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Monitoring and assessing of sustainable development in the urban area of Ouagadougou based on SDG 11.3.1 indicator and the city biodiversity index

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Abstract: Urban growth can induce changes in the use and transformation of urban land. In the context of rapid urbanization, monitoring key indicators of sustainable development is essential. The aim of this study was to monitor and assess the level of sustainable development in the city of Ouagadougou between 2002 and 2022, based on global indicators such as Sustainable Development Goal 11.3.1 indicator and the Singapore City Biodiversity Index. A remote sensing and Geographic Information System approach was used to acquire and analyze open-source geospatial data. The results show an increasing inefficiency in land use, with excessive consumption to population growth until 2013. Between 2013 and 2022, this trend declined, but urban biodiversity nevertheless decreased significantly, with a 40% loss of natural areas between 2002 and 2022. Fragmentation of natural areas, due to infrastructure development, has amplified this degradation, posing ecological risks to the city. This study underlines the importance of strengthening the ecological connectivity of urban spaces to improve their sustainability and resilience. It also recommends reorienting urban strategies by integrating nature-based solutions and placing biodiversity preservation at the heart of sustainable urban development policies.
Keywords: *Land Use, Nature-based solutions, Ouagadougou, Sustainable development, Urban biodiversity, Urbanization.*

1. Introduction

Sustainable development represents a compass and a force for driving transformative change on our planet, notably Sustainable Development Goal 11 (SDG 11) dedicated to "sustainable cities and communities," which aims to make cities and communities sustainable, resilient, safe and inclusive [1]. Rapid population growth and urbanization in Africa have irreversible effects on natural resources [2]. They have led to environmental degradation [3], water and sanitation problems, loss of biodiversity, proliferation of slums, air pollution, and urban insecurity [4, 5]. By 2050, African cities will be home to an additional 900 million inhabitants, representing two-thirds of the African population [6]. This urban growth will lead to greater pressure on urban land use and consumption of natural resources, potentially compromising sustainable development goals.

Ouagadougou is the largest city in Burkina Faso, in terms of space and population. It accounts for 45% of the urban population, with an annual growth rate of approximately 4.4% [7]. Urban sprawl, inadequate infrastructure, and pressure on the environment are the most pressing challenges in a city [8]. The challenges of population growth, city expansion intensive use of natural resources, and the impacts of climate change in the city, such as pressure on water, soil degradation, extreme temperatures and heat stress, and flooding.

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SDG 11.3.1 indicator, "ratio of land consumption rate to population growth rate," is one of the two indicators of target 11.3. It represents a key tool for continuously assessing the effectiveness of sustainable urbanization policies. It measures the level of land-use efficiency of cities [9], beyond simple analyses of their spatial dynamics over a given period [10, 11, 12, 13, 14, 15]. In recent years, studies have been undertaken using the SDG 11.3.1 indicator to predict future changes in land cover and use, as well as for sustainable management of population growth. For example, large-scale geospatial data from the Chinese Academy of Sciences for the years 2010 and 2015 were used to assess urban land-use efficiency by integrating the SDG 11.3.1 indicator, as well as additional indicators from 338 cities in 58 countries and regions in Asia, Europe, and Africa [16]. In addition, other recent studies on a European scale by Cimini et al. [17] and in South Africa by Mudau et al. [9] have used the ratio between the land consumption rate and population growth rate (LCRPGR) as an indicator for assessing sustainable urbanization.

SDGs 11, 13, and 15 are interconnected in that they address crucial issues related to urban sustainability, climate action, and ecosystem protection. Urban biodiversity is essential for improving the urban quality of life and regulating climate [18]. The Singapore City Biodiversity Index is an international tool for assessing the state of biodiversity in cities and implementing conservation actions [19].

In the context of Ouagadougou, where land and urban biodiversity are under pressure, the joint assessment of SDG 11.3.1 indicator and the urban biodiversity Index is essential to monitor and guide urban development by generating evidence for formulating urban strategies in a nature-based solutions-oriented approach. This paper focuses on time series analysis using geospatial data to identify land use change in Ouagadougou over the period 2002 to 2022, to determine SDG 11.3.1 indicator and the urban Biodiversity Index.

2. Materials and methods

2.1. Study Area

Ouagadougou, the capital of Burkina Faso, is located in the central region at 12°22'12.00" N and 1°31'48.00" W. It is a dynamic city Sahelian. Thus, the population is growing rapidly. In 2019, it had a population of 2.4 million [7]. Spatially, it is continually expanding beyond territorial limits, representing approximately 530 km^2. There were no natural obstacles to curbing the city's sprawl. The morphological elements that structure Ouagadougou's urban space are the three dams to the north of the city center, and the natural zones that include the Bangr Weogo urban park and other areas. The urban road network is radially organized from the city center. Ouagadougou is vulnerable to the consequences of climate change and loss of biodiversity due to urban growth. Since 2012, the city has been administratively organized into 12 arrondissements and 55 sectors (Figure 1).

