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Green Innovation, Carbon Storage and Perceived environmental quality in Lagos State University, Nigeria

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Abstract. A sustainable university has been defined as a higher educational institution that addresses, involves and promotes the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfil its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles. Earlier studies on green innovations have basically centered on the environmental benefits and were purely descriptive in nature. Several others examined the effect of green innovation on soil organic carbon by comparing street trees of species. The present study would contribute to literature using a mixed research approach to empirically investigate the contributions of green innovation on carbon storage and perceived environmental quality in Lagos State University, Nigeria. Data for the study were obtained by collecting 100 surface (0 – 15cm) soil samples with the aid of a soil auger under campus trees, grasses, ornamental trees and vegetables (Amaranthus and green vegetable farms) across different land uses on campus. Also, data on green characteristics (tree height, tree size, canopy cover, density of herbs, basal cover and herbaceous cover) were measured using different ecological procedures, while 655 questionnaire copies were administered to staff and students to ascertain their perceived environmental quality of green innovation. Data obtained were analyzed using averages, simple percentages, One-Way Analysis of Variance, multiple regression analysis and principal components analysis. The results obtained showed that carbon storage significantly varied among the green innovation components with canopy cover contributing over 55% of carbon storage. The study revealed that canopy cover and tree size substantially contributed in carbon storage with canopy cover being more effective. PCA result identified beautification of LASU (19.8%), flood control (18.8%), promotion of urban ecology (15.8%) and improvement in air quality (9.5%) as the principal dimensions or perceived environmental quality of green innovation. The result further showed that green innovation characteristics have significant relationship with carbon storage. The study shows the importance of campus tree in carbon reduction and recommends the need for universities to give necessary recognition and incorporate these green components in physical planning.

Keyword:

Green innovation, Carbon storage, Tree characteristics, Perceived environmental quality, Lagos State

1. Introduction

In Africa and across the world, urban population and the extent of built-up areas are increasing progressively with more than 4.4 billion people inhabiting the urban areas [1]. This stable increase has multiple effects on the urban environment (flooding, increase in CO_2 and increase in temperature) mostly in the reality of climate change [2,3]. The increased spending on buildings and infrastructures as well as the demands of urban residents for properties and amenities are fundamental triggers of total greenhouse gas (GHG) and associated ecological problems [2]. As such, urban area constitutes a significant fragment of the overall carbon sequence and deliver ecosystem services for inhabitants [3]. Despite the contributions of urban areas to carbon, urban areas are also drivers of sustainable innovations aimed at reducing carbon concentration [2] and enhancing a sustainable urban environment. One of such innovations adopted by many cities in both the developed and some developing countries is the green innovation (GI) or measures that are seen or provided inside and outside the boundaries of cities to help in carbon sequestration and temperature reduction [4]. In the urban environment, the presence of GI can help in mitigating global warming by serving as carbon dioxide (CO_2) sink. By this way, urban GI like trees play vital role in achieving net zero emission of CO_2 and other greenhouse gases [5]. Cities are acknowledged in the literature to be answerable to 75 percent of global CO_2 emissions [6,7]. This amount of CO_2 in the atmosphere is however removed and stored in trees among other GI components. Takalo & Tooranloo [8] stated that green innovation (GI) is a key factor in upholding environmental management and that it has become an important tool for businesses (like institutions) to increase their market share (teaching and research) and stay alive in the long run. The implication is that a successful GI practice improves the institution’s position in teaching and learning, attracts students and investors, provides green services and enables the institution to gain competitive advantage [8].

Green innovation refers to all forms of innovation that minimize environmental damage and ensures that natural resources are used in the most effective way possible. Green product designs are all factors or components to be considered in GI. Green innovation may therefore be described an array of natural and anthropogenic green areas that offer ecological and societal roles in urban environments [3]. Green innovations are recognized to include all green components such as urban forest, ornamental trees, vegetables farms, parks and wildlife pathways among others. These green infrastructures are found in different sizes or dimensions and scales in cities, institutions, office, residential areas and around the neighbourhood among others [3]. In urban areas, urban GIs deliver diverse ecosystem services which include carbon sequestration, carbon storage and provide measures of adaptation to climate change [1]. The idea of green innovation has been exploited in urban situations as a way to increase city network and ensure that the benefits of nature-based solutions are allowed in urban environments enclosed by physical structures. In the current age of intensifying global temperature and the need for carbon sequestration, the matter of sustainability has occupied the centre stage of research. This has led the management of LASU to come up with diverse green innovation measures to ensure a sustainable environment for learning and teaching as well as a certain of research.

