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Air and Non-Air Ecosystem Services of Urban Trees in Ekiti State, South West, Nigeria

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Abstract: Air and non air quality benefits of urban trees cannot be overemphasized. Trees as important components of the ecosystem play important roles in tangible and intangible benefits that urban forests provides for the society. These benefits are based on the ability of urban trees in intercepting the flow of urban storm water, increasing property value, decreasing energy by improved cooling, mitigating air pollution by eliminating contaminants or preventing secondary pollutants, and sequestration of carbon dioxide. This study was carried out to estimate annual ecosystem system benefits of five urban trees, Sandbox (*Hura crespitans*), Eucalyptus spp (*Eucalyptus camadunlensis*), Pine (*Pinus caribea*), Mango (*Mangifera indica*) and Lipstick tree (*Bixa orellana* (in Ado Ekiti, South West, Nigeria, using the i-tree, National Tree Benefits Calculator developed by the United States department of Forestry. The benefits from the study carried out includes gaseous pollutants removal ($1.2 million), property value J ($187,055), storm-water control (33,413m^3/yr) and carbon sequestration potential (546t/CO_2). Mature trees had more economic and environmental benefits than young and growing tree. Mango (*mangifera indica*) had the highest benefits, this is due to its large surface area, large canopy and its size. This study recommends planting of more urban trees in Ado Ekiti. An understanding of air and non air quality ecosystem services provided by urban trees will help Government in greening of cities as trees provides support to human health, improve economic and environmental benefits and also assist in the process of landscaping which gives beauty to the environment.

Keywords: Trees, Ecosystem, Air Pollution, i-Tree, Ado Ekiti, Urban

1. Introduction

Ecosystem services are benefits, functions and values provided by urban forests to the environment and populace. They are also multiple benefits provided by urban forests to human well-being and the environments in balancing of the ecosystem habitants [1]. These services comprises of tangible and intangible products such as fruits, nuts, leaves, fuel wood, fodder, building materials, shade, water shield protection, windbreaks that ensures protection against hazardous environmental conditions and mitigating climate change [2, 1]. [3] classified essential ecosystem services as provisioning; (providing products and materials), regulating; (regulating ecosystem processes and the environment); cultural; spiritual and religious, recreation and ecotourism, aesthetic, inspirational, educational, sense of place and cultural heritage.

Trees are very important components of an ecosystem having significant impacts in purification of air and reduction in environmental hazards. They can affect the concentration of air pollutants, directly removing pollutants and emissions from the atmosphere [4]. Urban trees and forests play key roles in making cities more resilient to the effects of climate change and mitigation of climatic conditions such control of water erosion, improve air quality, store carbon, mitigating the urban heat island effect, improve shading and cooling system [5]. Trees and vegetation cover can also increase air dispersion, improving local air quality, although some tree features can also inhibit air flow and result in increased air pollution [6, 7]. During the photosynthesis process, trees plays regulatory functions in carbon sequestration, tree extracts carbon dioxide from the environment, sequesters the carbon within their biomass and decomposing woods are recycled to form carbon in soil. Several research are being performed on the various benefits obtained from urban forest ecosystem services. [8] reported an economic gain of $9.5 million for New York City in 1994 due to the elimination of a reported 1,821 metric tons of air pollution from trees. In their study conducted in Qatar, [4] estimated that carbon mitigation benefits at US$ 14 billion annually, with mature trees proving to be more beneficial than smaller trees to boost environmental conditions and sequestration of carbon. Urban forests have a beneficial effect on air quality by absorption of pollutants into the canopy of trees, sequestration of atmospheric CO_2 in woody biomass and reduction of temperature [9]. It should be noted that urban biodiversity is affected by the status of the original surrounding habitats, and by planning design and management of the built environment, which in turn is influenced by the economic, social and cultural values and dynamics of human populations. Even the backyard garden can harbor significant biodiversity and serve as tree diversity reservoir. Assessing the status and patterns of biodiversity is key to adaptation strategies for sustainable development at all levels. Biodiversity is important to people's well-being and to the Environment. Urban forests are also important because of their role in conserving, preventing loss of soil nutrients, reducing soil erosion effects and the related loss of soil nutrients [10]. Ekiti State is characterized by hills and is considered homogeneous due to the nature of the population, dialect, culture, and ecology of the inhabitants of tropical rainforest ecosystems. Ecosystem services from urban forests and green spaces in Ado Ekiti are not available for use in the urban planning activities of the State, so quantifying their services can be used to assess the actual and potential role of urban forests in providing environmental, social and economic benefits in Ado Ekiti, South West, Nigeria. This study therefore is undertaken to estimate ecosystem services provided by urban trees in Ado Ekiti, South West, Nigeria; these benefits includes air quality and non-air quality. An understanding of these ecosystem services provided by urban trees in Ado Ekiti, South West, Nigeria will help Government in greening of the city, greening of Ado Ekiti, South West, Nigeria with urban trees will provide support to human health, improve economic and environmental benefits and also assist urban city planners in the process of landscaping which gives beauty to the environment.

