


Promotion of tree in the compounds of Central-Benin cities (West Africa): an assessment of its assets and constraints

Prucelle Elisée Zohoun ^{1,3,*}, Emilia M. Azalou-Tingbé,² Soufouyane Zakari³ and Ibouaïma Yabi¹

¹Laboratory "Pierre Pagney" Climate, Water, Ecosystem and Development, Department of Geography and Land Management, University of Abomey-Calavi, PO Box 526, Cotonou, Benin, ²Laboratory of Anthropology and Sociology of Environmental, Educational, Rural and Gender Dynamics, Department of Sociology-Anthropology, University of Abomey-Calavi, PO Box 526, Cotonou, Benin and ³Laboratory of Cartography, Remote Sensing and Geographic Information Systems, Department of Geography and Land Management, University of Abomey-Calavi, 10 PO Box 1082, Cotonou, Benin

*Corresponding author. E-mail: zohounprucelle@yahoo.fr

Submitted: 24 October 2022; Received (in revised form): 7 March 2023. Accepted: 26 March 2023

Abstract

Nature-based solutions hold promise for cities, given their development challenges and vulnerability to climate change. This research is based on the fact that knowledge of public perceptions of trees is necessary for planning tree conservation and planting initiatives in rapidly changing landscapes. This article aims to identify the assets and constraints related to the promotion of trees in the compounds of the cities of Central Benin (cities of Parakou, Dassa-Zoumè and Savalou) based on the perceptions of urban residents. Samples of 370, 365 and 360 inhabitants respectively in Parakou, Dassa-Zoumè and Savalou are used to collect information. A SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis was performed on the responses obtained to identify assets (strengths and opportunities) and constraints (weaknesses and threats). The decision of the landowner, the lack of place, the lack of technicality, the socio-economic problems constitute the main constraints of the promotion of the tree in the cities of Centre-Benin. To meet the challenge, these cities have assets such as the majority proportion of landowners, the high level of education, the presence of several socio-cultural groups, the climate and favorable soils, the presence of nurserymen and the availability of seedlings, the national tree day.

Key words: nature-based solutions, city dweller, perception, sustainable cities, tree planting, urban forest

Introduction

Many cities in Africa are vulnerable to rapid tree loss due to the conversion of the land that bears them for roads, social amenities, buildings and other priorities. This hinders urban residents' access to green spaces and ecosystem services that are essential to life (Djibril et al. 2012; Olaleyé et al. 2013; Mensah 2014). Moreover, this trend is worrisome in light of the adverse effects of climate

change to which cities are most vulnerable (Nowak and Crane 2002). Thus, taking effective measures to protect and preferably restore already lost urban trees and the ecosystems of which they are a part is necessary for the promotion of sustainable cities. This is particularly urgent and important in light of Sustainable Development Goal 11, which involves making cities and human settlements safe, resilient and sustainable (FAO 2018).

© The Author(s) 2023. Published by Oxford University Press.

This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (<https://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact journals.permissions@oup.com

Interestingly, city dwellers in Central Benin cities are making the effort to conserve tree species or plant them in their *ground* for various reasons (Zohoun et al. 2020). Indeed, these urban residents are aware of the role of trees and have a broad knowledge of the ecosystem services provided by the urban forest (Zohoun et al. 2021). Trees already provide many benefits in urban and peri-urban areas and could provide even more if the introduction of trees into the urban fabric is integrated into urban planning and involves the population (Moustier et al. 1999). This form of planning is still very new in developing countries, and there is a lack of information on the relationship between city residents and the tree fabric. Notably, public participation is one of the new approaches to improve tree conservation and planting in urban areas (Garekæ et al. 2016; Ives et al. 2017).

The cities of Parakou, Dassa-Zoumè and Savalou belong to the same climatic and phytogeographic domain, same floristic composition; however, the three cities do not have the same level of urbanization and do not have the same sociolinguistic composition. This article examines whether urbanization and differences in sociolinguistic composition change residents' perceptions of the tree from one city to another.

This research is based on the fact that knowledge of public perceptions of trees is necessary for planning tree conservation and planting initiatives in rapidly changing landscapes. Thus, actions to be taken will be defined according to the information deficit actually observed and the needs identified. In addition, this research lays the groundwork for tree conservation and planting initiatives in the cities of Parakou, Dassa-Zoumè and Savalou in Central-Benin by identifying the strengths, weaknesses, opportunities and threats related to their promotion at the level of the inhabitants. To achieve the objective, six sections were defined.

Materials and methods

Study area

The cities of Parakou, Dassa-Zoumè and Savalou belong to the same climatic and phytogeographic domain and are located in the phytogeographic zone of Centre-Benin, precisely in the Guinean-Sudanese transition zone characterized by the clear Sudanian forest with abundant *Isoberlinia* (Akoègninou et al. 2006).

