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Residents' Perceptions of the Importance of Urban and Peri-Urban Forests in Goma

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Abstract

Rapid urbanization in sub-Saharan Africa is reshaping human-environment interactions, particularly in rapidly growing cities such as Goma in eastern Democratic Republic of the Congo. In this context, urban and peri-urban forests play important socio-economic, environmental, and cultural roles. However, evidence on how residents perceive and interact with urban forests across urban and peri-urban settings remains limited in Central Africa. This study examines how residents perceive, use, and assess the importance of ecosystem services provided by urban and peri-urban forests in Goma. A structured household survey was conducted between 23 and 29 March 2026 among 869 households almost equally distributed between urban and peri-urban neighborhoods. Data were analyzed using descriptive statistics and Chi-square tests. Results show that provisioning services were the most recognized and valued ecosystem services in both contexts, particularly food supply and medicinal uses. Construction wood and fuelwood were more frequently emphasized in peri-urban areas, while urban residents more strongly recognized environmental services such as air quality improvement and shade provision. Urban and peri-urban forests were also associated with recreational, spiritual, and social functions, with relaxation representing the main motivation for visiting wooded spaces. Significant spatial differences were observed regarding perceptions of forest importance and attachment to urban forests. Urban residents perceived stronger impacts associated with forest loss and expressed greater willingness to financially support urban forest conservation, despite lower vegetation availability. Satisfaction levels were highest for services related to living environment quality and neighborhood attractiveness, whereas stress reduction emerged as the least satisfactory ecosystem service in both contexts.

These findings highlight the multifunctional importance of urban forests in Goma and emphasize the need for inclusive and context-specific urban forestry strategies integrating livelihood needs, environmental quality, and social well-being.

Keywords

Urban Forests, Ecosystem Services, Residents' Perceptions, Urban-Peri-Urban Gradient, Goma

1. Introduction

Rapid urbanization across sub-Saharan Africa is profoundly reshaping ecological systems and human-environment interactions, driven by demographic growth, land-use change, and expanding urban infrastructure (Mchale et al., 2013; Mumuni et al., 2026). In eastern Democratic Republic of the Congo (DRC), cities such as Goma are experiencing intense demographic pressure, rapid land transformation, and increasing environmental vulnerability, partly exacerbated by population displacements linked to ongoing regional instability (Ndamiyehe, 2026). In such contexts, urban and peri-urban trees and forests constitute key components of socio-ecological systems, contributing simultaneously to livelihoods, environmental quality, and climate resilience (Nowak et al., 2014; Nowak & Dwyer, 2007).

Urban forests refer to the assemblage of trees, shrubs, lawns, and other vegetated and permeable surfaces occurring within highly modified urban ecosystems, where human activities largely shape their composition, extent, and spatial distribution (Roy et al., 2012). They may occur as individual trees in residential compounds, roadside plantings, or forest patches located on private, public, or institutional land (Prabha et al., 2020). Urban trees and wooded spaces provide a broad range of ecosystem services in rapidly growing tropical cities. These include provisioning services such as food, fuelwood, medicinal products, and construction materials, but also environmental and regulating services related to air quality improvement, temperature regulation, noise attenuation, and climate mitigation through carbon storage and sequestration (Nowak & Van den Bosch, 2019; Prabha et al., 2020; Roy et al., 2012). In addition, urban forests contribute to social well-being through recreational, cultural, spiritual, and psychological functions (Cilliers et al., 2013; Shackleton et al., 2015).

Despite these multiple benefits, the relative importance attributed to urban and peri-urban forest ecosystem services often varies according to local socio-economic conditions, urbanization intensity, and access to natural resources. Understanding these perceptions is particularly important because local knowledge and attitudes toward trees can strongly influence environmental behaviors, including tree planting, conservation practices, and participation in urban greening initia-

tives (Kaudo et al., 2022). However, in the Democratic Republic of the Congo, empirical evidence regarding how urban populations perceive and value the different functions of trees and urban forests remains limited.

Existing studies conducted in sub-Saharan Africa nevertheless suggest that residents tend to prioritize ecosystem services directly linked to household livelihoods and daily well-being. In many African cities, trees remain strongly embedded in livelihood strategies, particularly in contexts characterized by economic insecurity and limited public infrastructure (Kiribou et al., 2024). Previous studies conducted in the DRC and elsewhere in the region have shown that urban and peri-urban populations frequently emphasize provisioning services, especially food production and medicinal uses (Ndamiyehe et al., 2017; Semeki Ngabinzeke et al., 2021). Although these functions are essential for household resilience, their predominance may reduce the recognition of broader ecological and regulating services, including biodiversity conservation and climate regulation.

At the same time, urban green spaces are increasingly recognized for their contribution to human well-being and urban livability. Urban and peri-urban forests may improve neighborhood attractiveness, provide spaces for recreation and social interaction, and contribute to psychological restoration and environmental comfort (Kabisch et al., 2015). Nevertheless, the extent to which residents are satisfied with these services, or perceive them as sufficiently provided, remains poorly documented in many African cities, including in the DRC. Similarly, the degree of attachment to urban and peri-urban forests, the perceived consequences of their degradation or disappearance, and the willingness of residents to support their conservation remain insufficiently explored.

Another important issue concerns spatial inequalities in access to and perceptions of urban forests along the urban-peri-urban gradient. Urban and peri-urban areas often differ substantially in terms of vegetation cover, land availability, settlement density, and environmental pressures (Gabriel et al., 2017). Such differences may influence not only the availability of trees and forests, but also the ecosystem services recognized by residents, the ways these spaces are used, and the level of satisfaction associated with them. Despite these important contrasts, comparative empirical studies explicitly examining urban-peri-urban differences in perceptions and interactions with urban and peri-urban forests remain scarce in Central Africa.

