa*), a tree that is very beneficial to society. Some of the inhabitants living in slum areas lack the financial means to purchase gas cylinders for cooking. Consequently, many households rely on wood and charcoal as their cooking fuel. Energy consumption (wood and charcoal) in the rural commune is illustrated in photos c and d.



Photo plate 1. Deforestation

Source: OUEDRAOGO Pierre, field survey, february-april 2024

The alteration of the relief morphology

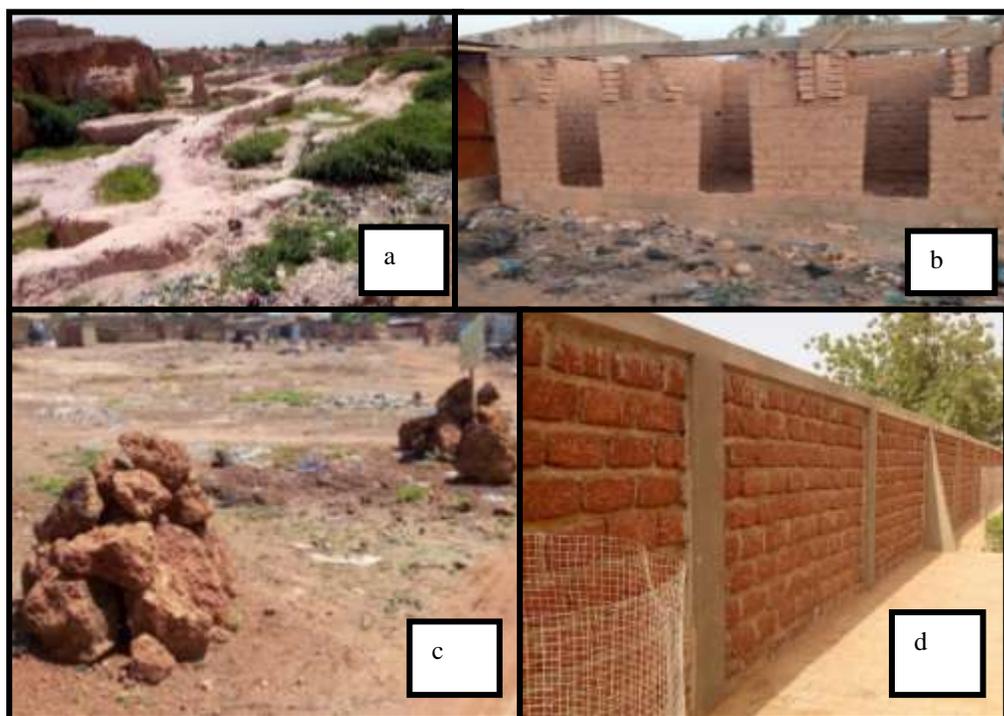
The urban expansion of Ouagadougou through the construction of undeveloped districts is deteriorating the morphology of the relief (see photographic plate no. 2).

The morphology of the relief of the rural district of Saaba has been altered for several reasons. This alteration is mainly linked to poverty and unemployment. Most of those who live in spontaneous neighborhoods do not have the financial means to acquire modern and adequate materials for the construction of housing. Unemployment drives some young people to engage in activities such as aggregate extraction and adobe brick making, which alter the morphology of the landscape. Photo "c" illustrates this situation. The mounds composed of stones are crushed by the young people who remove the aggregates and sell them for the construction of housing in the city.

Photo "a" shows a mound that was destroyed for several reasons. During the course of this study, we have six mounds that were destroyed. Some were destroyed during the manufacture of adobe bricks and the removal of clay (aggregates, banco).

Photograph "b" shows a building being constructed with adobe fibers. Nowadays, adobe bricks are being abandoned in favor of concrete blocks.

In the study area, we saw stone mounds destroyed for the benefit of the "cinder block industry." Photo "d" shows a wall built with cinder blocks.



Photographic plate 2. The destruction of the morphology of the relief

Source: OUEDRAOGO Pierre, field survey, february-april 2024

These human activities contribute enormously to the destruction and/or modification of the morphology of the relief. Figure No. 1 below shows the state of the construction materials of the habitats.

The analysis of this graph shows that 14.86 % of the households surveyed have houses built with mud bricks, while 30.48 % of those surveyed have houses built with both mud bricks and cement.

