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Sustainable Management of Green Spaces in the City of Dakar

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Abstract—The main objective of this study was to appraise the mode of management of public green spaces in the City of Dakar. To do this, the list of public green spaces was obtained from the inspection of green spaces (Water and Forests Directorate) in Dakar. We also conducted semi-structured interviews with representatives of the following institutions: the Department of Urban Landscapes and Public Spaces, the urban green spaces division of the City of Dakar, managers of public green paces across 7 municipalities out of 19 of the City of Dakar, the National Statistics and Demography Agency, and private sector actors. This was complemented by an exploratory study to investigate problems encountered in the field. The results clearly show that urbanization is detrimental to local biodiversity. As for the rate of coverage of green spaces in the city, the study reveals a different panorama: if we consider the City of Dakar as a whole, the inhabitants need for green spaces is satisfied. However, a ratio per inhabitant of 0.33 m² indicates that the ratio of green space per inhabitant in the municipality of Dakar Plateau is very insufficient. Finally, a survey of the technical services of seven municipalities revealed that the managers of green spaces were interested in sustainable management. They also already adopted practices to meet the challenges of sustainable management. Furthermore, the analysis of the responses show that the treatment of the issues is unequal, and that many technical obstacles to the sustainable management of public green spaces were encountered. In conclusion, this study made it possible to propose a set of good practices for the management of green spaces, and technical support for all managers within the technical departments.

Keywords— PCET - Urban Landscape - Vegetated - Municipalities - Technical Services.

INTRODUCTION

In the past, the "wild" nature of the city was perceived as a constraint on urban development; today, through a revaluation of green spaces, it has once again become an indispensable tool for renewal, appeal and functionality (economic, cultural, ecological, psychological, health-related, etc.). They are the main islands of nature in the urban fabric. Green spaces are a response to, or even a bulwark against, urbanization [1].

Urban vegetation has important ecological, urban planning, social and economic functions [2]. As part of the matrix of green and blue networks, the benefits of green spaces are manifold and constitute a significant means of preserving urban biodiversity [3]. Among other benefits, we can add the effectiveness of vegetated spaces in mitigating the effects of urban microclimates that has

been widely demonstrated, whether for its shading effect or its evapotranspiration potential [4]. Vegetation also generates numerous other benefits in terms of public health, energy savings and property value [5].

With its geomorphology and rapid urbanization, the city of Dakar faces numerous environmental constraints and challenges that expose it to the risks of climate change [6]. The general state of the environment in Dakar is deteriorating due to the intensification of land use and the anthropization of natural environments. This is also characterized by pollution of the air, groundwater, marine waters (the Bay of Hann in particular) and surface waters.

In Senegal, decentralization has transferred 9 powers to local authorities, including the environment and natural resource management. Article 3 of the General Code of Local Authorities stipulates that "local authorities are responsible for designing, programming and implementing economic, social and environmental development initiatives of local interest". These authorities, which are supposed to be closer to the population, must provide basic services in the context of a redefined territorialization of public policies. As a result, the City of Dakar, with its expertise in urban planning and environmental governance, has turned its attention to integrating an adaptation strategy. This strategy requires knowledge of past exposures and sensitivities, and consideration of current and future climate trends.

To this end, the City of Dakar, in its vision of "a city oriented towards good governance and sustainable development for the wellbeing of its populations", has carried out several studies, including an Environmental Action Plan, the analysis of social and biophysical vulnerabilities, Agenda 21 and the identification of risk zones, enabling it to understand its sensitivity and exposure to climate change. Aware of the urgency of climate change, the Dakar has undertaken to draw up a Territorial Climate and Ecology Plan (PCET), enabling it to adapt, reduce its greenhouse gas emissions and contribute to the implementation of the National Determined Contribution.

It is in this context that the present study aims to characterize public green spaces of the City of Dakar and to analyze their management methods, in order to determine the effectiveness of its management method. In other words, are the conditions right for sustainable management of green spaces?

I. METHODS

The study took place in the city of Dakar, which is made up of nineteen municipalities. Fig. 1 shows the administrative boundaries of the study setting, the City of Dakar. Located in the far west of the African continent, Dakar is a large metropolitan center. The capital of Senegal is bordered on three quarters by the Atlantic Ocean and to the east by the towns of Pikine and Guédiawaye.