Overall, the cities of Parakou, Dassa-Zoumè and Savalou have many assets that could contribute to the promotion of trees. From an environmental point of view, the cities enjoy a transitional Sudano-Guinean climate, with average rainfall ranging from 1100 to 1200 mm spread over 7–8 months. This rainfall context favors the development of several tree species (indigenous and exogenous). From a pedological point of view, the three towns are developed on soils dominated by essentially tropical ferruginous soils that are favorable for tree planting.

In the 2013 general population and housing census, the total population of the urban neighborhoods of Parakou was 255 478 (INSAE 2016a). In Dassa-Zoumè, the urban population was 29 461 while in Savalou, it was 38 162 (INSAE 2016b). In addition, the population of the city of Parakou is experiencing a significant increase. The urban population growth rate is 4.90 between 2000 and 2013 and exceeds the national rate of 3.5% in Benin. The population density in the city of Parakou is 579 inhabitants per km². As for the cities of Dassa-Zoumè and Savalou, they have an average population density that increased from 38 inhabitants per km² in 2002 to 52 inhabitants per km² in 2013 (INSAE 2016a,b).

Sampling and data collection

In this research, the compound is considered as a closed ground which is composed of a set of houses occupied by one or several households.

In other to set the sample size, 'un survey conducted on 90 randomly inhabitants per city, for the exploratory phase, allowed us to determine the proportion of people who recognize at least three categories of ecosystemic services set by the Millenium Ecosystem Assessment' (Zohoun et al. 2021). In addition, this proportion allowed us to determine the sample minimum size by using the following formula of Dagnelie (1998).

$$n = \frac{U_{1-\alpha/2}^2 \times P(1-P)}{d^2} \quad (1)$$

With n: sample minimum size; P: proportion of respondents who recognize at least three categories of tree ecosystem services, determined during the exploratory phase; $U_{1-\alpha/2} = 1.96$, the value of the normal random variable for a risk $\alpha = 0.05$; d: margin of error is 5%.

Table 1 presents the sample size per city.

A survey form consisting of 17 questions divided into 6 sections was used. These are (1) structure of respondents and compounds, (2) afforestation and provenance of seedlings in the compounds of the cities of Central Benin, (3) reasons for the absence of trees in the compounds and perceptions on the problems related to the presence of trees, (4) participation and incentive of the population to reforestation, (5) awareness and knowledge of legal provisions and actions of public and private services on the tree and (6) preferences and wishes of city dwellers in terms of development.

To collect data, three techniques were used in the field. The first, direct observation, was used to assess the presence of trees. The second technique was the administration of a questionnaire. The third is the interview method. It was useful for respondents who could not read or write. The advantage of the interview was that it facilitated understanding of the topic and avoided unanswered questions. The interview was addressed primarily to the owners or tenants living on the plots or their children or representatives who were at least 17 years old (with a secondary education). Data collection was carried out from December 2019 to February 2020 in Parakou, and from August to November 2020 in the cities of Dassa-Zoumè and Savalou.

Data analysis

A descriptive analysis of the information collected made it possible to determine the profile of the respondents, namely, gender, age, level of education, socio-professional activity and the structure of the compounds (average area, average number of people per compound, proportion of owners and tenants). Analysis of strengths, weaknesses, opportunities and threats related to tree promotion. The data were recorded in tables. For each question asked in each section, the data analysis consisted

Table 1: Sample size per city

Cities	Pre-sample	Proportion (P)%	Sample size
Parakou	90	40	370
Dassa-Zoumè	90	61.11	365
Savalou	90	63.33	360

Source: Data processing results, December 2019.

of interpreting the proportion of respondents in relation to the total number of respondents concerned. These proportions are determined by calculating percentages as follows:

$$P = F_o * 100/N \quad (2)$$

where P = Proportion (in %), F_o = frequency of a response and N = size of the relevant sample.

On the basis of the frequencies observed in the sections, an analysis of the strengths, weaknesses, opportunities and threats related to the promotion of the tree in the cities of Central Benin was made to bring out the points to be enhanced in relation to the theme examined and the problems that will need to be curbed.

Results

Profile of respondents and compounds

In the three selected cities, the surveys were conducted in all urban districts and neighborhoods. Tables 2 and 3 present the profile of respondents and the structure of compounds by city, respectively.

Analysis of Table 2 shows that the average age of respondents ranges from about 35 to 42 years depending on the city. The proportion of respondents with at least a high school education is highest in all cities. In addition, there was considerable participation of women in the survey. Also, most of the socio-professional groups found in the cities are represented in the sample. Overall, the respondents were diverse in terms of age, gender, education level and socio-professional group.

A reading of Table 3 shows that the average number of people living in a plot is a minimum of 10 per city. The average minimum area is 450 m² on average with a high proportion of homeowners.

Description of afforestation and origin of seedlings in the compounds of the towns of Central Benin

Description of afforestation

Throughout the study area, there are compounds with no trees, some with little woodland and others with some woodland (Table 4).