In Goma, recent studies have mainly focused on residential afforestation practices, barriers to tree planting, and the ecological dynamics of urban vegetation (Ndamiyehe, 2026). However, less attention has been given to the multifunctional roles attributed to urban forests and wooded spaces by residents themselves. Little is known about how urban and peri-urban populations perceive ecosystem services, use forested spaces, evaluate the quality of services provided, and express attachment to urban and peri-urban forests. Understanding how residents interact with and perceive these spaces is essential for identifying both pressures on urban and peri-urban forests, such as resource extraction or degradation, and op-

portunities for community-based management, conservation, and restoration initiatives (Kimaro & Lulandala, 2013).

Against this background, the present study primarily aims to analyze the importance attributed to trees and urban forests by residents of Goma, with particular attention to differences between urban and peri-urban areas. Beyond the perceived importance of trees, the study also examines the ecosystem services and functions recognized by residents, their levels of satisfaction with services provided by urban and peri-urban forests, and the degree of attachment and interaction of local populations with wooded spaces.

More specifically, the study addresses the following research questions:

1) What ecosystem services and functions of urban and peri-urban forests are recognized by residents in Goma?

2) What importance do residents attribute to urban and peri-urban forests, and to what extent are local populations attached to these wooded spaces?

3) To what extent are residents satisfied with the ecosystem services provided by urban and peri-urban forests in Goma?

4) How do these perceptions differ between urban and peri-urban neighborhoods of the city of Goma?

2. Materials and Methods

2.1. Study Area

The study was conducted in the city of Goma, located between 29.06˚ and 29.17˚ East longitude and between −1.70˚ and −1.60˚ South latitude, in eastern Democratic Republic of the Congo (**Figure 1**). The city lies at an altitude of approximately 1,500 meters above sea level and is characterized by a tropical highland climate, with an average annual rainfall of about 750 mm and a mean annual temperature of 25˚C.

Goma is experiencing rapid urban growth and strong demographic pressure, resulting in marked heterogeneity in land-use patterns and unequal access to green spaces. In 2024, the city's population was estimated at 1,202,356 inhabitants (Mairie de la Ville de Goma, 2024). However, the ongoing regional security crisis, marked by significant population movements to and from the city, particularly since January 2025, has likely altered these figures, although updated statistics are not yet available.

The city covers an area of approximately 62 km^2 and comprises both densely built urban areas (14 neighborhoods) and peri-urban zones (3 neighborhoods) characterized by higher vegetation cover (Ndamiyehe, 2026). In these peri-urban areas, land availability and tree presence are generally greater. Preliminary analyses of vegetation cover indicate levels exceeding 30% in peri-urban zones, compared to values ranging from 1.1% to 28.5% in urban areas. These contrasts provide a relevant framework for analyzing differences in tree-related practices, perceptions, and behaviors among residents.

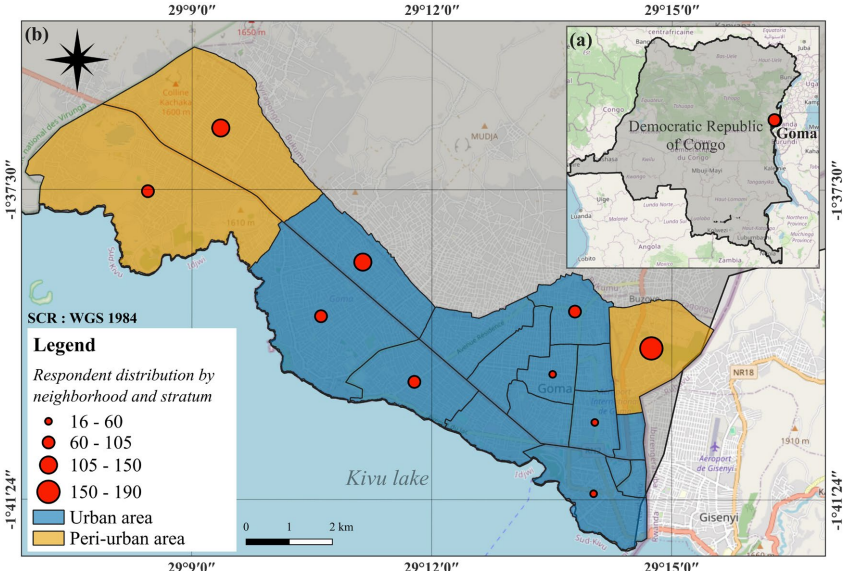

Figure 1. Study site map in (a) Democratic Republic of the Congo and (b) sample distribution across the study area, showing urban and peri-urban zones.

2.2. Sampling and Data Collection

Data were collected between 23 and 29 March 2026 through a structured household survey conducted in both urban and peri-urban areas of Goma. A stratified sampling design was adopted, using municipality type (urban vs peri-urban) as the primary stratification criterion. This approach ensured a balanced representation of respondents across the two settings and allowed for the analysis of potential differences in tree-related behaviors.

The sample size was determined to ensure adequate representativeness of the target population and diversity of responses. It was calculated using the following equation (Statitique-Canada, 2010).

$$n^* = \frac{N * t_\alpha^2 P(1-P)}{\left[N * k^2 + t_\alpha^2 P(1-P)\right]}$$

where N represents the total population size (1,202,356 inhabitants). The parameter k is the margin of error, reflecting presents a balance between desired precision and resources. It is often set a 5% or higher when resources are limited (Derra et al., 2023). In this case, a margin of error of 2.5% was adopted to ensure a more balanced distribution of respondents across strata (urban and peri-urban). The parameter ta denotes the critical value from the normal distribution, equal to 1.96 for a 95% confidence level. P represents the proportion of the target population. As one individual per household was surveyed and given the average household size of six in eastern DRC, P was targeted to 1/6.