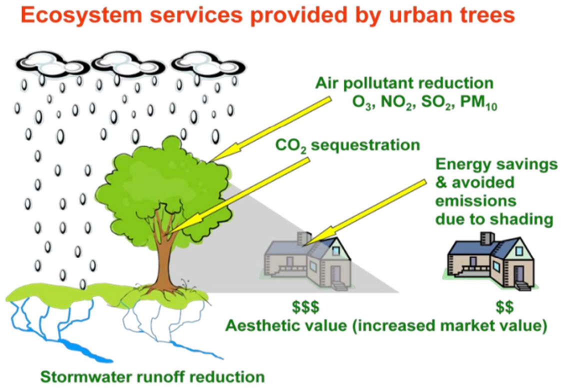

Figure 1. *Economic and Environmental ecosystem services of trees; adapted from Don Phillips (Assessment of Ecosystem Services Provided by Urban Trees: Public Lands within the Urban Growth Boundary of Corvallis, Oregon.*

Table 1. *Urban trees identified in Ado Ekiti.*

Tree Species	Family	RD (%)	RDo (%)	IVI	H' (cm)
Gmelina arborea	Verbenaceae	12.9	2.07	7.49	0.26
Terminalia mantaly	Combretaceae	11.56	1.42	6.49	0.25
Termilina cattappa	Combretaceae	8.6	0.14	4.37	0.21
Tectona grandis	Verbenaceae	6.72	0.83	3.77	0.18
Spathodea campamilata	Bignanonaceae	5.65	2.21	3.93	0.16
Termilinia ivorensis	Combretaceae	5.11	4.05	4.58	0.15
Cola accumulata	Sterculiaceae	4.57	3.92	4.24	0.14
Anacardium occidentale	Anacardiaceae	3.49	2.78	3.14	0.12
Calliandra protorica	Nimosacea	3.49	6.74	5.12	0.12
Trenia orientalis	Ulinaceae	3.49	0.31	1.9	0.12
Loneshocarpus sericeus	Papilionaceae	3.23	2.92	3.07	0.11
Terminalia senegalensis	Combretaceae	3.23	2.42	2.83	0.11
Vitex dominiana	Verbenaceae	2.42	0.86	1.64	0.09
Lineshocarpus sericeus	Papilionaceae	2.15	1.6	1.87	0.08
Spondia mombin	Anacardiaceae	1.88	1.59	1.74	0.07
Sterculia tracangatia	Sterculiaceae	1.61	1.96	1.79	0.07
Citrus sinesis	Rutaceae	1.34	0.15	0.75	0.06
Pinus caribea	Pinueae	1.34	9.93	5.64	0.06
Plumeria rubra	Rubiaceae	1.34	2.14	1.74	0.06
Albizia zygia	Mimosaceae	1.08	4.01	2.54	0.05
Ficus exasperata	Moraceae	1.08	0.87	0.97	0.05
Gliricidia sepium	Papilionaceae	1.08	0.3	0.69	0.05
Morinda lucida	Rubiaceae	1.08	0.94	1.01	0.05
Senna siamea	Mimosaceae	1.08	1.59	1.33	0.05
Bix orellana	Bixaeae	0.81	1.24	1.02	0.04
Mangifera indica	Anacardiaceae	0.81	5.11	2.96	0.04
Millentia thonigii	Papilionaceae	0.81	0.53	0.67	0.04
Moringa oleifera	Moringaceae	0.81	0.99	0.9	0.04
Pterocarpur mildbreadii	Papilionaceae	0.81	0.65	0.73	0.04

Tree Species	Family	RD (%)	RDo (%)	IVI	H' (cm)
Reltophorum peltocarpum	Rubiaceae	0.81	4.31	2.56	0.04
Acacia auriculiformis	Mimosaceae	0.54	1.98	1.26	0.03
Alstonia booneii	Apocynaceae	0.54	3.04	1.79	0.03
Theobroma cacar	Combretaceae	0.54	1.32	0.93	0.03
Zyziyium guinesis	Myrtaceae	0.54	0.64	0.59	0.03
Azadichrata indica	Meliaceae	0.27	3.3	1.78	0.02
Bauhinia momtandra	Caesalpiniaceae	0.27	1.25	0.76	0.02
Bliglia sapida	Sapindaceae	0.27	2.14	1.21	0.02
Cocos nucifera	Arecaceae	0.27	1.78	1.03	0.02
Delonix regia	Casalpindiceae	0.27	2.42	1.35	0.02
Eucalyptus camadunlensis	Myrtaceae	0.27	3.04	1.65	0.02
Ficus lutea	Moraceae	0.27	4.31	2.29	0.02
Ficus vogeliana	Moraceae	0.27	0.36	0.31	0.02
Hura crespitan	Euphorbraceae	0.27	1.32	0.79	0.02
Kigelia africana	Bignanonaceae	0.27	1.84	1.06	0.02
Leucena leucocephala	Mimosaceae	0.27	2.02	1.14	0.02
Psidium guayava	Myrtaceae	0.27	0.39	0.33	0.02
Vitellaria paradoxa	Sapotaceae	0.27	0.21	0.24	0.02
Total			99.96	99.98	3.22

