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Analysis of Anthropogenic Disturbances of Green Spaces along an Urban–Rural Gradient of the City of Bujumbura (Burundi)

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Abstract: Bujumbura city has diversified but unevenly distributed green spaces. The typology and anthropogenic disturbances of these green spaces are still unknown. This study presents a typology of green spaces along the urban–rural gradient through a literature review. It assesses the presence of anthropogenic disturbances through inventories in 100 m × 100 m grids. Data reveal that Bujumbura's green spaces are made up of green squares concentrated exclusively in urban areas, cemeteries present in peri-urban areas and sports green spaces observable all along the urbanization gradient. These green spaces are more exposed to trampling, which is more present in administrative entities with a peri-urban morphological status, as opposed to various constructions in administrative entities with an urban status. Finally, significative pairwise associations of anthropogenic disturbances were observed. The results show the need to protect these green spaces from all kinds of anthropogenic disturbances by raising the eco-responsible awareness of the population and the municipal authorities.

Keywords: green spaces; Bujumbura; peri-urbanization; anthropogenic disturbances; urban ecology

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1. Introduction

Urbanization has become a global phenomenon as a result of the urban transition that started in the second half of the 20th century [1,2]. Indeed, in 1950, only 30% of the world's population lived in urban areas, a proportion that has increased to 57% in 2021 [3]. Urbanized areas, which occupy nearly six million square kilometers, or 1.17% of the Earth's surface, are expected to increase by more than one million square kilometers by 2030 [4].

In developing countries, particularly in Sub-Saharan Africa, urbanization is currently happening at a high speed due to the combined effects of rural–urban migration, natural population growth and civil wars [5]. In addition, this demographic explosion in urbanized areas takes place in a context of absence of planning that has prevailed since the 1950s [6]. The result is an accelerated urban spatial dynamic materialized through a dual process of densification of already built spaces and generally of an anarchic extension of the built environment in an area that conserves its rural characteristics, leading to the creation of urban and peri-urban areas, respectively [7,8]. This situation is not without environmental consequences.

Indeed, through uncontrolled urban spatial expansion, urbanization puts significant pressure on natural ecosystems through their fragmentation, leading to a regression of the green space coverage [9,10] and an alteration of their ecological functionality [8,11–14]. Yet,

green spaces, considered as vegetated surfaces in urbanized environments, are essential in urbanized environments to mitigate several scourges, such as temperature increase, biodiversity loss, and degradation of social interactions, health conditions and the wellbeing of inhabitants [15–18]. However, the degree of influence of green spaces on the wellbeing of urban dwellers varies according to several criteria, such as the type of green space and the types and magnitudes of anthropogenic disturbances [19–21].

Several typologies of green spaces have been proposed based on function, ownership status and physical characteristics [22–29]. Other typologies have been based on the degree of naturalness by distinguishing between natural, rural and peri-urban green spaces [30]. However, these typologies focus rather on European and Asian cities, and rarely on African cities where the few existing typologies focus only on the city of Kumasi in Ghana [31] and the cities of Kinshasa [7] and Lubumbashi [12,13] in the Democratic Republic of the Congo. No typology, however, has a universal scope due to the high variability in environmental and urban planning contexts, a situation that makes it difficult to compare studies [32].

In African cities, green spaces in urbanized areas are subject to anthropogenic disturbances [8,13]. These disturbances are consequent to the observed gaps in their land tenure security, the uncooperative attitude of the general public, the low level of coordination among stakeholders involved in their management and the low priority given to them in the municipal budgets [33,34].

Bujumbura city, the political and economic capital of the Republic of Burundi, is not spared by this alarming trend since its spatial growth is marked by the densification of existing central neighborhoods, and by the progressive destruction of green spaces to install new habitats and other infrastructures such as roads and monuments [5,35]. In addition, housing estates are being created on the outskirts of the city without any overall plan or coherence in order to contain the constantly increasing demand for housing [5], amplifying the anthropogenic disturbance of the various residual green spaces in the city, which are unevenly distributed and whose ecological functionality is still poorly known [35]. It has recently been known that the recent green spaces typology of Bujumbura was only based on soil moisture (terra firma and wetland green spaces) and socio-economic factors (domestic garden) [36]. There is, on the one hand, a need for a more detailed typological analysis of the public green spaces of Bujumbura to improve and adapt their management. On the other hand, adapting the green spaces preservation measures is important to characterize the anthropogenic disturbances to which they are subjected, and which are assumed to act in a synergistic manner. However, considering the spatial pattern, the ecological functionalities and management of green spaces change according to the extent of urbanization [13], which is crucial to study green spaces within cities by considering separately urban and peri-urban areas.