The calculated sample size was 854 households. However, the final survey included 869 households, exceeding the target sample by 15 households. Although the sample size was initially determined proportionally to population size, the final allocation was designed to facilitate meaningful comparisons between urban

and peri-urban populations. Neighborhoods were classified into urban and peri-urban strata based on two complementary criteria: their geographical distance from the city center and their level of vegetation cover. According to Ndamiyehe (2026), urban neighborhoods in Goma are generally characterized by low vegetation cover (<30%), whereas peri-urban neighborhoods exhibit substantially higher vegetation cover (30% - 60%). To ensure balanced representation of perceptions across both environments, the final sample was distributed almost equally between urban (438 households) and peri-urban areas (431 households).

Within each stratum, households were selected across neighborhoods using a proportional allocation approach based on population distribution while taking accessibility conditions into account. In peri-urban areas, all three neighborhoods (Bujovu, Lac Vert, and Mugunga) were included in the survey. In urban areas, seven neighborhoods were selected: Himbi, Keshero, Les Volcans, Mabanga Nord, Majengo, Murara, and Ndosho.

To capture a broad range of perceptions regarding urban and peri-urban forests, the selection of sampled respondents also considered proximity to forested areas and the presence or absence of trees within residential compounds. Approximately one-third of respondents were selected from avenues located near urban or peri-urban forest patches. In addition, 23.1% of respondents surveyed (n = 201) lived in residences without trees, while the remaining respondents lived in residences containing one or more trees. This sampling strategy ensured the inclusion of individuals exposed to diverse environmental conditions and experiences. Within each selected residence, one respondent aged 18 years or older, was interviewed.

Data were collected using a structured questionnaire organized into several thematic sections, including:

- socio-demographic characteristics;
- perceptions and recognition of ecosystem services provided by urban and peri-urban forests;
- perceived importance of trees and forests;
- uses and visitation of forested spaces;
- attachment to urban forests and perceptions of forest loss;
- willingness to support urban forest conservation;
- satisfaction with ecosystem services provided by urban forests;

For variables related to the perceived roles and uses of urban and peri-urban forests, respondents were allowed to select multiple response options and identify all services they considered important or commonly used. Services were subsequently ranked according to the proportion of respondents citing them. As responses were not mutually exclusive, cumulative percentages may exceed 100%.

For perception and satisfaction variables, respondents were asked to indicate their level of agreement with a series of statements regarding the benefits of urban and peri-urban forests, including their contribution to mental well-being, living environment quality, attractiveness, neighborhood property values, daily stress

reduction, and local economic development. Responses were recorded using a five-category agreement scale comprising: "Strongly disagree", "Slightly disagree", "Moderately agree", "Agree", and "Strongly agree". Percentages were calculated and reported for each response category.

The questionnaire was pre-tested prior to implementation to ensure clarity and internal consistency. Data collection was conducted through face-to-face interviews by trained enumerators, improving data reliability and minimizing misinterpretation. Each interview lasted approximately 30 to 40 minutes, depending on the respondent's level of engagement. Data were collected using the KoboCollect v2024.2.4 mobile application (Harvard Humanitarian-Initiative, 2024).

2.3. Data Analysis

Survey data were cleaned, harmonized, and coded prior to statistical analyses. Descriptive statistics, including frequencies and percentages, were computed to characterize respondents' profiles and summarize perceptions, ecosystem service recognition, visitation patterns, attachment levels, and satisfaction with urban forest ecosystem services.

For multiple-response questions related to ecosystem services and forest functions, proportions were calculated independently for each response category using the total number of respondents within each municipality type as denominator. Ecosystem services were subsequently grouped into four major categories: provisioning services, environmental and regulating services, social and cultural services, and ecological services.

Comparisons between urban and peri-urban areas were conducted using Chi-square (χ^2) tests of independence to assess differences in perceptions of ecosystem service importance; visitation frequencies and attachment to urban and peri-urban forests; perceived impacts associated with forest loss; willingness to financially support urban and peri-urban forests conservation. Differences were considered statistically significant at $p < 0.05$.

Graphical representations were produced to illustrate contrasts between urban and peri-urban areas regarding recognized ecosystem services, forest uses, perceived importance, and satisfaction levels. Comparative bar plots and mirrored percentage charts were particularly used to facilitate visualization of differences between municipality types. All statistical analyses were conducted using the R software environment version 4.4.3 (R Core Team, 2025), with a significance level set at $p < 0.05$. Graphical outputs were produced using the ggplot2 package (Wickham, 2009).

3. Results

3.1. Respondent Profile

The sample comprised a total of respondents from both urban and peri-urban areas of Goma, with a relatively balanced gender distribution (54.4% male and 45.6% female) (**Table 1**). Most participants were aged between 31 and 40 years

(37.9%), followed by those aged over 50 years (33.7%) and 18 - 30 years (28.4%). In terms of education, most respondents had completed secondary education (42.4%), while a substantial proportion reported no formal education (23.1%) or university-level education (20.1%). Housing status indicated that the majority were property owners (60.8%), with the remainder being tenants (37.6%).

Regarding occupational profiles, respondents were predominantly engaged in small-scale trade (21.9%), followed by unemployment (16.8%), casual labor (10.1%), and farming activities (5.6%). Other occupations, including teaching, health services, and humanitarian work, were less represented. Overall, the sample reflects a diverse socio-demographic composition, with a predominance of economically active individuals and a relatively high proportion of respondents with at least secondary education (Table 1).