2. Materials and Methods

2.1. Study Area

This study was conducted in Ado-Ekiti in Ekiti State, Southwestern, Nigeria. Ekiti State is one of the developing states in Nigeria with a relatively low population of about 2.2million according to 2006 census. The State is mainly an upland zone, rising over 250 meters above sea level. It lies on an area underlain by metamorphic rock. The topography is generally undulating with a characteristic landscape that consists of old plains broken by steep-sided out-crops that occur singularly in most part of the state. Such rock out-crops exist mainly at Aramoko Ekiti, Efon Alaaye, Ikere Ekiti, Igbara Odo Ekiti and Okemesi Ekiti. The State is dotted with rugged hills, notable ones being Ikere Ekiti Hills in the south, Efon Alaaye Hills on the western boundary and Ado Ekiti Hills in the centre. The State enjoys tropical climate with two distinct seasons. These are the rainy season (April to October) and the dry season (November to March). Temperature ranges between 21° and 28°C with high humidity. The south westerly wind and the northeast trade winds blow in the rainy and dry (Harmattan) seasons respectively [11]. Tropical forest exists in Ado Ekiti which is dominated by the Ekitis, a sub-ethnic group of the Yoruba tribe in Nigeria.

2.2. Data Processing and Analysis

The urban forest structure were calculated using basal area and newton's volume equations;

Basal area

$$BA = \frac{\pi D^2}{4} \quad (1)$$

Where: BA = Basal area (m^2), D = Diameter at breast height (cm) and л= pie (3.142). The total basal area for each city was obtained by adding all trees basal area in the city.

Volume

$$V = \pi h \frac{[Db^2 + 4\,(Dm)^2 + Dt^2]}{24} \quad (2)$$

Where: V = Tree volume (m^3), π = 3.142, h = tree height, Db, Dm and Dt = tree cross-sectional area at the base, at the middle and top of merchantable height respectively. The total volume for each city was obtained by adding all individual trees volume computed for the city.

2.3. Urban Tree Species Diversity Indices

2.3.1. Species Relative Density (RD)

Species relative density index by [12], was used in determining species diversity of this urban forest.

$$RD = \left(\frac{ni}{N}\right) x\ 100 \quad (3)$$

Where: RD (%) = species relative density; n_i = number of individuals of species i; N = total number of all individual trees of all species in the entire community.

2.3.2. Species Relative Dominance (RDo)

Species relative dominance (RDo (%)), was assessed by Aidar *et al.*, (2001) equation.

$$RDo = \frac{(\Sigma Bai\ x\ 100)}{\Sigma Ban} \quad (4)$$

Where: Ba_i = basal area of all trees belonging to a particular species *i*; Ba_n = basal area of all trees in a city.

2.3.3. Importance Value Index (IVI)

The Importance Value Index (IVI) was estimated by [12] equation.

$$IVI = \frac{(RD\ x\ RDo)}{2} \quad (5)$$

Where: IVI= Important value index;
RD= species relative density; RDo =Species Relative Dominance.

2.3.4. Species Diversity Index

Shannon-Wiener diversity index (H') by [13, 14] was used to determine species diversity of the urban forest.

$$H' = \sum_{i=1}^{s} P_i \, In(P_i) \quad (6)$$

Where: H' = Shannon-Wiener diversity index; S = total number of species in the community;

p_i = proportion of S made up of the ith species; ln = natural logarithm.

Ecosystem services of urban forest for this study were divided into air quality and non-air quality benefits. Air quality benefits includes the removal of gaseous pollutants viz-a-viz CO_2, NO_2, PM_{10}, O_3, VOC and SO_2 while non-air quality benefits includes storm water conservation, property valuation and energy conservation. Assessing the environmental and economic contributions of urban trees in Ado Ekiti, was estimated on the basis of their magnitude to intercept urban storm water runoff, add property value, reduce electricity through increased cooling, minimize air pollution by removing pollutants and sequestration of carbon dioxide. One important tool that was employed to achieve this is the use of the i-*Tree* model. The *i-Tree* model (The National Tree Benefits Calculator (NTBC)) developed by Casey and Davy tree experts has been applied to estimates various ecosystem functions in different countries based on their climatic zones [8, 15-19, 4]. The i-Tree was developed by [20]. It assesses urban forest structure and consequent ecosystem services and values. Though it was designed to be useful in America and Europe, it can be applicable in Africa especially in Nigeria as some of the tree inventories in the software are found in the tropical forest ecosystem. To utilize the NTBC calculator in assessing environmental and economic of trees, four important parameters are require, the location of the trees (climatic and ecological zone/region), name of the trees (either the common name or the scientific name as inputted in the NTBC software), the various sizes of the trees and the various land use(s) of the trees. NTBC recognizes six climatic zones; Temperate, Arid, Mediterranean, Polar, Mountains and Tropical (Figure 2); Nigeria is located in the tropical region and its trees has similar morphological parameters as that of the tropical region located in the US. For this study, after taking inventories of the trees located in Ado Ekiti, Nigeria, five most abundant trees were selected, these are;

a) Sandbox (*Hura crespitans*);
b) Eucalyptus (*Eucalyptus camadunlensis*);
c) Pine (*Pinus caribea*);
d) Mango (*Mangifera indica*);
e) Lipstick tree (*Bixa orellana*).

