ESJ Natural/Life/Medical Sciences

Woody Species Composition, Diversity And Structure of Vegetation of Peri-Urban Park in Leo, Burkina Faso

Ganaba Souleymane,
Semdé Kadidia,
Kagambèga Wenemi François,
Dao Moussa,
Environment and Forestry Department, Institute for Environment and Agricultural Research (INERA), National Centre for Scientific and Technological Research (CNRST), Ouagadougou, Burkina Faso

Doi:10.19044/esj.2021.v17n43p218

Submitted: 22 October 2021
Accepted: 27 October 2021
Published: 31 December 2021

Cite As:
Souleymane G., Kadidia S., François K.W., & Moussa. D.,(2021). *Woody Species Composition, Diversity And Structure of Vegetation of Peri-Urban Park in Leo, Burkina Faso* European Scientific Journal, ESJ, 17(43), 218. https://doi.org/10.19044/esj.2021.v17n43p218

Abstract

This work aims to fill a gap in knowledge of the Burkina Faso Southern Sudanese flora and vegetation. The woody vegetation of the forest park of the Scholl Complex in Léo comprises a total of 26 families, 63 genera and 81 species including native and introduced ones. The fallow is the unit that contains all families and genera and 93% of species. The most abundant species of units of the Park are *Terminalia avicennioides* (Combretaceae), *Piliostigma thonningii* (Fabaceae-Caesalpinioideae), *Daniellia oliveri* (Fabaceae-Caesalpinioideae), *Vitellaria paradoxa* (Sapotaceae), *Detarium microcarpum* (Fabaceae-Caesalpinioideae), *Diospyros mespiliformis* (Ebenaceae), *Annona senegalensis* (Annonaceae) and *Pteleopsis suberosa* (Combretaceae).

The species that regenerate the most and that will ensure the sustainability of the peri-urban forest resources are *Gardenia erubescens* (Rubiaceae), *Piliostigma reticulatum* (Fabaceae-Caesalpinioideae), *Vitellaria paradoxa*, *Annona senegalensis*, *Terminalia avicennioides* (Combretaceae), *Diospyros mespilifomis* and *Azadirachta indica* (Meliaceae).

The most threats on vegetation and flora of the School Complex are fraudulent human exploitation, parasitic pressure and progressive intrusion of *Azadirachta indica*.

Peri-urban park resources conservation measures concern the replanting of vegetation in degraded areas and incentives for wood production for local populations. A management program for threatened or rare species, control of invasive alien plants and domestic animals and the development and improvement of habitat to create a future urban park.

Keywords: Urban Ecology, Nature Conservation, Urban Vegetation Management, Burkina Faso

1. Introduction

The growth of populations worldwide is real as it is documented by several authors (Fuwape et al. 2010; Barron et al, 2016). Africa and Asia are the least urbanized regions of the world, with an urban proportion of 40 per cent and 42 per cent, respectively. But Africa had the world's highest rate of urban population growth, averaging 3.4 per cent per year during 2005-2010 (United Nations, 2011).

In Burkina Faso, the whole population increased from 5,638,203 in 1975 to 10,312,609 in 1996 and to reach 20,487,979 in 2019 (INSD, 2020). The country's urbanization rate increased from 6.4%in 1975, to 22.7% in 2006 and reach 26.3% in 2019 (INSD, 2009, 2020). It is also recognized since the last decade that urban land and rural land is a time bomb that must be defused. Peri-urban area is understood as undeveloped areas or undeveloped peripheral area of the city. New land acquisitions and real investments are pushing back the fields and pastures of the old villages that seek to resist these new occupants. Misunderstandings and conflicts of use arise over the possession of land ceded or sold with related plant resources that are no longer accessible to former users according to the terms of transfer or sale. However, the main actions of protection of urban forests are theorecal for the different actors (communities, forest services, former landowners and new buyers). Then, decreasing the city's pressure on forest resources is appropriate to conserve the rich existing forest resources. So there is an ongoing process of deforestation in the study area linked to migration pressure and climate change. The deforestation describes the complete long-term removal of tree cover in forest formation.

The high population pressure has resulted in land fragmentation and land degradation (Kleemann et al, 2017). Increased food requirements and demand for wood energy are gradually breaking the balance between the physical environment and the population. According to Geist and Lambin (2001) and Angelsen and Kaimowitz (1999), deforestation and degradation

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

agents are individuals, households, businesses or institutions, which affect forest cover, both in terms of surface area and in terms of structure. The direct causes of deforestation and degradation, in other words, are activities that directly affect forest cover as agricultural expansion, wood-consuming demand, bushfires, overgrazing, poor exploitation of non-timber forest products (NTFPs), artisanal gold mining.
In the province of Sissili, the interlocking causes and effects of deforestation are the result of an unfavorable global climate situation over the past three decades, strong land pressure due to a growing demand for cropland. Indeed, the production system has remained rudimentary, a need for forest resources, mainly energy wood (firewood and charcoal). Then, main causes of deforestation are linked to the increased need for land for agriculture which is accentuated by a large migration of people (Ouédraogo, 2010; Nébié, 2015) and population growth.

Furthermore, vegetation of this Sudan region is unknown compared to other parts of the country. This situation led to the initiation of this study to fill the knowledge gap in a peri-urban area. The aim of this paper is to evaluate tree diversity and structure in a peri-urban forest in order to contribute to the creation of a future urban forest for biodiversity conservation, climate change mitigation, human safety, wellbeing and nutritional security and promote urban plants.

1. Materials and methods

2.1. Study area

The province of Sissili is located in the Centre-West region, in the south of Burkina Faso near the border with Ghana (Figure 1). It is a vast plain not very rugged where the plains and plateaus dominate. It is slightly disturbed in the western part by hilly elevations varying from 300 to 400 meters above the sea level. Most of the provincial territory is covered by tropical ferruginous soils. In terms of texture, the province's soils are mainly composed of clay, silt and sand (Ouédraogo et al., 2010).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

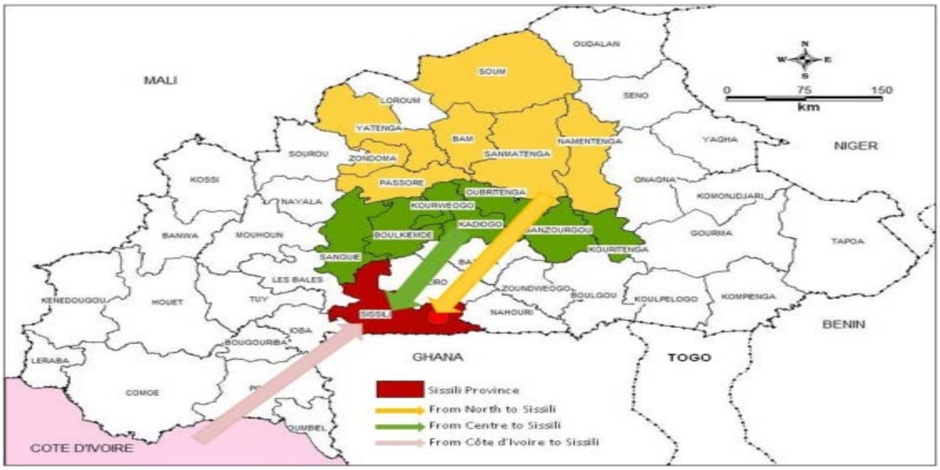

Figure 1. Site location and migration trends in Sissili province (Ouédraogo *et al*, 2009)

The urban commune of Léo, capital of the province, is located at a distance of 160 km from the capital of the country (Ouagadougou) and of 10 km north to the border with Ghana. The study is located at the crossroads of national road No. 6, National Road 13 and National Road No. 20. The municipality of Leo covers an area of 95.900 km² and is geographically located at 11°4' and 11° 12' north latitude and 2°3' and 2°10' west longitude. The study site is a peri-urban forest park that is part of the domain of a 50 ha primary and secondary school complex in Leo, managed by the ‘Religious of the Immaculate Conception’

Located in the Sudan-Sahel climatic zone, the study site is characterized by the alternation of two contrasting seasons: a dry season from October to April and a rainy season from May to October. However, the rainfall of recent years becomes rarer and concentrated during the months of July, August and September. The 2020 rainy season was spread from mid-April to October so that relative humidity is high between July and October.
The average annual rainfall calculated over the ten years (1999-2011) is 943 mm. Subsequently, 2010 and 2011 are years with little water (with 639.8 and 645.6 mm) compared to the last eleven years. The annual potential evapotranspiration is approximately 1,660 mm. The vegetation of the school complex area is relatively dense with mainly shrub savannah dominated by Combretaceae resulting from the evolution of fallow land. However, it is now in continuous degradation due to fraudulent cutting actions by local populations so that seed trees remain in the northern part close to the riverside dwellings.