Thus, the purpose of our study is based on three hypotheses: (i) the green spaces of Bujumbura city are not only less diversified in types but also more concentrated in the urban area due to the proximity of diverse public services involved in their management; (ii) due to building extension and modernization, the most important anthropogenic disturbances of the green spaces of the city of Bujumbura are constructions, which are present in zones with urban morphological status; (iii) there are associations of anthropogenic disturbances in the studied green spaces in the urban and peri-urban zones.

2. Materials and Methods

2.1. Study Area

The city of Bujumbura was created in 1897 on the borders of Tanganyika lake by the Germans on a site called Kajaga. Since then, it was known as the economic and political capital of the country until February 2019 [37]. Located in the western part of Burundi (Figure 1), between latitudes 3°30′ and 3°51′ S and longitudes 29°31′ and 29°42′ E, it covers an area of 10,462 hectares, whereas it was estimated at 30 hectares in 1907 [38]. It is administratively split into three communes (Muha, Mukaza and Ntahangwa) that cover thirteen administrative entities or urban zones. A municipality, whether urban or rural,

is a decentralized territorial authority with legal personality and organic and financial autonomy [39]. A group of rural municipalities form a province; a group of urban municipalities compose a city. A rural municipality is subdivided into zones and census hills while the urban municipality is subdivided into zones and districts. Consequently, a zone is a deconcentrated district of the municipality, an intermediate between the municipality and the census hill or district.

