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Urban Forest Sustainability in Residential Areas in the City of Santo Domingo

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Abstract: Cities are territories vulnerable to climate change. An alternative to increase resilience and mitigate the effects of the climate context is urban forest planning to increase ecosystem services. This research constructed a forest cover sustainability index, based on 147 semi-structured interviews with residents of four residential areas of the city of Santo Domingo (Gazcue, Zona Colonial, Ciudad Nueva, and San Carlos), in which information was collected based on both benefit perception and tree management in their home and nearby public areas. The socioeconomic characteristics of the population and the information gathered from the measurements of the urban forest in both public and private areas of the city during the 2016–2019 period were considered, including these four residential areas, which established the ecosystem services provided by the urban forest. The results showed that Gazcue had a higher value in the forest cover sustainability index. The factors that influenced this result were: job stability, medium-high income, and property ownership. Likewise, the added value of the territory, whether in terms of tourism or the socioeconomic value of the population that inhabits it, is closely related to a greater attention to urban planning, prioritizing the conservation and landscape harmony that the arboreal component can provide. In conclusion, urban forest planning in cities should consider tree species, the design and structure of spatial arrangements, and a competent legal framework that can meet the challenges of territorial sustainability and contribute to the resilience and mitigation of climate change impacts.

Keywords: sustainability; urban forest; ecosystem services; climate change; urban planning

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1. Introduction

According to the United Nations data, cities occupy 3% of the planet's surface, are home to approximately 60% of the world's population, and consume about 75% of the natural resources [1]. From the 18th century to the present day, the urban expansion model has been perpetuated, favoring industry and displacing new neighborhoods to the cities' periphery, and absorbing new territories [2]; the continuous expansion and the demand for food increase competition for the natural resources of rural lands [3].

Cities are a social construction integrated by natural components such as water, soils, and trees, which are substantially modified due to city infrastructure; these actions put urban populations at risk in the current context of climate change, where rising temperatures, heat and cold waves, as well as disasters have more severe impacts in cities devoid of trees [4].

Urban forest influences urban environmental conditions, providing ecosystem services reflected in improved air quality, shade, microclimate, reduced atmospheric pollutants, which contribute to human well-being and increased property values in urban environments [5–7]. Therefore, urban planning processes should focus on cities' sustainability and present and future needs of services, infrastructure, communication, and green spaces [2,8].

The urban forest is undoubtedly an indispensable component for cities' sustainability [9] and socioenvironmental and emotional well-being, although the latter is rarely considered or valued [10]. However, the design of the spatial arrangement and structure of the tree component in the city is variable; it directly influences the quality and quantity of ecosystem services that can be provided to the urban area [11].

The dichotomous conflict between the environment and urbanization is mainly caused by factors such as the absence or poor urban planning, poor selection of tree species, and lack of studies or inadequate application of these in public spaces [12,13]. Although the concepts of sustainability and governance have been discursively included in urban development frameworks, the lack of technical–administrative capacities of governments limit proper implementation, good management, and planning in cities; this is added to the deficiency of public policies that contribute to improving ecosystem services in the urban context, resilience, and mitigation of the effects of climate change [14,15].

The main problems faced by cities have been documented over time, as well as how urban forest can be a strategy for adaptation and mitigation to climate change; some of the benefits they provide are: increased soil infiltration capacity; decreased stormwater runoff; conservation, restoration, and increase of flora and fauna; a decrease in temperatures in urban areas (differentiated according to the presence of forest cover), improved air and water quality; and increased socioemotional well-being of the population [10,16–19].

In developing countries, there are few environmental assessments in the urban context, mainly due to the lack of baseline information on the effects of urbanization on the environmental component and urban life quality [4]. Although several plausible studies have been carried out for the evaluation and monitoring of the benefits and ecosystem services provided by the urban forest, a framework of specific indicators has yet to be established, which should also comprehend the inclusion of different social actors who can cooperate in the planning, maintenance, and monitoring of the forest resource [20,21]. This work attempts to advance along these lines, focusing the object of study on a geographical area especially conditioned by extreme weather events: the Caribbean and, more specifically, in Santo Domingo.

In the Dominican Republic, the factors that have contributed to the increase in temperature (from 0.8 to 1.5 °C), change in soil permeability, increase in the frequency of floods, and other meteorological phenomena that have impacted the city of Santo Domingo during 1995–2018 are urban development, poor urban planning, loss of trees in private homes due to the sale of these lands for building construction, and land replacement with asphalt [13]. Understanding what factors influence the population to conserve trees in homes or public spaces and how this is reflected in the sustainability of urban forest cover is crucial to promote public policies that contribute to the conservation of urban forests in cities as a strategy to promote resilience and adaptation in the urban context in the face of climate change.

As we have previously stated, this research aims to further data collection to support policy decisions, identifying a sustainability index of forest cover in four urban areas of Santo Domingo, Dominican Republic. For this, we will analyze the perception of the population concerning the benefits of the urban forest, their management, socioeconomic characteristics of the different zones, and analysis of urban forest measurements, with the use of the iTree tool, to estimate the ecosystem services of the forest cover of each urban zone.

The Dominican Republic is a very vulnerable country to the effects of climate change such as floods, severe and frequent drought events, alteration of rain patterns, and the urban island effect. The urban forest may help to tackle some of the issues and challenges faced by residents in modern cities, including lack of human well-being, inequity in access to green areas and recreational spaces, food sovereignty, and accelerated urban sprawl [22]. However, to view and acknowledge the urban forest as an effective element within cities to better adapt and mitigate climate change, a comprehensive understanding and widespread dissemination among citizens and local authorities on the services and benefits given by the urban forest is critical. The research addresses an emerging topic of research at a local and global level in a transdisciplinary way.