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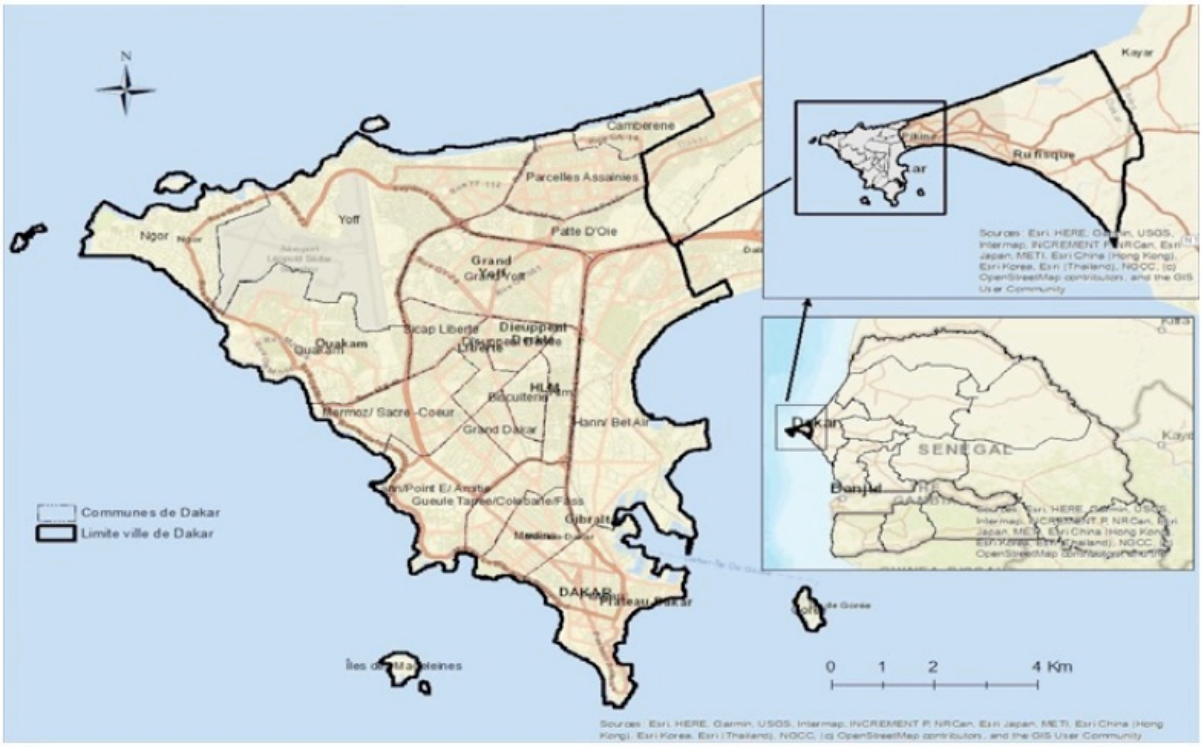

Source : Rapport Étude de vulnérabilité de la Ville de Dakar face au changement climatique, 2020

Figure 1: Delimitation of the administrative district of the City of Dakar

A. Data collection methods

The list of public green spaces was obtained from the green spaces inspectorate (water and forest directorate) in Dakar. We also conducted semi-structured interviews with representatives of the following institutions: the Urban Landscapes and Public Spaces Directorate (DPUEP), the City of Dakar's division for horticulture and green spaces, the National statistics and demography agency (ANSD), and private sector actors.

A survey was then carried out to appraise the sustainable management of green spaces in the City of Dakar and identify obstacles to its implementation. The survey was based on predetermined sustainable management principles, and targeted green space managers. The methodology implemented is based on the method employed by [7], which consisted in determining the management principles essential to good maintenance of green spaces. These principles are guidelines that relate to a particular issue and can give rise to a multitude of actions or practices. These management principles are based on evaluation criteria selected by scientific or professional committees (which have the advantage of being recognized as having a significant influence on environmental issues), and French national labels. The labels used are EVE from Ecocert, Ecojardin from Plante & Cité, and Villes et Villages fleuris from CNVVF.