The University in the past 20 years has put in place green components which are portrayed by the existence of campus trees, grasses and flowers. Also, vegetables farms are allowed both on and off the campus (around the institution's perimeter fence) which play substantial tole in carbon sequestration and carbon storage. These green components play active role in reducing the inherent consequences of heat island effects. This is intended in order to make the institution a sustainable university that addresses and promotes the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfil its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles. In addition, the green innovation measures put in place by Lagos State University, Nigeria (LASU) across her various campuses is intended to improve the production process of the institution (which is teaching and research) and improve the utilization rate of resources (incorporating green components in buildings). As such, GI in LASU is as a strategy to achieve environmental protection and economic and institutional growths since effects of environmental degradation have turned into a major threat to the institution's existence. Therefore, GI is an important tool that can help institutions like LASU to achieve environmental sustainability and plays an important role in achieving competitive advantage, taking a cue from the submission of Chu *et al.* [9] and Takalo & Tooranloo [8]. As a result of the environmental importance of GI and to ensure sustainability, several studies have been carried out.

Earlier studies on green innovations have basically centred on the environmental benefits and several were purely descriptive in nature. Several others examined the effect of green innovation on soil organic carbon by comparing street trees of species [2,10,11,12]. For instance, the study of Ariluoma *et al.* [2] examined carbon storage and sequestration across urban trees of different species. The study only concentrated on carbon storage in soil under tree canopies, but ignored the potency and efficacy of other green components in carbon storage and sequestration. Nevertheless, the study of Lindén *et al.* [13] made an attempt at quantifying carbon stocks in urban soils under lawn, shrubbery and herbaceous perennials. The study nevertheless failed to quantify the carbon stocks in tree leaves, trees, flowers and mixture of urban components. Other studies examined the contribution of GI to mitigating environmental risks [14]; others examined GI as a way of creation of new opportunities for environmentally friendly practices [15] and several others examined the role of GI in reducing pollution rates [16,17,18,19]. Other studies assessed the ecological reputation of GI [20,21]. These studies did not however investigate the dynamics in carbon stocks in different GI components and failed to examine the perceived importance of GI in ensuring environmental quality. The present study contributed to literature using a mixed research approach to empirically investigate the contributions of green innovation on carbon storage and perceived environmental quality in Lagos State University, Nigeria. The present study also examined the effect of green innovation attributes or characteristics (tree height, tree size, canopy cover, density of herbs, basal cover and herbaceous cover) on carbon stock dynamics. The essence is to identify GI that contributes most to carbon sequestration and environmental quality.

2. Results and Discussions

2.1. Tree Parameters

Tree height is a significant feature for assessing tree biomass and examining tree life history [22,23]. The result in Table 1 and Figure 1 showed that the measured heights for the 20 tree stands ranged from 6.23 to 13.09 m with a mean value of 9.86 m. This means that trees in the study area have appreciable heights and can positively impact on the environment. This is because tree height is an essential ecological tree parameter that plays varying roles in light interception, soil erosion control and carbon sequestration among others [23]. Arzai and Aliyu [24] and Nowak et al. [25] stated that tree height is a significant tree component that determines the total amount of light that the tree intercepts for photosynthesis. Iwara [26] alleged that tree height helps in soil erosion control by reducing the erosive power of raindrop, while Lal [27] noted that it plays a significant role in carbon sequestration. The height of trees measured in this study can help in soil erosion control and carbon sequestration among other ecological functions. In a related study, Eneji et al. [28] reported that tree size contributes substantially to carbon sequestration. This is so as the study found a positive but insignificant association between tree height and carbon sequestration. Also, Agboola et al. [29] reported that carbon stock estimate of the aboveground pool was higher than the belowground pool and found carbon storage to be low in litter and herb.