The rest of the document is organized as described below. The second section describes the materials and methods used for this research, beginning with a description of the geographical area where the work is located. Hereunder, the results obtained are presented and discussed, with different maps representing the analysis in the selected areas. Lastly, the main conclusions of the research are presented. The results will provide elements for scientific work and information to advance the country's 2030 agenda, the national development strategy, the national climate change policy, and the Sustainable Development Goals.

2. Materials and Methods

2.1. Study Area General Description

The Dominican Republic is located on Hispaniola, the second largest of the Greater Antilles in the Caribbean Sea Basin. Its geographical coordinates are 17°36′ and 19°58′ N and 68°19′ and 72°01′ W, located in the northern hemisphere, south of the Tropic of Cancer. The city of Santo Domingo, founded in 1508 during the Spanish colonial period, located on the western bank of the Ozama River, is the capital of the country [23]. This research was carried out in the eldest sectors of the city of Santo Domingo: Zona Colonial, Ciudad Nueva, San Carlos, and Gazcue, belonging to the National District of the city of Santo Domingo.

2.1.1. Zona Colonial (Colonial Zone)

The Colonial Zone of Santo Domingo is the eldest in Latin America and served as a model of urbanization for other colonial cities. Founded in 1496, functioning as a link between Spain and the New World, with a port on the Ozama River from where explorations were directed to territories such as Cuba, Mexico, and South America [24]. By the end of the 16th century, after the exhaustion of the gold reserves of the Colonial Zone, it was gradually marginalized and isolated, moving the commercial and exploration links to the western margin of the same river, by Nicolás de Ovando. It was the first permanent European settlement on the American continent and the seat of the government of the Crown of Castile in the New World. It preserves the most important buildings of the sixteenth century, which is why UNESCO declared it a World Heritage Site. It has a walled city where the expansion of the city of Santo Domingo took place from the 16th to the 18th century. Nowadays, it is a tourist area visited by more than one million people annually [23].

The industrial growth model of Santo Domingo led to a restructuring of the territorial space, with the political–administrative and commercial functions shifting to the Colonial Zone. The middle and upper social classes moved to the west of the city. At the same time, the poor population settled in the lowlands at a short distance from the Colonial Zone, expanding a belt of precariousness. By the 1980s, the tourism development trend restructured the urban system of the territory. In the following decades, after the eighties, the lack of infrastructure maintenance and tenancy promoted the deterioration of the architectural heritage. It brought problems of water management, garbage collection, and contamination of the Ozama River [24].

2.1.2. Ciudad Nueva

This was the first sector outside the walls of the city of Santo Domingo, and its first blueprint was drawn by the engineer J.M. Castillo in 1884, the streets being marked with numbers at the beginning. Its origin marked a milestone in an ancient city; due to the socioeconomic needs of an urban expansion, it overflowed its walls. It was considered a "colonial zone's patio" because of the marginal recreational environment provided on the west side of the walls. The sector has a population of 12,540 inhabitants [23].

2.1.3. San Carlos

It is bordered to the north by Villa Francisca and Villa Consuelo, to the west by San Juan Bosco and Gazcue, to the south by Ciudad Nueva, and to the east by Colonial City. It has 10,843 inhabitants [23]. Migrants populated San Carlos, and indigenous people highly poor and marginalized, whose main occupation was to work the land as peasants, supplying primary food products to Santo Domingo [25].

2.1.4. Gazcue

This sector is recognized as an area of urban and architectural heritage declared as such in 2013 by the City Council of the National District; this regulation sought to recover and revitalize its residential character, promote sustainable urban development, and preserve elements of heritage interest [26]. It is considered one of the eldest sectors of Santo Domingo, populated by upper-middle-class individuals, with a population of 12,562 inhabitants [23].

We know today's Gazcue is a territory outlined as a suburban settlement in the early twentieth century. This sector has gone from housing high-income social classes, as well as great floristic and landscape richness that led it to be called an "urban garden", to being a space of constant clash between the conservation of the natural beauty of the place and the real estate development that is deteriorating the territory through the construction of housing infrastructure mainly for the exploitation of the surplus-value of the territory [26].

2.2. Methodology

One hundred and forty-seven (147) semi-structured interviews were conducted with residents of the study areas, distributed into 30 interviews in Zona Colonial, 39 in Ciudad Nueva, 30 in Gazcue, and 48 in San Carlos. In these interviews, information was collected on the perception of the benefits and management of forest in their homes and public areas and the interviewee's socioeconomic characteristics (Table 1).

Table 1. Variables considered for the interviews in the four sectors of Santo Domingo (possible recorded responses are described in parentheses).