In the city of Parakou, of all the observations made, 22.43% of compounds have no trees compared to 77.57% that do. Of the latter, 36.24% have only one tree, and 63.76% have two or more trees.

In Dassa-Zoumè, 97% of the compounds have at least one tree, while those that do not have any trees are 3%.

In the town of Savalou, more than 50% of the compounds have no trees. However, some compounds have two or fewer trees. Of the total sample, 95 compounds with at least two trees are in this situation, representing 26.38%.

The trees in the wooded compounds come from a variety of sources (Table 5) and are then cared for to grow.

Origin of seedlings

When it comes to acquiring seedlings, respondents are heavily invested in purchasing and self-production. Indeed, the majority of trees planted in the cities studied come first from purchase and then from residents' own production. The other sources vary from one city to another, with a high frequency of trees found on site in Savalou (22.34%).

Reasons for the absence of trees in the compounds and perceptions of problems related to the presence of trees

Reasons for the absence of trees in the compounds

Residents of the different cities gave a variety of reasons for the absence of trees in their homes (Table 6).

The analysis of Table 6 shows that in the cities of Parakou and Savalou, the owner's decision, lack of space and lack of technical skills are the reasons mentioned in order of importance. In addition, the financial inability to buy seedlings was mentioned by a significant number (10.5%) of respondents in the town of Savalou. In the town of Dassa-Zoumè, the lack of space was cited first, followed by the owner's decision and the lack of technical knowledge. In total, apart from the large number of compounds that mentioned the inability to buy seedlings in the town of Savalou, the reasons for the absence of trees in the residences in order of importance are the owner's decision, lack of space and lack of technical expertise.

Table 2: Profile of respondents

Structure	Cities		
	Parakou	Dassa-Zoumè	Savalou
Total number of observations	370	365	360
Average age of respondents (years)	34.95 ± 12.89	42.33 ± 15.06	40.80 ± 12.91
Proportion of women (%)	45.95	35.89	24.17
Proportion of men (%)	54.05	64.11	75.83
Level of education			
No education (%)	4.59	20.55	19.17
Literate (%)	12.43	3.01	11.11
Primary (%)	21.35	19.73	20.83
Secondary (%)	41.08	31.23	33.33
University (%)	20.54	16.44	15.56
Professional activities			
Employed (civil servants and others) (%)	25.14	20.00	17.50
Learners (pupils and students) (%)	17.30	10.96	15.28
Craftmen (%)	23.24	30.40	33.89
Traders (%)	27.30	19.18	18.33
Farmers (%)	2.16	14.52	13.89
Housewives (%)	3.51	-	-

Source: Field data processing results, December 2019 to November 2020.

Table 3: Compound structure

Structure	Cities		
	Parakou	Dassa-Zoumè	Savalou
Total number of observations	370	365	360
Average number of people per plot	9.94 ± 6.06	11.68 ± 7.43	11.07 ± 6.52
Average plot size (m ²)	465.11 ± 258.78	500 ± 141.42	680 ± 183.70
Proportion of owners	70.54%	76%	50%
Proportion of tenants	29.46%	24%	50%

Source: Field data processing results, December 2019 to November 2020.

Table 4: Afforestation in the compound

Cities	% of the number of trees per concession				
	Zero tree	1 tree	2–5 trees	6–10 trees	>10 trees
Parakou	22.43	28.10	47.03	2.16	0.28
Dassa-Zoumè	3.01	3.29	34.52	39.18	20.00
Savalou	50.27	23.23	23.88	2.22	0.27

Source: Results of field data processing, December 2019 to November 2020.

Table 5: Origin of seedlings used in wooded compound

Origin of the plants	Cities		
	Parakou	Dassa-Zoumè	Savalou
Purchase	74.21	49.99	56.14
Donation from a public or private service	5.93	24.57	13.96
Own production	35.19	52.82	40.78
Found on site	14.63	2.82	22.34
Others	0.70	1.41	3.35

Source: Field data processing results, December 2019 to November 2020.

Table 6: Reasons for lack of trees in compound

Why don't you have trees in your compound?		Proportion%		
		Parakou	Dassa-Zoumè	Savalou
Why don't you have trees in your compound?	D ^{landowner}	62.65	27.27	34.25
	No ^{money}	2.41	9.09	10.50
	Lack ^{technicality}	8.43	18.18	24.31
	Lack ^{location}	22.89	45.45	29.28
	Nature ^{land}	2.41	0	1.10
	Stray ^{animals}	1.20	0	0.55

D^{landowner}, decision of the landowner; No^{money}, No money to buy plants; Lack^{technicality}, lack of technicality; Lack^{location}, lack of location; Nature^{land}, nature of the land; Stray^{animals}, stray animals.

Source: Results of field data processing, December 2019 to November 2020.

Perceptions on problems related to the presence of trees

All respondents (with or without trees) were asked whether the presence of trees in the dealership was related to any problems. The results are presented in Table 7.