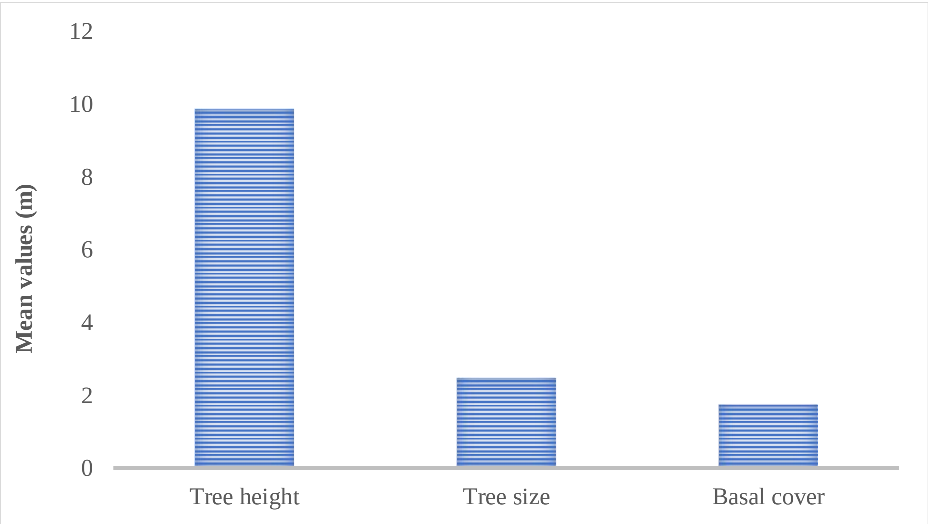

Figure 1. Mean values of tree height, tree size and basal cover

Table 1. Tree components in LASU

Tree components	Min	Max	Mean	Std. Dev
Tree height (m)	6.23	13.09	9.86	2.24
Tree size (m)	0.9	3.9	2.48	0.86
Canopy cover (m^2)	4.60	18.60	12.38	4.31
Basal cover (m)	0.2	3.0	1.74	0.90

In addition, Table 1 and Figure 1 showed that tree size ranged from 0.9 to 3.9 m with a mean value of 2.48 m. Tree size provides a measure of tree performance, and plays a fundamental role in carbon storage or carbon sequestration. This is because large trees are recognized in the literature to absorb more carbon from the atmosphere than smaller trees [30,31,32]. The differences in the measured tree size for the 20 sampled tree stands may be attributed to varying degrees of anthropogenic disturbances and tree age. This is consistent with the findings of Iwara et al. [33], Martinez-Meza & Whitford [34], Iwara [23] and Ogundele [30] when they attributed high tree size to reduced anthropogenic disturbance. Also, Lalfakawma et al. [35], Iwara et al. [33] and Ogundele [30] attributed high DBH to the presence of high climax tree species. However, the high tree sizes measured among the sampled trees in LASU have the tendency for carbon storage. This agrees with the findings of Mildrexler et al. [31] that large trees stored 33 to 46% of the total aboveground carbon (AGC) stored by individual species. In another study, Lutz et al. [36] stated that trees with large-diameters store considerable quantities of carbon required to lessen climate change. Also, Stephenson et al. [37] cited in Mildrexler et al. [31] stated that a single large tree is able to store the similar quantity of carbon to the forest in a year more than in an individual medium-sized tree of the similar type. Canopy projection area (CPA) or canopy cover ranged from 4.6 to 18.6 m2 with a mean value of 12.38 m.

The mean value suggests that the CPA of the sampled trees were big and broad which may have impact on carbon sequestration. The high and broad CPA measured for trees is presumably attributed to the age of trees, reduced disturbance and presence of high climax tree species. Pretzsch et al. [38] stated that canopy projection area determines carbon sequestration, shading, filtering of fine air particulates, and risk of wind-breaking. In addition, Srinivas et al. [39] examined urban trees for carbon sequestration and management of climate change and disasters and revealed that the canopy of a tree plays essential function in decreasing the amount of carbon emissions that emanate from industrial activities. Also, Singh et al. [40] reported carbon stock in above-ground and below-ground biomass in varying locations averaged 1901 metric tonnes of carbon per hectare with carbon dioxide sequestration of 6977 tonnes per hectare. The CPA for tree in the present study may be able to sequester carbon. This is consistent with the submission of Zhao et al. [41] stated that there was a substantial amount of carbon stored within aboveground vegetation and soil. Gorte [42] stated that all parts of a plant—the stem, limbs and leaves, and roots—contain carbon, but the proportion in each part varies enormously, depending on the plant species and the individual specimen’s age and growth pattern.