Socioeconomic	Environmental Perception	Forest Quality
Gender (female, male)	Likes trees inside their property (yes/no)	Green Index (green infrastructure/population density)
Type of housing (owned, rented, leased, borrowed, other)	Sowing/planting (yes/no)	Number of trees
Yard type (gray *, gray–trees, plants)	Knows who is responsible for public green areas maintenance (yes/no)	Forest cover (%) **
Marital status (married, unmarried, single, divorced, widowed)	Fertilizes their garden (yes/no)	Percentage of trees less than 15.2 cm in diameter
Occupation (unemployed, public employee, private employee, tradesman, self-employed, pensioner)	Pays for gardener services (yes/no)	Pollution removal (ton/year)
Level of education (primary, secondary, bachelor's, master's, doctorate, vocational–technical training, other study)	Water their garden (several times, once a week, occasionally)	Carbon storage (ton/ha)
Income (0–263, 281–526, 544–789, 807–1053, 1070–1316, 1333–1579, 1596 or more) ***	How do you distribute the cost of garden maintenance (monthly maintenance fee, fertilizers, pesticides, irrigation, labor)?	Oxygen production (ton/year)
	Are you willing to pay for green areas maintenance?	Carbon sequestration (ton/year)
	Benefits from trees (yes/no)	Avoided runoff (m^3/year)

Table 1. *Cont.*

Socioeconomic	Environmental Perception	Forest Quality
	What is your perception about trees in the neighborhood? (benefit, issue)	Avoided carbon emissions (ton/year)
	Relates construction work to flooding (yes/no)	
	Has access to public parks (yes/no)	
	Feels safe in public parks (yes/no)	
	Perceives benefits from public parks (yes/no)	
	Perceives problems in public parks (yes/no)	
	Recycles (yes/no)	
	Prepares organic fertilizer (yes/no)	
	Belongs to a community organization (yes/no)	

* Refers to concrete patio; ** forest cover responds to the percentage contrasted with total forest cover for each neighborhood; *** exchange rate equivalent to 57 Dominican pesos (Central Bank of the Dominican Republic, accessed 11 June 2021).

For the analysis of the forest cover ecosystem services, we took the data from the calculation made with the iTree Eco Field Guide V6.0 software (open source software, created by Dr. David J. Novak, Northern Research Station, USDA, Madison, WI, USA) from 26 April 2016, which were taken for the four zones and named "forest quality". iTree Eco version 6 is a flexible software application designed to use data collected in the field from single trees, complete inventories, or randomly located plots throughout a study area along with local hourly air pollution and meteorological data to quantify forest structure, environmental effects, and value to communities [27].

2.3. Information Analysis

Information gathered from the interviews was categorized into environmental perception information, socioeconomic characteristics, and the iTree data were referred to as forest quality. A frequency analysis was performed on the responses obtained. The data for each category were standardized to a range of 0.1 with INFOSTAT 2018 Software (National University of Córdoba, Córdoba, Argentina). To identify the significant association of the variables with each urban area, a principal component analysis (PCA) was performed [28]; out of the 52 interview items applied, 25 had a significant association to the neighborhoods, which are shown in Table 1; with these variables three indexes were constructed: environmental perception, socioeconomic, and tree quality. The value of each index is the average of the values of its component variables (see Table 1). Lastly, the three indices were summed to obtain the forest cover sustainability index for each urban area. With the information collected from the four indices, geographic maps of each site were constructed in the WGS 1984 UTM 19 N geographic system.

3. Results and Discussion

The socioeconomic component analysis showed that Gazcue is the area with a predominance of inhabitants who own their homes, with vegetation in the backyard, many of them pensioners or private companies' employees where salaries range from USD 807 to more than USD 1596.5 per month. Of the four zones studied, Gazcue is the one with the most favorable and stable socioeconomic characteristics compared to the others. Zona Colonial is mainly associated with professional training up to doctorate degrees and housing with a semi-paved patio and some trees. On the other hand, San Carlos and Ciudad Nueva are more associated with citizens living in rented, leased, or borrowed houses, most of which lack trees in the yards. The highest school grade is between elementary and high school. The range of income is from 0 to 526 dollars, working as independent workers, merchants, or unemployed.

According to the socioeconomic index (Figure 1), Zona Colonial was the area with the highest score, registering around 53%, followed by Gazcue with 47%, Ciudad Nueva with 46%, and San Carlos with 44%, which means that from a general perspective Zona Colonial has better socioeconomic indicators for most of the population considered in this study in comparison to the values presented by the other urban zones. It should be noted that although Gazcue has better socioeconomic conditions associated with it according to the results of the principal component analysis, these conditions belong to a small percentage of inhabitants, which is why it was placed third in the index position (Appendix A, Table A1).