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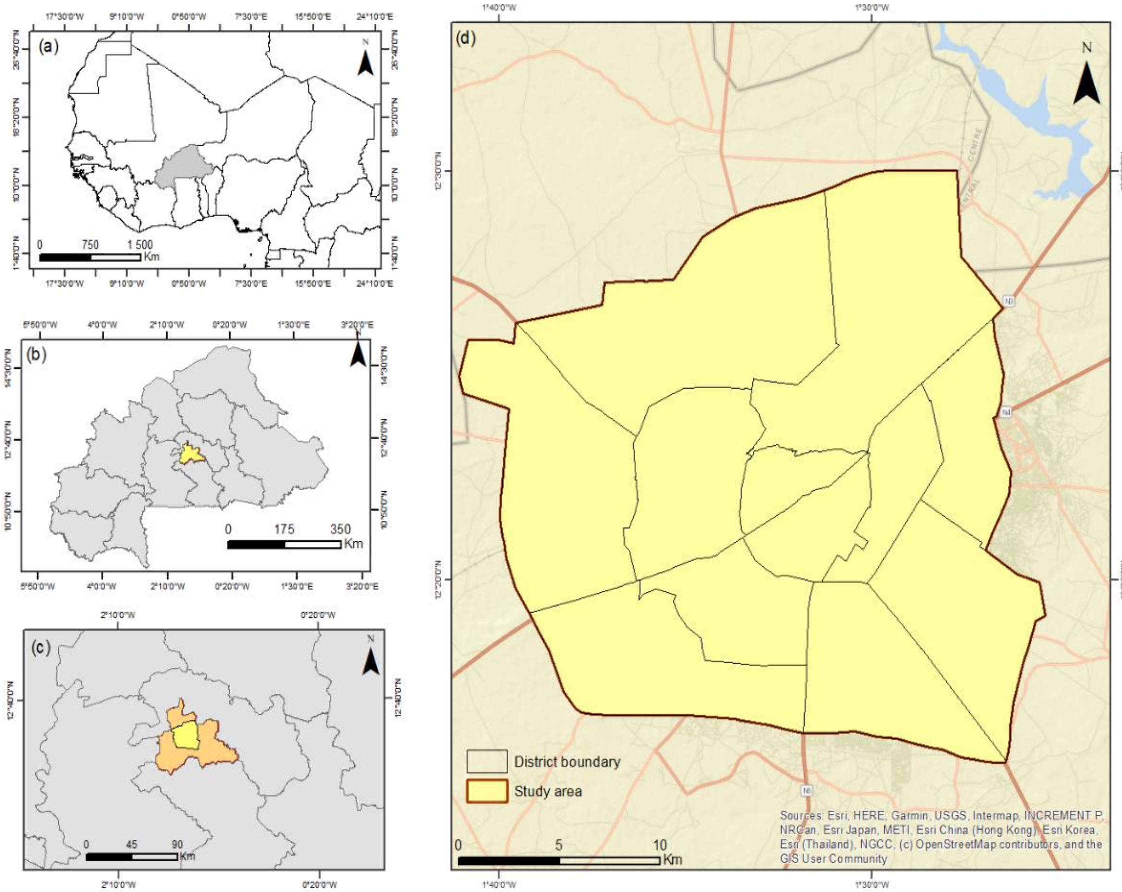

Figure 1.
Study area location.

2.2. Research Methods

2.2.1. Data Sources and Acquisition Methods

Remote sensing and GIS were used to analyze land use changes in the city of Ouagadougou between 2002 and 2022. The images used were free data from the Landsat 7 (2002), Landsat 8 (2013), and Landsat 9 (2022) satellites. These were acquired from the USGS Earth Explorer website (https://earthexplorer.usgs.gov/) in October. These images had a resolution of 30 m and included several spectral bands (Appendix A).

The demographic data used in this study were those of the Burkina Faso National Institute of Statistics and Demography (INSD), derived from population censuses and official annual projections Table 1.

Table 1.
Populations of the city of Ouagadougou in 2002, 2013 and 2022.

Year	Population
2002	918 967
2013	1 999 366
2022	2 805 888

2.2.2. Data Processing and Analysis

First, data pre-processing was carried out to correct atmospheric, radiometric, and geometric distortions, and to improve image visualization and interpretability. Next, an unsupervised method was applied for land-cover classification based on spectral features [20, 21]. This unsupervised classification was generated based on the calculation algorithm integrated into GIS software. Finally, in QGIS, unsupervised classification was performed using the semi-automatic classification plugin. Satellite images were categorized as urbanized areas (built-up areas), urban forests, shrublands, grasslands, water bodies, and bare soil. Urbanized areas represented dense concentrations of buildings, roads, and human infrastructure, or more generally mineralized land where urban activities dominate the landscape.