Basal cover which is the proportion of the tree stem or trunk that protrudes into the ground is also essential tree components that play essential roles in carbon sequestration and nutrient distribution in the soil [23,42]. It also enhances soil structure by loosening the soil for easy infiltration [23]. The basal cover for measured tree stands is shown in Table 1 and Figure 1. Basal cover ranged from 0.2 to 3m with a mean value of 1.74 m implying that trees in the area had sizeable trunks that protrude into the ground. The result showed that high basal cover was measured in LASU. The low basal cover measured for some trees may be attributed to the presence of young trees, while the high basal cover measured for trees is attributed to the presence of high climax trees (trees with many years of existence). In a related study, Iwara et al. [33] attributed high basal cover of trees to the presence of high climax tree species and reduced site disturbance (absence of clearing and tree cutting). Like tree size, basal cover mostly big basal structure is shown in the literature to sequester more carbon than smaller basal cover. This agrees with the findings of Balderas-Torres et al. [43] that two forests with the same species and basal area, there will be more carbon where trees are larger.

2.2. Soil properties and soil organic carbon

2.2.1. Level of available phosphorus across green innovation sites

Phosphorus is an essential nutrient for plant growth, and is a primary fertilizer element. Table 2 showed that the mean concentration of available phosphorus (Av. P) was considerably high in green vegetables and ornamental plants with mean values of 219.66 mg/kg and 60.44 mg/kg respectively, while low content was recorded in campus tree with a mean value of 5.47 mg/kg. This implies that green vegetables and ornamental plants soils are richer in Av. P than in other green innovation sites considered in this study. The increase in available phosphorus especially in green vegetables may be attributed to the application of organic wastes (organic manure) which favourably enhances the availability of phosphorus [44,45]. The result reported here as well as the assertion is consistent with the findings of Osemwota [44] who reported increase in Av. Phosphorus to the introduction of substances containing high organic matter. The content of Av. Phosphorus varied significantly among the studied green innovation sites ($F = 2.624$, $p<0.05$).

Table 2. Mean Av. P (mg/kg) content across green innovation sites

Stats	**Green innovation sites**				
	Campus tree	**Urban Park**	**Grass**	**Ornamental plants**	**Green vegetables**
Average	40.95	7.73	5.47	60.44	219.66
Std dev.	0.004	0.001	0.001	0.002	0.002

F = 2.624; Sig = 0.000

2.2.2. Level of total nitrogen across green innovation sites

Total nitrogen (TN) is one of the most important plant nutrients and forms some of the most mobile compounds in the soil crop system. The mean total nitrogen content was high in urban park soil followed by ornamental plant and campus tree with mean values of 0.123%, 0.098% and 0.094% respectively (Table 3). The content of TN varied significantly among the green innovation sites ($F = 1355.78$, $p<0.05$). The high TN content in urban park soil is attributed to litterfall from different trees and grasses which help to increase the organic matter content of the soil. The absence of litter raking favours the increase in organic matter which enhances the accretion of TN content in the soil. The comparatively low TN content in grassland soil may be attributed to low amount of litter returned to the soil. Bokhtiar & Sakurai [46] stated that organic carbon, total N, and available P contents in the soil tend to increase to a large extent with the increase in organic matter (derived from dead leaves, stems and branches or tree biomass).