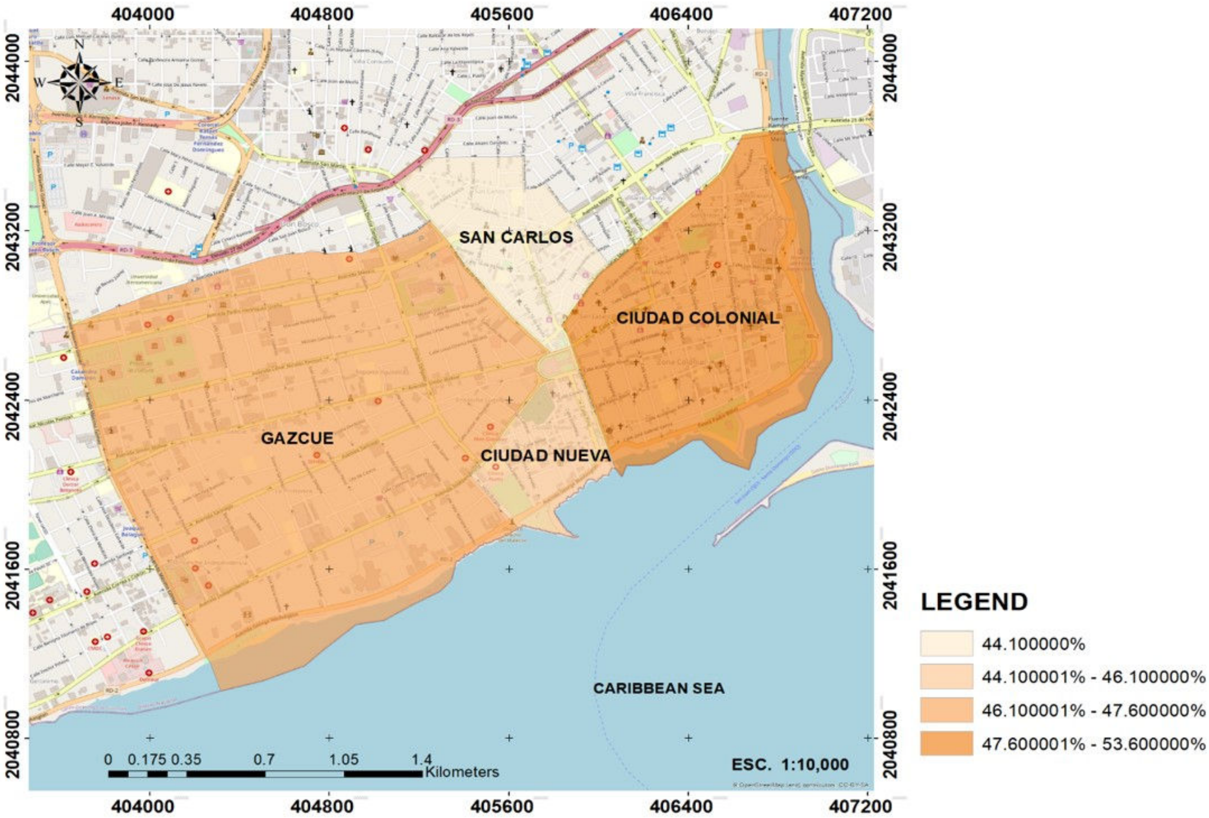

Figure 1. Socioeconomic index of four zones of the city of Santo Domingo, Dominican Republic. Source: Own elaboration based on data collected in the field (Zona Colonial is the popular name of Ciudad Colonial).

Regarding the environmental perception of PCA, the significant factors in Gazcue are that inhabitants of the area like to have trees on their property and plant them in their yard or land. They pay for garden maintenance services, and they do not have access to public parks. In this area, organic management and recycling practices are more frequent, and they perceive a relationship between continuous construction and flooding. In Ciudad Nueva, residents do not perceive the benefits of public parks and consider them to be unsafe places. Meanwhile, in Zona Colonial and San Carlos, although they perceive benefits from the neighborhoods' trees, they do not associate them with recycling or organic fertilizer practices; they do not consider a relationship between construction and flooding the city in both neighborhoods (Appendix A, Table A2).

In contrast to the factors of association by neighborhoods, the environmental perception index shows Zona Colonial with the highest value (54%), followed by Gazcue (50%), San Carlos (48%), and Ciudad Nueva (47%) (Figure 2), which means that the perception of the interviewed inhabitants related to environmental benefits is greater than the percentage presented in the con-structed index.