Forests represent dense woodlands and are home to a variety of plant species. Shrubs, on forest edges or in semi-natural habitats, took the form of dense bushes. Meadows are vast expanses of grass that are often used for grazing or cultivation. Water bodies are rivers and dams. Bare soil is an area devoid of vegetation, directly exposing the land surface, and is often subject to erosion and environmental degradation in the absence of vegetation protection. The study area was cut from the raster image by using the extent of the city of Ouagadougou. Figure 2 shows the methodological approach.

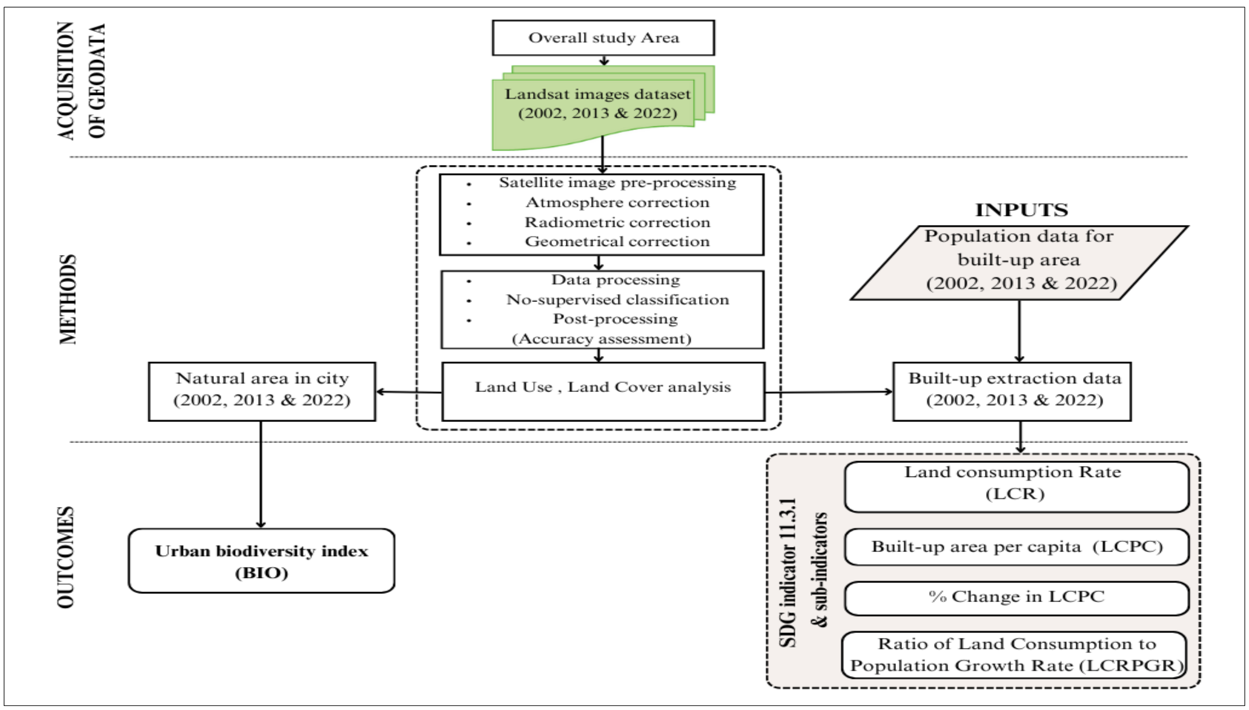

Figure 2.
The workflow of the methodological approach used for the study.

2.2.3. Post-Processing

A confusion matrix was used to assess the accuracy of the remote sensing image classification. Once unsupervised classification was performed in QGIS, the "Semi-automatic classification (SCP)" plugin compared the classification produced by the software with Landsat 7, 8, and 9 satellite images. To perform this evaluation, a sample of 50 random points was created. In this study, all the images used for classification had an overall accuracy of 82.74%. According to Ismail et al. [22] and Onyango et al. [23], an overall classification accuracy of between 80% and 100% is acceptable. The values of the statistics and the Kappa coefficient, whose determination formula is highlighted in Equation (1), were calculated using the classification algorithm. For the six classes in all the classification images, the

Kappa statistic values were generally between 0.59 and 1.00, attesting to the reliability of the classification data.

$$k = \frac{\mathrm{N} \sum_{i=1}^{n} mi,i - \sum_{i=1}^{n} (GiCi)}{\mathrm{N}^2 - \sum_{i=1}^{n} (GiCi)} \qquad (1)$$

Where:
- i is the class number
- N is the total number of classified values compared to truth values
- mi,i is the number of values belonging to truth class i that have also been classified as class i (i.e. values found along the diagonal of the confusion matrix)
- Ci is the total number of predicted values belonging to class i
- Gi is the total number of truth values belonging to the class

2.3. Calculating Indicators

The ratio between the land consumption rate and population growth rate (LCRPGR) was used to measure land-use efficiency. This basic indicator is the ratio of a city's annual spatial growth rate to its annual population growth rate over a given period [24]. In addition, a secondary indicator was used to explain the actual growth patterns, and a secondary indicator has been associated. This is land use per capita (LCPC), which corresponds to the amount of land used per capita. This represents the average amount of land consumed by each person during the year of analysis. The percentage change in the amount of land consumed per capita between the analysis years (% Change in LCPC) was also calculated.