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Table 1: Management principles to good maintenance of green spaces

Issues	Management principles
Biodiversity	- Diversify the species used: encourage biodiversity in the choice of species to be planted in green spaces, by diversifying species, promoting spontaneous plants, etc. - Diversify on-site habitats: enable a wider range of plant and animal species to settle in green spaces. - Connecting green spaces: creating opportunities for species to live and reproduce between different green spaces.
Water	- Reduce water consumption in green spaces: save water resources, particularly for watering. - Reduce the use of drinking water: preserve drinking water by using other water sources.
Soil	- Preserve the physical and chemical qualities of soil: protect soil from sealing, compaction, erosion and contamination. - Rationalize inputs: assess soil needs and give priority to organic matter.
Management	- Know the issues and follow them up: know the issues of green spaces in order to understand the influence of management on them, then motivate teams, adjust management, or communicate on it. - Communicate on green space management: raise public awareness of issues, justify management choices, encourage public participation. - Differentiate plant management according to site use: adapt site management according to public use. - Rationalize maintenance operations: assess the frequency and importance of maintenance such as pruning, to reduce management costs. - Manage plant health: prevent and treat plant

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	diseases. - Reduce or stop the use of phytosanitary products. - Fight invasive species: fight invasive species that impact on green space issues. - Reduce, reuse and recycle green waste: promote alternatives to avoid the creation of waste.
Landscape	- Diversify atmospheres and landscapes according to public use: create a landscape that corresponds as closely as possible to public expectations. - Encourage diversified, long-term flowering: ensure the presence of plants and aesthetic qualities all year round.

The questionnaire was then sent to the heads of technical services in the nineteen municipalities of the City of Dakar. Respondents' anonymity was ensured to guarantee candid answers. The questionnaire consisted of nineteen questions, each corresponding to a previously established management principle, with the exception of the first, which sought to determine the respondent's interest in sustainable management. Four questions could be answered with a yes or no, and fourteen were more open-ended. Of the nineteen municipalities surveyed, seven completed the questionnaire. This may be due to the following reasons: the municipality in question has no technical services, problems of governance, or the public green spaces in these municipalities are not significant enough for the municipality to make it a concern.

Finally, direct observation enabled us to uncover practical problems encountered in the management of public green spaces: the site chosen was the square named “la Place de l'indépendance”. This made it possible to compile a large number of notes and photographs of the green space observed. Using the measurement tools available in Google Earth software, followed by processing in Microsoft Excel, we also calculated the perimeter and surface area of the green space studied (Refer to Fig. 4).

B. Approach to Analysis

Using the data collected, we first calculated the coverage rate, then the green space/inhabitant ratio. This also enabled us to draw up a floristic list with information on genus, family and biological types.

1) Coverage rate

Is the area of public and green space as a proportion of total city space or green coverage ratio.

For the City of Dakar, the green space coverage rate was calculated according to the formula :

GR = AVSx / TAx * 100 with :

GR = green space coverage rate in a city x ;

AVSx = surface area of vegetated public spaces in the city; and

TAx = total area of the city.

Green space/inhabitant ratio

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Aims to assess the greeness and can help in identifying the critical areas, which in turn can be used to identify action areas for improving the quality of vegetated areas.

The ratio of green space per inhabitant in Dakar was calculated using the following formula:

RGs/inh.= SEVx / Pa with :

RGs/inh. = ratio of green space per inhabitant in a city x ;

AVSx = surface area of the city's parks;

Pa = number of inhabitants in the city.

The World Health Organization (WHO) recommends 10 m^2 of green space per inhabitant:

if REV/h < 10 m^2: the ratio of green space per inhabitant is not reached;

if REV/h ≥ 10 m^2: the green space per capita ratio is achieved.

II. Results

A. Characterization of green spaces in the city of Dakar

1) Plant regrowth rate

The City of Dakar, with a surface area of 79 km^2, has around 1,321 ha of vegetation cover, representing a vegetation cover rate of around 17% of the total surface area of the City of Dakar.

The ratio is 11.53 m^2 of public green space per inhabitant in the city of Dakar, whereas the WHO standard calls for 10 m^2 of public green space per inhabitant. The ratio of green space per inhabitant in Dakar is therefore satisfactory.