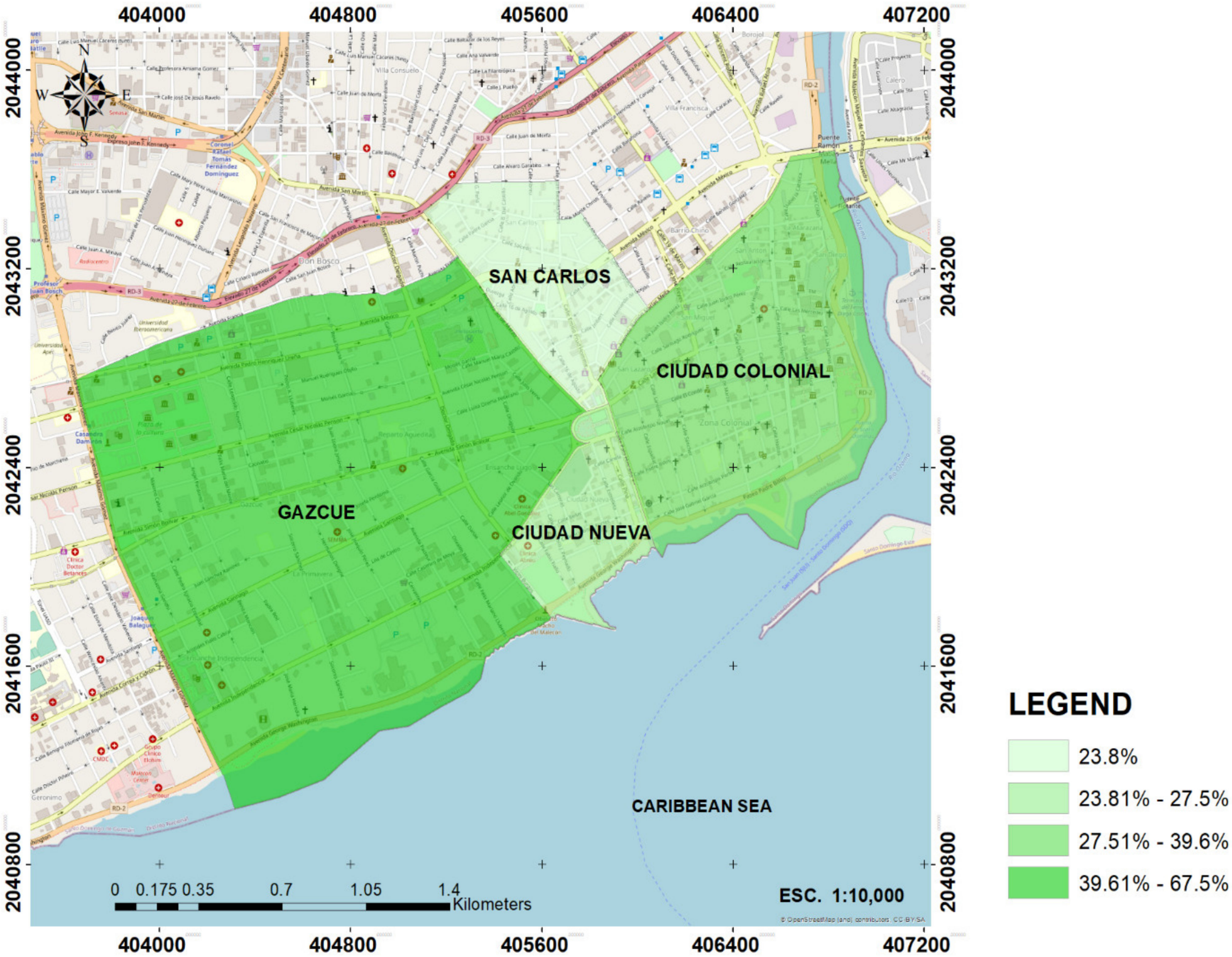

Figure 2. Environmental perception index of four zones of the city of Santo Domingo, Dominican Republic. Source: Own elaboration based on data collected in the field (Zona Colonial is the popular name of Ciudad Colonial).

Factors associated with the quality of urban forest, which are directly related to the ecosystem services they provide, have a higher value in the Gazcue zone (number of trees, percentage of forest cover, carbon storage, pollution removal, avoided runoff, and avoided carbon emission). Zona Colonial presented a weak association with the percentage of trees smaller than 5 cm and carbon sequestration (ton/year), which means that it does not have a significant association with the number of trees in that diameter range. In the case of San Carlos and Ciudad Nueva, they were not associated with any factor (Appendix A, Table A3).

Unlike previous indices, the forest quality index shows that Gazcue is superior to the rest of the neighborhoods with 67.5%, while Zona Colonial did not exceed 39.6%, Ciudad Nueva 27.5%, and San Carlos 23.8% (Figure 3). According to the index scores obtained by each neighborhood, Gazcue maintains greater forest cover and therefore has further benefits in terms of carbon capture and storage and other environmental benefits quantified for this index. It should be noted that Gazcue has historically been considered an "urban garden" because of its floristic richness, a condition that has been maintained over time [26].