Geologically, the commune of Leo extends on a Precambrian crystalline platform turning the overall relief flat; essentially consisting of granitic crystalline rocks. The major are ferruginous soils that are not leached into sandy-argillic materials with a thickness ranging from 40 to 60cm

(BUNASOL, 1990). The territory of the commune is dominated by anthropogenic savannah vegetation and some gallery forests along streams associated with agricultural areas, peri-urban and an urban area with tree and shrub parks.

The population of Leo is composed of several ethnics groups namely Gurunsi Nuni, Sissala, Dagara, Moosé, Fulani and Gurunsi Lelle. The indigenous population belongs to the Nuni ethnic group which is the patrilineal society (Yago 1984). As in the whole province, the commune of Leo is characterized by large migrations because of the richness of its flora and soil. These migrations in recent years (period 2007-2019 (Figure 1) have led to population growth and profound changes in the rural economy. These migratory flows are fueled by Moosé and Fulani ethnics groups because famine and poor harvest occurs in the central and northern part of the country. This situation led to a rapid change in the population of the commune which almost double between 1986 and 2006 from 26,640 to 51,037 inhabitants, with a density ranging from 27.78 to 52, 53 inhabitants per square kilometer and a variable growth rate of 14 to 25% for the same period and a 33% peak in 2002 (INSD, 2008). The population increased by 67.64% between 2006 and 2019, according to the results of the last general population and habitat census in 2019 (INSD, 2020).

The mode of farming in the commune of Leo is generally traditional with little mechanization of agricultural practices. The main crops are cereals (mil, sorghum, maize and rice), cash crops (peanut, cowpea, sesame, soybeans, cotton, yam, potato and cassava) and vegetable crops (Napon, 1994). Livestock farming remains an activity reserved for the Fulani, the natives contenting themselves with small-breed farming (goat, sheep, etc.). Leo's weekly market is an opportunity for trade between Ghana and Burkina Faso.

The study site is a peri-urban forest park of 50 ha in the domain of Maria Stella Yazura School Complex in Leo. Bush burning was found to be a common practice in our study communities during dry seasons throughout the communal territory and in the area of the School Complex. The production of charcoal is also an income-generating activity in the municipality.

1.2. Methods

Sampling design and data collection

The sampling in this study focuses on a stratified survey because of the variability of woody vegetation parameters in the study site. Then, we have divided the population into more homogeneous subpopulations (relative to these parameters) called strata. The strata are then probed independently of each other (with survey rates that may vary).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The strata are defined from the 2018 Google Earth satellite image. These are: orchards (mango plantations) bare surfaces, habitat (primary, secondary and housing establishments), recent cropland on plateaus, Shallows and Fallows of shrub savannah (Table I). It is a random survey stratified to one degree where the plot units are rectangular squares of 0.1ha.

Table I. Distribution of population samples in forest inventory

Field unity	Vegetation type	Area (ha)	Small square	Small square number
Fallows	Shrub savannah	38,02	1, 2, 3, 4, 6, 10, 11, 12, 13, 15, 17, 22, 23	13
Shallows	Shrub savannah	2,57	14,16	2
Cropland	Agroforestry park	5,22	5, 7, 8, 9	4
Habitation and school area	Shade plantation	2,51	18, 21	2
Barred soil	Naked soil	1,7	19, 20	2

The choice was guided by practical considerations of field achievement. Indeed, in dense tropical forest formations we consider rectangular squares 10 to 25 m wide, arranged along the parallel forest tracks. Circular squares can be considered in open forest formations where progression is easier (CTFT, 1989).

The survey rate of 4.6% was chosen taking into account the feared error between 5% and 20% at the P-0.95 probability threshold (CTFT, 1989). So, the error to be feared is proportional to the value of Student (t-2, for n > 30), the coefficient of variation which is 50% for the shrub savannah and inversely proportional to the square root of the total number of plots (n=23) according to CTFT (1989).

The data collection was taken from the squares of each sampling unit (Table II). The movement is carried out according to the north-south direction on the transect line in each sampling unit; the measurements were made on the trees inside the square. As for the boundary trees, they were considered to belong to the square in the event that the presumed centre of the summer is within the circle (FAO, 1980).

Dendrometric measurements are done to estimate woody vegetation cover, tree total height and their diameter at breast height (DBH) with a limit of 5 cm. Trees with a DBH of less than 5 cm are counted in the regeneration. Furthermore, the health status of trees were assessed (using a scale including drying, cutting, leaf parasitic attacks and fires) as well as the height and diameter of cutting, strains and releases of stumps.

Table II : Characteristics of Maria Stella Yazura School Complex landscape unities

Plots	Landscape	Topography	Soil type	Main species			Anthropogenic **pressures**
				Trees	Shrub	Herbaceous	
1	Fallows	Plateau	Sandy clay	*Parkia biglobosa* *Vitellaria paradoxa*	*Combretum nigricans* *Detarium microcarpum*	*Microchloa indica* *Cyperus sp.*	Fire, tracks
2	Fallows	Plateau	Sandy clay		*Detarium microcarpum* *Terminalia avicennioides*		Fire, tracks
3	Fallows	Plateau	Sandy clay	*Mangifera indica* *Vitellaria paradoxa*	*Piliostigma thonningii*	*Hyptis suaveolens*	Tracks
4	Fallows	Plateau	Sandy clay	*Vitellaria paradoxa*	*Piliostigma thonningii*		Tracks
5	Cropland	Plateau	Sandy clay	*Parkia biglobosa* *Vitellaria paradoxa*	*Daniellia oliveri* *Piliostigma thonningii*	*Hyptis suaveolens* *Pennisetum pedicellatum*	Tracks
6	Fallows	Plateau	Sandy clay	*Parkia biglobosa* *Vitellaria paradoxa*	*Pteleopsis suberosa* *Piliostigma thonningii*	*Hyptis suaveolens* *Andropogon gayanus* *Lippia chevalieri*	Fire, tracks, pasture
7	Cropland	Plateau	Sandy clay	*Vitellaria paradoxa*	*Piliostigma thonningii*	*Pennisetum pedicellatum*	Tracks, pasture
8	Cropland	Plateau	Sandy clay	*Parkia biglobosa* *Vitellaria paradoxa*	*Piliostigma thonningii* *Combretum spp.*	*Senna obtusifolia* *Hyptis suaveolens* *Ocimum americanum*	Tracks, pasture
9	Cropland	Plateau	Sandy clay	*Vitellaria paradoxa*	*Piliostigma thonningii*	*Hyptis suaveolens* *Pennisetum pedicellatum* *Senna obtusifolia*	Tracks, pasture
10	Fallows	Plateau	Sandy clay	*Parkia biglobosa* *Vitellaria paradoxa* *Afzelia africana*	*Terminalia avicennioides* *Daniellia oliveri*	*Hyptis suaveolens* *Pennisetum pedicellatum*	Tracks, pasture

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

11	Fallows	Axis of drainage	Loamy clay	*Parkia biglobosa Vitellaria paradoxa Afzelia africana*	*Piliostigma thonningii Daniellia oliveri*		Tracks, pasture
12	Fallows	Axis of drainage	Loamy clay	*Vitellaria paradoxa*	*Piliostigma thonningii Combretum molle*	*Microchloa indica Hyptis suaveolens*	Tracks, pasture
13	Fallows	Axis of drainage	Loamy clay	*Vitellaria paradoxa Diospyros mespiliformis*	*Piliostigma thonningii*		Tracks, pasture
14	Shallow	Axis of drainage	Loamy clay	*Khaya senegalensis Afzelia africana*	*Piliostigma thonningii Combretum glutinosum*	*Hyptis suaveolens*	Pasture
15	Fallows	Axis of drainage	Sandy clay	*Parkia biglobosa Lannea microcarpa*	*Piliostigma thonningii Combretum*		Tracks, pasture
16	Shallow	Axis of drainage	Loamy clay	*Mitragyna inermis Parkia biglobosa Afzelia africana*	*Diospyros mespiliformis*	*Oriza sativa Echinochloa stagnina Hyparrhenia rufa*	Tracks, pasture
17	Fallows	Plateau	Sandy clay	*Vitellaria paradoxa Parkia biglobosa Afzelia africana*	*Piliostigma thonningii Terminalia avicennioides*	*Hyptis suaveolens Pennisetum pedicellatum*	Tracks, pasture
18	School area	Plateau	Sandy clay	*Azadirachta indica Vitellaria paradoxa*		*Crotalaria retusa*	Tracks, pasture