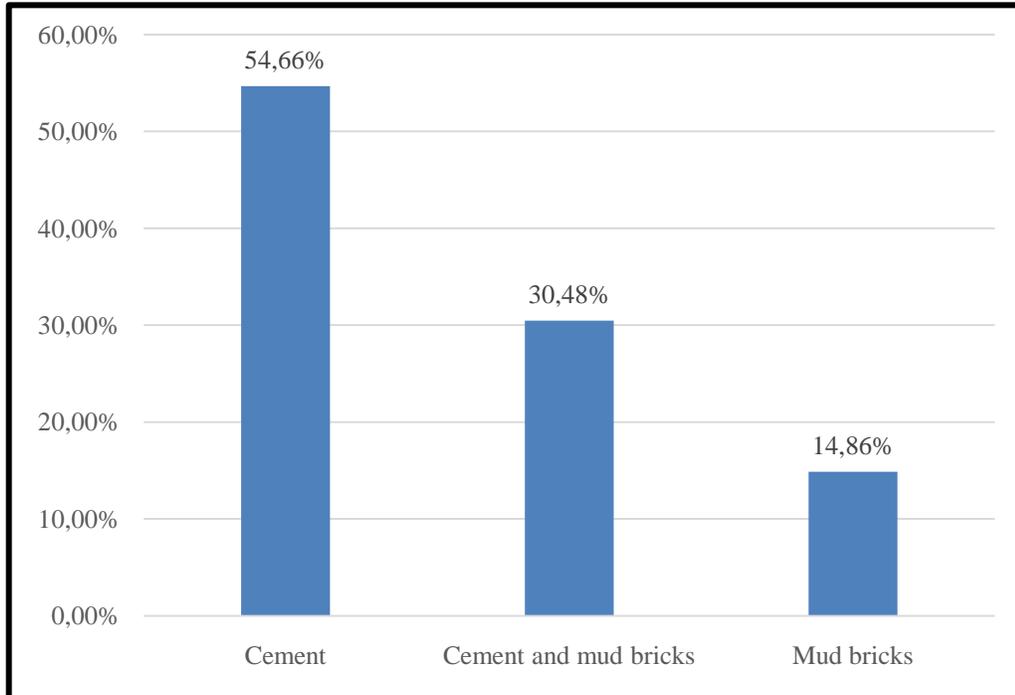


Figure 1. The building materials
Source: field survey, February-April 2024



Photographic plate 3. Pollution of the environment and living environment
Source: OUEDRAOGO Pierre, field survey, February-April 2024

Pollution of the environment and living environment

Ouagadougou's urban sprawl has led to environmental pollution in the rural commune of Saaba, as well as the living conditions of its inhabitants. This pollution can be explained by several factors. Poor management of household and industrial waste is the main cause. This study shows that 35.34 % of households surveyed do not have trash cans, and 69.97 % have not subscribed to garbage collection facilities. Among them, riverside residents dump their household waste in the river. Industries, particularly the alcoholic beverage manufacturing one, dump its residues into the river. This industrial and household waste gives off very nauseating odors, thus polluting the living environment of residents and affecting their health. Photograph "a" shows this situation. Some households dispose of their waste either in reserves or in undeveloped plots. In addition, several garbage collection facilities, due to a lack of dumps, dump their waste into the environment. Photograph "b" shows waste discarded by households and some collection facilities in a large reserve. This scattered waste pollutes the environment and the living conditions of the population.

Incineration is practiced by households and collection agency agents when illegal dumping sites are full. Photograph "c" shows the incineration of waste in a "bancotiere", quarry hole. According to local residents, the incineration process can last two to three days because the quarry hole is large and deep. The smoke pollutes the environment and causes respiratory illnesses among local residents. Graph 2 shows the waste disposal sites.

According to this graphic, 30.04 % of households surveyed incinerate their waste. Respectively, 16.13 % and 17.34 % of respondents dispose of their waste in undeveloped plots and small empty spaces. In addition to this there is air pollution due to greenhouse gas emissions. Commuting is the source of greenhouse gas emissions. Indeed, some respondents (21.55%) commute between Saaba and their workplace (Ouagadougou city centre) using personal motorised vehicles.