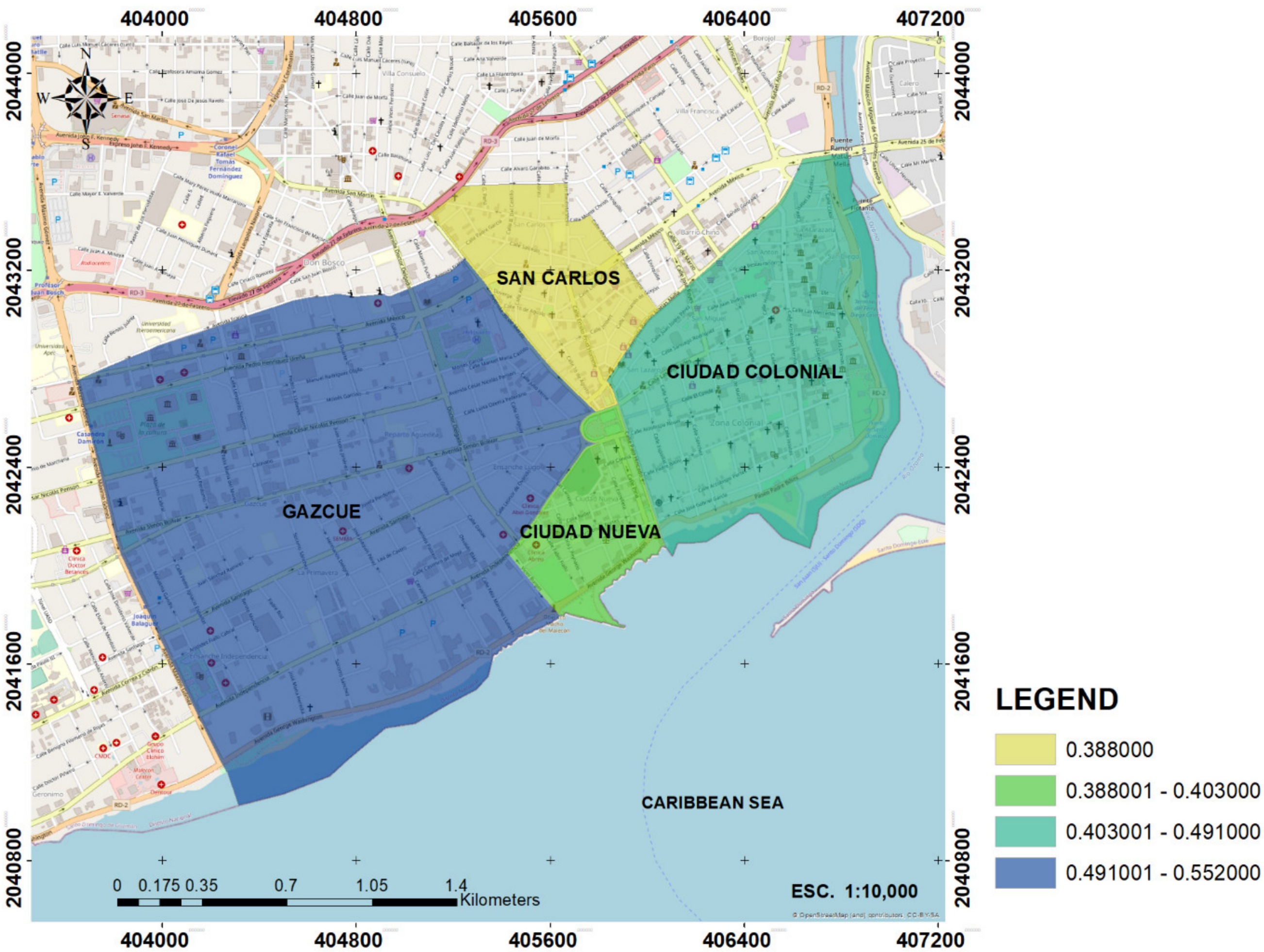

Figure 3. Forest quality index of four zones of the city of Santo Domingo, Dominican Republic. Source: Own elaboration based on data collected in the field (Zona Colonial is the popular name of Ciudad Colonial).

Ultimately, the forest cover sustainability index is the result of the sum of the three indices shown above; the results infer which neighborhood has better conditions to maintain the forest cover and therefore have greater environmental benefits for the urban area; in this sense, Gazcue presented a higher valuation than the rest (55%), mainly due to the value obtained in the quality of forest cover. However, Zona Colonial (49%) maintained high environmental and socioeconomic perception indexes (Figure 4). It is worth mentioning that both sites are those with better living conditions for the population, as well as greater environmental awareness compared to Ciudad Nueva (40%) and San Carlos (38%), neighborhoods where the population has less stability in terms of income and housing, as well as lower levels of formal education.

According to results shown by this index, Gazcue is more likely to conserve and care for the forest cover followed by Zona Colonial; the historical planning supports both neighborhoods to maintain the landscape for the delight of tourists and the upper social classes, compared to Ciudad Nueva and San Carlos, which have been urban areas of greater marginalization and occupied mainly by migrant or working-class inhabitants [25].

The discussion on which social setting benefits environmental conservation within cities is still ongoing [29]. The results of this study contribute to elucidate an answer.

Various indices presented in this research demonstrate that, in the urban context of Santo Domingo, the four zones studied show significant differences in the socioeconomic dimension, making clear that Gazcue and Zona Colonial have a close relationship with the presence of trees, mainly in private homes, and their care. Our results confirm the findings of Gazcue, and Zona Colonial are related and perceived to a context of economic prosperity in addition to be historically representative [30]. It also claims that the upper social classes have better forest cover from private properties and, to a lesser degree, from public spaces.