The indicator method, based on the indicator definitions used in the Singapore City Biodiversity Index [19] was used to assess the state of the local urban biodiversity. This is a widely recognized framework designed to help assess and monitor biodiversity and its protection in cities [25]. This method includes several ways of assessing the state of biodiversity, distinguished by input data such as natural areas, natural land connectivity, biodiversity in built-up areas (birds), and changes in the number of vascular plants, birds and arthropods. However, in this study, we focused on natural areas, representing the proportion of land belonging to natural land classes relative to all land within a city. Therefore, considering that any urban land close to a natural state supports biodiversity by providing habitat, as defined by the Singapore index, natural areas in Ouagadougou consist of urban forests, shrublands, grasslands and water bodies according to our classification. The formulae used to calculate the indicators are as follows:

$$\mathrm{LCRPGR} = \frac{(\text{Land Consumption rate})}{(\text{Population growth rate})} \qquad (2)$$

Built-up area per capita (m^2/person): $\mathrm{LCPC} = \frac{(\mathrm{UrBUt})}{(\mathrm{Popt})}$ (3)

Where:
- UrBUt is the total built-up area/city in the urban area at time t (in square meters).
- Popt is the population in the urban area in time t.

Total change in built-up area: %Change in LCPC$= \frac{(\mathrm{UrBUt+n} - \mathrm{UrBUt})}{\mathrm{UrBUt})} * 100$ (4)

Where:

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- UrBUt +n is the total built-up area in the urban area/city in time the current or final year
- UrBUt is the total built-up area of the urban area/city in time the past/initial year

Urban biodiversity index: $$\mathrm{BIO} = \frac{\text{natural areas}}{\text{area of city}} * 100 \quad (5)$$

3. Results

3.1. Changes in Land Use and Cover in Ouagadougou

Land use in the city of Ouagadougou has undergone a heterogeneous evolution between 2002 and 2022. In 2002, the shrubland areas had the highest in terms of land use. These were located at the periphery of the city's built-up area (Figure 3a). From 2013 onwards, changes in land use showed a progressive artificialization of peripheral green zones in all geographical directions. Built-up land has the largest surface area in the city (Figure 3b). This land artificialization will continue until 2022 (Figure 3c). The results of the spatial analysis of land use show a predominance of land in built-up areas, the surface areas of which reach the administrative limits of the city to the east and south. We also noted a growth in the areas of land allocated to urban forests and water bodies.

In terms of geospatial analysis, land use and cover changes in the city of Ouagadougou were significant in the peri-urban area around the green belt, which once formed the boundary of the planned city between 2002 and 2013. There was a marked decline in natural areas in the northern part of the city. However, there has been an increase in the natural areas in the circular (arc-shaped) zone encompassing the western, southern, and eastern parts of the city. Moreover, between 2013 and 2022, there was a significant decrease in natural spaces in the western, southern and eastern parts of the city, where construction has increased (Figure 3). During the study period (2002-2022), changes in natural areas were considerable. In the peripheral zone, nature areas literally underwent a continuous decline, while in the center, they underwent a less significant transformation.