Apart from the city of Dassa-Zoumè, where more than 3/4 of respondents link the presence of trees to a problem despite

being the best forested city (Table 4), the proportion of respondents finding problems with the presence of trees is relatively low compared to those who find no problem in the other two cities.

Participation and encouragement of the population in reforestation

This concerns the rate of participation in reforestation, the motivation to participate in planting work in both private and public sites, and the level of awareness of the population on the issue.

Participation in reforestation

Table 8 presents the frequency and opportunities for respondents to participate in reforestation activities.

The data in Table 8 reveal that in all three cities, a high proportion, more than half of the respondents have never participated in reforestation activities. Although some people have participated more than three times in reforestation activities, the participation rate is low. Apart from the city of Parakou, where there is a relatively large number of private initiatives in tree planting, it can be seen that, in general, Arbor Day (1 June) is the main occasion on which people plant trees or participate in reforestation.

Incentives for reforestation

For future actions, it would be useful to evaluate the incentives for trees planting. This would allow us to assess the level of interest of the population in trees. Table 9 presents the results obtained after questioning about incentives.

With respect to the incentives offered to plant more trees in the compounds, the majority of respondents mentioned the availability of space, the provision of seedlings and protective materials. However, 31% in Parakou, 19% in Dassa-Zoumè and about 21% do not need any assistance to increase tree planting in their compounds.

With regard to tree planting in public spaces, while many make their participation a condition, there is still a proportion of 50% of respondents in Parakou, 8% in Dassa-Zoumè and 33% in Savalou who do not require assistance for their participation in public works.

Awareness of the population and knowledge of the legal provisions and actions of public and private services regarding the tree

The aim here is to assess the level of awareness of the issue of trees in the city.

Awareness of the population

Awareness raising is an effective action to raise the population's awareness. The results obtained after evaluation are presented in Table 10.

Table 10 shows that, apart from the city of Dassa-Zoumè where more than 75% of respondents said they had been sensitized on tree planting, the rate of sensitization in the other two cities is relatively low. In all cities, the radio was the channel through which the majority of respondents received information/awareness. This was followed by television and Arbor Day. Newspapers were almost the last channel.

Table 7: Problems related to the presence of trees

		Proportion%		
		Parakou	Dassa-Zoumè	Savalou
Do you see any concerns related to the presence of trees in your compound?	YES	27.03	79.45	30.56
	NO	72.97	20.55	69.44
If yes, Which?	Dirty (production of dead leaves)	24.32	78.36	27.78
	Attract mosquitoes, insects, birds	8.92	68.49	25.28
	Risk of accident (falling branches...)	1.62	55.89	12.22
	Threatening of buildings (house...)	7.84	47.67	22.22
	Attract evil spirits	0.81	2.74	4.17
	Attract evil spirits	0.81	2.74	4.17

Source: Field data processing results, December 2019 to November 2020.

Table 8: Participation in reforestation

		Proportion%		
		Parakou	Dassa-Zoumè	Savalou
Have you ever participated in reforestation activities?	Never	58.10	62.19	77.22
	1 time	10.27	25.75	16.11
	2 times	3.24	7.67	4.72
	3 times	3.78	1.64	1.38
	More than 3 times	24.59	2.74	0.55
	When did you participate in reforestation actions?	Arbor Day	38.71	82.6
Community activities		10.97	5.07	6.10
NGO		2.58	0.72	0/0
Private initiative		47.74	11.59	6.10

Source: Field data processing results, December 2019 to November 2020.

Table 9: Incentives for reforestation work

		Proportion%		
		Parakou	Dassa-Zoumè	Savalou
What would encourage you to plant or care for more trees in your compound?	Financial or in-kind incentive	8.92	55.89	26.67
	Free provision of seedlings	38.92	58.36	38.05
	Free provision of protective materials	32.70	49.04	29.16
	Availability of space	57.57	21.10	35.83
	No assistance	31.08	19.45	20.83
What would encourage you to participate in planting efforts in your neighborhood or borough or city?	Financial or in-kind incentive	10.27	76.71	24.44
	Official right to use the potential products (fruits, wood, etc.)	34.59	60.82	28.33
	Support for necessary materials	37.57	49.86	32.5
	No assistance	50.82	8.61	33.89

Source: Field data processing results, December 2019 to November 2020.

Knowledge of legal provisions and actions of public and private services on the tree

The level of awareness of the population can be perceived by their knowledge of the repression of deforestation and also by their knowledge of local actions by public and private services. The results are presented in [Table 11](#).

The majority of respondents report being aware of penalties for unauthorized tree cutting. In contrast, there is little awareness of local initiatives to plant, conserve or protect trees in the city by private or public agencies.

Preferences and wishes for development

The preference here is related to certain categories of species that we had defined according to the current uses of the tree in the study area. The preference is related to the priority given to socioeconomic facilities by the urban dwellers of central Benin.