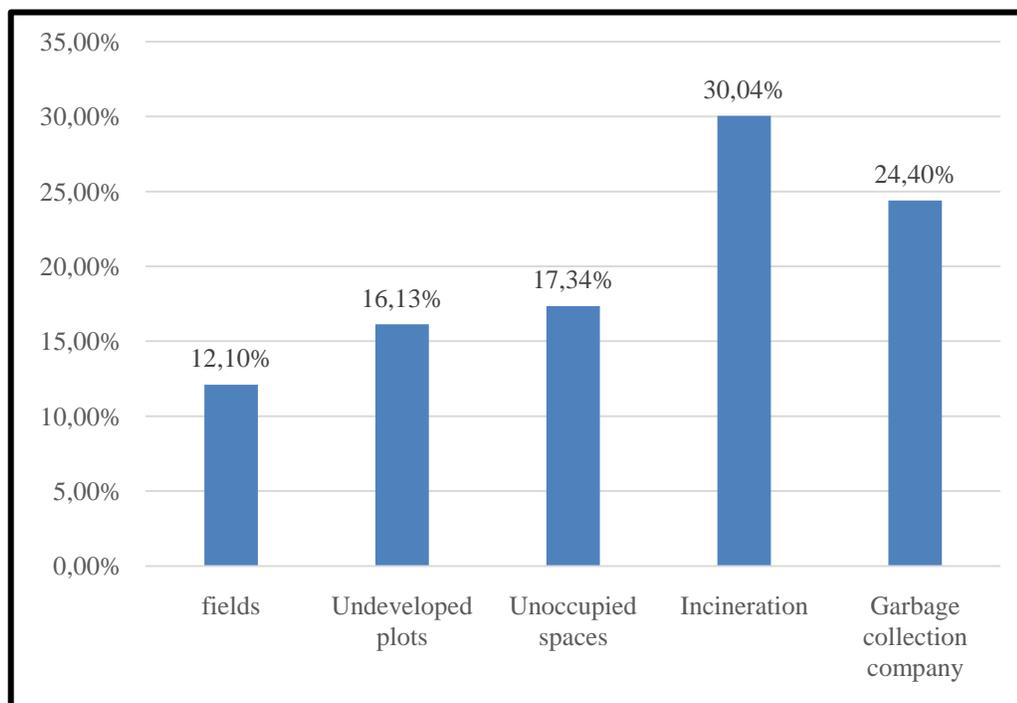


Figure 2. Waste disposal locations
Source: field survey, february-april 2024

Discussion

Being adjacent to the city of Ouagadougou, the rural district of Saaba receives a large proportion of the city dwellers. This study showed that 86.57 % of those living in informal settlements are not from Saaba. The strong population growth has caused the urban district of Ouagadougou to exceed its territorial limits and take over the land in the surrounding areas.

The expansion of Ouagadougou has led to an increase in housing in Ouagadougou and the rural district of Saaba. This result is similar to the result of Ouédraogo & al. (2023). Their study showed that the sprawl of Ouagadougou has led to a no limit expansion of housing areas from the city center to the periphery to the detriment of other land uses such as agricultural areas. This situation has led to a 78.12 % increase in built-up areas in Ouagadougou while 42.24 % of the agricultural land area has been lost. The uncontrolled urbanization of the Aurès (Algeria) has led to a loss of natural and agricultural spaces and intensive artificialization of ecosystems (Soto et al., 2024). The increase in housing area and the grabbing of agricultural land are at the root of environmental consequences.

Between 2000 and 2020, the vegetation in the rural district experienced significant degradation. The wooded savannah has almost disappeared and the shrub savanna is disappearing. This result corroborates that of Sawadogo (2022). His study revealed that between 2000 and 2020, in the rural district of Toussiana, the wooded savannah almost disappeared and the shrub savanna experienced a significant decline. The expansion of the city of Chelghoum El Aïd (Algeria) has significantly transformed open spaces, leading to a considerable reduction in green and natural spaces (Zaari & Djeflal, 2025). This degradation is linked to human activities.

The use of wood and charcoal as a source of energy has also contributed to deforestation. Observation revealed that in undeveloped neighborhoods, several households use them. Regarding the energy sources used for cooking, these are mainly wood and charcoal. According to Zoma & al. (2022), they are used exclusively by 31.87% of households. Their research further confirmed that 17.5 % of households combine wood and charcoal with butane gas while 21.25 % use both charcoal and gas. Ouedraogo's study (2012) revealed that respectively 30 % and 22 % of firewood and charcoal collected in the Gonsé forest are insidiously transported to the surrounding villages and the city of Ouagadougou between 6 p.m. and 6 a.m.

This study shows that 14.86 % of households surveyed have homes built with mud bricks. And 30.48 % of those surveyed have houses built with both mud bricks and cement. The construction of mud bricks in informal settlements is due to the low income of the population. In 2012, adobe bricks were durable and less expensive. In fact, a brick was sold at 15 FCFA per unit or two at 25 FCFA. Eight years later, an adobe brick in Ouagadougou has decreased in size while the price has multiplied by 2,5 (35 FCFA/unit). This situation is explained, according to residents, by the difficulty of accessing land and the high cost of live. Since 2019, adobe bricks have increasingly disappeared in favor of concrete blocks (Sawadogo, 2024).

In the rural commune of Saaba, the environment is heavily polluted by poor household and industrial waste management. Indeed, 35.34 % of the households surveyed do not have garbage cans and 69.97 % have not subscribed to garbage collection facilities. As a result, waste is thrown into the environment, polluting the environment (air and water) and the living environment of the population. In the commune of Ziniaré (Burkina Faso), the study by Dahani (2025) showed that the management of household solid waste is a concern because it is abandoned by operators in quarries and in waterways, the main source of water pollution. In the Democratic Republic of Congo, in the Ma-

diata district (outskirts of the city of Kinshasa), poor household waste management is one of the main causes of disease and pollution (Guylain & al., 2023).

Conclusion

This study revealed that the expansion of the Ouagadougou metropolitan area has had numerous environmental consequences for the rural commune of Saaba. It has led to the degradation of vegetation, particularly the Gonsé forest and the wooded savannah. The construction of neighborhoods and the use of wood and charcoal as sources of energy have caused deforestation. The construction of homes with materials such as concrete blocks and adobe bricks has contributed to the destruction and/or modification of the morphology of the relief. The environment and the living conditions of the populations are polluted due to the poor management of household and industrial waste.

The hypothesis of the study, which stipulated that the degradation of vegetation, the modification of the morphology of the relief and the pollution of the environment are the main environmental consequences induced by the sprawl of Ouagadougou, is confirmed.

In view of the situation prevailing in the rural district of Saaba, it is necessary to take the environment into account in urban developments, with a view to its preservation.

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