19	Bare ground	Bare ground	Sandy clay			*Hyptis suaveolens* *Crotalaria retusa*	Tracks, pasture
20	Bare ground	Bare ground	Sandy clay	*Afzelia africana* *Daniellia oliveri*	*Piliostigma thonningii*	*Pennisetum pedicellatum*	
21	School area	Bare ground	Sandy clay	*Vitellaria paradoxa* *Parkia biglobosa*	*Cassia siamea*		Tracks, pasture
22	Fallows	Plateau	Sandy clay	*Vitellaria paradoxa* *Parkia biglobosa*	*Piliostigma thonningii* *Terminalia avicenniodes*	*Pennisetum pedicellatum* *Microchloa indica*	Tracks, pasture
23	Fallows	Plateau	Sandy clay	*Vitellaria paradoxa* *Burkea africana*	*Gardenia erubescens* *Daniellia oliveri* *Terminalia avicennioides*	*Pennisetum pedicellatum* *Microchloa indica* *Lippia chevalieri*	Fire, tracks, pasture

Data analysis

Data collected were processed using Excel, and R statistical software. The first software was used for diversity indices calculation, the second one for statistical analysis where the Fisher test was used to verify hypotheses on the difference of variables.

All species registered in this study were categorized into their respective families and genera. Alpha diversity indices were computed for bulk species (both adult and juveniles).

To examine the effect of land use on specific richness, we considered family richness, genera richness, and species richness as the number of families or genera or species occurring in a given land use type.

Each vegetation type was characterized by alpha diversity indices: species richness (S), Shannon-Weaver diversity index (H) and Pielou evenness index (E) (Brower and Zar, 1984). The Pielou's evenness measures the similarity of the abundance of the different woody species sampled. Its value varies between 0 and 1. The value tends to 0 when one or few species had higher abundance than others and 1 in the situation where all species had equal abundance (Magurran, 2004).

The species richness S is the total number of species recorded in a given vegetation type. Shannon diversity index (H) was expressed as:

(i) $N_0 = S$, where S is the number of species in a plot;

(ii) $N_1 = e^H$, where $H = -\text{Sum } (P_i * \ln(P_i))$ is Shannon's index;

(iii) $N_2 = 1/D$, where $D = \text{Sum } (P_i^2)$ is Simpson's index, with Pi relative abundance of species in a plot.

N_0 is the effective number of species in the sample regardless of their abundance. N_1 measure the number of abundant species in the sample. N_2 is the number of very abundant species.

Evenness (E) = $H/ \ln (S)$. It is an expression of the balance in the distribution of individuals among the species. Its value approaches 0 when one species is highly dominant and 1 when all species have similar densities. E is independent from species numbers occurring on a plot.

The importance value of each species or family was calculated per vegetation type. The importance value index was considered as the sum of Relative Frequency and Relative Dominance according to the following parameters:

(i) Frequency = number of plots in which the species or family occurs /total plot number × 100.

(ii) Relative Frequency (Rel Div) = frequency of a species or family / sum of all frequencies × 100.

(iii) Relative Dominance (Rel Dom) = total cover of a species or family / total cover of all × 100.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

(iv) Relative Density (Rel dens) = density of a species or family / total densities of all × 100
(v) Importance value = Relative Frequency + Relative Dominance + Relative Density
To estimate the effect of the explanatory variables climate and land use on specific richness, species richness, genera richness, and family richness (response variables) we used Generalized Linear Models with Poisson errors.

4. Results

Floristic composition

The woody flora of the forest park of the peri-urban park of Leo comprises a total of 26 families, 63 genera and 81 species (Table III). The flora includes 8.5% of exotic species and 92.5% of native plants. The life form of plants includes 2.5% lianas, 32.1% shrubs and 65.4% trees.
The most abundant species of units of the Park are *Terminalia avicennioides* (Combretaceae), *Piliostigma thonningii* (Fabaceae-Caesalpinioideae), *Daniellia oliveri* (Fabaceae-Caesalpinioideae), *Vitellaria paradoxa* (Sapotaceae), *Detarium microcarpum* (Fabaceae-Caesalpinioideae), *Diospyros mespiliformis* (Ebenaceae), *Annona senegalensis* (Annonaceae) and *Pteleopsis suberosa* (Combretaceae).
The fallows is the unit that contains all families and genera and 93% of species. The other units are relatively poorly represented in diversity with a specific diversity ranging from 6 to 31% of species (Table II).

Table III. Summary of species composition and diversity measures for trees ≥ 5 cm dbh in five vegetation patches

Diversity index / land use type	Shallows	Cropland	School area	Fallows	Barred soil
Species richness	28	32	6	81	6
Genera richness	19	27	5	57	6
Families	13	14	4	22	4
Margalef	5,063	6,329	1,517	10,436	1,729
Shannon–Weaver	3,280	4,040	2,114	4,694	1,974
Simpson	4,968	8,469	3,521	16,227	3,115
Evenness	0,7987	0,881	0,716	0,938	0,679

The families with the largest number of woody species are Combretaceae (14 species), Fabaceae-Caesalpinioideae (8 species), Fabaceae-Mimosoideae (7 species), Anacardiaceae (6 species), Rubiaceae (6 species), Fabaceae-Faboideae (5 species), Euphorbiaceae (4 species), and Verbenaceae (4 species). The least species-rich families represented by a single species are the Annonaceae, Bignoniaceae, Bombacaceae, Celastraceae, Chrysobalanaceae,

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Ebenaceae, Loganiaceae, Olacaceae, Polygalaceae, Sapotaceae, Simaroubaceae, Sterculiaceae, Tiliaceae (Table IV).

Phytogeography type	Family	Species	Life form	Origin
PA	Fabaceae-Mimosoideae	*Acacia polyacantha* Willd.	Tree	Native
AT	Fabaceae-Caesalpinioideae	*Acacia sieberiana* DC.	Tree	Native
SZ	Fabaceae-Caesalpinioideae	*Afzelia africana* Sm. ex Pers.	Tree	Native
S	Fabaceae-Caesalpinioideae	*Albizia chevaleri* Harms	Tree	Native
NT	Anacardiaceae	*Anacardium occidentale* L.	Tree	Exotic
S	Annonaceae	*Annona senegalensis* Pers.	Shrub	Native
SZ	Combretaceae	*Anogeissus leiocarpa* (DC.) Guill. &Perr.	Tree	Native
IM	Meliaceae	*Azadirachta indica* A. Juss.	Tree	Exotic
S	Malvaceae	*Bombax costatum* Pellegr. &Vuillet.	Tree	Native
SZ	Euphorbiaceae	*Bridelia ferruginea* Benth.	Shrub	Native
AM	Euphorbiaceae	*Bridelia micrantha* Hoxchst.	Shrub	Native
AT	Fabaceae-Caesalpinioideae	*Burkea africana* Hook.f.	Tree	Native
IM	Fabaceae-Caesalpinioideae	*Senna siamea* (Lam.) Irwin &Barneby	Tree	Exotic
AT	Fabaceae-Caesalpinioideae	*Cassia sieberiana* DC.	Tree	Native
S	Vitaceae	*Cissus populnea* Guill. &Perr.	Shrub	Native
SZ	Cochlospermaceae	*Cochlospermum planchonii* Hook.f.	Shrub	Native
SZ	Combretaceae	*Combretum aculeatum* Vent.	Shrub	Native
S	Combretaceae	*Combretum adenogonium* Steud. exA.Rich.	Shrub	Native
S	Combretaceae	*Combretum collinum* Fresen.	Shrub	Native
S	Combretaceae	*Combretum fragrans* F. Hoffm.	Shrub	Native
SZ	Combretaceae	*Combretum glutinosum* Perr. ex. DC.	Tree	Native
SZ	Combretaceae	*Combretum micranthum* G. Don.	Shrub	Native
AT	Combretaceae	*Combretum molle* R. Br. ex G. Don	Shrub	Native
S	Combretaceae	*Combretum nigricans* Lepr. ex Guill. &Perr.	Tree	Native
PA	Combretaceae	*Combretum paniculatum* Vent	Shrub	Native
AT	Rubiaceae	*Crossopteryx febrefuga* (Afzel. ex G. Don) Benth.	Tree	Native