Table 1. Socio-demographic characteristics of respondents by municipality type.

Category	Modality	Peri-Urban	Urban	Total
Age	18 - 30 years	114 (26.45%)	133 (30.37%)	247 (28.42%)
	31 - 50 years	168 (38.98%)	161 (36.76%)	329 (37.86%)
	Over 50 years	149 (34.57%)	144 (32.88%)	293 (33.72%)
Education level	No formal education	128 (29.7%)	73 (16.67%)	201 (23.13%)
	Primary	47 (10.9%)	61 (13.93%)	108 (12.43%)
	Secondary	179 (41.53%)	189 (43.15%)	368 (42.35%)
	Graduate	69 (16.01%)	106 (24.2%)	175 (20.14%)
	Postgraduate	2 (0.46%)	6 (1.37%)	8 (0.92%)
	Other (specify)	6 (1.39%)	3 (0.68%)	9 (1.04%)
Gender	Female	200 (46.4%)	196 (44.75%)	396 (45.57%)
	Male	231 (53.6%)	242 (55.25%)	473 (54.43%)
Housing status	Tenant	174 (40.37%)	153 (34.93%)	327 (37.63%)
	Owner	256 (59.4%)	272 (62.1%)	528 (60.76%)
	Other (specify)	1 (0.23%)	13 (2.97%)	14 (1.61%)

3.2. Recognized Ecosystem Services and Functions of Urban Forests

Residents of Goma recognized a broad range of ecosystem services and functions provided by urban and peri-urban forests, with provisioning and environmental services being the most frequently cited (Figure 2). Food supply emerged as the most recognized ecosystem service in both peri-urban (81.7%, $n = 352$) and urban neighborhoods (86.3%, $n = 378$).

Other commonly recognized provisioning services included traditional medicine, construction wood, and energy wood. Marked differences were observed between the two spatial contexts. Construction wood was more frequently recognized in peri-urban areas (47.1%, $n = 203$) than in urban neighborhoods (19.9%,

n = 87), whereas traditional medicine was more frequently reported in urban areas (55.0%, n = 241) compared with peri-urban areas (44.8%, n = 193).

Environmental and regulation services were also widely acknowledged by respondents. Air quality improvement was recognized by 46.9% (n = 202) of peri-urban respondents and 55.0% (n = 241) of urban respondents, while shade and cooling services were reported by 42.9% (n = 185) and 49.1% (n = 215), respectively. In contrast, ecological services such as biodiversity conservation and soil fertility improvement remained comparatively less recognized, with proportions generally below 10% in both urban and peri-urban areas.

Urban and peri-urban forests were also associated with multiple social and recreational functions. Among respondents who reported regularly visiting forested spaces, the use of wooded areas as resting places (relaxation and leisure) represented the dominant motivation in both peri-urban (62.0%, n = 267) and urban areas (66.0%, n = 289). Places of worship, where local populations conduct religious activities, also constitute one of the most frequently reported reasons for visiting forested areas, particularly in peri-urban neighborhoods (28.0%, n = 121) compared with urban areas (19.0%, n = 83). Spatial differences were also observed for other functions. Nature observation was more commonly cited in peri-urban areas (16.0%, n = 69) than in urban neighborhoods (9.9%, n = 43), whereas cultural and sports-related activities were more frequently reported in urban areas.

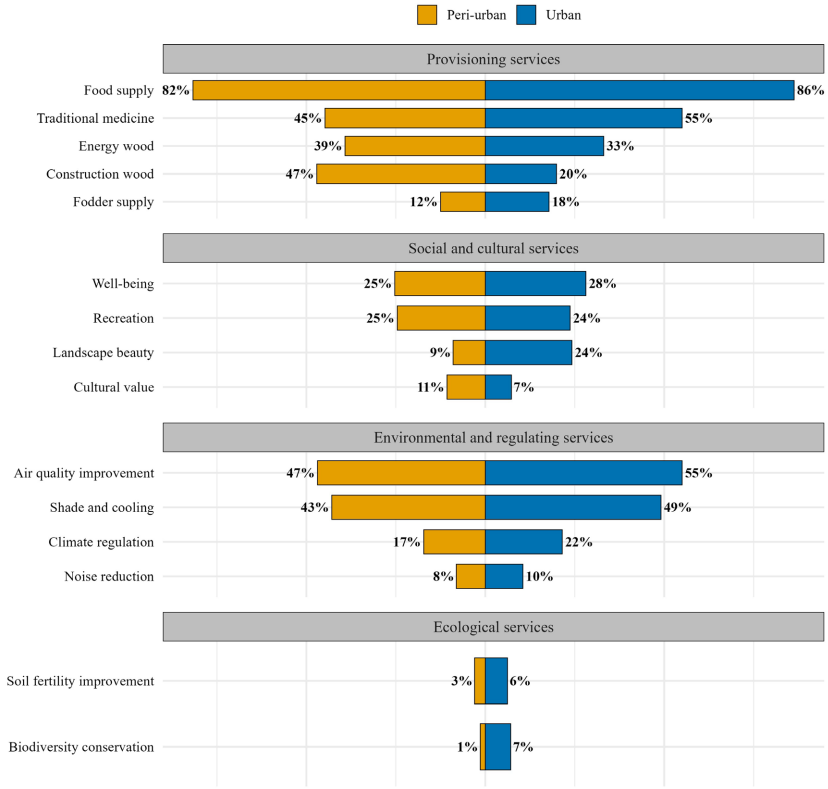

Figure 2. Ecosystem services provided by urban and peri-urban forests as perceived by residents in Goma. Results are based on multiple-response questions, meaning that respondents could select more than one ecosystem service category.