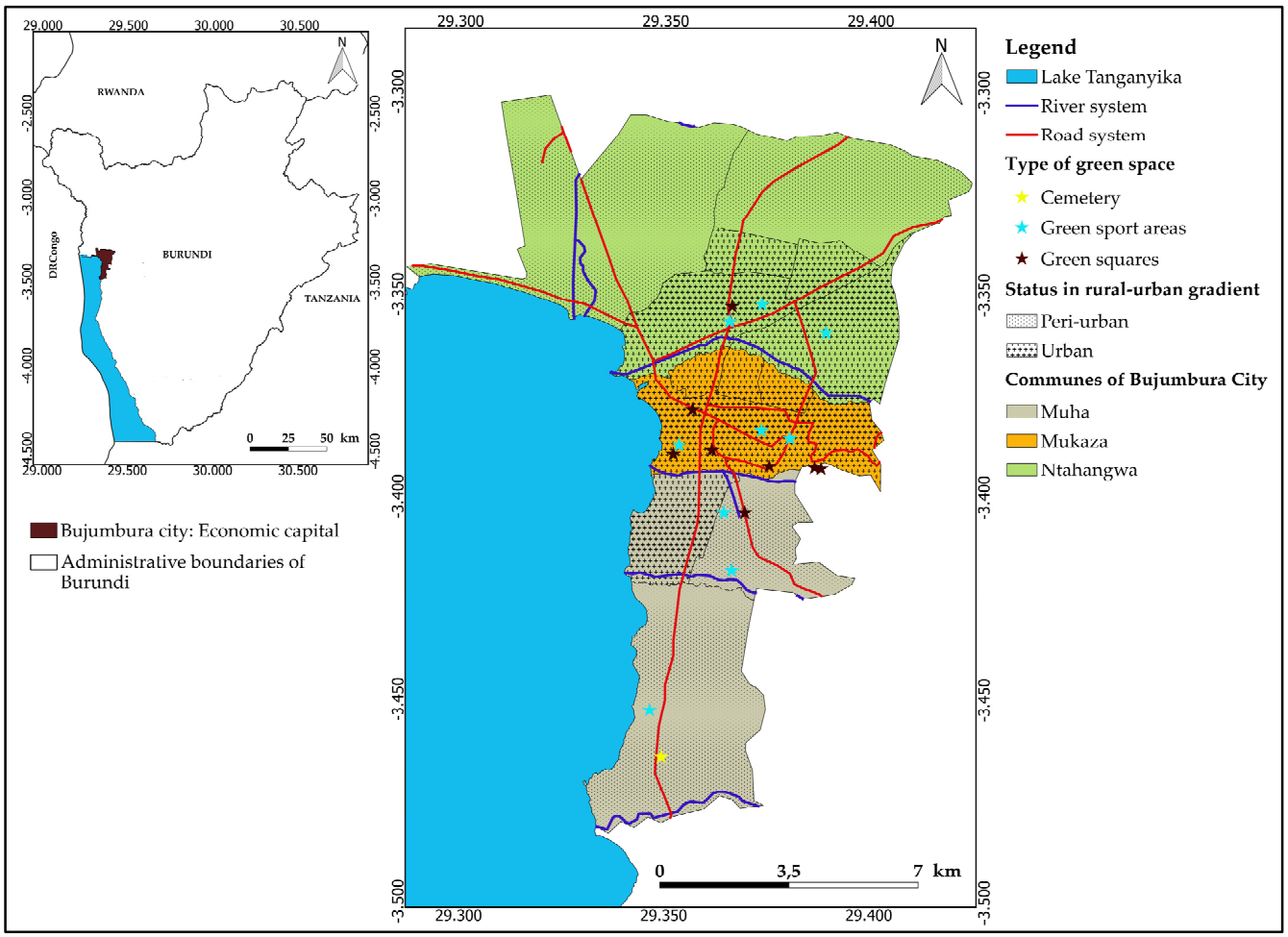

Figure 1. Location of Bujumbura city in the Republic of Burundi, near Tanganyika Lake. The municipalities of the city have both morphological statuses of urban and peri-urban areas. Within these areas, three types of green spaces have been found and located.

The climate of Bujumbura is characterized by a dry season and a rainy season, each with two variations: the long dry season (June to mid-September), the short dry season (mid-December to mid-February), the long rainy season (mid-February to May) and the short rainy season (mid-September to December). The average annual temperature is above 23 °C with a total rainfall of between 800 and 1000 mm [40]. The relief is characterized by a plain that rises from west to east, with an average altitude of 820 m. Ntahangwa is the largest river flowing through the city. If clay soils dominate the north of this river, the south is dominated by sandy soils [35]. Water-logged or flooded during the rainy season, clay soils become very hard during the dry season and show shrinkage cracks. The natural vegetation of the region is savanna, miombo woodland and wetlands [41]. Miombo woodland is mainly dominated by trees of the genus *Brachystegia* and *Uapaca*. The undergrowth is very sparse and is dominated by grass species [42]. According to the phytogeographical classification of [43], Burundi is covered by two regional centers of endemism: the Afromontane region (an archipelago-like regional center of endemism)

and the Lake Victoria Regional Mosaic. Bujumbura belongs to the Lake Victoria Regional Mosaic. The natural vegetation has almost disappeared in the Bujumbura region, except in the Rusizi Natural Reserve (5932 ha), located 15 km north of the city, and in Kibira National Park, the largest montane rain forest reserve of the country (40,000 ha), located less than 35 km to the northeast [36]. This is due, among other reasons, to the use of charcoal as the main energy source for the urban population of Bujumbura [44]. It has previously been demonstrated that, when studying the spontaneous vegetation in the city of Bujumbura, ruderal plant assemblages dominate in the most urbanized areas, while in the outskirts of the city, the vegetation shows similarities to natural plant assemblages in the region [41]. Fishing, industry, administration and urban agriculture are the main socio-economic activities carried out by the city's population, estimated at 497,166 inhabitants in 2008 [45] and 792,504 inhabitants in 2022 [46]. In this city, urban agriculture has considerable importance. It is dominant in 50% of the urban territory that is not built. All food plants adapted to the soils and climate of the region are grown in these spaces (e.g., maize, cassava, soybeans, peanuts and vegetables), mainly for consumption at the household level. Cultivation of rice in the swamps northwest of the city (Kiyange and Carama) and cotton is an important source of income for urban farmers. Urban horticulture is also under development within this city, and it currently receives support (since November 2001) from the Burundian Ministry of Agriculture and the Food Agriculture Organization (FAO). It has been reported that the average number of children per household and the literacy rate were about 4.8 and 82.6%, respectively, in 2017 [47]. Traditional practitioners of Burundian medicine collect further plants from these wetlands and from terra firma vegetation to treat various diseases of humans and livestock [48].