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

SZ	Fabaceae-Caesalpinioideae	*Daniellia oliveri* (Rolfe) Hutch. &Dalz.	Tree	Native
A	Fabaceae-Caesalpinioideae	*Delonix regia* (Bojer ex Hook.) Raf.	Tree	Exotic
S	Fabaceae-Caesalpinioideae	*Detarium microcarpum* Guill&Perr.	Tree	Native
AT	Fabaceae-Mimosoideae	*Dichrostachys cinerea* (L.) Wight & Am.	Shrub	Native
SZ	Ebenaceae	*Diospyros mespiliformis* Hochst. ex A. DC.	Tree	Native
SZ	Fabaceae-Mimosoideae	*Entada africana* Guill. &Perr.	Small Tree	Native
SG	Fabaceae-Faboideae	*Erythrina senegalensis* DC.	Tree	Native
S	Euphorbiaceae	*Exoecaria grahamii* (Stapf)	Shrub	Native
SZ	Rubiaceae	*Feretia apodanthera* Del.	Shrub	Native
SG	Moraceae	*Ficus sur* Forssk.	Tree	Native
AT	Moraceae	*Ficus sycomorus* (Miq.) C. C. Berg	Tree	Native
Pal	Phyllanthaceae	*Flueggea virosa* (Roxb. ex Willd.) Voigt.	Shrub	Native
S	Rubiaceae	*Gardenia erubescens* Stapf et Hutch.	Shrub	Native
Pal	Rubiaceae	*Gardenia ternifolia* Schumach. &Thonn.	Shrub	Native
IM	Verbenaceae	*Gmelina arborea*Roxb. ex Sm.	Tree	Native
S	Malvaceae	*Grewia cissoides* Hutch. &Dalz.	Shrub	Native
AT	Simaroubaceae	*Hannoa undulata* (Guill. &Perr.) Planch.	Tree	Native
AT	Apocynaceae	*Holarrhena floribunda* (G. Don) Dur. &Schinz	Shrub	Native
SZ	Phyllanthaceae	*Hymenocardia acida* Tul.	Tree	Native
S	Meliaceae	*Khaya senegalensis* (Desr.) A. Juss.	Tree	Native
S	Anacardiaceae	*Lannea acida* A. Rich.	Tree	Native
S	Anacardiaceae	*Lannea barteri* (Oliv. Engl.	Tree	Native
SZ	Anacardiaceae	*Lannea microcarpa* Engl. & K. Krause	Tree	Native
AT	Anacardiaceae	*Lannea velutina* A. Rich.	Shrub	Native
IM	Anacardiaceae	*Mangifera indica* L.	Tree	Exotic
SZ	Celastraceae	*Maytenus senegalensis* (Lam.) Exell.	Shrub	Native
SZ	Rubiaceae	*Mitragyna inermis* (Willd.) Kuntze	Tree	Native
S	Anacardiaceae	*Ozoroa insignis* Del.	Shrub	Native
SZ	Chrysobalanaceae	*Parinari curatellifolia* Planch. exBenth.	Tree	Native

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Pal	Fabaceae-Mimosoideae	*Parkia biglobosa* (Jacq.) R. Br. ex. G. Don	Tree	Native
S	Fabaceae-Faboideae	*Pericopsis laxiflora* (Benth.) van Meeuwen	Tree	Native
SZ	Fabaceae-Caesalpinioideae	*Piliostigma reticulatum* (DC.) Hochst.	Small tree	Native
AT	Fabaceae-Caesalpinioideae	*Piliostigma thonningii* (Schumach.) Milne-Redh.	Small tree	Native
SZ	Fabaceae-Mimosoideae	*Prosopis africana* (Guill. &Perr.) Taub.	Tree	Native
S	Meliaceae	*Pseudocedrela kotschyi* (Schw.) Harms	Tree	Native
SZ	Combretaceae	*Pteleopsis suberosa* Engl. &Diels	Shrub	Native
SZ	Fabaceae-Faboideae	*Pterocarpus erinaceus* Poir.	Tree	Native
SZ	Apocynaceae	*Saba senegalensis* (A. DC.) Pichon	Liana	Native
SZ	Rubiaceae	*Sarcocephalus latifolius* (Sm.) E.A.Bruce	Shrub	Native
S	Anacardiaceae	*Sclerocarya birrea (A.Rich.) Hochst.*	Tree	Native
AT	Polygalaceae	*Securidacalonge pedunculata* Fres.	Tree	Native
SZ	Malvaceae	*Sterculia setigera* Del.	Tree	Native
SG	Bignoniaceae	*Sterospermum kunthianum* Cham.	Tree	Native
GC	Apocynaceae	*Strophanthus sarmentosus* DC.	Liana	Native
Pal	Loganiaceae	*Strychnos spinosa*Lam.	Small tree	Native
AM	Fabaceae-Caesalpinioideae	*Swartzia madagascariensis Desv.*	Tree	Native
IM	Verbenaceae	*Tectona grandis L. f.*	Tree	Exotic
PA	Combretaceae	*Terminalia avicennioides* Guill. &Perr.	Small tree	Native
SZ	Combretaceae	*Terminalia laxiflora* Engl.	Tree	Native
SZ	Combretaceae	*Terminalia macroptera* Guill. &Perr.	Tree	Native
SZ	Meliaceae	*Trichilia emetica* Vahl.	Tree	Native
S	Sapotaceae	*Vitellaria paradoxa* Gaertn. f.	Tree	Native
AT	Lamiaceae	*Vitex doniana* Sweet	Tree	Native
AT	Ximeniaceae	*Ximenia americana* L.	Shrub	Native
Pal	Rhamnaceae	*Ziziphus mauritiana* Lam.	Small tree	Native

Phytogeography types (Raunkier, 1934): AM: Afro-Malagasy species, AT: Afro-tropical, GC: Guinea-Congolese, IM: Indo Malean, N: Neotropical, PA: African pluri-regional, Pal: Paleotropical, Pan: Pantropical, Sudan, SG: Sudan-Guinean, SZ: Sudan-Zambezian

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The five most important families in each vegetation patch according to decreasing order of family importance value are in Table V. The first most Family in all vegetation is the Fabaceae.

Table V: The five most important families in each vegetation patch according to decreasing order of family importance value (FIV).

Shallows	RelDiv (%)	Rel dens (%)	Rel Dom (%)	FIV (%)
Fabaceae	14,81	42,51	34,36	91,69
Combretaceae	25,93	31,88	23,18	80,99
Anacardiaceae	14,81	5,80	19,02	39,64
Rubiaceae	7,41	2,42	10,53	20,35
Annonaceae	3,70	4,35	3,06	11,11
Others (8)	33,33	13,04	9,85	56,23
Total	100,00	100,00	100,00	300,00
Cropland				
Fabaceae	32,35	51,49	47,39	131,23
Sapotaceae	2,94	10,45	43,60	56,98
Combretaceae	23,53	14,18	4,31	42,02
Rubiaceae	8,82	2,99	1,55	13,36
Annonaceae	2,94	4,48	1,09	8,51
Others (9)	29,41	16,42	2,07	47,90
Total	100,00	100,00	100,00	300,00
School area				
Fabaceae	40,00	48,15	29,0	117,11
Sapotaceae	20,00	22,22	22,2	64,44
Meliaceae	20,00	18,52	24,7	63,20
Verbenaceae	20,00	11,11	24,1	55,25
Total	100,00	100,00	100,00	300,00
Fallows				
Fabaceae	27,71	29,54	30,65	87,89
Combretaceae	20,48	29,72	24,83	75,04
Anacardiaceae	9,64	4,27	9,12	23,02
Sapotaceae	1,20	7,64	12,40	21,24
Rubiaceae	6,02	6,66	5,16	17,84
Others (17)	34,94	22,18	17,85	74,97
Total	100,00	100,00	100,00	300,00
Barred soil				
Fabaceae	50,00	44,44	35,74	130,19

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Simaroubaceae	16,67	44,44	57,11	118,22
Ebenaceae	16,67	5,56	3,70	25,92
Combretaceae	16,67	5,56	3,45	25,67
Total	100,00	100,00	100,00	300,00

The five most abundant species in each vegetation patch according to decreasing order of the importance value index are in Table V. The two most important species are in Shallows (*Piliostigma thonningii* and *Combretum glutinosum*) in Cropland (*Vitellaria paradoxa* and *Piliostigma thonningii*), in School area (*Azadirachta indica* and *Cassia siamea*) introduced species and in Fallows (*Terminalia avicennioides* and *Daniellia oliveri*) and in Barred soil (*Hannoa undulata* and *Daniellia oliveri*. Table VI illustrates all the woody species recorded in the peri-urban park in Leo.