Ado Ekiti urban trees was divided into two major sizes (based on their diameter at base height (Dbh)).

1) Young trees (0-15 inches);
2) Mature trees (16-45 inches).

The young trees are *Hura crespitans*, *Eucalyptus camadunlensis* and *Bixa Orellana,* while mature trees are *Mangifera indica* and *Pinus caribea*. Land use types were divided into four groups based on NTBC tool; single family residential, industrial/commercial business, park/vacant land. All of the urban trees for this study are singled family residential as Ado Ekiti is a growing urban city in Nigeria and such, planting of trees is a new development.

3. Results and Discussion

Urban tree diversity indicators are usually estimated to bring the floristic diversities and abundance of different urban forest to similar scale for comparison, which is important for conservation purposes. The higher the value of Shannon-Wiener tree species diversity index (H′), the higher the tree species richness of such urban forest ecosystem. The study shows Ado Ekiti with a Shannon-Wiener tree species diversity index (3.22). Urban tree species diversity and richness is an essential part of forest ecosystem which contribute immensely to the effective functioning of an urban forest ecosystem and satisfaction of human desires [21, 22].

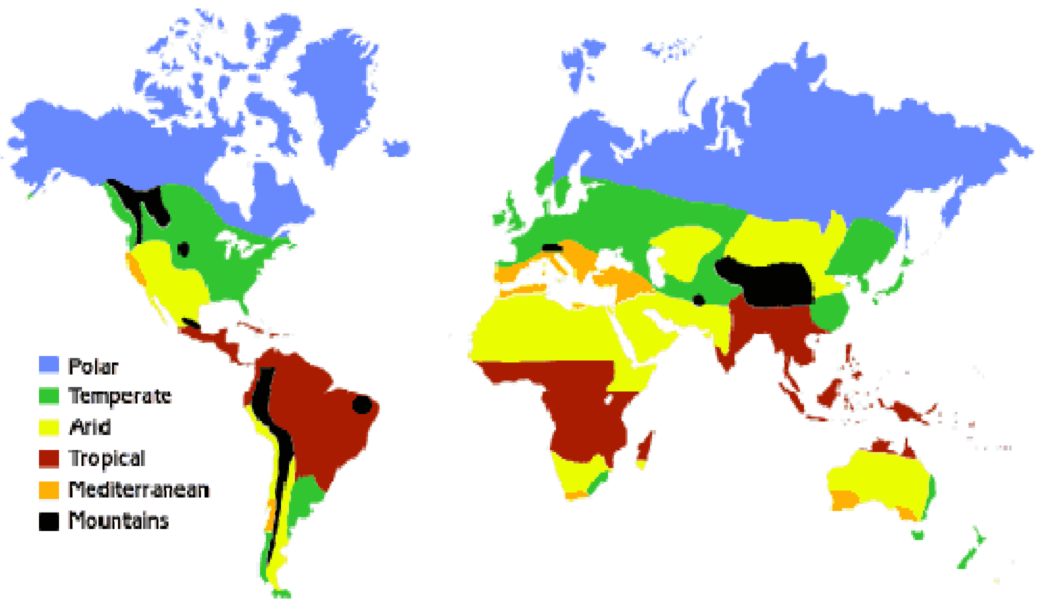

Figure 2. *World Climatic Zones showing Africa located in the Tropical region i.e hot and wet all year. Source: Courtesy of the UK Meteorological Office.*