3.3. Perceived Importance of and Attachment to Urban Forests

The ecosystem services perceived as most important by respondents were mainly related to subsistence and environmental well-being (Figure 3). Fruit provision was identified as the most valued service in both peri-urban (72.4%) and urban neighborhoods (77.8%). Medicinal functions were also frequently prioritized, particularly in urban areas (42.9%) compared with peri-urban areas (33.9%). Conversely, provisioning functions related to energy wood and construction materials were more strongly emphasized in peri-urban neighborhoods (25.8% and 26.4%, respectively) than in urban areas (14.8% and 10.5%).

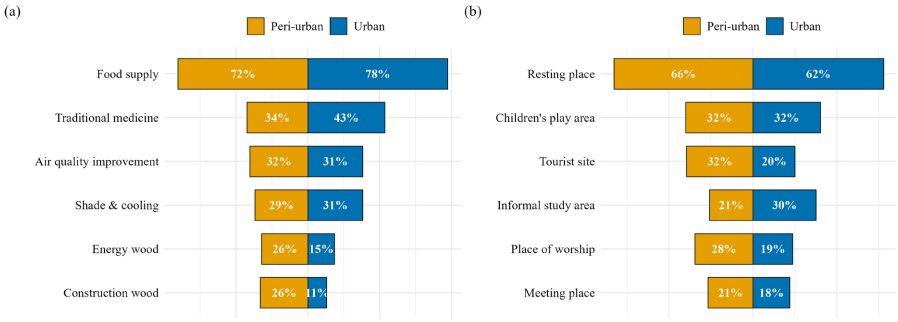

Figure 3. (a) Roles of trees perceived as most useful; (b) Main uses of wooded sites reported by the population of the city of Goma.

Approximately 63.7% of respondents ($n = 554$) reported regularly visiting urban and peri-urban forests. The proportions were comparable between urban neighborhoods (62.1%, $n = 272$) and peri-urban neighborhoods (65.4%, $n = 282$) (Figure 4), with no statistically significant difference observed between the two groups ($\chi^2 = 0.902$, $p = 0.342$). Access to forested areas was predominantly free of charge (68.5%), whereas paid access represented 27.0% of responses and mixed or negotiable access conditions accounted for 4.8%.

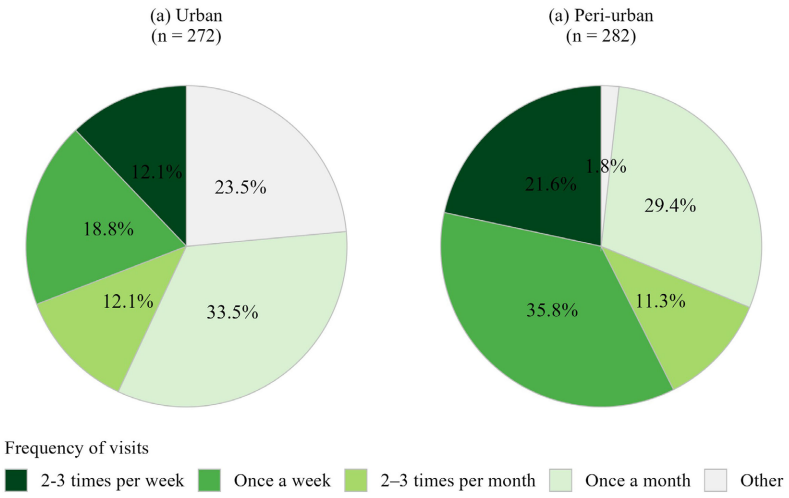

Figure 4. Reported frequency of visits to urban and peri-urban forests by residents in Goma.

Respondents generally perceived the disappearance of trees and forests as having important consequences on their daily lives (Table 2). Perceptions differed significantly between urban and peri-urban residents ($\chi^2 = 92.05$, $p < 0.001$). Very high impacts associated with forest loss and related ecosystem functions were reported by 52.7% of urban respondents ($n = 231$), compared with 30.2% ($n = 130$) in peri-urban areas. In contrast, moderate impacts were more frequently reported in peri-urban neighborhoods (41.5%, $n = 179$) than in urban areas (13.9%, $n = 61$).

These perceptions were also reflected in respondents' willingness to support urban and peri-urban forests conservation and maintenance efforts. Willingness to financially contribute to the maintenance and reinforcement of urban and peri-urban forests differed significantly between the two contexts ($\chi^2 = 142.1$, $p < 0.001$). Positive responses ("Yes") were reported by 47.7% of urban respondents ($n = 209$), compared with 42.2% ($n = 182$) in peri-urban areas. Conversely, refusal to contribute financially was substantially higher in peri-urban neighborhoods (43.6%, $n = 188$) than in urban areas (11.2%, $n = 49$).

Table 2. Residents' willingness to financially support urban forests and perceived impacts of forest loss in Goma.

Variable	Modality	Peri-Urban	Urban	Statistical Comparison
a) Are you willing to contribute financially to maintain and strengthen the presence of trees and forests in the city?	No	188 (43.6%)	49 (11.2%)	$\chi^2 = 142.1$ $p < 0.001$
	Yes	182 (42.2%)	209 (47.7%)	
	Maybe	61 (14.2%)	180 (41.1%)	
b) What impact would the loss of trees and forests have on your daily life?	No impact	3 (0.7%)	0 (0%)	$\chi^2 = 92.05$ $p < 0.001$
	Low impact	22 (5.1%)	25 (5.7%)	
	Moderate impact	179 (41.5%)	61 (13.9%)	
	High impact	97 (22.5%)	121 (27.6%)	
	very high impact	130 (30.2%)	231 (2.7%)	

3.4. Satisfaction with Ecosystem Services Provided by Urban Forests

The results reveal contrasting levels of satisfaction with the ecosystem services provided by urban and peri-urban forests in Goma, with substantial differences observed both across service categories and between urban and peri-urban areas (Figure 5).