2.2. Segmentation of the Urban–Rural Gradient Zones

In order to analyze the morphological status of the different administrative entities composing the city, Bujumbura was gridded by 698 square grids of 25 ha each, enabling the observation of urbanization morphology on Google Earth [49]. A flowchart based on the morphological characteristics of the different zones along the urban–rural gradient was used to qualify each of the sub-zones as urban or peri-urban [50]. Urban zones combine high densities and proportions of built-up zones as opposed to peri-urban zones that have some discontinuity of the built-up area at lower proportions [50]. In the context of Bujumbura (Figure 1), the zones with an urban morphological status area are characterized by popular neighborhoods and medium standing, very dense buildings and paved streets. Unfortunately, with houses that date from 1850 to 1983, they can have a small part with no marked roads. Zones with peri-urban morphological status are under development and generally not characterized by a clear road infrastructure. The older part of the peri-urban area consists of houses that date from 1983.

2.3. Data Collection

2.3.1. Green Space Sampling

To facilitate a parcel analysis [50], we first made a pre-identification on Google Earth of the green spaces that have a minimum surface of one hectare. These were identified in the field in November 2020, in a rather random and simple way by following the boulevards, pavements and avenues of the city [7,34,51,52]. The geographical coordinates of the sampled green spaces were mapped using Arc GIS 10.2 software (Figure 1).

2.3.2. Typological Analysis

The inventory focused on public green spaces without taking into account their management type. The literature review of existing green space inventories as well as the field observations allowed the establishment of an adapted typology.

In the absence of a single typology that covers all these particularities, we combined four existing typologies to characterize the green spaces of Bujumbura: (i) the typology of the Association of Engineers of the Cities of France (1995) described by [53], (ii) the typology

of [22] in France, (iii) the typology implemented by [23] in Belgium and (iv) the typology used by [7] in the Democratic Republic of the Congo. Among the existing typologies, those of [7,13,31] were used in this study since they are adapted to the socio-ecological context of the city since they have the particularity of classifying green spaces on the land use.

2.3.3. Definition and Inventory of Anthropogenic Disturbances of Bujumbura's Green Spaces and Their Indicators

Definitions of the types of anthropogenic disturbances and their indicators were developed prior to the fieldwork. They were based on exploratory observations and contacts with the population living close to the green spaces. Indeed, exchanges with local populations, through focus groups of 9 to 12 people, made it possible to identify and validate the types of anthropogenic disturbance. In total, ten focus groups were organized, as more than eight new indicators were no longer cited. Eight disturbance types were selected (Table 1) and their identification consisted of noting the presence or absence of the corresponding indicator(s) in each grid cell in which green spaces were identified. The size of the selected grid cells allowed for a parcel-based and sub-square kilometer analysis [50]. The number of grid cells for each green space depended on its area and shape. In total, 18 green spaces were identified. These green spaces were located in five administrative entities with different morphological statuses. A total of 14 green spaces, with 111 grid cells, were located in entities with urban morphological status. Four green spaces, located in two entities with peri-urban morphological status, were covered by 48 grid cells.

Table 1. List of types and indicators of anthropogenic disturbances of green spaces in the city of Bujumbura, based on exploratory observations made from September to October 2021.

Types of Disturbance	Indicators
Buildings	Presence of houses, monuments, parking lots, tiles, sports surfaces, bleachers, makeshift housing
Crops	Presence of crop plants
Rubble	Presence of construction debris
Flooding	Presence of stagnant water from washing vehicles, carpets or tents
Military installations	Presence of tents, obstacles, shelters, trenches, etc.
Household waste	Unauthorized dumping of household waste
Improvised parking lots	Presence of vehicles, motorcycles and bicycles
Bare floors	Observation of the ground without vegetation cover, mainly due to trampling and livestock grazing

Based on the study of [54], the data analysis was based on the model which describes disturbance processes according to a set of characteristics; notably, type of disturbance (classification of events or observations), frequency (extent of the disturbance), the spatial structure of the disturbance (in this case the urban–rural gradient) and synergy (the interaction with other disturbances). Relative frequencies were calculated for each type of anthropogenic disturbance from the presence-absence data [54]. To test that the most important anthropogenic disturbances of the green spaces of the city of Bujumbura are constructions, mainly present in zones with urban morphological status, the Friedman test, an alternative procedure to the analysis of variance method for repeated measures [55,56], was performed under SPSS to compare the different types of disturbance in terms of their frequencies [53,57]. It allowed the comparison of more than two matched samples by determining whether the values of the samples were different from those of the other samples [55,58]. When the null hypothesis of the Friedman test, assuming there is no difference between the frequencies of occurrence of the eight disturbance types along the urbanization gradient, was rejected, post hoc tests were applied [55,56] to compare pairwise the different types of disturbance in order to identify those disturbances that would be different from each other in terms of frequency of occurrence. To verify the existence of associations of anthropogenic disturbances in the studied green spaces in the urban and

peri-urban zones, a Chi-square test of independence was performed to assess the presence of positive or negative associations between disturbance types [49].