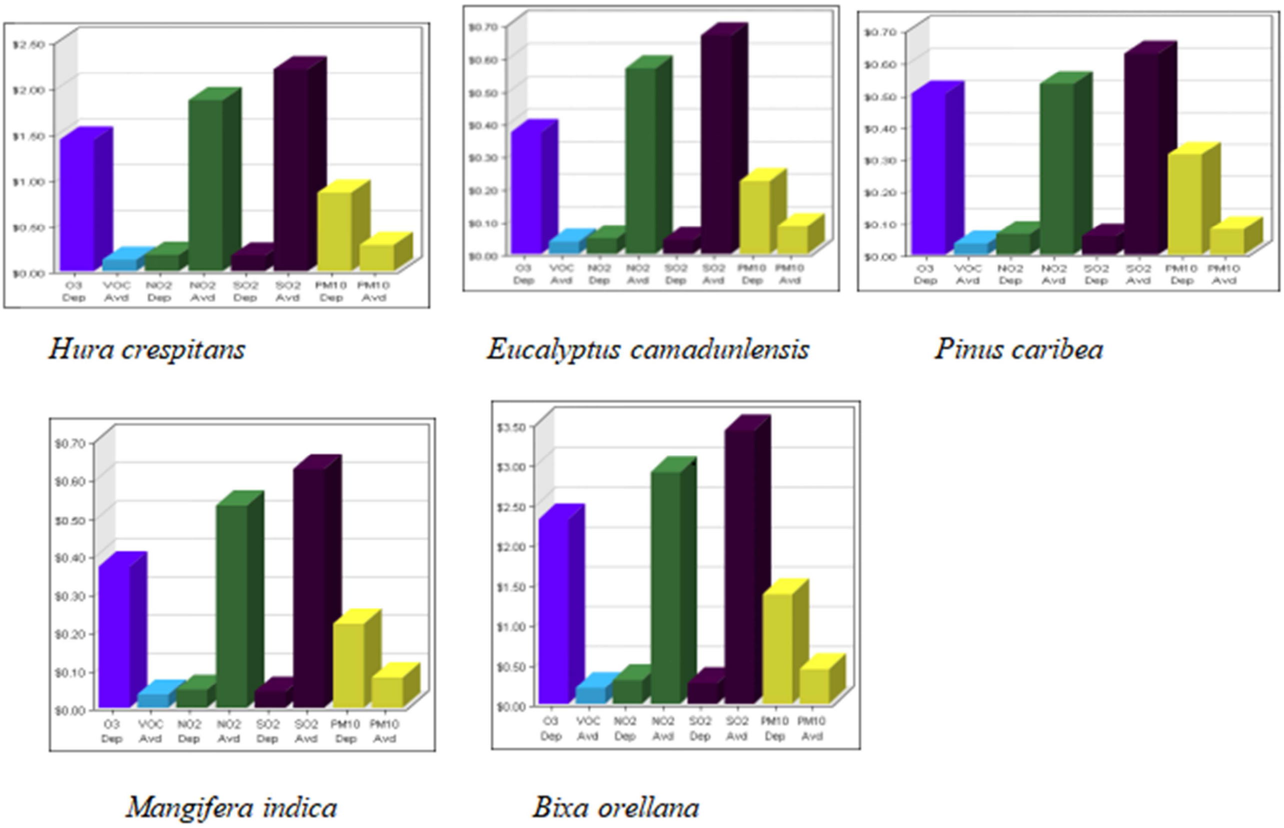

Figure 3. *Air quality benefits of urban trees in Ado Ekiti, Nigeria.*

3.1. Air Quality Benefits

3.1.1. Removal of Air Pollutants

Figure 3 shows the various air quality benefits of the selected urban trees. Pollution i.e, the release of harmful substances to the environment is a serious health issue causing sicknesses to human; these include asthma, coughing, headaches, respiratory and heart disease, and cancer. It is estimated that over 150 million people living in environment where ozone levels violates air quality standards; in addition people are affected when dust and other particulate levels are considered "unhealthy." [23]. Generally urban trees and forest can reduce the health impacts of pollution by absorbing pollutants like ozone, nitrogen dioxide and sulfur dioxide through leaves, intercepting particulate matter like dust, ash and smoke, releasing oxygen through photosynthesis, lowering air temperatures which reduces the production of ozone and reducing energy use and subsequent pollutant emissions from power plants (Casey and Davey tree, 2019) [24]. It is important to note that urban trees also releases biogenic volatile organic compounds (BVOCs) which can contribute to ground-level ozone production. Trees remove gaseous air pollutants are removed primarily by urban trees uptake through leaf stomata, though gases can also be removed through plant surfaces, inside leaves, gases diffuse into intercellular spaces and sometimes are absorbed by water films to form acids or react with inner leaf surfaces [25].

Gaseous pollutants removal of urban trees in Ado Ekiti follow the order *Eucalyptus camadunlensis>Hura crespitans>Mangifera indica> Pinus caribea> Bixa orellana*. (Figure 3). The emitting power of ozone (O_3) in all the trees follow the order *Mangifera indica> Hura crespitans> Eucalyptus camadunlensis >Pinus caribea> Bixa orellana*, an indication that young and growing trees emits ozone more than mature trees. Ozone emission by trees has been reported in various studies [26, 27, 19]; ground level O_3 is one of the most important air pollution problems in the world. They causes damages to plants to a greater extend through irreversibly destroying plants parts and tissues which lead to low crop yields and forest growth [28]. Ozone affects human temporarily or chronically via the respiratory as well as the cardiovascular systems [29].