Preference for tree species

[Table 12](#) presents the distribution of respondents according to their preferences for the different species categories listed.

Table 10: Population awareness rate

		Proportion%		
		Parakou	Dassa-Zoumè	Savalou
Have you been reached by the awareness campaigns around tree planting?	YES	36.75	84.11	36.67
	NO	63.24	15.89	63.33
By what means of awareness were you reached?	Radio message	30.54	77.53	34.16
	TV message	27.57	58.90	26.94
	Newspaper articles	11.62	24.66	6.94
	Arbor Day/Week	24.32	18.90	11.39

Source: Field data processing results, December 2019 to November 2020.

Table 11: Knowledge of legal provisions and actions of public and private services on trees

		Proportion%		
		Parakou	Dassa-Zoumè	Savalou
Did you know that there are local penalties for unauthorized cutting of trees?	YES	63.78	89.32	45.56
	NO	36.22	9.32	51.94
Are you aware of local initiatives to plant, conserve or protect trees in the city?	YES	11.62	6.30	1.39
	NO	88.38	91.78	95.83

Source: Field data processing results, December 2019 to November 2020.

Table 12: Preferences for species categories

		Proportion%		
		Parakou	Dassa-Zoumè	Savalou
What species do you particularly like and would like to plant around you?	Fruit species	84.86	73.97	56.39
	Medicinal species	45.40	2.74	46.67
	Ornamental species	25.14	–	17.5
	Wood energy species	–	12.74	1.94
	Timber and service species	–	4.38	2.78
	Marketable species	–	12.05	2.78
	All categories	9.46	0.82	13.33

Source: Field data processing results, December 2019 to November 2020.

It can be seen that the choice of the interviewees is mostly for fruit species according to the different cities. Next come medicinal species, then ornamental species.

Wishes in terms of development

In urban areas, socio-economic facilities are of great importance. For example, we looked at the importance of green spaces to residents. Table 13 presents the priorities for urban development according to the respondents.

The assessment of the development priority showed that the development of the water supply network, asphalt streets, sanitary facilities and commercial facilities take precedence over green spaces.

SWOT analysis related to tree promotion in the compounds of the cities of Central Benin

Overall, the cities of Parakou, Dassa-Zoumè and Savalou have many assets that could contribute to the promotion of trees. From an environmental point of view, the cities enjoy a

transitional Sudano-Guinean climate, with average rainfall ranging from 1100 to 1200 mm spread over 7 to 8 months. This rainfall context favors the development of several tree species (indigenous and exogenous). From a pedological point of view, the three towns are developed on soils dominated by essentially tropical ferruginous soils that are favorable for tree planting. The average size of the compounds is at least 450 m² with a high proportion of owners (70.54%) in Parakou, 76% in Dassa-Zoumè, and 50% in Savalou, giving them the possibility of having space for tree planting and the power to make decisions. In addition, we note the presence of several socio-cultural groups and a predominantly educated population with an average level of secondary education. This characterizes a population with a broad knowledge of the traditional roles and uses of trees and a population predisposed to improving its attitudes towards natural resources in general and tree care programs in urban landscapes in particular. With the exception of the city of Savalou, where 50% of the compounds have no trees, the analysis of afforestation reveals that at least 75% of the compounds in Parakou and Dassa-Zoumè have at least one tree with a high

Table 13: Respondents' priorities for urban development

Area of development		Parakou	Dassa-Zoumè Rank	Savalou
How would you prioritize (1–10) the following amenities to be implemented in your neighborhood/city to make life more enjoyable?	Cultural facilities (museum, library, youth center...)	5 ^è	4 ^è	9 ^è
	Sports facilities (playgrounds)	4 ^è	5 ^è	2 ^è
	Drinking water supply network	3 ^è	1 ^{er}	1 ^{er}
	Sanitary equipment (public toilets, dispensaries...)	2 ^è	2 ^è	4 ^è
	Asphalted streets	1 ^{er}	8 ^è	6 ^è
	Commercial facilities (local market, stores...)	6 ^è	3 ^è	3 ^è
	Shaded streets	7 ^è	6 ^è	7 ^è
	School equipment of proximity	8 ^è	9 ^è	5 ^è
	Green spaces	9 ^è	7 ^è	8 ^è
	Public transport facilities (bus cab)	10 ^è	10 ^è	10 ^è

Source: Field data processing results, December 2019 to November 2020.

probability of being purchased or self-grown. This indicates a great interest in trees. Indeed, except for the city of Dassa-Zoumè where the majority of respondents linked a problem to the presence of the tree (although few compounds are without trees), respondents in the cities of Parakou and Savalou for the most part see no problem. Also, more than 63% in Parakou, 89% in Dassa-Zoumè and 45% in Savalou claim to be aware of the legal provisions governing trees in all locations. The strong preference for fruit species (85%) in Parakou, 74% in Dassa-Zoumè and 56% in Savalou is a real asset because it could motivate and facilitate the planting of trees because of nutritional or economic interests (marketing of fruits and others).