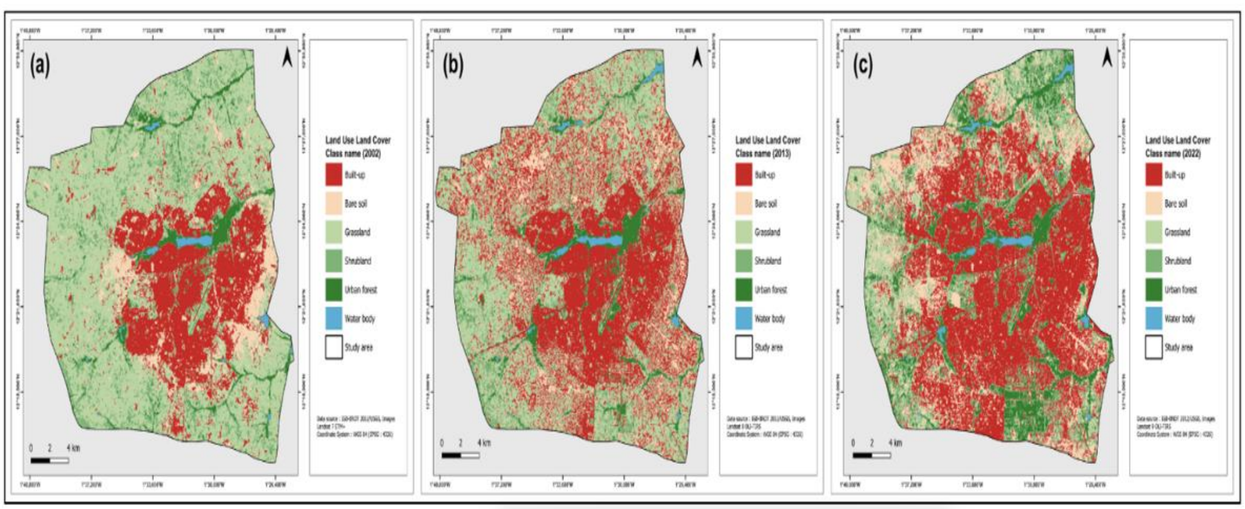

Figure 3.
Land use and cover trends in Ouagadougou in 2002, 2013 and 2022.

Spatial analysis between 2002 and 2022 shows the evolution of land occupation and use. In 2002, built-up land accounted for 23.74% of the total area, compared to 69.44% of natural areas (forests, shrublands, meadows and water bodies). In 2013, built-up land accounted for 42.62% of the total surface area, compared with 50.13% in natural areas. By 2022, built-up land accounted for 44.83% of the total area, compared to 40.81% for forests, shrublands, meadows, and water bodies Table 2. Figure 4 summarizes the evolution of land use and land cover between 2002 and 2022.

Table 2.
LULC statistics for the city of Ouagadougou between 2002 and 2022.

LULC Class	2002		2013		2022	
	Area (Km²)	% Cover	Area (Km²)	% Cover	Area (Km²)	% Cover
Urban Forest	23.18	4.35	28.29	5.31	58.70	11.01
Shrubland	71.34	13.38	45.26	8.49	79.78	14.97
Grassland	271.35	50.91	188.00	35.27	71.94	13.50
Built-up	126.54	23.74	227.16	42.62	238.94	44.83
Bare soil	36.32	6.81	38.63	7.25	76.58	14.37
Water body	4.29	0.80	5.68	1.06	7.09	1.33
Total	533.03	100	533.02	100	533.03	100

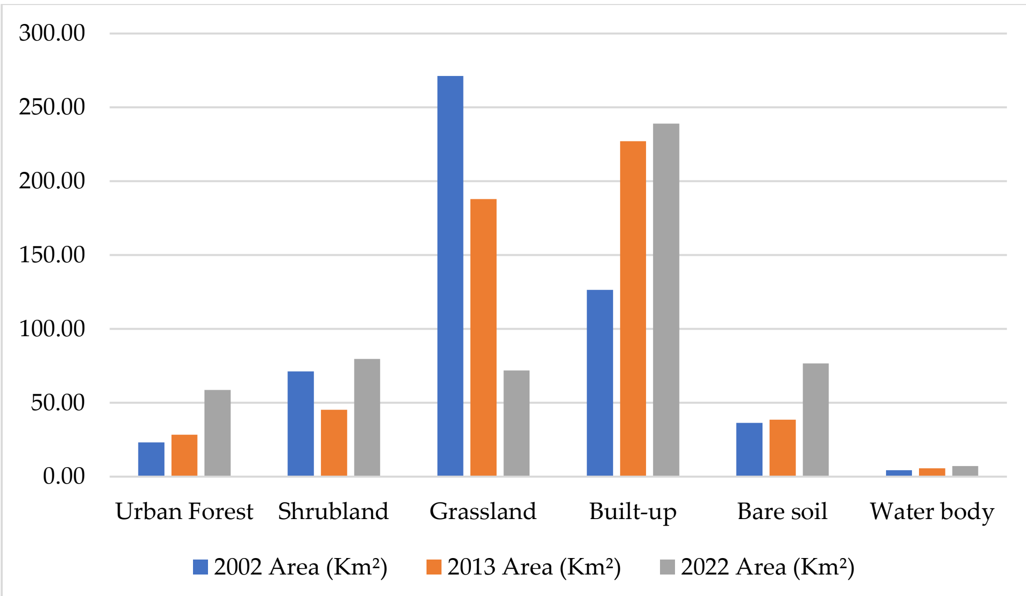

Figure 4.
Evolution of land use and land cover between 2002 and 2022.

Between 2002 and 2013, land covered by grasslands and shrubs in the city of Ouagadougou declined significantly. The grassland and shrubland decreased by 30.72% and 36.56% respectively during this period Table 3. During this period, the areas of built-up land and urban forests increased by 79.52% and 22.04% respectively. Between 2013 and 2022, the grassland area decreased drastically (-61.73%), with continued conversion to built-up and bare land. Urban forests, bare land and shrubland increased by 107.48%, 98.22%, and 76.27% respectively.

Table 3.
Change in LULC in the city of Ouagadougou between 2002 and 2022.