Table VI: The five most abundant species in each vegetation patch according to decreasing order of the importance value index (IVI).

Shallows	Relfreq (%)	Rel dens (%)	Rel Dom (%)	IVI (%)
Piliostigma thonningii	40,10	32,30	3,03	75,43
Combretum glutinosum	15,46	11,56	3,03	30,05
Combretum molle	9,18	6,07	6,06	21,31
Lannea microcarpa	3,38	13,19	3,03	19,60
Mitragyna inermis	1,93	10,21	3,03	15,17
Others (23)	29,95	26,67	81,82	138,44
Total	100,00	100,00	100,00	300,00
Cropland				
Vitellaria paradoxa	10,45	43,60	4,55	58,59
Piliostigma thonningii	29,85	14,42	7,58	51,84
Parkia biglobosa	4,48	26,42	1,52	32,41
Daniellia oliveri	6,72	3,91	1,52	12,14
Diospyros mespiliformis	3,73	0,00	6,06	9,79
Others (27)	44,78	11,66	78,79	135,22
Total	100,00	100,00	100,00	300,00
School area				
Azadirachta indica	18,52	24,68	42,86	86,06
Cassia siamea	44,44	28,14	14,29	86,87
Delonix regia	3,70	0,82	14,29	18,81
Gmelina arborea	11,11	24,13	14,29	49,53
Vitellaria paradoxa	22,22	22,22	14,29	58,73
Total	100,00	100,00	100,00	300,00
Fallows				

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Terminalia avicennioides	14,16	12,46	0,56	27,18
Daniellia oliveri	8,16	8,13	5,03	21,31
Vitellaria paradoxa	7,69	12,40	0,56	20,65
Detarium microcarpum	7,88	7,40	3,35	18,63
Piliostigma thonningii	7,74	6,59	3,63	17,96
Others (76)	54,38	53,02	86,87	194,27
Total	100,00	100,00	100,00	300,00
Barred soil				
Hannoa undulata	44,44	57,11	12,50	114,05
Daniellia oliveri	33,33	32,05	12,50	77,88
Combretum collinum	5,56	3,45	25,00	34,01
Detarium microcarpum	5,56	0,00	25,00	30,56
Diospyros mespiliformis	5,56	3,70	12,50	21,75
Parkia biglobosa	5,56	3,70	12,50	21,75
Total	100,00	100,00	100,00	300,00

Vegetation structural characteristics

The density of adult woody vegetation is higher in the fallows with 2 161 stem/ha. The Fallows occupied by rice cultivation has an average wood density of 970 stem/ha and the field 202 stem/ha. Schools and bare soil have low densities of 135 and 75 stem/ha respectively (Figure 2).

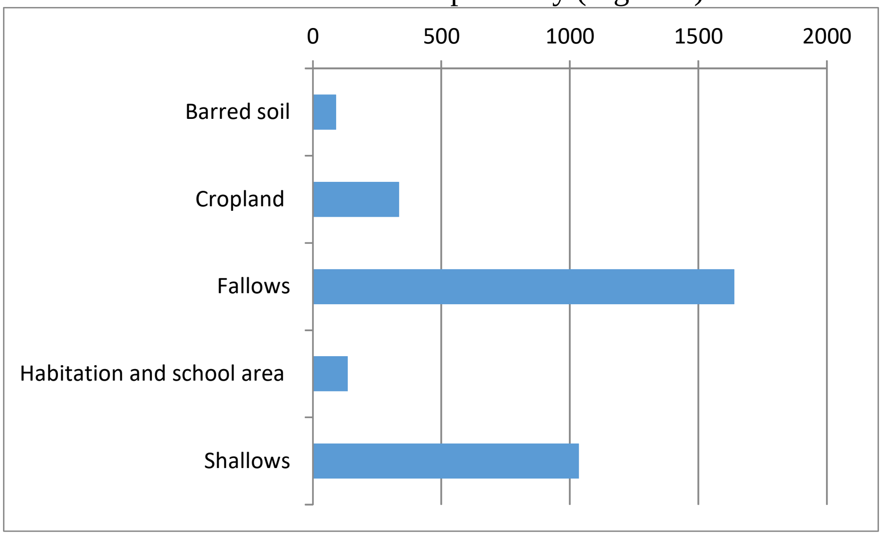

Figure 2 : Woody stems density for each vegetation patch in the peri-urban forest park of Léo

Woody plants' basal area differs significantly in the different vegetation units with the highest values in the fallows and shallows (Figure 3). Woody

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

vegetation cover rate following the different vegetation units shows that school areas represent the highest rate followed respectively by the shrub savannah and the croplands. Logically, barred soil has the lowest soil cover rate of 1% of the area (Figure 4). .

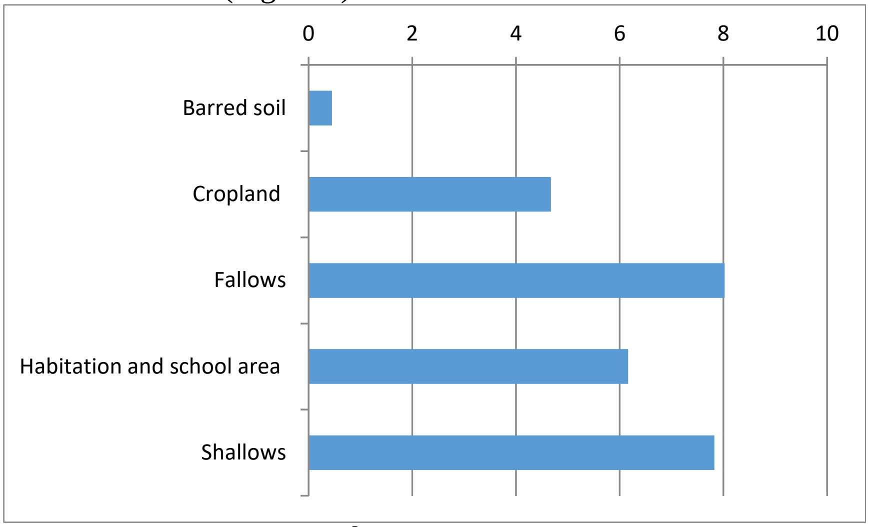

Figure 3: Basal area of woody tree (m^2/ha) for each vegetation patch in the peri-urban forest park of Léo

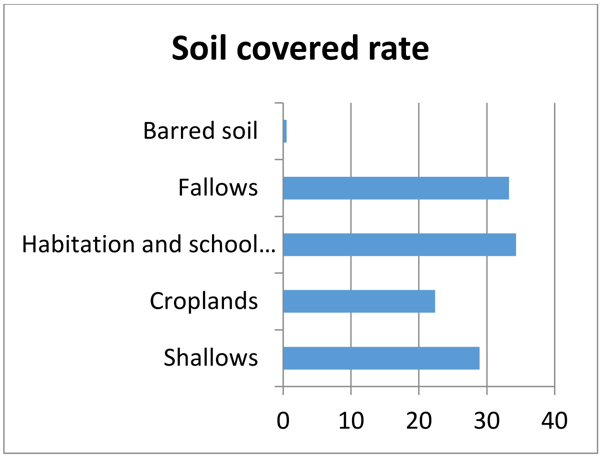

Figure 4: Woody vegetation cover rate for each vegetation patch in peri-urban park of Léo

Trees population dynamics

The health status of the woody species of the peri-urban park is mainly characterized by threats such as Loranthaceae parasitism, withering and leaf spot due to microscopic mushroom (Figure 5). Then, 96.9% of stands present leaf spot disease on shea tree (Akrofi and Amoah, 2009).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