3. Results

3.1. Typology of Green Spaces along the Urban–Rural Gradient of the City of Bujumbura

The literature review and the field observations revealed that the green spaces in Bujumbura are mainly made up of green sports areas (stadiums and sports centers), green spaces accompanying roads, green spaces accompanying public buildings (whose role is to enhance the building), green spaces accompanying industrial and commercial establishments, green spaces of social and educational establishments (gardens of nurseries, primary and secondary schools and universities), trees of alignment, green squares, cemeteries, traffic circles and nurseries. These green spaces can be grouped into three distinct types: green squares, green sports areas and cemeteries, and are rather small in size, only up to 20 hectares for the largest green space (Table 2).

Table 2. Spatial data of the 18 green spaces present along the urban–rural gradient of the Bujumbura city. GS: green space, EA: administrative entity, GC: geographic coordinates, SL: southern latitude, EL: eastern longitude, MS: morphological status, NC: number of grid cells, P: perimeter, TG: type of green space, GS: green squares, GA: green sports area, CE: cemetery.

GS	AE	GC		MS	NC	Area (m^2)	P (m)	TG
		SL	EL					
1	Rohero	3°22′42.43″	29°21′24.24″	U	35	207,800.00	2011.89	GS
2	Kanyosha	3°27′09.54″	29°20′47.20″	PU	18	97,441.96	1274.12	GA
3	Musaga	3°24′13.74″	29°22′10.29″	PU	10	56,600.50	1034.88	GS
4	Kanyosha	3°27′50.94″	29°20′57.39″	PU	10	47,051.50	965.45	CE
5	Rohero	3°23′32.67″	29°22′31.64″	U	11	62,860.08	932.60	GS
6	Gihosha	3°21′33.89″	29°23′21.23″	U	9	43,474.50	859.68	GA
7	Rohero	3°23′00.59″	29°22′24.81″	U	9	49,677.99	846.90	GA
8	Rohero	3°23′13.48″	29°21′12.48″	U	6	39,878.50	842.18	GA
9	Rohero	3°23′21.44″	29°21′07.40″	U	6	39,236.00	833.60	GS
10	Rohero	3°23′34.76″	29°23′17.02″	U	8	35,719.96	795.65	GS
11	Ngagara	3°21′10.58″	29°21′58.83″	U	4	37,514.10	787.11	GS
12	Ngagara	3°21′23.97″	29°21′56.81″	U	6	30,754.55	757.94	GA
13	Rohero	3°23′33.83″	29°23′11.44″	U	7	31,144.50	742.86	GS
14	Musaga	3°24′13.73″	29°21′51.95″	PU	6	22,272.00	653.29	GA
15	Rohero	3°23′07.56″	29°22′49.81″	U	4	14,071.00	477.12	GA
16	Ngagara	3°21′08.67″	29°22′25.13″	U	4	11,440.00	432.09	GA
17	Musaga	3°25′05.41″	29°21′58.85″	PU	4	10,054.93	421.35	GA
18	Rohero	3°23′17.93″	29°21′41.29″	U	2	10,680.51	405.18	GS

In relation to the number of green spaces found in urban and peri-urban zones, cemeteries are absent in urban zones but present in peri-urban zones in small proportions (20.0%). Green sports areas are present in urban (46.2%) and peri-urban (60.0%) zones. Green squares are also present in urban (53.8%) and peri-urban zones (20.0%). Considering the importance of each type of green space as a proportion of the total area, cemeteries represent 20.2% in the zones with peri-urban morphological status, against 55.6% and 24.3% for green sports areas and green squares, respectively. In the zones with urban morphology, green squares dominate green sports areas (69.15% vs. 30.82%) while cemeteries are absent (Figure 2).