Table 3. Mean total nitrogen content (%) across green innovation sites

Stats	Green innovation sites				
	Campus tree	**Urban Park**	**Grass**	**Ornamental plants**	**Green vegetables**
Average	0.094	0.123	0.072	0.098	0.086
Std dev.	0.003	0.003	0.002	0.002	0.002

F = 1355.78; Sig = 0.000

2.2.3. Organic carbon content (%) across green innovation sites

Carbon is a chief constituent of soil organic matter; as such carbon is vital as a main source of Co2 and atmospheric CO_2 concentrations. The result in Table 4 showed that the mean organic carbon (OC) contents of soils across the selected green innovation sites ranged from 0.912 – 2.920% The proportion of OC was to a greater extent higher in the urban park soil followed by campus tree soil and green vegetation soil than with mean values of 2.920%, 1.993% and 1.912% respectively (Table 4). The content of OC varied significantly among the green innovation sites (F = 32.405, $p<0.05$). The high OC content in the urban park soil is attributable to the protection of the soil from soil erosion that would have resulted in the loss of nutrients as well as high organic matter accumulation in the soil via litterfall from dead leaves which helped to increase the organic matter content of the soil. The absence of litter raking may also be responsible for the high OC content in the urban park and campus tree soils. The comparatively low OC content in the grass soil may be attributed to low production of litter. In a related study, Didion and Dhillon [47] stated that carbon from deadwood and non-woody litter presents the largest input to the soil C pool, but this is altered with the kind of practice put in place such as litter raking.

Table 4. Mean organic carbon content (%) across green innovation sites

Stats	Green innovation sites				
	Campus tree	**Urban Park**	**Grass**	**Ornamental plants**	**Green vegetables**
Average	1.993	2.920	1.375	1.562	0.912
Std dev.	0.002	0.002	0.002	0.001	0.001

F = 32.405; Sig = 0.000

2.2.4. Level of bulk density (g/cm3) across green innovation sites

Bulk density is one measurement frequently made to evaluate structure. The higher the bulk density the more compact the soil and the lower the pore space. If the bulk density is less or near to 1.0 it means, that the soil density is low and have high organic matter content. When soil's bulk density value is less, the available water and water holding capacity of the soil is higher. The proportion of bulk density (BD) in the studied soils is shown in Table 5. It showed that the proportion of BD was comparatively higher in the green vegetable soil followed by the grassland soil with mean values of 1.352 g/cm3 and 1.263 g/cm3 respectively, while low BD content was found in campus tree soil with a mean value of 0.944g/cm3. The low BD contents in the campus tree soil is attributed to the increase in organic matter. In a related study, Njoku et al. [48] attributed low BD content to animal dung and stated that the dumping of organic wastes reduces bulk density and increase total porosity of soils. In all, the bulk density of studied soils is comparatively low due to the input of different quantities of organic wastes. The result in Table 5 further reveal that the content of BD varied significantly among the green innovation sites (F = 98.71, p<0.05).

Table 5. Mean Bulk density (g/cm3) across green innovation sites

Stats	Green innovation sites				
	Campus tree	Urban Park	Grass	Ornamental plants	Green vegetables
Average	0.944	1.182	1.263	1.166	1.352
Std dev.	0.003	0.002	0.002	0.002	0.003

F = 98.71; Sig = 0.000

2.2.5. Carbon stock (tonnes/ha) across green innovation sites

SOC is one of the largest and active carbon pools. It exists as inseparable components of biomass and soil organic matter. Its storage in soil organic matter is important in mitigating global climate change and improves the livelihood of resource-poor farmers [49]. The result in Table 6 showed that the stock of organic carbon t/ha varied significantly in the soil of the various green innovation sites (F = 1102.42, p<0.05). It showed that high stock of organic carbon t/ha was observed in the urban park soil followed closely by campus tree soil and then ornamental plants, while roadside soil had the lowest storage with mean values of 10352.24 t/ha, 5631.88 t/ha, 5463.46 t/ha and 3697.55 t/ha respectively (Table 6). The high stock of organic carbon in the urban park and campus tree soils may be attributed to the absence of human disturbance (absence of litter raking under tree canopies) which makes available sufficient litter that help to enhance and facilitate increase in the organic matter base of the soil. Also, the high stock of organic carbon in the urban park and campus tree soils is consistent with the study of Edmondson et al. [50] when they found that most of the soil in urban green spaces (such as lawns, woodlands and gardens) is rarely disturbed and so retains SOC. In another study, Gardi & Sconosciuto [51] attributed decrease in SOC stock to increasing human disturbance mostly increasing cultivation time. Also, Preez et al. [52) found that 58% of soil organic matter is made up of stock of organic carbon. Awoonor et al. [53] stated that soil organic carbon (SOC) stocks vary with land-cover and land-use is often strongly correlated with organic matter content. This means that the stock of organic carbon in the soil is a function of organic matter among other factors. As shown in the Table 6, green innovation sites with little human disturbance have high carbon stock (t/ha).