VOC (volatile organic compounds) contributions to air quality though at a little or no level is exhibited by all the urban trees in Ado Ekiti (Figure 3). Volatile organic compounds emissions generally depends on temperature as trees generally lowers their temperature; increased tree cover has been shown to also reduce volatile organic compounds and invariably reduces ozone [30]. VOC emission rates also vary by species, for instance, studies carried out by [31, 32] to estimate VOC of nine genera of United States urban forest, i.e, genera that have the highest standardized isoprene emission rate and therefore the greatest relative effect among genera on increasing ozone, the studies showed that *Casuarina spp*., has the greatest VOC, it was followed by *Eucalyptus spp., Liquidambar spp., Nyssa spp., Platanus spp., Populus spp., Quercus spp., Robinia spp* and *Salix spp*.

As represented in Figure 3, all the urban trees exhibit high concentration of SO_2 and NO_2 removal from the atmosphere; trees remove these gaseous substances through their leaf pores, some are also removed through their surfaces. These gases diffuse on the leaf surface and are absorbed by water to form acids materials [25]. The removals of gaseous pollutants are easily conducted in plants and are more permanent than the rate of particles removal which involved absorption and conversion of the gases on the leaf interior. Pollutants are highly concentrated in urban cities but healthy urban forests can safely remove air pollutant to increase the quality of air availability to human.

Urban trees helps in ameliorating atmospheric CO_2 through two pathways; they store up CO_2 in their roots, trunks, stems and leaves as they grow and in woody products after they are harvested. Trees near residential buildings can reduce heating and air conditioning demands, thereby reducing emissions associated with power production. Carbon sequestration and storage capacity of trees are determined by tree size distribution [33]. CO_2 is divided into two in this study, sequestered and avoided, sequestered indicates the cooling impacts of tree which indirectly reduces emissions in power plants while the avoided is a function of CO_2 absorbed in and stored in various plants parts.

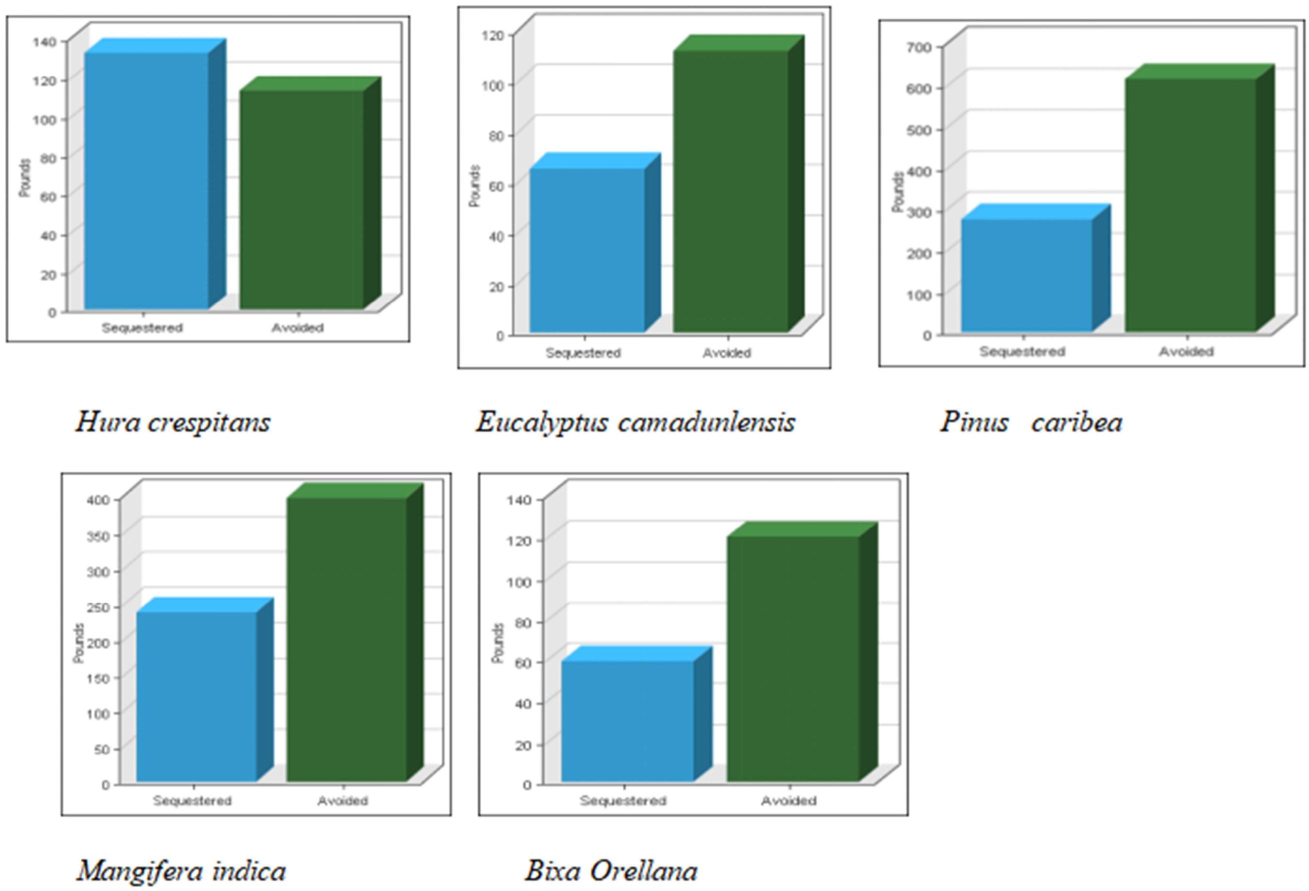

Figure 4. *Carbon sequestration potentials of the selected urban trees in Ado Ekiti, Nigeria.*