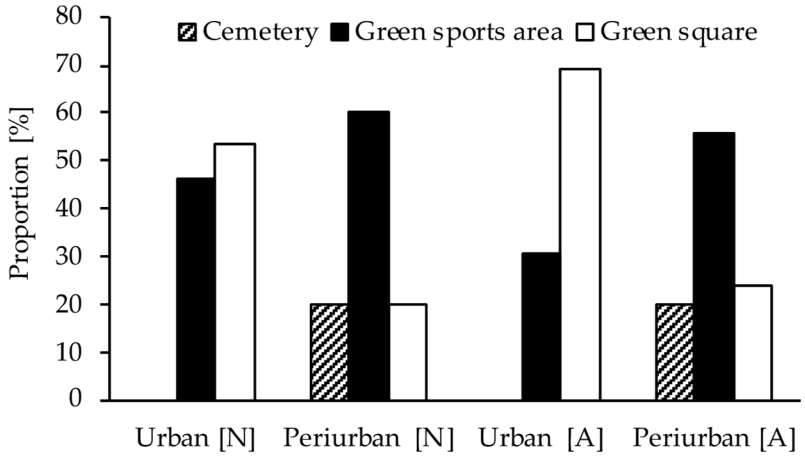

Figure 2. Presence and abundance of green spaces in the urban and peri-urban parts of Bujumbura expressed as a proportion of the number of green spaces (N) or as a function of the total area (A) of the green spaces.

3.2. Types and Indicators of Disturbance of Green Spaces in Bujumbura

3.2.1. Distribution of the Types of Anthropogenic Disturbances of the Green Spaces of Bujumbura Observed in the Field

A study of the distribution of the eight types of anthropogenic disturbance on the identified green spaces indicated different frequencies of occurrence according to the urbanization gradient considered. In the administrative entities with an urban morphological status, bare soil and constructions were the most frequent types of disturbance, with proportions of about 79.3% and 47.7%, respectively, of the total number of grid cells inventoried. The other types of disturbance showed low or zero frequencies, as is the case of rubble. In the administrative entities with a peri-urban morphological status, bare soil, constructions and crops were the dominant types of disturbance with proportions of about 85.4%, 35.4% and 39.6% of the total inventoried grid cells, respectively. Rubble and military installations showed low frequencies while flooding, garbage and improvised parking lots showed zero frequencies (Figure 3).

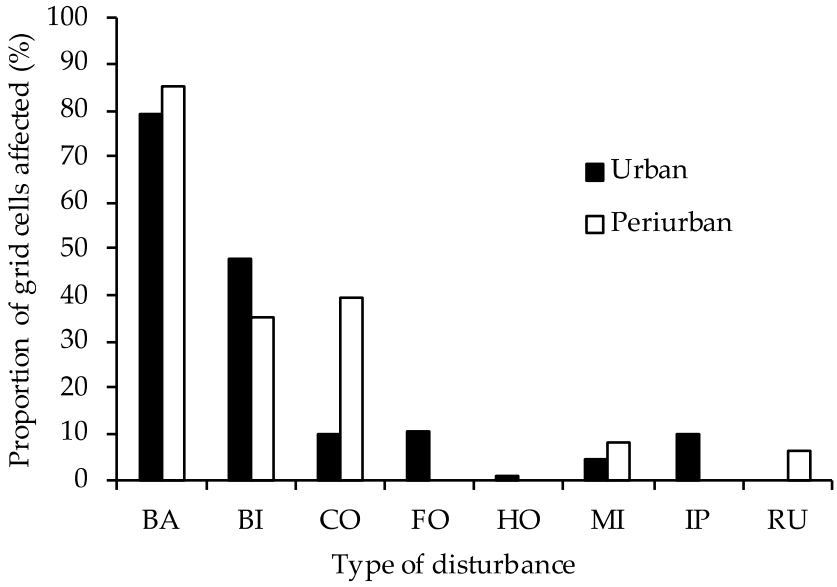

Figure 3. Proportion of grid cells affected by type of disturbance in sampled green spaces in urban and peri-urban zones of the city of Bujumbura. BA: bare ground, BI: building, CO: crops, FO: flooding, HO: household waste, MI: military installations, IP: improvised parking lot, RU: rubble.

In addition, the results of the Friedman test with $\chi^2 = 368.86$ ($p < 0.001$) in urban and $\chi^2 = 146.43$ ($p < 0.001$) in peri-urban entities showed a highly significant difference between the frequencies of the eight disturbance types along the urbanization gradient. The results of the post hoc test indicated that the disturbance types "buildings" and "bare soil" showed significant differences ($p < 0.05$) from the other disturbance types in terms of frequencies of occurrence. For the other frequencies regarding crops, rubble, flooding, military installations, garbage and improvised parking lots, significant differences were not observed.