2) Phytodiversity in green spaces

The plant population of the roadside alignments and polygonal green spaces is made up of 38 tree species. To these can be added the plant species that make up the flowerbeds, hedges and lawns:

Ficus benjamina;

Bougainvillea spectabiis;

Zoysia japonicazenith

Icora coccigea;

Marraya paniculata

B. Sustainable management of green spaces

Overall, managers are familiar with management principles. They apply them regularly or are interested in applying them.

Respondents strive to put these management principles into practice. Over 60% of these principles are applied (see Fig. 2), with the exception of:

- Connecting green spaces;
- Preserve the physical and chemical qualities of the soil;
- Promote long-term flowering and diversity;

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- Know the issues and monitor them;
- Reduce, reuse and recycle green waste.

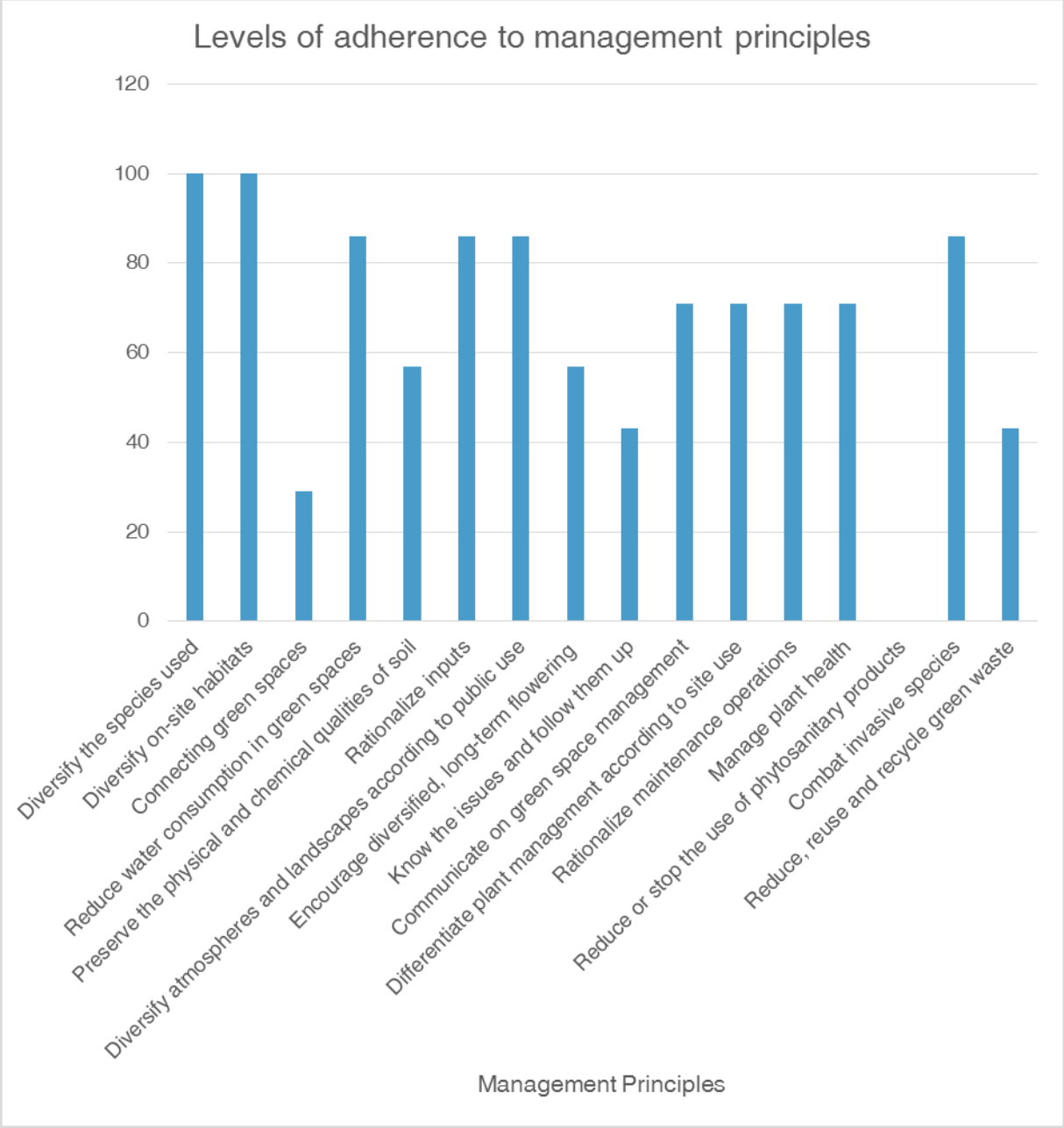

Figure 2: Level of adherence to the different management principles

Other principles are adopted by 75% or more, such as:

- Diversify the species used;
- Diversify site habitats;
- Reduce water consumption in green spaces;

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- Regulate the use of inputs;

- Diversify atmospheres and landscapes according to public use;

- Fight invasive species.

The difficulties encountered during implementation to meet these challenges are closely linked to a "technical brake", and the managers often make the following comments:

- There is a lack of agent skills and a need for training;

- They acknowledge a lack of knowledge about the issue or the means of dealing with it;

- A problem of organization;

- A strong will but insufficient follow-up.

C. Difficulties encountered in the day-to-day management of public green spaces in Dakar

A case study was carried out at the square named “Place de l'indépendance” situated in the Dakar Plateau minicipality. The choice was justified by the fact that “la Place de l'Indépendance” is one of the few public green spaces to be classified and still managed by the City of Dakar's public green spaces division.

Dakar-Plateau is one of the nineteen municipalities of the city of Dakar. It is built on the rocky tip of the Cape Verde peninsula. It is bordered to the south by the cape “Cap Manuel”. This outcrop is encircled by a cornice cut into the rock (Refer to Fig. 3).

At the time of the 2002 census, the commune had 32,795 homes, 6,872 households and 4,644 concessions. At the end of 2007, official estimates put the population at 36,901 people. Covering an area of 7 km^2.

Figure 3: Location map of the commune of Dakar-Plateau

Fig. 4 shows an example of the result obtained by tracing the polygons corresponding to the square under study,” la place de l’indépendance”, along the section bordering Avenue George Pompidou and Avenue Hassan II. Sidewalks and parking spaces all around the observed green space delimit the study area.

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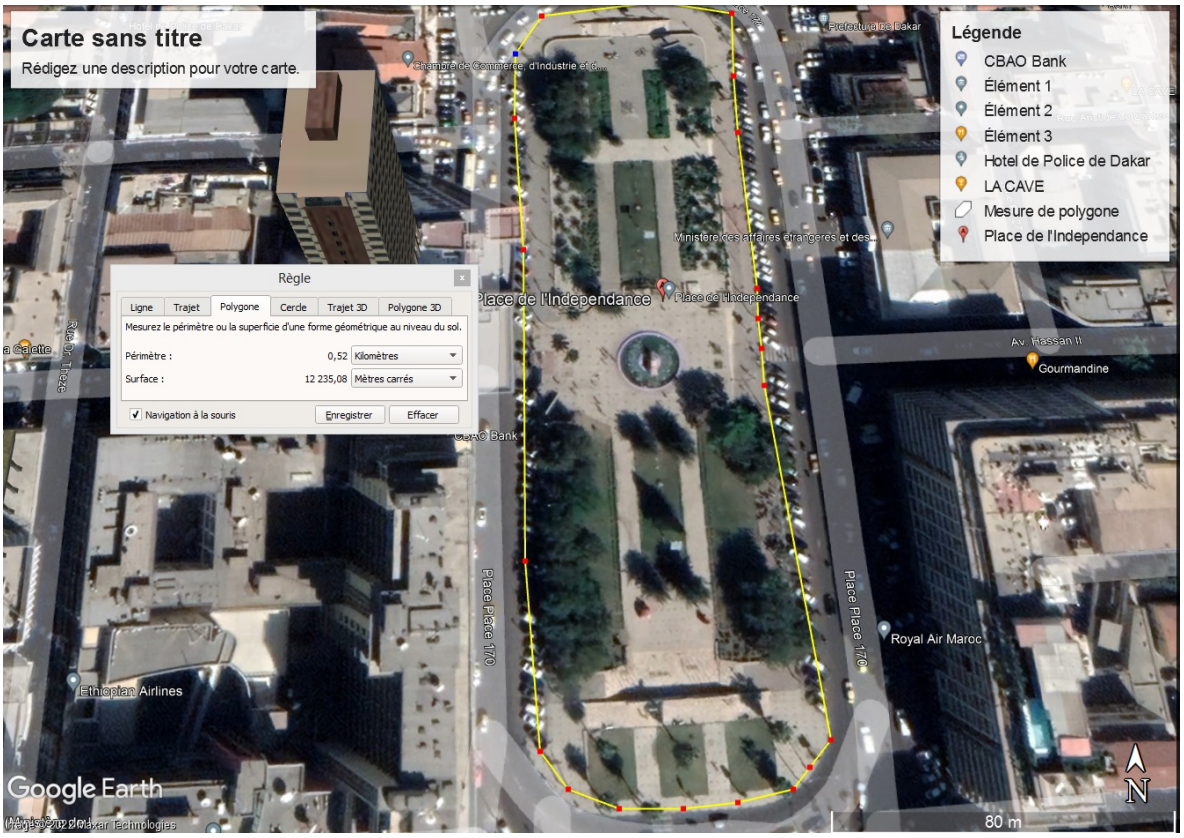