However, there are certain weaknesses that need to be noted. Despite the high proportion of compound with trees in Dassa-Zoumè (97%), there are still compounds without trees in the cities of Parakou (22%) and Savalou (50%). The main reasons given in order of importance are the owner's decision, lack of space, and lack of technical expertise. In addition, most respondents in the various cities have never participated in a reforestation activity and are seeking incentives such as free seedlings, provision of protective equipment (although they emphasize the availability of space), and the official right to use the potential products of the plantations in public places.

However, there are many opportunities available to the State and for resident's actions to address the weaknesses identified. There is the national policy which, in line with the Sustainable Development Goals (SDGs), places particular emphasis on the promotion of sustainable cities and the fight against climate change. There is also the presence of the Forestry Service for advisory support, monitoring and phytosanitary treatment if necessary, the presence of nursery gardeners who ensure the availability and supply of improved seeds and seedlings except in the town of Savalou where nurserymen are rare, and the presence of local radio stations (Radio Ilèma at Dassa-Zoumè, Radio Cité at Savalou, Office des Radios et Télévisions du Bénin (ORTB) at Parakou). The presence of local radio stations, the first channels through which some respondents were reached by the awareness campaigns, and the existence of the national tree day, which reminds people of their duty to protect the environment and remains the main occasion on which people reforest (39% in Parakou, 83% in Dassa-Zoumè and 88% in Savalou).

With regard to threats to the promotion of trees in the cities of central Benin, there is a gap between political intentions and the reality on the ground, and insufficient awareness among residents. There is also a virtual absence of non-governmental organizations (NGOs) working on urban forestry and little

involvement of public service actors, which indicates the lack of interest in urban forestry in local development. The other major threat to the promotion of trees in particular and urban forestry in general is the priority given by city dwellers to certain socio-economic facilities at the expense of green spaces. This denotes the socio-economic realities of the cities of Central Benin in particular and Benin in general. Figure 1 summarizes the assets and constraints related to the promotion of trees in the cities of Central Benin.

Discussion

In view of the results, initiatives to maintain and increase the number of trees in the landscape of the cities of Parakou, Dassa-Zoumè and Savalou are a priority. In addition, it is noted that urban populations give an interest to the tree in their environment. Indeed, Africa is a continent where the traditional relationship between people and their environment, especially the tree and the forest, is alive both in their food and material aspects and in their spiritual and cultural aspects (FAO 2012).

The owner's decision, the lack of space and the lack of technicality are the major constraints to tree planting in the residences of the cities of Parakou, Dassa-Zoumè, Savalou. The landowner's decision is cited as the reason for the absence or limitation of trees in the compounds, and this can be explained by the fact that the status of land tenure limits some tenants to planting trees. This constraint results from the fact that tree planting is perceived as the exercise of land ownership and therefore prohibited to tenants by some landlords (Ncutirakiza Ndamiyehe et al. 2017). In addition, lack or inadequacy of space remains a common reason for urban dwellers in African cities. Indeed, this reason was cited by city dwellers in N'djamena (FAO 2012) and Kinshasa (Ncutirakiza Ndamiyehe et al. 2017). In the city, the tree and the urban dweller are in competition for the use of space and land. The latter as a growing medium for trees is scarce due to the fact that urban space is furnished by several types of structures and infrastructure (Buisseres et al. 2009). All this leaves very little room for tree planting (Ncutirakiza Ndamiyehe et al. 2017). Furthermore, the low afforestation rate could be explained by the problems related to trees mentioned by several residents, namely the dirtiness created by the production of dead leaves, the presence of insects and birds, the risk of accidents and the threats that trees pose to buildings. This last reason is well founded according to Carter (1995). According to Carter, poorly planted or unsuitable trees pose a danger to city dwellers, either directly through falling branches



Figure 1: SWOT analysis of tree promotion in the compounds of the cities of central Benin

or the tree itself, or indirectly through the threats to human safety posed by branches hanging from overhead power lines and the hiding places that trees provide for attackers. However, these threats can be easily avoided by a rational choice of species and their regular maintenance. In view of this reality, it is necessary to identify, outside the residential area, other open spaces such as institutional land, sidewalks, parks, able to accommodate trees.

In addition, several socioeconomic factors have been reported to explain city residents' support for tree enhancement programs (Arabomen et al. 2021). Knowledge of the benefits of trees, having a paid job or business, residing in the city for more

than 20 years, and education would increase the likelihood of donating time or money to community forestry activities.