Table 6. Mean Carbon stock (tonnes/ha) across green innovation sites

Stats	Green innovation sites				
	Campus tree	Urban Park	Grass	Ornamental plants	Green vegetables
Average	5631.88	10352.240	5209.750	5463.460	3697.850
Std dev.	10.9441	17.599	6.587	8.039	5.955

F = 1102.42; Sig = 0.000

2.3. Influence of tree characteristics on carbon stock dynamics

Multiple regression analysis was employed to understand the influence of a set of tree characteristics (tree height, tree size, canopy projection area and basal cover) on carbon stock. In doing so, only the soil and tree components results of campus trees were collated and used. Soil data on ornamental plant, grass and green vegetables were not included in the analysis due to the absence of trees in the sampled soil. Similar approach was employed by Edmondson et al. [50] in assessing the contribution of urban trees to SOC in the UK. Also, in this analysis, urban park was not included because tree components were not estimated. The result obtained is presented in Table 7.

The result showed that there was a strong multiple correlation (0.607) between the tree components (TH, tree size, BC and CPA) and carbon stock. The coefficient of multiple determination (R2) indicated that 36.9% of the changes in carbon stock was accounted for by the combination of the above set of tree components. Similar result was reported by Iglesias et al. [54] where a direct relationship was reported between canopy cover percentage and carbon storage. Information on the significance of the predictor variables indicated that carbon stock was not principally influenced by the tree components. However, the strength of each tree components was ranked using the standardized regression coefficients (beta). The result showed that CPA (0.566) wielded the most influence on carbon stock, this was closely followed by tree size (0.347).

Among the four or predictor variables, tree height was the least factor that exercised immense influence on carbon stock. Canopy projection area plays a vital role in carbon storage as such, it stores large amount of carbon. Through a process called photosynthesis, tree leaves pull in carbon dioxide and water and use the energy of the sun to convert this into chemical compounds such as sugars that feed the tree [55,56,57]. However, as a by-product of that chemical reaction oxygen is produced and released by the tree. It is projected that one large tree can provide a day's supply of oxygen about four people. Trees likewise store carbon dioxide in their fibres helping to clean the air and reduce the negative effects CO2 could have had on our environment. According to the Arbor Day Foundation, in one year a mature tree will absorb above 48 pounds of carbon dioxide from the atmosphere and release oxygen in exchange [55]. This shows the role tree leaves and their canopies play in carbon dioxide absorption or storage. Apart from carbon storage, tree canopies play essential role in soil erosion control and in temperature moderation. Tree canopies in both tropical and temperate areas can be vital homes for numerous animals and plants. A dense canopy cover will allow little light reach the ground and will lower temperatures. The canopy protects the soil from the forces of denudation like rainfall and helps to moderate wind force.

Table 7. Summary of multiple regression analysis

Predictor Variables	**Coefficients**		
	B	**B**	**t-value**
Tree height	0.466	0.095	0.292*
Tree size	6.221	0.347	0.973*
Canopy projection area	1.436	0.566	1.946*
Basal cover	2.781	0.227	0.783*
Test results			
F- value	2.189*		
R	0.607		
R^2	0.369		
Constant	5620		