Figure 4: Aerial view of the square "la place de l'independence" (Google earth, 2022)

After analysis, the area obtained is approximately 12235 square meters. This represents a vegetation cover rate of around 0.17% of the Dakar-Plateau municipality. And a per capita ratio of 0.33 m^2 of green space per inhabitant of the Dakar Plateau municipality, whereas the WHO standard stipulates 10 m^2 of public green space per inhabitant. It therefore appears that the ratio of green space per inhabitant in the municipality of Dakar Plateau is highly inadequate.

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Figure 5: Pictures taken at the square "la place de l'independence" (City of Dakar, 2021)

The difficulties encountered are related to monitoring and maintenance and concern:

- In the photos above (Fig. 5), we can see that the green space is in a poor state of health and safety. This is due to the incivility of vagrants, beggars and street vendors. Without regular monitoring, these individuals regularly damage urban furnitures, transforming the green space into a cesspit. Plants are often mutilated (branches cut off, bark stripped, leaves, roots and flowers removed);

- Insufficient financial resources and a lack of effective fund-raising strategies. The technical services' resources have been considerably reduced, from 111 agents to just 5. Logistical resources have also been considerably reduced. Since full communalization, the central authority has been able to support local authorities in carrying out development projects, but once the work has been completed, the municipality is fully responsible for it.

- Exorbitant maintenance costs: as an example: water bills are exorbitant due to watering with drinking water.

Despite the efforts made by decentralized government departments through the Ministry of Urban Planning, much remains to be done to improve the management of public green spaces in the city of Dakar.

III. Discussion

The ratio of 11.53m^2 of public green spaces per inhabitant of the City of Dakar found in this research is higher than the WHO standard of 10 m^2 of public green spaces per inhabitant. The City of Dakar has a greater quantity of green space than the City of Châteauroux, Tours and Orléans [8]. The City of Dakar is well represented in terms of its tree area or classified areas. The richness of its tree heritage and its development (Example: the Hann Park), the presence of parks and public green spaces, as well as natural spaces (accompaniment of green paths) justify this result. In the current study, we only listed 38 plant species, but there are many more. [9] identified 102 species. In reality, the floristic diversity of horticultural stations and the benefits that stakeholders can derive from them are not well understood, as are the problems linked to these ornamental species [10]. Despite this, there is an exponential proliferation of nurseries and ornamental gardens with the main concerns being the ornamental quality or economic value of cultivated plants [11]. From the point of view of taxonomic diversity, the ornamental flora of the City of Dakar is made up of 81 genus distributed in 39 families. The most common genus are *Bougainvillea, Nerium*, *Cordia* and