3.2.2. Association between the Types of Anthropogenic Disturbance of the Green Spaces of Bujumbura

In the parts of the city with a peri-urban morphological status, one single association was observed, that of which between buildings and bare soil. In the parts of the city with an urban morphological status, buildings were linked to military installations and improvised parking. An association between crops and military installations was also observed; the military installations interact with the improvised parking lots (Table 3).

Table 3. Results of χ^2 independence tests for association of anthropogenic disturbances in Bujumbura green spaces (* = $p < 0.05$). The baseline data are from gridded inventories of these disturbance types conducted on 18 green spaces in the city of Bujumbura of at least 1 ha in area in November 2020. BA: bare ground, BI: building, CO: crops, FO: flooding, HO: household waste, MI: military installations, IP: improvised parking lot, RU: rubble.

Peri-urban zones						
	BA	RU	CO	MI		
BI	4.49 *	1.76	2.84	2.39		
BA		0.90	3.48	0.75		
RU			2.10	2.62		
CO				0.39		
Urban zones						
	BA	FO	HO	CO	MI	IP
BI	3.49	1.12	0.92	0.63	0.52 *	9.12 *
BA		0.14	0.26	0.05	1.37	1.01
FO			0.12	1.48	0.64	3.43
HO				0.11	0.05	0.11
CO					14.71 *	1.34
MI						5.31 *

4. Discussion

4.1. Typology of Green Spaces in Bujumbura

Several typologies of green spaces have been proposed and no inventory is able to cover all the particularities that exist in every city around the world due to the differences in natural conditions (geomorphological, climatic, biological), history and social composition [32]. In a European context, the authors of [59] clearly showed differences between green spaces as parks and gardens; natural and semi-natural spaces; green corridors; allotments, community gardens and urban farms; outdoor sports facilities; amenity green spaces; provisions for children and young people; cemeteries, churchyards and other burial grounds; and other public spaces. The authors of [60] produced an inventory of 25 urban green space types, falling into 10 subgroups and 4 main groups (amenity green spaces, functional green spaces, semi-natural habitats and linear green spaces). Other inventories are based on usage [61], based mainly on scale [62] or cover informal urban green spaces [28]. Some typologies combine urban green spaces with other open spaces such as squares, pedestrian areas, or cycling areas [63]. In China, the authors of [24] reclassified green spaces into nine types (public parks, plaza-green spaces, nurseries, green buffer zones, attached

green spaces, residential green spaces, roadside green spaces, riparian green spaces and scenery forests). This classification is based on urban green space functions, land use and property information. In Africa, the authors of [31] revealed that there are different forms of urban green spaces and grouped them into seven categories (semi-private spaces; parks, street trees and roadside plantations; public green areas; public and private tree plantations on vacant lots; green belts; woodlands and peri-urban farming areas; rangelands and forests close to urban areas; natural forests under urban influence; and trees planted for environmental protection and aesthetic purposes).

Furthermore, social initiatives, technological advances, environmental awareness and the creativity of urban planners and city dwellers are perpetually leading to new types of urban green spaces [32]. In this study, we combined four existing typologies, which have the advantage of associating each type of green space with the corresponding land use, as well as the status of the owner [7]. Consequently, these typologies allowed us to classify the green spaces of the city of Bujumbura into green squares, green sports spaces and cemeteries on the basis of their land use. These green spaces are present with varying frequencies along the urbanization gradient. In fact, green squares are present exclusively in urban entities, while sport green areas are present in urban and peri-urban zones and cemeteries are present in peri-urban zones only, hence confirming our first hypothesis. Indeed, the distribution of green spaces in Bujumbura city is based on the age of the different neighborhoods of the city and their socio-economic diversity [35,64]. Thus, in the Rohero zone, the oldest, inherited from the colonization period and characterized by a high standard of living, there are many green squares and sports green areas. In contrast, in the Kanyosha zone, the most recent city part and characterized by a precarious standard of living, only a few sports green areas and a cemetery are present.