*Significant at 5% significance level

Also, tree size is an essential tree component associated with carbon stock. This result shows that tree size has positively and substantially contribute to carbon stock has been reported by earlier in LASU. This is because a unit increase in tree size will result in 34.7% increase in the amount of carbon sequestered or stored. This result agrees with the findings of Lal [27] and Baul et al. [58] that found tree size to have significant influence on the carbon stock. Also, Gorte [42] stated that tree size is a vital tree parameter that contributes to carbon sequestration. Similarly, the study of Eneji et al. [28] found that tree size contributes substantially to carbon sequestration. This is so as the study found a positive but insignificant association between tree height and carbon sequestration. The amount of carbon that a tree can store over its lifetime depends on its size. This is so as trees with large sizes or DHB are able to store more carbon than smaller trees of the same species because they have more space to store carbon. In line with this, Mildrexler et al. [31] found that larger trees store more carbon. The study reported that as trees grow bigger and larger, each additional growth measured in centimetre of stem diameter corresponds with an increase in carbon storage. Also, Pan et al. [59] stated that forest carbon accretion is vital for mitigating current climatic change because individual large trees store a considerable percentage of the total carbon in living trees. Therefore, tree parts are able to reduce the amount of carbon in the atmosphere by sequestering carbon yearly in every new growth [31,60]. This is in that as a tree grows, it stores more carbon by holding it in its newly developed and accumulated tissue. As such, the amount of carbon sequestered every year increases with the size and health of the trees. The result in Table 7 therefore identifies canopy projection area and tree size as the tree components that substantially contribute to carbon storage in the study area.

2.4. Perceived environmental quality of green innovation

Principal components analysis (PCA) was employed in this part of the study to identify principal components of perceived environmental quality of green innovation. This statistical technique was employed due to the number of variables used to measure the perceived environmental quality of green innovation. The way people perceive green innovation is dependent on several factors, one of maybe the existence of green components in their area over as well as knowledge on the usefulness of green innovation or infrastructure. The result obtained is presented in Table 8. The result obtained showed that PCA result of 23 variables resulted in the extraction of four components that accounted for 63.9% of the variation in the data set. Using component loadings of ±≥0.8 as the criteria for selecting variables, principal component one (PC1) had strong and positive loading on a variable; the variable was it makes the university beautiful and attractive (0.839). PC1 was responsible for 19.8% of total variance in the perceived set of data on the environmental quality of green innovation and the positive loadings of the variable indicated increase in the beautification and attractiveness of the University. As a result of the variable that loaded on PC1, it therefore represented beautification of LASU. PC2 had a variable that loaded positively on it; the variable was flood control measure (0.836). PC2 was responsible for 18.8% of the total variance in the variable set and the positive loadings represented increase in flood control in the study area. PC2 represented flood control. PC3 accounted for 15.8% of total variance in the perceived set of data and had also one variable that loaded on it. The variable was it contributes to urban agriculture by providing fruits (0.877). PC3 could be said to represent promotion of urban ecology. PC4 was responsible for 9.5% of total variance in the set of data and had only one variable that loaded on it. The variable was air quality improvement or removal of pollutants (0.866). PC4 symbolized improvement in air quality. The result presented in Table 8 therefore identifies beautification of LASU, flood control, promotion of urban ecology and improvement in air quality as the principal dimensions or perceived environmental quality of green innovation in the area. These four components to a large extent explain the ecological importance of green innovation in LASU and by extension in Nigerian universities.

The first extracted component which is the most importance because it has the highest level of explanations shows green innovation contributes to beautification of LASU. This is so as a result of the availability of different tree species with broad canopies in the area. The freshness of the environment, the greenness of the environment and ambiance atmosphere LASU enjoys is due to the presence of green innovation. Residential areas and offices as well as faculties with trees, flowers and other green components embellish the scenery and attract people to the area. Also, the second extracted components shows that importance of green innovation in flood control. The roots of trees help to loosen the soil which makes it possible for rainwater to easily infiltrate the soil. The presence of green components improves the soil structure which makes the soil safe to erosion and soil loss. This result is consistent with the findings of Erickson [61] that trees and soils in urban areas function together to reduce stormwater runoff. Green components like trees reduce stormwater flow by intercepting rainwater on leaves, branches, and trunks. Some of the intercepted water evaporates back into the atmosphere, and some soaks into the ground reducing the total amount of runoff that must be managed in urban areas.