Codiaeum [9]. These plant species are easy to reproduce by cuttings and/or seeds. Which justifies the fact that they are frequently found in the urban landscape. In addition, perennial species constitute 94.5% of the ornamental flora. As for annual species, they represent only 5.5% of the species recorded. In terms of biogeographic distribution, pantropical and American species are respectively 33.94% and 12.84% of the horticultural flora. African species only represent 5.5% of this ornamental flora. It is likely that these species are more adapted to the current bioclimatic conditions of Senegal than certain strictly African species. The preponderance of these introduced species certainly has as its origin, their promotion as species adapted to the urban environment, and due to their use during reforestation and regreening campaigns [12]. With the consequence of a predominance of foreign species in urban green spaces [13]. Added to this, humans, by settling, fragment and degrade, or destroy natural spaces, thus leading to a loss of local biodiversity [14]. The enhancement of endogenous plant species in urban green spaces has therefore become a significant means of promoting the conservation of biodiversity and the restoration of urban ecosystems [15].

Regarding the adoption of sustainable management principles, the results of the survey conducted in seven municipalities in the City of Dakar show that green space managers are aware of the need for sustainable management of green public spaces, and have even adopted measures consistent with the Management Principles appraised in this study. Municipalities are working to diversify their choices of plant species and habitats. Also if they wish, they can request support from the Technical Services Directorate of the City of Dakar and the Living Environment Directorate.

However, a detailed analysis shows that the adoption of sustainable management principles by municipalities is not consensual. Indeed, in the municipalities surveyed, certain environmental issues are taken into account effectively in the various management plans, while others are ignored. The obstacles to the adoption of all management principles are mainly technical. Whilst the social aspect and the political brake have not been noted.

For issues of sustainable management of green spaces, such as water saving for example, we see a homogeneous stage of progress. First, there are communities which respond effectively to the issue through concrete and effective actions, by favoring the choice of hardy or succulent plant species, by avoiding lawns where resources do not allow it, and by paying attention to overconsumption of drinking water. Furthermore, some municipalities are aware of the issue but maintain unsuitable practices such as the use of the drinking water network for watering. The results of the survey are therefore encouraging, and show that it is possible to improve the sustainable management of green spaces in the City of Dakar. With a little ingenuity, and the capacity building of technical agents, certain environmental issues can be improved, and technical obstacles reduced considerably. Finally, if we consider the City of Dakar as a whole, we have the impression that the need for green spaces per inhabitants of the City of Dakar is satisfied. But the results of a more detailed analysis, the case study at the square “la Place de l'Independence”, in the minicipality of Dakar-Plateau, contrast with this result, and instead show that public green spaces are either insufficient or unevenly distributed among the 19 municipalities of the City of Dakar. Indeed, the municipality of Dakar Plateau is very far from the 10 m^2 of public space recommended by the World Health Organization for each inhabitant. From this observation, it therefore follows the need for the municipal authority to give more interest and space to public green spaces (gardens, parks, squares, etc.) in the future local development plans and do more efforts to mobilize resources for their development and sustainable management.

IV. CONCLUSION

Taking the city of Dakar as a whole, a calculated ratio of 11.53 m^2 of public green space per inhabitant meets the World Health Organization (WHO) standard. The richness of its plant heritage justifies this result. In this study alone, we identified 38 plant species.

Furthermore, it appears from the survey of public green space managers in the City of Dakar that they are all aware of the need for sustainable management of public green spaces. In this way, many environmental issues are already taken into account. They are either currently being tested or have already been adopted.

Finally, a case study at public green space “La Place de l'indépendance”, and in the Dakar-Plateau municipality, reveals a different panorama. Indeed, a calculated ratio of 0.33 m^2 of green space per inhabitant of the Dakar Plateau municipality, whereas the standard (WHO) calls for 10 m^2 of public green space per inhabitant, shows that public green spaces are either insufficient, or unevenly distributed between the nineteen municipalities of the City of Dakar. As a result, the municipal authorities need to pay more attention to public green spaces (gardens, parks, squares, etc.) in future local development plans, and make greater efforts to mobilize resources for their development and sustainable management.

Prospects :

Looking ahead, it will be interesting to determine objectively verifiable indicators for the sustainable management of public green spaces, in order to implement the most comprehensive method of systemic analysis, with the emphasis on promoting appropriate and sustainable practices. This will also provide a better understanding of the most appropriate actions and their respective impact on achieving sustainable development objectives. Finally, it is also relevant to consider in future research the aspects linked to the way in which green spaces are used and appropriated by the beneficiary populations.

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