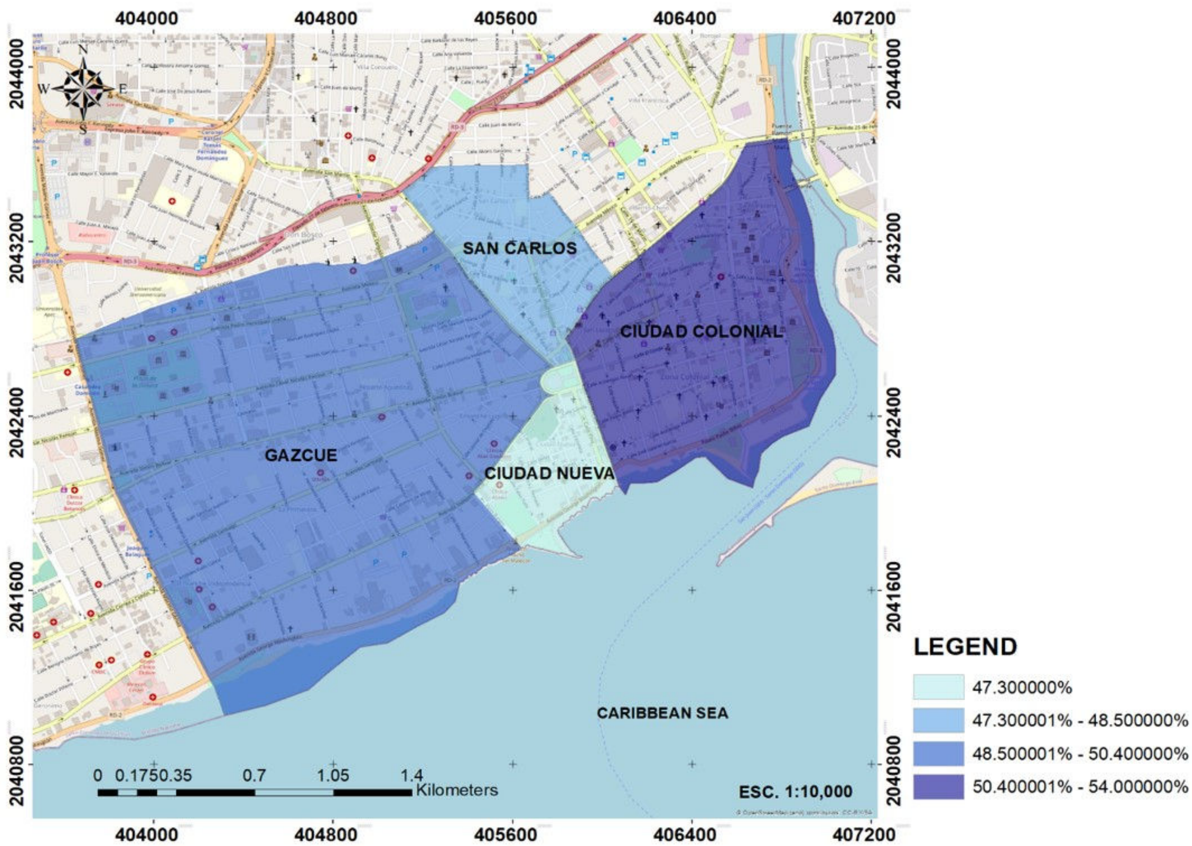

Figure 4. Sustainability index of four zones of the city of Santo Domingo, Dominican Republic. Source: Own elaboration based on data collected in the field (Zona Colonial is the popular name of Ciudad Colonial).

The population's perception of the benefits (environmental or social) or detriments (damage to property, disruption of public services, threat to public safety) that trees can cause are determinants for their conservation and establishment [31]. The results found in Gazcue related to the perception of trees seem to indicate that individuals prefer to have trees on their property because of the landscape service they provide. The non-monetary valuation of ecosystem services perceived by society positively influences the conservation of the tree component [32].

In Ciudad Nueva and San Carlos, historically marginalized and with rapid urbanization and overcrowding, there was less forest cover in private areas but a more marked tendency toward public wooded areas and precariousness in their care. Public parks or green areas present social problems such as insecurity and lack of maintenance [33]. The lower socioeconomic stratum tends to maintain public spaces with forest cover; however, this component is dispensable in private properties due to its high contribution of ecosystem services [30]. Likewise, these areas tend to have a shorter time of urbanization, which is a relevant factor in the loss of forest cover [32].

Although it is necessary to rethink the model of the peripheral expansion of cities [2], the verticalization of urban development also has severe consequences in terms of quality of life in the socioemotional and environmental spheres [30]; therefore, the challenge of urban sustainability continues.

The benefits of trees are indisputable; however, inadequate planning on the tree species to be established in cities entails important problems. A decade ago, it was established that 80% of the tree species established in Santo Domingo are not appropriate for the city, with up to 30% of them being introduced species, which has a direct impact on instability in the ecosystem and biodiversity, habitat, and food for the local fauna. Likewise, there have been problems of broken sidewalks due to superficial roots or large trees that were planted in limited spaces and with little resistance to the impact of hurricanes [34].

The scarcity of phytosanitary care is an important factor in the deterioration of urban trees. There is a lack of studies that gather documentation on pests and diseases that attack urban trees and recommend management activities that prevent damage that in the long run can be transformed into economic losses and that also affect people's quality of life [34]. This document does not elaborate on the tree species found in the three neighborhoods; however, the problems described above may have an influence on the perception of the inhabitants interviewed.

4. Conclusions

This study showed that factors such as job stability, medium-high income, and property ownership are closely related to the establishment and quality of urban forest, i.e., the sustainability of forest cover.

A relevant aspect that became evident in the results of this study is the added value of the territory, whether in the tourism or socioeconomic sphere of the population that inhabits it, is closely related to greater attention in urban planning, giving priority to the conservation and landscape harmony that the tree component can provide.

Although there is still a long way to go in research on urban forest planning, there are three relevant points to consider about the benefits and ecosystem services they provide: tree species, design, and spatial arrangements.

As we have pointed out, the urban forest is undoubtedly an indispensable component for the sustainability of cities, providing ecosystem services reflected in improved air quality, contributing to well-being, and positively affecting the private value of properties. However, the proliferation of trees in urban environments goes beyond the private sphere as the external effects are evident, reaching all the inhabitants of the area and the city. For all these reasons, urban planning of green spaces with trees should play a central role in the agenda of local decision makers. Planning must be supported by competent public policies in line with the challenges of territorial sustainability and establishing criteria of social co-responsibility. The government will have to strengthen its capacities for planning, management, and facilitation of processes concerning incorporating and monitoring urban trees to provide resilience and mitigation of climate change impacts.

Based on the results obtained in the analysis, which show different patterns depending on the socioeconomic characteristics of the areas studied, it would seem appropriate to promote policies designed according to the specificities of each neighborhood rather than general policies with a global approach for the entire city. That is, in some cases, it will be appropriate for the policy to focus on the maintenance of trees in public parks, while in other cases the focus should be on increasing safety or in other areas it might be more appropriate to establish urban planning regulations that require the construction and maintenance of private green areas, for example, in neighborhoods with a high socioeconomic level.

However, the study opens different avenues for completing and expanding the analysis in the future. For example, it would be interesting to link the existence of green areas with the evolution of housing prices or, along other lines, to analyze what type of plant species are most suitable for public or private areas in each neighborhood.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Principal component analysis—Socioeconomic Index (Standardized data: Cases read 4, skipped cases 0. Classification variables: Zone).