The third extracted component shows the relevance of green innovation on the promotion of urban ecology. This perhaps is one of the numerous benefits of the existence of green components in urban area. The presence helps to increase the presence of trees with inherent ecological impacts on biodiversity conservation. The planting of trees, grasses and among others in urban areas help in preserving or restoring the ecological integrity of critical natural systems while allowing for well-suited human activities and continued productive economic use of the lands [62]. The creation of urban ecology provides shade and reduce temperatures as well as significantly increases human comfort and reduce the amount of energy needed for cooling. In a related study, Cook [62] stated that integrating natural processes into cities enhance ecosystem services and maintains a healthy functioning planet for future generations.

The last extracted component also shows the importance of green innovation in improvement air quality. This process helps to make the academic environment more conducive for learning by improving the health and wellbeing of both staff and students. Trees as well know help to store carbon dioxide using their fibres which help in cleaning the air thereby reducing the negative effects that CO_2 will have on the learning environment. The presence of different tree species with varied sizes provides a day's supply of oxygen for the people. Trees also help to purify the air breathe in the environment. This is attainable through a recognized process of photosynthesis during which plants clean the air through taking in carbon dioxide and releasing oxygen [63,64]. In addition to producing clean air for us to breathe, trees also remove pollutants from the air that could otherwise contribute to health problems for residents. In addition to producing clean air for us to breathe, trees also remove pollutants from the air that could otherwise contribute to health problems for residents. Gaseous pollutants such as ozone, carbon monoxide, nitrogen dioxide, and sulphur dioxide are absorbed into a tree through tiny openings in leaves called "stomata", and then are broken down within the tree [64,65].

Table 8. PCA result showing dimension environmental quality of green innovation[a]

Variables	Principal components			
	PC_1	PC_2	PC_3	PC_4
Makes the university beautiful and attractive	.839	.141	.267	.050
Reduction in temperature	.712	.014	.115	.408
Reduction of urban heat island effect	.693	.272	.219	.219
Aesthetic enjoyment	.670	.376	.363	.132
Improvement of health and wellbeing	.658	.252	.380	.178
To have a conducive resting place	.639	.430	.200	.019
Provision of recreational opportunities	.612	.298	.369	.077
Good and conducive for habitation	.361	.319	.100	.189
Flood control measure	.094	.836	.152	.180
Soil erosion control	.179	.706	.075	.423
Noise reduction	.198	.697	.339	.239
Increase in property value	.329	.663	.105	.185
Provision of serene environment	.471	.625	.126	.114
Soil improvements (increases permeability)	.252	.590	.503	.021
Improvement of soil fertility (litter decomposition and decay)	.338	.529	.479	.102
Contribute to urban ecology	.172	.083	.877	.127
Serve as valuable educational resource	.320	.184	.761	.074
Provision of habitats for a wide range of flora and fauna species	.238	.202	.718	.274
Wind speed modification (wind breakers)	.393	.167	.498	.603
Control climate change and provision of favourable micro-climate	.351	.408	.470	.199
Air quality improvement or removal of pollutants	.097	.213	.095	.866
Preservation and protection of rare and vulnerable species	.214	.282	.277	.783
Carbon reduction benefits via CO_2 sequestration	.343	.322	.354	.444
Eigenvalues	**4.56**	**4.32**	**3.63**	**2.18**
% variance	**19.81**	**18.77**	**15.77**	**9.5**
Cumulative exp.	**19.81**	**38.58**	**54.35**	**63.85**

[a]the underlined with coefficients ±≥0.8 are considered significant

3. Conclusion or Concluding Remarks

The study has shown that the existence of green innovation in LASU contribute substantially in carbon stock and ensuring environmental quality. The study identifies canopy cover or canopy projection area and tree size as essential tree components positively and substantially associated with carbon stock. These tree components are able to store the amount of carbon around the perimeter fence of LASU. The study also identifies beautification of LASU, flood control, promotion of urban ecology and improvement in air quality as the principal dimensions or perceived environmental quality of green innovation in the area. The extracted components show the diverse functions green innovation provides to the learning environment of LASU. The study has also shown the need for green innovation components to be incorporated in building plans in the university. The incorporation of green components will increase the number of trees in LASU which in the long-run will help in carbon sequestration and flood control among others.

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