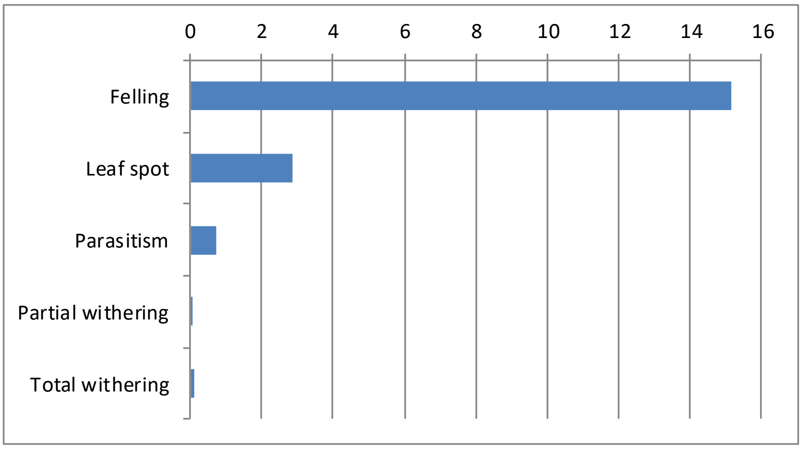

Figure 5: Health status expressed as a percentage of affected woody tree for each vegetation patch of the peri-urban park of Léo

The percentage of woody affected by cuttings in the peri-urban park of Leo is 15.2%. The distribution of these woody cuts is 13.1% in fallow land, 0.6% in bare soils, 1.3% in the shallows.

The most affected species by the felling or cuttings are *Terminalia avicennioides* 18.5%, *Detarium microcarpum* 14.6%, *Combretum colinum* 8.8%, *Piliostigma reticulatum* 8.5%, etc..

The species that regenerate the most and will ensure the sustainability of the forest potential in the forest park of the School Complex are *Gardenia erubescens*, *Piliostigma thonningii*, *Vitellaria paradoxa*, *Annona senegalensis*, *Terminalia avicennioides*, *Diospyros mespilifomis* and *Azadirachta indica* (Table VII). All these species are spontaneous except *Azadirachta indica* (nim) which was exotic and becomes sub spontaneous in the Sahelain countries. The regeneration of nim is observed in half of the small squares and is located in the fallows with seven small squares, shallows and croplands with two small squares in each field unit (figure 6).

Table VII: Structure of the main wood regenerations of the peri-urban forest park

Species	Stem number	Plots number	Stem density per plots
Afzelia africana	50	6	83,3
Annona senegalensis	138	16	86,2
Azadirachta indica	83	11	75,4
Daniellia oliveri	58	12	48,3
Detarium microcarpum	58	10	58
Diospyros mespiliformis	93	16	58,1
Gardenia erubescens	218	13	167,6
Piliostigma thonningii	166	15	110,6

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Pteleopsis suberosa	58	4	145
Sapium grahamii	62	12	51,6
Terminalia avicennioides	100	12	83,3
Vitellaria paradoxa	161	14	115

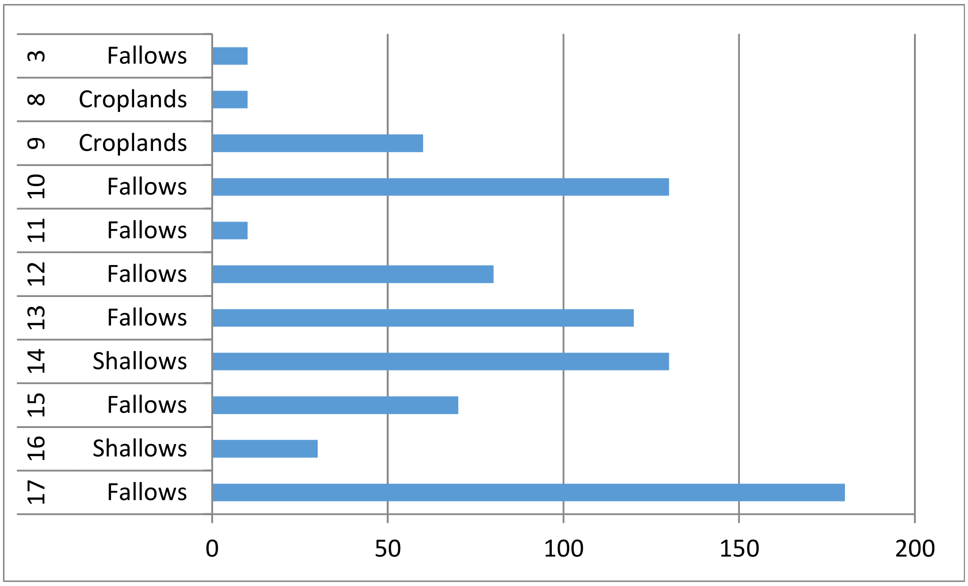

Figure 6: Regeneration rate (stem per ha) of *Azadirachta indica* by small square and field unit in the peri-urban park

5. Discussion

Floristic composition

The floristic composition of the peri-urban park of Léo corresponds to the vegetation generally described from the Sudan zone of West Africa (Devineau et al, 1991, Fournier, 1991). The most important families in terms of the number of individuals are Fabaceae, Combretaceae and Anacardiaceae. The dominance of Fabaceae is also mentioned in a study on a savanna of Korhogo (a town located in the North regions of Ivory Coast) by several authors (Koulibaly et al., 2006; Assese et al., 2009 and Amani et al., 2019).

The floristic composition of the peri-urban park comprises a total of 26 families, 63 genera and 81 species. The difference in species composition among patches might be due to micro-site factors. Generally, the growth of trees in semi-arid savanna ecosystems is determined by moisture, soil characteristics, landscape position (Scholes and Walker, 1993) and species specific growth requirements. The numbers of taxa found in Léo are lower than those obtained by Amani et al. (2019) with 287 species and Aké-Assi (2015) with 124 species in the Sudanese domain of Côte d'Ivoire at several sites and to 109 species of woody vegetation in the national park of

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Arly in Burkina Faso (Ouédraogo *et al.*, 2008). However, it's is higher than those obtained in a tropical savanna in the Sinsabligbini Forest Reserve in northern Ghana where 62 species in 19 families woody (Asase et al, 2009) and 68 woody species were recorded in Kenikeni Forest Reserve of Northern Ghana (Tom-Dery et al, 2013).

The most abundant woody plants are *Piliostigma thonningii*, *Combretum glutinosum*, *Combretum molle*, *Lannea microcarpa*, *Mitragyna inermis* are different of those found by Assese et al (,) in the tropical savanna in northern Ghana reserve where species such as *Dichrostachys cinerea* (L.) Wight & Arn. Fabaceae), *Pteleopsis suberosa* Engl. & Diels (Combretaceae), *Combretum collinum* Fresen. (Combretaceae), *Dalbergia afzeliana* G. Don. (Fabaceae), *Terminalia mollis* S.Vidal. (Combretaceae), and *Vitellaria paradoxa* C.F. Gaertn. (Sapotaceae) were found. The most abundant woody species in Kenikeni Forest Reserve of Northern Ghana were *Vitellaria paradoxa* (7.7%), *Detarium microcarpum* (6.7%), *Isoberlinia doka* (6.5%), *Afzelia africana* (6.5%), *Pterocarpus erinaceus* (5.7%) and *Burkea africana* (5.7%) (Tom-Dery et al, 2013), but some of these species are present in the peri-urban park in lower proportion.

In order to meet the challenges of the fight against climate change and urban heat waves, many cities are implementing tree planting programs to increase urban forests. Biological indicators related to diversity, density, endemism, horizontal and vertical structure of the formation make it possible to characterize plant formations. Barron *et al*. (2016) argue that the diversity of urban trees and the native origin of plants are important factors in an adapted urban forestry program. The fallows are the richest ecosystem on which protection actions must focus.

Fifty three (53) species were identified to be trees, 27 shrubs, 2 lianas representing 65.4, 32.1 and 2.5 respectively. Compared to those of Kenikeni Forest Reserve of Northern Ghana, the proportions are 79.4, 17.6 and 2.9% respectively according to Tom-Dery*et al.* (2013).