3.1.2. Carbon Sequestration

As shown in Figure 4, the total benefits derived from CO_2 sequestered from urban trees in Ado Ekiti isestimated to be 546000 kg/CO_2 (546t/CO_2); mature trees (*Mangifera indica and Pinus caribea*) sequester more CO_2 compared to the young trees in the study area, this study is similar to that carried out by [33] who opined in their work that difference between species in carbon sequestration and storage capacity are determined by their sizes, for instance, *Platanus hybrida* trees store 428.9 tons of carbon, which is more than one third of the total stored carbon (1,169 t) of urban forest street and park trees in Szeged (Hungary), it was followed by *Sophora japonica* with annual carbon sequestration values of (23.5 kg/tree on average), and *Celtis occidentalis* (15.8 t/yr). Healthy and well maintained trees sequester more CO_2 than unhealthy tress. Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered increases with the productivity rate and health of the trees (Bernard and [34]. Maintaining healthy trees will keep the carbon stored in trees though it can contributes to carbon emissions [35].

3.2. Non Air Quality Ecosystem Benefits

3.2.1. Storm Water

Urban tress like mini reservoirs play very prominent roles in storm water and flood control especially those located in single residential areas through intercepting and holding rain on leaves, branches and their barks. In doing this they increase infiltrations and storage of rain water through their roots systems and thus reducing soil erosion by reducing and slowing rainfall before they infiltrate into soils [24, 36]. Urban storm water runoff as a non-point source pollutants functions in washing chemicals surfaces such as roadways and parking lots into streams, wetlands, rivers and oceans. Generally the more impervious the surface, the more quickly pollutants are washed into waterways which includes ecosystems like drinking water, aquatic life and how the health of an ecosystem is affected [24].

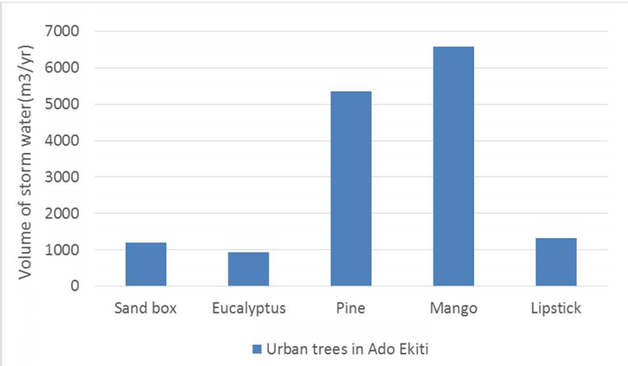

Figure 5. *Volume of storm water stored by the trees.*

The volumes of water (m^3/yr)/ released by the various urban trees in Ado Ekiti, Nigeria shows a total of 33,413 m^3/yr of storm water was released by the trees annually (Figure 5). Based on the rate of storm water in urban erosion and flood control of the trees as shown in Figure 5, *Mangifera indica* has the highest rate of storm water interception and absorption, followed by *Pinus caribea*, *Bixa orellana*, *Hura crespitans*and *Eucalyptus camadunlensis*. Rate of interception of storm water by the trees is associated with the sizes of the trees, more mature trees intercepts more storm water than young trees. Mature trees provide a large surface area for absorption of water by plants roots. This study is similar to a study carried out by [4] in their study which showed that mature trees in the state Qatar based on their sizes have a much higher benefits to intercept storm water in their root system for uptake.

3.2.2. Property Value

Trees located in front of single residential area raises the property value of such buildings than trees located in multi-family homes, parks or commercial properties [24]. To determine the property value of trees, the Leaf Surface Area (LSA) was applied. Generally, high number of urban trees within built up environment will have higher LSA value and the fewer the number of urban trees, the lower their LSA and the lower their property values. Urban trees values increase with rising numbers and sizes of the trees especially young growing healthy trees [37]. Growing trees increases values of property value until it get to a stage of decline when its values decreases due to loss in its structural and functional properties. Real estate agents work on this principle that trees can increase the "curb appeal" of property values thereby increasing their sale price; people are willing to pay more on residential buildings with more trees than homes with fewer trees.