The highest levels of satisfaction were associated with improvements in living environment quality and neighborhood attractiveness. In urban areas, the combined proportions of respondents expressing high to very high satisfaction ("Agree" and "Strongly agree") reached 54.6% for improvements in living environment quality and 41.4% for neighborhood attractiveness. In peri-urban areas, perceptions also remained generally positive, although responses were more frequently concentrated around moderate satisfaction levels. Nevertheless, 33.6% of peri-ur-

ban respondents reported high to very high satisfaction regarding improvements in living environment quality.

Economic-related ecosystem services were also more positively evaluated in urban neighborhoods. Approximately half of respondents expressed high to very high satisfaction regarding increases in neighborhood property value associated with urban and peri-urban forests, while satisfaction with the contribution of urban forests to local economic development reached about 56%. In peri-urban areas, positive perceptions remained comparatively lower and were largely dominated by moderate satisfaction levels.

Conversely, stress reduction emerged as the least satisfactory ecosystem service in both spatial contexts. In peri-urban areas, 62.4% of respondents expressed slight or strong dissatisfaction regarding the role of urban and peri-urban forests in reducing daily stress. Dissatisfaction levels also remained relatively high in urban neighborhoods (42.0%).

Mental well-being services occupied an intermediate position. In urban areas, 41.1% of respondents expressed high to very high satisfaction with the contribution of urban and peri-urban forests to mental well-being, compared with 28.3% in peri-urban areas.

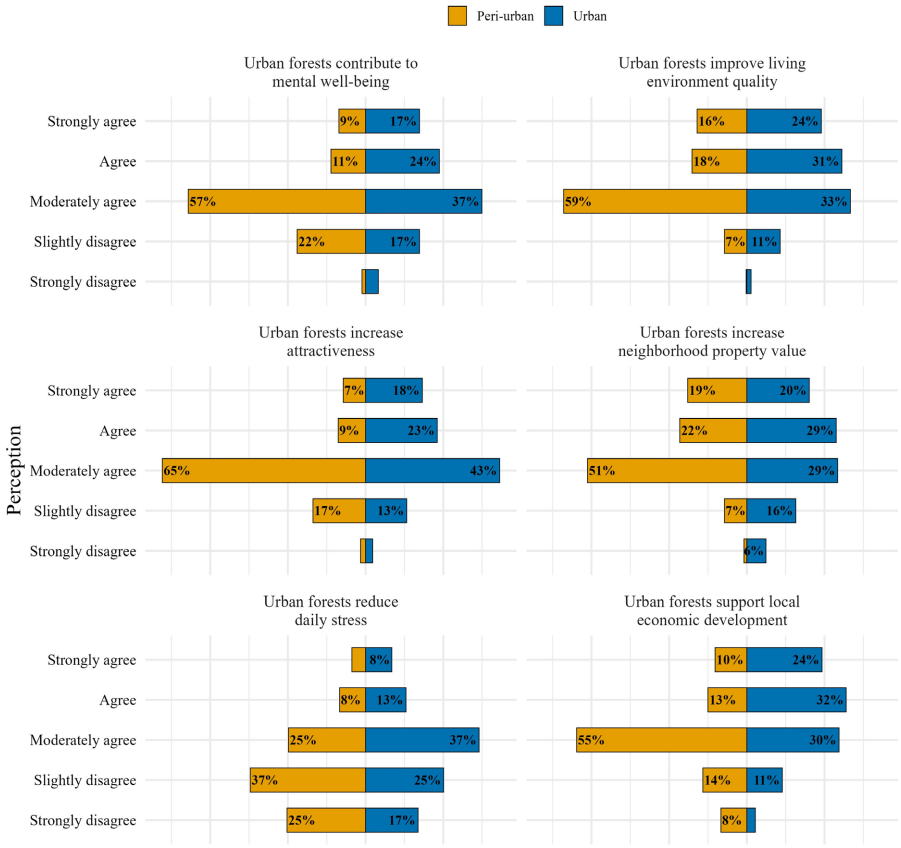

Figure 5. Levels of satisfaction with urban and peri-urban forests ecosystem services in urban (n = 438) and peri-urban (n = 431) areas of Goma. Percent labels below 5% were omitted from the graphs for clarity purposes.

4. Discussion

This study provides new empirical evidence on residents' perceptions, uses, and evaluations of urban and peri-urban forests in Goma, eastern DRC. By explicitly comparing urban and peri-urban contexts, the findings highlight substantial differences in the ecosystem services recognized, the functions attributed to wooded spaces, levels of satisfaction with ecosystem services, and attachment to urban and peri-urban forests of Goma. Overall, the results emphasize the multifunctional importance of urban forests while also revealing strong socio-spatial contrasts in the ways residents interact with and value these environments.

4.1. Multifunctional Importance of Urban Forests and Predominance of Provisioning Services

The results indicate that provisioning services constitute the most widely recognized and prioritized ecosystem services in both urban and peri-urban areas. Food provision emerged as the dominant ecosystem service recognized by respondents, followed by medicinal uses, energy wood, and construction wood. These findings confirm the strong integration of urban trees and forests into household livelihood strategies in rapidly urbanizing African cities. Similar patterns have been reported in Kinshasa (Ndamiyehe et al., 2017; Semeki Ngabinzeke et al., 2021) and other sub-Saharan African urban contexts, where urban vegetation contributes directly to food security, subsistence needs, and income diversification (Kiribou et al., 2024).