Population dynamics

The forest park of the school complex is relatively rich in terms of floristic diversity. However, it is subject to threats or factors that contribute to the degradation of its forest resources. Some observations showed daily holdings by cutting green wood and taking dead wood by women and men into the forest massif. These practices are favored by (i) the many tracks crisscross the forest massif and therefore limit the possibility of control and surveillance of the removal and exploitation of wood and associated resources and the introduction of vegetation fire; (ii) the lack of a structure or staff for the appropriate supervision of the forest massif, (iii) the farmers which does

not afraid by the religious sisters; (iv) the nature of local land tenure and related local mentalities.
The distribution of species seems to be determined by human activity rather than by the natural environment factors. In this context, useful species that are protected such as *Vitellaria paradoxa, Parkia biglobosa* are left in disturbed savannas, like in Korogho Sudan savanna (Koulibaly*et al.*, 2006).

Anthropogenic pressure on forest resources in the park could be explained by the nature of land tenure in the customary regime. Land tenure in the area is characterized by the absence of an individual private domain. Although there are individual farms, these do not confer on the land any status other than that of customary regime. This is how the fallow after some time becomes again collective property of the village. Forest commonly called "bush" is considered to be a community property, and therefore its woods can be exploited by anybody from all villagers. With the exception of sacred woods in which no human presence is permitted without prior special authorization, the exploitation of dead wood in the forest is not restricted. The inhabitants of the neighboring villages of the park can also make use of the forest (cutting of green wood, installation of fields of cultivation, grazing and transhumance etc. ...) provided that a verbal request is addressed to the owner village. The principles of agrarian land management are simple and known to all because they are present in most aspects of rural life (Diarra, 1999).

All the species that regenerate the most are spontaneous except *Azadirachta indica* (called nim) which was exotic at the origin and become sub spontaneous later. It is an insidious intrusion, manifested by a strong regeneration of nim seedlings in the natural formation, especially the park fallows. The development of nim invasion will create in the coming decades competition with indigenous species and reduces the plant diversity and consequently animal biological diversity of the natural formation. This was observed in the BognounouOuétian botanical park of the National Centre for Scientific and Technological Research in Ouagadougou, where actions of uprooting of nim carried out in 2017 did not eradicate the phenomenon. Indeed, the spread of germinating seeds continues with granivorous birds (Parrotta*et al.*, 1994, Ganaba 2000, Ganaba *et al.*, 2009; Guinko, 2013).
A previous work has shown that the growth of neem seedlings is 0.7 to 1cm in diameter at the base per year in India (Sahni, 1939). If the conditions of the site are favorable as is the case in the area of the Yazura School Complex, the growth is rapid after the first year. Thus, in 8 years, neem plantations in Cuba on fertile and clayey soils measured between 2.4 and 3.4 m cm in diameter at the base and 1.8 to 1.9 m high in Cuba (Betancourt, 1972) and Haîti (Lewis *et al.*, 1983). In West Africa, on some sites receiving an annual rainfall average of 800mm, the average height 4 years after planting was 3 to 5m with a biomass of 10 to 12m^3 (Anon, 1988). Yields of 2m^3 of wood from a 4-year-

old plantation with spacing of 4 m x 4 m near Ouagadougou (Burkina Faso) were reported by Sieder (1983). This means that it is a relatively fast-growing species that will produce fruits that will be disseminated by birds. The seeds will germinate and increase the number of regenerations and feet in the forest massif. It should be noted that *Azadirachta indica* is locally invasive and tends to replace local species (Hoffmann, 2021).

Green wood cuts concern the following species: *Parkia biglobosa*, *Anogeissus leiocarpa*, *Afzelia africana*, *Combretum spp*., *Pteleopsis suberosa*, *Pterocarpus erinaceus*, *Daniellia oliveri* as energy, craft and aerial fodder woods.

Loranthaceae are parasitic plants that compromise the production and survival of woody and herbaceous plants. These parasitic phanerogams are known as one of the main causes of shea tree mortality in the agroforestry parks in the Sahel (Boussim *et al.*, 1993). Loranthaceae are hemi-parasites, that is, their aerial tissues contain chlorophyll. They grow on the host's aerial organs and complete their life cycle at the expense of woody species. The spread of fruits and seeds is ensured by granivorous birds including the bearded.

Sustainable management of forest resources

Conservation measures are the application of legal and land protection, habitat preservation, measures to control the management of the massif's biological resources, the development and improvement of habitat to create an urban park. The replanting of vegetation in degraded areas and incentives for wood production for local populations are needed.

At the species level, a management program for threatened or rare species, control of invasive alien plants and control of domestic animals must be developed. The management of the strong regeneration of nim seedlings in the park involves a mechanical control by stump removal before their enter in production stage. This could reduce the possibility of dissemination by granivorous birds. This action would be easier in the middle of the rainy season by manual uprooting of seedlings with the root when the soil is well soaked in water.

This would reduce the disturbance of the environment by digging in the dry season. There is also a need to reduce the number of tracks that crisscross the massif and facilitate fraudulent cutting of green wood. Finally, there is a need for conservation of plant resources through the creation of a botanical garden to restore plants in degradation and protect useful and threatened plants. This botanical park on the outskirts of the city will help to retain dust and absorb pollution from the city and create a recreational setting for rest and in situ conservation of biodiversity.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

6. Conclusion and recommendations

This study sought to provide information on the effects of land use, tree diversity and structure in a peri-urban forest in order to formulate strategies that can contribute to the creation of a future Urban forest for biodiversity conservation. The results showed a significant difference in the number of genera and families of species found across the five contrasting vegetation units (i.e. fallows, shallows, cropland, habitation / school area and barred soil). Fallow is the unit that contains all families and genera and 93% of species. It should be noted that the most threats on vegetation and flora of the School Complex are fraudulent human exploitation, parasitic pressure and progressive intrusion of *Azadirachta indica*.

The threats relate to the exploitation and removal of wood, the many tracks that crisscross the massif, hunting and animal harvesting, intrusions and anthropogenic disturbances.

These results highlight the importance of active measures such as application of legal and land protection, habitat preservation, measures to control the management of the massif's biological resources, the development and improvement of habitat to create an urban park, the replanting of vegetation in degraded areas, incentives for local populations.

The flagship measures for the sustainable management of forest resources are: at the landscape level, create an urban botanical park to protect forest resources in the shrub savannah area by limiting indoor movement favoring abusive logging and at the species level develop a management program for threatened or rare species, control of invasive alien plants and control of domestic animals.

Conflict of interest. The authors declare that there is no conflict of interest for this article.

Contributions of authors. SG collected, processed and analyzed the data and then wrote and corrected the article. SK contributed to the data collection and the writing and correction of the article. FK analyzed the data and contributed to the writing and correction of this article. MD contributed to data collection and entry.

Acknowledgements

This work was funding by the “Foundation Jean Paul II pour la Sahel" coming within the framework of the project “Biological Diversity through The Promotion of Environmental Education at The Maria Stella Yazura School Complex in Leo” [Contract 2018/GF/102-38/AO/E]. We would like to express our sincere gratitude to Catholic Organization for Development and Solidarity (OCADES) of Koudougou and Maria Stella Yazura School Complex staff. We thank local people fortheir assistance and cooperation.We appreciatethe constructive comments receivedfrom anonymous reviewers.

References:

1. Aké-Assi E., 2015. Plantes à potentialité décorative de la flore du Sud de la Côte d'Ivoire : études taxinomique, ethnobotanique et essai de domestication de *Thunbergiaatacorensis*Akoegninou&Lisowski (Acanthaceae), une espèce nouvellement introduite. Thèse de Doctorat, UFR Biosciences, Université Félix Houphouët-Boigny, Côte d'Ivoire, 207 p.
2. Akrofi A. Y. andAmoah F. M., 2009. Pestalotia spp. causes leaf spot of *Vitellaria paradoxa* in Ghana. African Journal of Agricultural Research, 4 (4): 330-333. http://www.academicjournals.org/AJAR
3. Amani K.D.S.S., Kouassi F.A., Aké-Assi E.A., 2019. Diversité Floristique des Plantes à Potentialité Décorative Issues des Formations Naturelles du Nord de la Côte d'Ivoire. European Scientific Journal, 15 (15). https://doi.org/10.19044/esj.2019.v15n15p46
4. Angelsen A. andKaimowit D., 1999. Rethinking the Causes of Deforestation: Lessons from Economic Models . The World Bank Research Observer, 14(1): 73-98.
5. Anon. 1988.*Azadirachta indica* A. de Jussieu. *Bois et Forêts des Tropiques*, 217: 33-47.
6. Asase A, Ekpe P.K. and Amponsah J.Y., 2009. Floristic composition, abundance, and distribution pattern of woody plants in a tropical savanna in northern Ghana. *Journal of the Botanical Research Institute of Texas*, 3(1).
7. Barron S., Sheppard, S.R.J., Condon P.M., 2016. Urban Forest Indicators for Planning and Designing Future Forests, Forests 2016, 7(9), 208; https://doi.org/10.3390/f7090208
8. Boussim I.J., Sallé G., and Guinko S., 1993. Tapinanthus A parasite of shee trees in Burkina Faso. Phenology, biology and damage.*Bois et Forêts des Tropiques*, 238 : 53-65. http://bft.cirad.fr/cd/BFT_238_53-65.pdf
9. Brower, JE &Zar, JH.,1984. Terrain et laboratoireméthodesoratoires pour l'écologiegénérale .Marron Péditeur.
10. BUNASOL, 1990.Caractérisation des Sols du Centre-Sud de la province de la Sissilietesquissepédologique. Rapport techniqueN° 69.Bunasol, Ouagadougou.
11. CTFT (Centre technique forestier tropical), 1989. Mémento du forestier. « Techniques rurales en Afrique », 3e édition 1989, 1257p.
12. Diarra A., 1999. Étude d'un modèle d'aménagement des forêts naturelles en zone soudano-sahélienne au Burkina Faso. Mémoire M.Sc, Faculté de Foresterie et de Géomatique, Université Laval, 112p.

13. Devineau J.L., Fournier A., Kaloga B., 1997. Les sols et la végétation de la région de Bondoukui (Ouest burkinabé). Présentation générale et cartographie préliminaire par télédétection satellitaire (SPOT). Éditions de l'Orstom, Paris, 131p.
14. F.A.0., 1980. « Conservation des ressources naturelles en zones arides et semi-arides. *Cahier F.A.O. Conservation des sols*, 3, 1980.
15. Fournier A., 1991. Phénologie, croissance et production végétales dans quelques savanes d'Afrique de l'Ouest. Variation selon un gradient climatique. Editions de l'ORSTOM Collections Etudes et Thèses, Paris 1991, 306p. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_2/etudes_theses/36403.pdf
16. Fuwape J.A. et Onyekwelu J.C., 2011. Urban Forest Development in West Africa: Benefits and Challenges. Journal of Biodiversity and Ecological Sciences, 1 (1)1 :77-94. https://www.academia.edu/2317692/Urban_Forest_Development_in_West_Africa_Benefits_and_Challenges._Journal_of_Biodiversity_and_Ecological_Sciences_2011_1_1_77_94?auto=download
17. Ganaba S., 2000. Le neem. Un arbre dangereux ? Echo de la recherche. *Eurêka* n°32, CNRST, ISSN 1019-6927, 50pp : 13-16.
18. Ganaba S., Compaoré P., Ouédraogo S.J., Ouadba J.M., 2009. Contrôle de l'envahissement du neem. Cas du parc botanique du CNRST. Echos de la recherche. *Eurêka*, 11-16.
19. Geist H.J. etLambin E.F. 2001. What Drives Tropical Deforestation? A Meta-Analysis of Proximate and Underlying Causes of Deforestation Based on Subnational Case Study Evidence. Louvain-la-Neuve (Belgium). LUCC International Project Office. LUCC Report Series no.4.
20. Guinko S., 2013. Le neem. Arbre aux usages multiples pour le développement durable en milieu rural au Burkina Faso. Presses Universitaires de Ouagadougou , 88p. ISBN 979-10-90524-03-3.
21. Hoffmann J., 2021. Utilisation du Neem (*Azadirachta indica*) en agriculture. Lettre d'information de Tela Botanica du 18 février 2021
22. INSD (Institut national de la statistique et de la démographie), 2008. Recensement général de la population et de l'habitation (RGPH) de 2006 du Burkina Faso – Résultats Définitifs, MEF, INSD, 52p. http://www.cns.bf/IMG/pdf/RGPH_2006.pdf
23. INSD, 2009. La population du Burkina Faso de 1997 à 2006 par Région et Province. Projet ARC-SSN
24. INSD, 2020. Cinquième Recensement Général de la Population et de l'Habitation du Burkina Faso. Résultats Préliminaires, MEFD, INSD, 57p. http://www.insd.bf/n/contenu/enquetes_recensements/rgph-bf/RAPPORT%20PRELIMINAIRE%20RGPH%202019.pdf

25. Koulibaly A., Goetze, D., Traoré D. &Porembski S.(2006). Savanes protégées contre savanes exploitées: caractéristiques de la végétation soudanienne en Côte d'Ivoire. *Candollea* 61: 425-452.
26. Kleemann J., Inkoom J.N., Thiel M., Shankard S., Lautenbach S., & Fürst C., , 2017. Peri-urban land use pattern and its relation to land use planning in Ghana, West Africa. *Landscape and Urban Planning*, 165: 280–294. https://doi.org/10.1016/j.landurbplan.2017.02.004
27. Lewis, Walter H.; Elvin-Lewis, Memory P.F. 1983. Neem (*Azadirachta indica*) cultivated in Haiti. Economic Botany. 37(1): 69-70.
28. Magurran A (Ed.) (2004) Measurement biological diversity, Blackwell Science Ltd.
29. Napon A., 1994. Encadreurs et paysans au Burkina Faso. Une approche en termes de communication. MESSRS, ORSTOM, Programme de recherche: "politiques et développement agricoles et agro-industriels au Burkina Faso". Document n°7, Juillet 1994, 28p.
30. Nébié K.E., 2015. The dynamics between migration and land use and land cover change (LULCC) in Burkina Faso: a comparative case study. Master degree theses in Sociocultural Anthropology in the Department of Anthropology, University of North Carolina, Chapel Hill
31. Ouédraogo, I., 2010. Land Use Dynamics and Demographic Change in Southern Burkina Faso. PhD Forest Sciences, Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre, 64p. ISSN 1652-6880, ISBN 978-91-576-7476-0. © 2010 IssaOuedraogo, Alnarp, Print: SLU Service/Repro, Alnarp 2010
32. Ouédraogo I, Tigabu M., Savadogo P., Compaoré H., Odén P. C., Ouadba J. M., 2010. Land cover change and its relation with population dynamics in Burkina Faso, West Africa. Land Degradation and Development, 21 (5) : 453-462.https://doi.org/10.1002/ldr.981
33. Ouédraogo O., Thiombiano A., Hahn –Hadjali K. &Guinko S., 2008. Diversité et structure des groupements ligneux du parc national d'Arly (Est du Burkina Faso). Flora and VegetationSudano-Sambesica 11,5-16, Frankfurt, December 2008
34. Parrotta J.A. et Chaturvedi A.N., 1994. *Azadirachta indica* A. Joss.Neem, margosaMeliaceae Mahogany family.SO-ITF·SM·70 February 1994 UHM.https://www.fs.fed.us/global/iitf/pubs/sm_iitf070-8.pdf
35. Raunkier C., 1934. The life forms of plants and statistical plant of geography, Oxford University Press, Londres, Angleterre, 632 p.
36. Sahni, N.D. 1939. Nim germination. *Indian Fores*ter. 65(2): 117-118.

37. Scholes R.J., Walker B.H., 1993. An African savanna: synthesis of the Nylsvley study. Cambridge University Press, Cambridge, UK, 306 p.
38. Sieder, P. 1983. Large-scale afforestation in Upper Volta [Burkina Faso].Forst- und Holzwirt. 38(5): 112, 114, 116-118, 120.
39. Tom-Dery D., Hinneh P. and Asante W.J., 2013. Biodiversity in Kenikeni Forest Reserve of Northern Ghana.*African Journal of Agricultural Research*, 8(46): 5896-5904, DOI: 10.5897/AJAR12.1886. http://www.academicjournals.org/AJAR
40. United Nations, 2011. Urban Population, Development and the Environment 2011.Department of Economic and Social Affairs • Population Division • www.unpopulation.org. Copyright © United Nations, 2011, ST/ESA/SER.A/309?
41. [UN] United Nations, 2014.Department of Economic and Social Affairs, Population Division. World Urbanization Prospects: The 2014 RevisionHighlights. UN.
42. Yago Z., 1984. Le nuni, langue gourounsi de Haute-Volta. Thèse de doctorat 3e cycle Université d'Abidjan, 251p.