Urban tree planting is a potential strategy to improve ecological and economic problems (Ogunkalu et al. 2017). In addition to strengthening the public awareness system by the relevant departments, there is a need to improve the urban tree monitoring program under the auspices of the relevant municipal department. To optimize the presence of trees in the city, one solution would be to subject the right to build to an obligation to plant trees in residences. An optimum number of trees to be planted on a parcel could then be set by consensus in the municipalities. Also, it should be noted that each unit of occupation

requires specific requirements to facilitate planting and reforestation. In urban environments, trees must be able to withstand limited rooting space and reduced water availability in compacted soil (Mansell 2003; Watson and Kelsey 2006; Lahoti et al. 2020). Similarly, they must be able to withstand pollutants, high temperatures due to heat island effects. Also, different tree attributes play an important role in plant selection. For example, trees with dense and wide canopies lead to increase above-ground biomass and improved esthetic values, while trees with thick foliage remove air pollutants and provide shade, which leads to improved temperature (Pauleit and Duhme 2000; Jim 2013; Lahoti et al. 2020). Therefore, species selection is an important aspect of urban greening, as appropriate species selection could significantly improve the urban environment and increase the benefits derived from urban greening. However, the selection of native species remains a priority because native vegetation has an advantage over exotic species in improving the urban heat effect as well as in their ability to cope with heat stress (Aguiar 2012). Also, efforts to conserve and restore native vegetation in urban landscapes could promote greater concentrations of bird and plant species, ameliorating the projected decline in biodiversity due to rapid urban growth (Seto et al. 2012). Therefore, native or indigenous plants should be the first choice in tropical urban ecosystems (Ganaba 2020). In addition, it makes sense to plant fruit trees to promote what Kyle and Kimberly (2013) called ‘urban food forestry’.

Conclusion

It appears that the geographical context of the cities of Central Benin is favorable to the promotion of the tree both by their socio-demographic and natural characteristics. However, the level of afforestation in the compounds is low, if we assume that the ideal standard is 1.0 tree/inhabitant. In addition, the main reasons given are: the owner’s decision, lack of space and lack of technical expertise. As for the participation and encouragement of the population in reforestation, it is noted that city dwellers in Central Benin are not very accustomed to reforestation work and request incentives such as the free supply of seedlings, the supply of protective material and the official right to use the potential products from the plantations when it comes to public places. With regard to the population’s awareness of the tree, we note a low rate of people aware of the subject, which could explain the low rate of participation in reforestation activities. Indeed, when we look at the preferences and wishes of residents in terms of development, we note a priority given to needs related to the socio-economic problems faced by cities undergoing rapid urbanization in Africa. These priorities include the demand for food, water, sanitation, commercial facilities, etc.

In fact, the main assets for the promotion of the tree in the compounds of the cities of Central Benin are the majority proportion of landowners, the high level of schooling, the presence of several socio-cultural groups, the favorable climate and soils, the presence of nurserymen and the availability of seedlings, the national tree day. On the other hand, the decision of the landowner, the lack of space, and the lack of technical skills constitute the major constraints.

In view of these results, a communication on the contribution of trees in the management of development problems of cities and in the fight against global warming would be useful to correct the situation.

Acknowledgements

Our appreciation goes to Mr ALABI Arnold for his assistance in data collection. We also thank Mr YADES Arsène Jean de Dieu for their assistance with language style and grammatical errors checking.

Funding

This work was supported by the Scientific Council (CS) of the University of Abomey-Calavi (UAC).

Data availability

Raw data are available on reasonable request.

Conflict of interest statement. None declared.

Author contributions

Prucelle Elisée Zohoun (Conceptualization, Data curation, Investigation, Methodology, Writing—original draft, Writing—review & editing [lead]), Emilia M. Azalou-Tingbe (Funding acquisition [equal], Supervision [supporting], Validation [supporting], Visualization [supporting]), Soufouyane Zakari (Funding acquisition [equal], Supervision [supporting], Validation [supporting], Visualization [supporting]), and Ibouaïma Yabi (Funding acquisition [equal], Supervision [lead], Validation [lead], Visualization [lead]).

References

- Aguiar, A. C. (2012) ‘Urban Heat Islands: Differentiating between the Benefits and Drawbacks of using Native and Exotic Vegetation in Mitigating Climate’, Master of Science. Research thesis, School of Biological Sciences, University of Wollongong, p. 82.
- Akoègninou, A., Van der Burg, W. J., and Van der Maesen, L. J. G. (2006) *Flore Analytique du Bénin*, 1063 p. Cotonou et Wageningen: Backhuys Publishers.
- Arabomen, O. J. et al. (2021) ‘Residents’ Attitudes towards Tree Care Programs in Cityscapes’, *Revista Produção Desenvolvimento*, 7: 2446–9580. doi: [10.32358/rpd.2021.462](https://doi.org/10.32358/rpd.2021.462).
- Buisseres, G. et al. (2009) ‘Foresterie Urbaine’, in *Ordre des Ingénieurs Forestiers du Québec (éd) Manuel De Foresterie. 2è Edition. Ouvrage Collectif*, pp. 721–769. Québec: Edition multmondés.
- Carter, E. J. (1995) *L’avenir de la foresterie urbaine dans les pays en développement: un document de réflexion*, 52 p. Rome: FAO, Département des forêts.
- Dagnelie, P. (1998) ‘Statistique Théorique Et Appliquée’, *De Boeck Et Larcier, Belgique*, 2.
- Djibril, K. et al. (2012) ‘Evaluating Green Space Use and Management in Abidjan City, Cote D’Ivoire’, *International Journal of Economics and Management Engineering*, 2: 108–16.
- FAO (2012) « Etude sur la foresterie urbaine et périurbaine de N’Djaména, Tchad. Rôle et place de l’arbre en milieu urbain et périurbain » Appui à la formulation d’une stratégie et d’un plan d’action de la foresterie urbaine et périurbaine à N’Djaména, République du Tchad. Document de travail sur la foresterie urbaine et périurbaine n°6, 95 p. Rome.
- (2018) ‘Forests and Sustainable Cities’, *Unasylva*, 69: 3.
- Ganaba, S. (2020) ‘Floristic Diversity, Origins and Properties of City Trees in Burkina Faso’, *International Journal of Biological and Chemical Sciences*, 14: 1967–87.