Eigenvalues				Eigenvectors		
Lambda	Value	Proportion	Prop Accum.	Variables	e1	e2
1	13.53	0.45	0.45	Female	−0.2	0.19
2	9.52	0.32	0.77	Male	0.2	−0.19
3	6.95	0.23	1	Own house	0.27	−0.01
4	0	0	1	Rent house	−0.27	0.04
5	0	0	1	Loaned-lent house	−0.11	−0.25
6	0	0	1	Gray patio	−0.2	−0.07
7	0	0	1	Patio_plants	0.18	−0.11
8	0	0	1	Married/common law	0.27	−0.05
9	0	0	1	Single	−0.24	9.60×10^{-4}
10	0	0	1	Divorced	0.1	−0.16
11	0	0	1	Widower	−0.24	0.16
12	0	0	1	Unemployed	0.03	−0.24
13	0	0	1	Public employee	0.1	0.25
14	0	0	1	Private employee	0.13	0.07
15	0	0	1	Businessman	−0.22	0.13
16	0	0	1	Account worker	0.03	−0.15
17	0	0	1	Pensioner	0.25	0.12
18	0	0	1	Primary studies	−0.1	−0.28
19	0	0	1	Secondary studies	0.03	−0.3
20	0	0	1	Graduate	0.2	0.19
21	0	0	1	Master's degree	0.07	0.31
22	0	0	1	Doctorate	−0.09	0.3
23	0	0	1	Technical training-pro.	−0.18	0.24
24	0	0	1	Income 0–15,000	−0.19	−0.15
25	0	0	1	Income 16,000–30,000	−0.23	−0.13
26	0	0	1	Income 31,000–45,000	−0.21	0.18
27	0	0	1	Income 46,000–60,000	0.16	0.05
28	0	0	1	Income 61,000–75,000	0.16	0.27
29	0	0	1	Income 76,000–90,000	0.08	0.01
30	0	0	1	Income 91,000 or more	0.25	

Table A2. Principal component analysis—Forest Quality Index (Standardized data: Cases read 4, skipped cases 0. Classification variables: Zone).

Eigenvalues				Eigenvectors		
Lambda	**Value**	**Proportion**	**Prop Accum.**	**Variables**	**e1**	**e2**
1	6.89	0.69	0.69	Green index	0.37	−0.01
2	2.46	0.25	0.93	Number of trees	0.37	0.18
3	0.66	0.07	1	Forest cover	0.27	−0.25
4	0	0	1	Percentage of trees	0.06	0.61
5	0	0	1	Contamination removal	0.37	0.14
6	0	0	1	Carbon store	0.36	0.14
7	0	0	1	Oxygen production	−0.34	0.26
8	0	0	1	Carbon sequestration	0.06	0.6
9	0	0	1	Runoff avoided	0.38	0.01
10	0	0	1	Carbon emission	0.34	−0.25

Table A3. Principal component analysis—Environmental Perception Index (Standardized data: Cases read 4, skipped cases 0. Classification variables: Zone).

Eigenvalues				Eigenvectors		
Lambda	**Value**	**Proportion**	**Prop Accum.**	**Variables**	**e1**	**e2**
1	21.34	0.48	0.48	like tree property	−0.1	0.09
2	13.09	0.3	0.78	don't like tree property	0.1	−0.09
3	9.57	0.22	1	plant the yard	−0.07	0.15
4	0	0	1	don't plant	0.07	−0.15
5	0	0	1	know which entity cares	0.12	−0.22
6	0	0	1	don't know which entity cares	−0.12	0.22
7	0	0	1	fertilize the yard	0.17	0.1
8	0	0	1	don't fertilize the yard	−0.17	−0.1
9	0	0	1	hire gardening	−0.14	0.21
10	0	0	1	don't hire gardening	0.14	−0.21
11	0	0	1	water the yard several times	−0.19	0.08
12	0	0	1	water the yard once	0.18	−0.15
13	0	0	1	water the yard occasionally	0.18	−0.03
14	0	0	1	area maintenance	−0.12	−0.09
15	0	0	1	monthly maintenance expense	−0.07	0.25
16	0	0	1	spend on fertilizer	0.09	0.22
17	0	0	1	spend on pesticide	0.06	−0.04
18	0	0	1	spend on irrigation	−0.18	−0.14
19	0	0	1	gardening labor	0.1	0.01
20	0	0	1	willingness to pay for maint.	0.21	0.07
21	0	0	1	no WTP for maint.	−0.21	−0.07
22	0	0	1	willingness to pay	0.07	0.24
23	0	0	1	perceive tree benefit owner	0.14	0.12
24	0	0	1	perceive tree issue	−0.14	−0.12

Table A3. *Cont.*

Eigenvalues				Eigenvectors		
Lambda	**Value**	**Proportion**	**Prop Accum.**	**Variables**	**e1**	**e2**
25	0	0	1	perceive tree benefit neighbor	0.21	−0.02
26	0	0	1	don't perceive benefit	−0.21	0.02
27	0	0	1	connection with construction	−0.21	−0.02
28	0	0	1	no connection construction	0.21	0.02
29	0	0	1	public park access	0.19	−0.13
30	0	0	1	no public park access	−0.19	0.13
31	0	0	1	feel safe	−0.01	0.26
32	0	0	1	don't feel safe	0.01	−0.26
33	0	0	1	public park benefit	0.07	0.26
34	0	0	1	no public park benefit	−0.07	−0.26
35	0	0	1	public park issue	−0.22	0.01
36	0	0	1	no public park issue	0.22	−0.01
37	0	0	1	recycle	−0.18	−0.02
38	0	0	1	don't recycle	0.15	0.02
39	0	0	1	don't know recycle	0.12	0.01
40	0	0	1	prepare compost	−0.2	−0.09
41	0	0	1	don't prepare compost	0.18	−0.05
42	0	0	1	belong community society	−0.11	−0.23
43	0	0	1	don't belong commun. society	0.16	0.17
44	0	0	1	don't answer if belong comm.	−0.01	0.27

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