LULC Class	2002-2013		2013-2022		(Overall Change) 2002-2022	
	Area (Km²)	% Change	Area (Km²)	% Change	Area (Km²)	% Change
Urban Forest	5.11	22.04	30.41	107.48	35.52	153.21
Shrubland	-26.08	-36.56	34.52	76.27	8.44	11.83

Grassland	-83.35	-30.72	-116.06	-61.73	-199.41	-73.49
Built-up	100.62	79.52	11.77	5.18	112.39	88.82
Bare soil	2.31	6.37	37.94	98.22	40.26	110.84
Water body	1.39	32.37	1.41	24.83	2.80	65.23

3.2. SDG 11.3.1 and Secondary Indicators

The average amount of land consumed per person over the study period (2002-2022) shows a decline. In the city of Ouagadougou, each inhabitant used less built-up space during this period. The land area per capita decreased from 130 m² in 2002 to 114 m² in 2013 and 85 m² in 2022 Table 4. In terms of percentage change, there was a decrease in the average amount of space occupied by each person between 2002 and 2013 (- 12.8%); between 2013 and 2022 (- 25.1%) and more globally (- 34.6%) between 2002 and 2022. A negative value of the variation in land consumption per capita indicates that the area occupied per person is decreases.

Regarding the SDG 11.3.1 indicator, the results in Table 4 show that over the period 2002 - 2013, the city of Ouagadougou recorded the highest annual land consumption rate (LCR), at 0.072, compared with a rate of 0.006 per year between 2013-2022. However, over the entire study period (2002-2022), the annual land consumption rate has reached 0.044. The LCRPGR shows a rate of 1.10 for the period 2002-2013, while for the period 2013-2022, this rate is 0.15 (Figure 5). When we consider the period 2002-2022, the LCRPGR was 0.84.

Table 4.
Indicator calculation results.

Year	Land consumption per capita - LCPC (m²)	% Change in LCPC	Land Consumption Rate (LCR)	Ratio of Land Consumption Rate to Population Growth Rate (LCRPGR)
2002 -2013	130.24	- 12.8	0.072	1.10
2013-2022	113.62	- 25.1	0.006	0.15
2002-2022	85.16	- 34.6	0.044	0.84

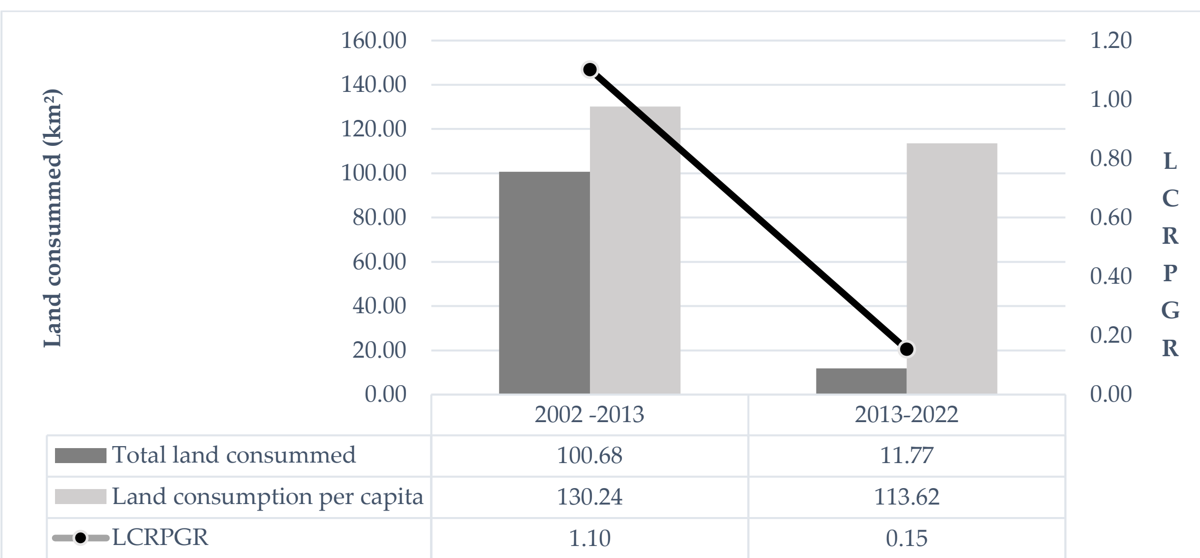

Figure 5.
SDG 11.3.1 indicator based on urban land use and cover change detection.

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3.3. Natural Areas as Indicators of Urban Biodiversity

The proportion of a city's total surface area, which is close to a natural state, provides information on urban biodiversity. Between 2002 and 2022, the percentage of natural areas within the city limits of Ouagadougou fell from 69.45% in 2002 to 50.13% in 2013 and then to 40.81% in 2022. This decline is an indicator of the overall state of urban biodiversity in Ouagadougou (Figure 6).

Figure 2.
Indicator on urban biodiversity evolution in Ouagadougou.