The predominance of provisioning services likely reflects the socio-economic realities of Goma, where many households face economic insecurity and limited access to formal resources. In such contexts, urban and peri-urban forests are not only perceived as ecological infrastructures, but also as essential livelihood-support systems. This situation may have been reinforced by recurrent security crises in eastern DRC, which have led to large-scale population displacements toward Goma and the establishment of numerous internally displaced persons (IDP) camps around the city, hosting hundreds of thousands of displaced people (UNHCR, 2025). In this context, the relatively high importance attributed to construction wood in peri-urban areas may also be associated with the establishment and expansion of these camps, which increases the demand for temporary shelter materials and fuelwood.

Urban and peri-urban forests were also strongly associated with recreational, spiritual, and social functions. Relaxation and leisure emerged as the principal motivations for visiting forested spaces in both spatial contexts, while religious activities represented another important use category. These findings support previous observations showing that urban green spaces in African cities often fulfill multifunctional social roles extending beyond ecological or productive functions (Cilliers et al., 2013; Shackleton et al., 2015).

At the same time, the coexistence of provisioning, recreational, environmental, and spiritual expectations highlights the multifunctional but potentially compet-

ing roles attributed to urban and peri-urban forests in Goma. Urban forests are simultaneously perceived as spaces for resource extraction, environmental regulation, social interaction, and psychological well-being. Such multifunctionality may create important management trade-offs between conservation objectives, recreational functions, and productive uses, particularly in contexts characterized by strong demographic pressure and limited urban land availability.

In contrast, ecological services such as biodiversity conservation and soil fertility improvement were only marginally recognized by respondents. This limited recognition of supporting and ecological services has also been documented in other developing urban contexts (Roy et al., 2012). Such patterns suggest that residents tend to prioritize direct and tangible benefits over less immediately perceptible ecological functions. This imbalance may also reflect the limited development of environmental education and public awareness programs related to the ecological roles of urban trees and forests, a challenge already highlighted in previous studies conducted in Goma and other cities of the Democratic Republic of the Congo (Kaudo et al., 2022; Ndamiyehe et al., 2017). Although understandable from a livelihood perspective, this limited recognition of ecological functions may reduce public support for biodiversity-oriented urban forestry strategies and long-term ecological restoration initiatives.

4.2. Urban-Peri-Urban Differences in Perceived Importance and Attachment to Forests

The results revealed marked differences between urban and peri-urban residents regarding the perceived importance of urban forests and attachment to wooded spaces. Urban respondents more frequently reported very high importance associated with the presence of urban and peri-urban forests in their neighborhoods, perceived stronger impacts related to forest loss, and expressed greater willingness to financially support conservation initiatives. In contrast, peri-urban respondents generally expressed more moderate perceptions regarding both the importance of forests and the consequences of their disappearance. Although peri-urban neighborhoods in Goma generally contain greater vegetation cover, urban residents appeared to attribute greater importance to the remaining green spaces available in densely built environments. These findings may suggest that green spaces acquire greater perceived value when access to vegetation becomes limited in highly urbanized settings.

Such patterns are consistent with studies showing that green spaces tend to acquire greater social and environmental value in urban contexts where vegetation becomes relatively scarce (Wolch et al., 2014). In Guangzhou, China, Jim & Chen (2006) reported that urban residents strongly valued the environmental and recreational functions of urban green spaces despite increasing urban pressure on vegetation. Their study particularly highlighted the importance attributed to environmental quality improvement, aesthetic value, and recreational opportunities in densely populated neighborhoods.

The results observed in Goma may also be linked to the environmental functions expected from green spaces in urbanized environments. A systematic review conducted by (Bowler et al., 2010) demonstrated that parks and tree-covered areas generally remain cooler than surrounding built-up areas and contribute to local thermal regulation. Urban green spaces are also widely recognized for their contributions to environmental quality, public health, and psychological well-being, particularly in neighborhoods where access to vegetation is limited (Kabisch et al., 2015; Wolch et al., 2014). In the context of Goma, these functions may reinforce the perceived value of remaining wooded spaces within densely urbanized neighborhoods.

Beyond environmental and recreational functions, respondents also strongly emphasized livelihood-related benefits associated with urban and peri-urban forests. The predominance of provisioning and directly beneficial ecosystem services observed in Goma is consistent with findings reported in other tropical African cities. In urban and peri-urban Kinshasa, Gabriel et al. (2017) found that residents mainly associated trees with tangible livelihood-related functions, particularly fruit production and shade provision. Their study further showed that fruit production represented one of the principal motivations for tree planting and agroforestry adoption among urban households. Similar tendencies were observed in the present study, where food supply, medicinal resources, energy wood, and construction materials emerged among the most recognized ecosystem services associated with urban forests. These findings suggest that, in rapidly urbanizing tropical contexts, urban and peri-urban forests are strongly integrated into household livelihood systems and daily survival strategies.

In contrast to these highly valued provisioning services, ecological services such as biodiversity conservation and soil fertility improvement remained weakly recognized by respondents in Goma. Similar observations were reported in Kinshasa by Gabriel et al. (2017), where respondents primarily emphasized utilitarian functions of trees while ecological functions received comparatively limited attention. This pattern may reflect the predominance of immediate household needs and livelihood concerns in contexts characterized by economic vulnerability and limited environmental awareness programs.

Peri-urban respondents also tended to report more moderate perceptions regarding the impacts associated with forest loss and lower willingness to financially contribute to urban and peri-urban forests maintenance. Similar urban-peri-urban gradients in ecosystem service perceptions have been described in studies showing that ecosystem service provision varies substantially according to vegetation cover and urban structure across cities (Larondelle & Haase, 2013). In greener environments, certain ecosystem benefits may be perceived as more accessible and therefore less threatened than in highly urbanized neighborhoods.