- Garekae, H., Thakadu, O. T., and Lepetu, J. (2016) 'Attitudes of Local Communities towards Forest Conservation in Botswana: A Case Study of Chobe Forest Reserve', *International Forestry Review*, **18**: 180–91.
- INSAE (2016a) Cahier des villages et quartiers de ville du département des Collines (RGPH-4, 2013).
- (2016b) Cahier des villages et quartiers de ville du département du Borgou (RGPH-4, 2013).
- Ives, C. D. et al. (2017) 'Capturing Residents' Values for Urban Green Space: Mapping, Analysis and Guidance for Practice', *Landscape and Urban Planning*, **161**: 32–43.
- Jim, C. (2013) 'Sustainable Urban Greening Strategies for Compact Cities in Developing & Developed Economies', *Urban Ecosystems*, **16**: 741–61.
- Kyle, H. C., and Kimberly, A. N. (2013) 'Introducing Urban Food Forestry: A Multifunctional Approach to Increase Food Security and Provide Ecosystem Services', *Landscape Ecology*, **28**: 1649–69.
- Lahoti, S. et al. (2020) 'Vegetation Structure, Species Composition, and Carbon Sink Potential of Urban Green Spaces in Nagpur City, India', *Land*, **9**: 107.
- Mansell, M. G. (2003) *Rural and Urban Hydrology*. London: Thomas Telford Ltd.
- Mensah, C. A. (2014) 'Urban Green Spaces in Africa: Nature and Challenges', *Ecosystem*, **4**: 1–11.
- Moustier, P. et al. (1999) Agriculture périurbaine en Afrique subsaharienne. Actes de l'atelier, 20-24 avril 1998, Montpellier, France, Cirad, Coraf. Montpellier, France, Cirad, Colloques. 278 p.
- Ncutirakiza Ndamiyehe, J.-B. et al. (2017) 'Rôle, Présence Et Besoin D'arbres Dans le Paysage Urbain De Kinshasa', *Annales De l'UNIGOM*, **VII**: 87–102.
- Nowak, D. J., and Crane, D. E. (2002) 'Carbon Storage and Sequestration by Urban Trees in the USA', *Environmental Pollution*, **116**: 381–9.
- Ogunkalu, O. A. et al. (2017) 'Survey of Benefits and Constraints of Urban Trees in Kaduna Metropolis', *World News of Natural Sciences*, **11**: 19–27.
- Olaleye, D. O., Ayoade, O. J., and Omisore, E. O. (2013) 'A Multivariate Analysis of Factors Influencing Green Space Provision in Residential Neighbourhood of Sub-Saharan African Cities', *Environment and Earth Science*, **3**: 138–46.
- Pauleit, S., and Duhme, F. (2000) 'Assessing the Environmental Performance of Landcover Types for Urban Planning', *Landscape and Urban Planning*, **52**: 1–20.
- Seto, K. C., Güneralp, B., and Hutyra, L. R. (2012) 'Global Forecasts of Urban Expansion to 2030 and Direct Impacts on Biodiversity and Carbon Pools', *Proceedings of the National Academy of Sciences of the United States of America*, **109**: 16083–8.
- Watson, G. W., and Kelsey, P. (2006) 'The Impact of Soil Compaction on Soil Aeration and Fine Root Density of *Quercus Palustris*', *Urban Forestry & Urban Greening*, **4**: 69–74.
- Zohoun, P. E. et al. (2020) 'Diversity, Tree Structure and Description of Afforestation in the Urban Concessions of Parakou in Central Benin', *Journal of Applied Biosciences*, **154**: 15842–52.
- Zohoun, P. E. et al. (2021) 'Characterization of the Ecosystem Services Rendered to the Population by Trees in the City of Parakou in Central Benin', *Landscape Architecture and Regional Planning*, **6**: 8–18.