4. Discussion

Urban expansion is a complex phenomenon. With the growing interest in the sustainable development of cities, the evaluation of indicators makes it possible to monitor changes in the urban environment and provides a decision-making tool. The results show a significant increase in land artificialization of land in the city of Ouagadougou between 2002 and 2022. Over the same period, the built-up land increased by 112.39 km^2. Rapid population growth is, therefore, one of the factors driving the increase in land consumption in the city of Ouagadougou.

Regarding land use, the calculation of SDG 11.3.1 indicator, indicates that between 2002 and 2013, the ratio between the rate of land consumption and the rate of population growth (LCRPGR >1) was greater than 1. This indicates that, during this period, the annual rate of land consumption exceeded that of population growth, illustrating the inefficiency of land use. This phenomenon is explained by accelerated urbanization induced by rural exodus and natural population growth, which led to a 206% increase in population in 2013 compared to then in 2002. Consequently, new needs in terms of housing, infrastructure, and services have led to the horizontal expansion of the city [26]. In addition, several previous studies have linked weak urban planning to land speculation, informality, and slum expansion, with excessive consumption of urban land. Thus, Sory [27] pointed out that the model of land promotion by real estate companies characterized by institutional limitations has led to the delegitimization of public authorities in the land mobilization process and, consequently, a loss of public control over peri-urban land development. Ouedraogo et al. [28] also observed, in their intensive analysis of land use and occupation dynamics between the cities of Bobo Dioulasso and Ouagadougou, that the landscape is changing rapidly in Ouagadougou rather than in Bobo due to urbanization, the

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consequences of which are vulnerable to flooding and heat island effects. The trends observed in Ouagadougou were part of a broader regional and global context. The 2017 Sustainable Development Goals report on the LCRPGR confirms the results obtained between 2002 and 2013. Indeed, the report revealed that the rate of urban land expansion exceeded the rate of urban population growth in all regions of the world during the period 2000-2015 [29]. Low efficiency of urban land use is an observation particularly common in the majority of cities in developing countries. In Addis Ababa, the study by Koroso et al. [30] showed that the LCRPGR reached 1.02 between 2005 and 2019, while the overall LCRPGR values of two suburban areas of Bole and Akaki-Kaliti reached 3.16 and 3.62 respectively between 2007 and 2019.

However, our results show a trend between 2013 and 2022. An LCRPGR of less than one; indicates that the annual rate of population growth was greater than that of land consumption during this period. This change can be explained by the fact that more land was consumed outside of Ouagadougou's administrative boundaries. Changes within administrative boundaries are less significant and the population continues to grow. Indeed, because the majority of the areas outside the administrative boundaries of the city of Ouagadougou are unplanned, it is difficult to apply the LCRPGR determination principle to an area whose population is unknown. The second possible factor is the improvement in urban planning instruments and land tenure policies in Burkina Faso. With the development of the land use plan for the city of Ouagadougou, rules applicable to easements contribute to the preservation of certain natural urban lands. Nevertheless, the LCRPGR is globally lower than 1 (LCRPGR = 0.84) over the study period between 2002 and 2022.

On the other hand, the combination of secondary indicators, notably land use per capita (LCPC), shows a 55% decrease (138 m^2 between 2002 and 2013, 14 m^2 between 2013 and 2022, and 79 m^2 between 2002 and 2022). It should be noted that the choice of scale and interval can influence the accuracy of the results. These observations were also made by de Schiavina et al. [31] on the multi-scale estimation of land use efficiency (SDG 11.3.1) over 25 years using free open global data. More than 60% of African cities in the study have an LCPRGPR between 0 and 1, even though African cities are sprawling faster than their population is growing. The method for assessing urban land-use efficiency, while informative, has certain limitations, particularly in its application to the city of Ouagadougou, where the analysis does not consider urbanized areas beyond administrative boundaries. The concept of dynamic and functional city boundaries is discussed to demonstrate the need to adopt a functional city boundary for the measurement of the indicator. In his book "Urban Growth Analysis and Remote Sensing: A Case Study of Kolkata, India 1980-2010", Bhatta [32] explained that building expansion is not limited to the administrative boundaries of an area. Indeed, when an area reaches its maximum building capacity, this pressure can spread to neighboring areas and lead to urban sprawl that is not reflected in the analysis based solely on the local population. Therefore, rather than considering population proportion as a function of local built-up areas alone, it is essential to examine the relationship between population proportion and built-up area proportion for each zone, as well as the surrounding areas. However, a functional boundary that does not represent the official city boundary for which the demographic data are associated may eventually lead to more variable scenarios. Thus, the absence of disaggregated demographic data beyond the official city limits, due to the character of unplanned built-up areas, does not allow the creation of hypothetical boundaries for the measurement of SDG 11.3.1 indicator.