4.2. Anthropogenic Disturbances of Green Spaces in Bujumbura

Urban green spaces are among the most degraded ecosystems in African cities [31], in particular, due to the rapid and unplanned expansion of built-up areas [8,11]. In this context, the desire to transform the architectural image of Bujumbura city, the objective of the public authorities to provide sports infrastructure and the phenomenon of gentrification [64] were at the origin of the construction of new infrastructures such as hotel residences, offices, commercial buildings and banks. In addition, the concern to commemorate the history of Burundi following the socio-political events that have characterized it since its independence, together with the objective to protect military strategic places in the city, are at the origin of the fragmentation and the shrinking of some emblematic green spaces in favor of monuments and military positions. In the African context, this situation is quite similar to the one observed in the municipalities of Treichville in Abidjan (Ivory Coast), in Lubumbashi and in Kolwezi (both situated in the southeastern part of the Democratic Republic of the Congo) where green spaces are threatened by the construction of shops, informal businesses, the installation of car garages, residential landmarks, etc., [65–67]. However, the installation of military positions in green spaces is a particularity of Bujumbura city, in order to protect strategic positions in the city. The authors of [68] specify that peri-urbanization and associated actions on green spaces will continue until 2090 without any planning.

In addition, with the repeated passages of residents on green spaces, bare soil areas appear rapidly, leading to a modification of soil properties by sealing them [69,70]. However, our results underline that the green spaces of Bujumbura are not only threatened by bare soil resulting from trampling following improvised passages, but also from various constructions along the urbanization gradient at different frequencies. Indeed, residents of green spaces consider these areas as shortcuts, thus testifying to the presence of trampling [70]. These observations confirm partly our second hypothesis according to which various constructions as well as bare soil, especially due to trampling, is visible along the urbanization gradient, while military positions are only present in administrative entities with an urban morphological status. These perturbations are largely due to the incivility

and absence of eco-responsible behavior of local populations who consider these spaces free of any restriction [65].

In Sub-Saharan Africa, agriculture is a growing activity for survival in peri-urban areas, but its development threatens (semi-)natural vegetation elements and formations, which are considered crucial for sustainable development. This corroborates our findings that crop disturbances are significantly more present in peri-urban green spaces in Bujumbura and confirm the second part of our second hypothesis. The authors of [54,55,71] argue that populations living in peri-urban areas seek to ensure their survival, by any means, in a context of economic degradation and with little concern for the preservation of vegetation. This is typically the case of the military forces who install small fields next to their positions, a practice also observed concerning the guards of sports infrastructures.

4.3. Association between Types of Anthropogenic Disturbances of Green Spaces in Bujumbura

The authors of [72] state that human disturbances often interact synergistically, hence confirming our results. Indeed, within the green spaces of Bujumbura, each time constructions such as monuments or sports facilities were erected, access paths were laid out and parking lots were created. In addition, the Republic of Burundi has experienced a decade of socio-political instability leading to a certain degree of insecurity in the cities, including Bujumbura [73,74]. To improve this situation, military positions have been set up in green spaces, which required the construction of housing or shelters, in addition to parking lots for their vehicles on which water could stagnate after cleaning them. Similarly, according to the UNDP, 64.9% of the Burundi population lives on less than USD 0.0196 (BIF 41.054) per adult per month in the context of acute food insecurity [75]. As a result, there is an economy of scavenging characterized by, among other things, the development of vegetable gardens by the military, near their positions in green spaces, a situation also observed in Lubumbashi in the southeastern part of the Democratic Republic of the Congo [13]. The tendency for vegetable gardening development is also another phenomenon observed within sports infrastructures. Indeed, the guards arrange vegetable gardens for the production of food for their respective families, due to the scarcity of the land [76], thus supporting our third hypothesis related to the association of anthropogenic disturbances. It corroborates the findings of [54] that certain anthropogenic disturbances are often related to other types of degradation. Urban developments coupled with anthropogenic actions have been reported by [77], who state that they are the main constraints to the sustainability of urban vegetation.

5. Conclusions

This study presented a typology of the green spaces of Bujumbura city. It also identified the anthropogenic disturbances to which these spaces are subjected. A literature review revealed that green squares, green sports areas and cemeteries are among the types of green spaces encountered in Bujumbura. On the basis of the inventories, it appears that green spaces are exposed to anthropogenic disturbances, notably agriculture in peri-urban areas, as opposed to the development of military positions and the construction of monuments, buildings and sports facilities, which are more pronounced in urban areas. Trampling as a type of anthropogenic disturbance is present on green spaces in urban and peri-urban areas. The synergies between the different types of anthropogenic disturbances amplify their negative impact.

This study is a continuation of our research on green spaces in the city of Bujumbura and on the analysis of the anthropogenic pressures to which they are exposed. It was written to raise awareness. All stakeholders (municipal technical services, local administrations, non-profit associations and sports club associations) in charge of managing green spaces should invest more in protecting their green spaces against all kinds of disturbances. They should also promote environmental education in order to safeguard them and the ecosystem goods and services that they provide.

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