The high proportion of respondents regularly visiting urban and peri-urban forests further confirms the important social role of wooded spaces in Goma. Urban green spaces in African cities frequently provide multiple ecosystem services

simultaneously, including recreation, cultural functions, social interaction, and household well-being (Cilliers et al., 2013). This multifunctionality was also evident in the present study, where relaxation and leisure represented the principal motivations for visiting forests in both urban and peri-urban areas. Similarly, Shackleton et al. (2015) emphasized that urban green spaces in African cities are closely associated with recreation, spirituality, and socio-cultural practices that contribute to residents' well-being.

However, the activities associated with forest use differed between the two spatial contexts. Nature observation was more frequently reported in peri-urban areas, whereas cultural and sports-related activities were more common in urban neighborhoods. In Berlin, Kabisch & Haase (2014) observed that the use and appreciation of urban green spaces vary according to accessibility, spatial organization, and socio-demographic context. In Goma, the stronger orientation toward nature observation in peri-urban areas and toward cultural and sports activities in urban neighborhoods likely reflects differences in settlement density, accessibility, and everyday interactions with wooded spaces across the urban-peri-urban gradient.

4.3. Satisfaction with Ecosystem Services Provided by Urban

The findings reveal substantial differences in satisfaction levels across ecosystem service categories and between urban and peri-urban areas. Satisfaction was highest for services related to living environment quality, neighborhood attractiveness, and local economic development, particularly among urban respondents. These results indicate that urban residents perceive urban and peri-urban forests as important contributors to environmental quality, neighborhood attractiveness, and urban livability.

The comparatively higher levels of satisfaction observed in urban neighborhoods may appear paradoxical given the generally lower vegetation cover in these areas. However, this may again reflect the higher relative value attributed to existing green spaces in densely urbanized environments, where ecosystem services become more visible and socially appreciated because of their scarcity.

At the same time, the coexistence of high perceived importance and only moderate satisfaction levels suggests that existing urban and peri-urban forests may not fully meet residents' expectations and needs. This may reflect insufficient green space availability, unequal spatial distribution of vegetation, environmental degradation, or limited accessibility to well-managed wooded areas.

Conversely, stress reduction emerged as the least satisfactory ecosystem service in both urban and peri-urban contexts. This suggests that, despite the recognized environmental and recreational roles of urban and peri-urban forests, current green spaces may remain insufficient to adequately address psychosocial pressures associated with rapid urbanization, insecurity, and densely populated living conditions in Goma. Similar limitations regarding the mental restoration potential of urban green spaces have been observed in other rapidly urbanizing cities characterized by high socio-environmental stress (Kabisch et al., 2015).

Mental well-being services occupied an intermediate position, with higher levels of positive satisfaction observed in urban areas. This again suggests that urban populations may experience stronger perceived psychological benefits from green spaces due to the relative scarcity of vegetation in highly built environments.

4.4. Implications for Urban Forestry Governance and Planning

The findings of this study have important implications for urban forestry policies and green infrastructure planning in Goma and similar African cities. First, the predominance of provisioning functions highlights the need to integrate livelihood considerations into urban forestry strategies. Urban greening initiatives that neglect residents' subsistence needs may be limited to local support, particularly in economically vulnerable contexts.

Second, the relatively limited recognition of ecological services indicates the importance of strengthening environmental awareness regarding the broader ecological functions of urban forests, particularly biodiversity conservation, climate regulation, and long-term ecosystem resilience.

Third, the strong attachment expressed by urban residents toward trees and forests suggests that urban populations may support policies aimed at conserving and expanding green infrastructure, provided that these interventions remain socially accessible and contextually adapted. In densely urbanized neighborhoods, small-scale greening initiatives such as roadside tree planting, community green spaces, and pocket forests could substantially improve environmental quality and residents' well-being (Vergriete & Labrecque, 2007).

In peri-urban areas, urban forestry strategies may benefit from integrating multifunctional approaches combining environmental conservation with livelihood-support functions, including agroforestry systems, community woodlots, and sustainable resource management practices.

Overall, the findings suggest that urban and peri-urban forests in Goma are not only ecological infrastructures, but also essential socio-economic, cultural, and psychological assets whose perceived importance varies across the urban-peri-urban gradient. Understanding these differentiated perceptions is therefore critical for designing inclusive, socially accepted, and context-adapted urban forestry strategies capable of strengthening urban resilience in rapidly growing and environmentally vulnerable African cities.

5. Conclusion

This study provides new insights into the perceived importance and ecosystem services associated with urban and peri-urban forests in the rapidly growing city of Goma, Democratic Republic of the Congo. The findings highlight the multifunctional importance of urban forests for local populations. Provisioning services, particularly fruit supply and medicinal resources, emerged as the most recognized and valued functions. Environmental and social benefits such as air quality improvement, shade provision, recreation, and spiritual uses were also acknowledged.

Important differences were observed between urban and peri-urban areas. Urban residents expressed stronger attachment to trees and forests, perceived greater impacts associated with forest loss, and showed higher willingness to support urban and peri-urban forest conservation despite generally having lower access to vegetation and wooded spaces. These results suggest that the perceived importance of urban and peri-urban forests may increase under conditions of relative scarcity in densely urbanized environments.

Overall, the study shows that urban and peri-urban forests in Goma are perceived not only as ecological infrastructures, but also as important socio-economic, cultural, and psychological assets. Effective urban forestry strategies should therefore combine livelihood support, environmental conservation, and socially inclusive greening approaches adapted to local contexts. Future research should integrate ecological, spatial, and social approaches and expand comparative analyses across other rapidly urbanizing cities.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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