Urban development trends in Africa have a significant impact on urban biodiversity [33]. Calculation of the BIO indicator in the city biodiversity index revealed a decline in the biodiversity-rich habitat areas in the city of Ouagadougou. From 69.43% natural areas in 2002, these have fallen to 50.13% in 2013 and to 40.81% in 2022. The results indicate that urban growth is a scourge for biodiversity. Indeed, a global study assessing the current status (2014-2021) of biodiversity hotspots in the African region, conducted by Ayeni et al. [33], highlighted the loss of land mass in each biodiversity hotspot and identified the direct and indirect impacts of urban development on biodiversity. Although global in scope, this study corroborates our results in calculating the biodiversity indicator, which has shown a continuing loss in recent years. In addition, the study by Ren et al. [34] simulated global urban expansion from 2016 to 2050 and assessed its impacts on natural habitats at global, biome, and ecoregion scales. They estimated that urban land will increase by 280 to 490,000 km^2 between 2016 and 2050, resulting in a loss of 110 to 190,000 km^2 of natural habitats worldwide. Kandil et al. [35] demonstrated that in Alexandria, Egypt, between 2005 and 2019, the ecological footprint of built-up land was greater than that of the built-up land, resulting in an ecological deficit.

However, these results are only general indications. Connectivity is an important determinant of biodiversity assessment, and the quantity of natural spaces within a city does not necessarily indicate an abundance of biodiversity. The ecological connectivity of natural spaces is essential for facilitating the movement of species. However, urban infrastructure development projects, particularly roads in the city of Ouagadougou, have significantly contributed to the fragmentation of spaces without leaving the slightest continuity. The Singapore Index for monitoring biodiversity and its protection in cities distinguishes several ways of calculating biodiversity indicators, such as the number of natural spaces (BIO-1), connectivity of natural spaces (BIO-2) and presence of birds (BIO-3) [19]. Determining BIO-1 alone did not allow us to specify the current state of urban biodiversity in the city of Ouagadougou. We must pool all possible indicators, particularly that of the connectivity of natural spaces. The BIO-1 indicator, which is based on the number of natural areas, provides a solid basis for assessing the evolution of biodiversity in the urban environments.

5. Conclusions

This study aimed to monitor and assess the level of sustainable development in the urban area of Ouagadougou over 20 years between 2002 and 2022. By combining the remote sensing approach with the calculation of recognized global indicators such as SDG 11.3.1 indicator and the Singapore City Biodiversity Index, the results show that land use has not been sufficiently efficient over the period studied. The ecological footprint of built-up land has increased, resulting in ecological deficits. Therefore, Ouagadougou's urban model is unsustainable. The Singapore City Biodiversity Index also shows a decline in urban biodiversity in Ouagadougou. These results are essential for understanding a city's ecological challenges and issues. They represent a basis for reflection for urban planners and managers to better integrate local urban strategies for sustainable land use and urban biodiversity restoration, focusing on nature-based solution approaches to move the city of Ouagadougou towards sustainability and urban resilience.

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Author Contributions:
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Appendix A.
List of satellite images used for the study and their acquisition dates.

	Acquisition date	Bands	Wavelength (Micrometer)	Spatial resolution (Meters)
Landsat 9 OLI-TIRS bands	12/10/2022	Band1 -Coastal aerosol	0.43-0.45	30
		Band2-Blue	0.45-0.51	30
		Band3-Green	0.53-0.59	30
		Band4-Red	0.63-0.67	30
		Band5-Near Infrared	0.85-0.87	30
		Band6-SWIR1	1.56-1.65	30
		Band7-SWIR2	2.10-2.29	30
		Band8-Panchromatic	0.50-0.67	15
		Band9-Cirus	1.36-1.38	30
		Band10-Thermal Infrared1	10.60-11.19	100
		Band11-Thermal Infrared2	11.50-12.51	100
Landsat 8 OLI-TIRS bands	27/10/2013	Band1 -Coastal aerosol	0.43-0.45	30
		Band2-Blue	0.45-0.51	30
		Band3-Green	0.53-0.59	30
		Band4-Red	0.63-0.67	30
		Band5-Near Infrared	0.85-0.87	30

		Band6-SWIR1	1.56-1.65	30
		Band7-SWIR2	2.10-2.29	30
		Band8-Panchromatic	0.50-0.67	15
		Band9-Cirus	1.36-1.38	30
		Band10-Thermal Infrared1	10.60-11.19	100
		Band11-Thermal Infrared2	11.50-12.51	100
Landsat 7 ETM+ bands	21/10/2022	Band1-Blue	0.441-0.514	30
		Band2-Green	0.519-0.601	30
		Band3-Red	0.631-0.692	30
		Band4-Near Infrared	0.772-0.898	30
		Band5-SWIR1	1.547-1.749	30
		Band6-TIR	10.31-12.36	60
		Band7-SWIR2	2.064-2.345	30
		Band8-Panchromatic	0.515-0.896	15