Table 2. *Property values of selected urban trees in Ado Ekiti, Nigeria.*

Tree	Size (inch)	Property value
Sand box	12.4	$24,708
Eucalyptus	8.9	$15,660
Pine	34	$44,370
Mango	24.4	$99,188
Lip stick	12	$3,219

The total property values of Ado Ekiti urban trees based on the total number of trees inventory is about $187,055 annually (Table 2). As trees mature, their property values will invariably increase, this is due to increase in their LSA which accumulates incrementally over time because as tree grows, they tends to add more leaf surface area for every growing season which depends on the type and nature the tree, for instance in table 1, *Hura crespitans* with a DbH of 12.4 inch will add 80 square feet of LSA this year which will increase subsequently in years ahead, and the property value will increase accordingly. *Bixa Orellana* with 12 inch diameter will add 42 square feet of LSA this year and in subsequent years will add more, this will invariably increase its property value.

Table 2 also reveal that mature trees *Mangifera indica* and *Pius caribea* will with time decline in property values as they mature since they would have undergone complete structural and functional properties changes. Studies has been carried on the contributions of urban trees to property values, for example [4] working on the property values of urban trees in Qatar showed that a 10-inch *Acacia tortilis* with about 163 square feet (around 15 m^2) of leaf surface the year it is planted, with good maintenance in subsequent years, the tree will increase in size and structural functions thereby adding more leaf surface area (LSA), this will increase its property value. Also, it was estimated that a mature *Acacia tortillis* with a 45-inch will add 0 square feet of LSA the year after planting, as well as in subsequent years, since it has reached its life growth limit.

3.2.3. Energy Consumption

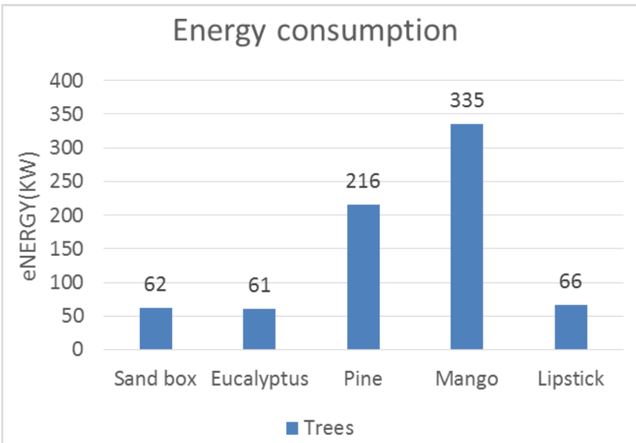

Figure 6. *Energy consumption of urban trees in Ado Ekiti.*

About 430,000 Kw of energy was conserved by urban trees in Ado Ekiti (Figure 6). Trees are important in modifying climate and conserving energy through shading which reduces amounts of heat absorbed and stored in buildings (urban heat island), evapotranspiration (loss of water through plant parts) which converts liquid water to vapour thereby cooling the air by utilizing solar energy resulting in heating air and by using their canopies to slow down winds reducing the amount of heat lost from a home, especially where conductivity is high.

Figure 6 also shows that mature trees (*Mangifera indica* and *Pinus caribea*) conserve more energy than young trees (*Hura crespitans*, *Eucalyptus camadunlensis* and *Bixa Orellana*). The energy conservation ability of trees is affected by sizes of tree and the nature of their canopies. Based on the type of tree, *Mangifera indica* has the highest energy conservation rate followed by *Pinus caribea*. Mature trees reduces wind speed by up to 50%, this influences warm air movement and affects pollutants along streets and in urban canyon. Established trees reduce wind speeds by up to 50% and influence the movement of warm air. Trees reduce conductive heat loss from building, translating into potential annual heating savings of 25% [20]. Another important factor affecting energy saving potential of urban trees is the direction and location of the trees, for instance, trees shading east and west walls keep buildings cooler. In winter, allowing the sun to strike the southern side of a building can warm interior spaces. If southern walls are shaded by dense evergreen trees there may be a resultant increase in winter heating costs.

4. Conclusion

This study assessed the environmental and economic contributions of Sandbox (*Hura crespitans*), Eucalyptus (*Eucalyptus camadunlensis*), Pine (*Pinus caribea*), Mango (*Mangifera indica*) and Lipstick tree (*Bixa Orellana*) urban trees in Ado Ekiti, South West Nigeria. Environmental and economic benefits was estimated based on the magnitude of the urban trees to intercept urban storm water runoff, adding property value, reducing electricity by enhanced cooling, minimizing air pollution by removing pollutants or avoiding the formation of secondary pollutants, and carbon dioxide capture and sequestration, using the i-tree National Tree Benefits Calculator (NTBC) developed by the United States Forestry Department. Young trees and mature were compared based on their environmental and economic benefits, the study shows that mature trees possesses more benefits than young trees for removing air pollutants, storm water, energy conservation and property value, this is due to mature possessing large diameter at base height (DBH), large surface area for absorption, ability to modify climate and conserving energy through shading which reduces amounts of heat absorbed and stored in buildings.

This study shows that mango (*mangifera indica*) has higher benefits to intercept storm water, property value, carbon sequestration potential and also higher urban island cooling ability. This study recommends planting of more urban trees in Ado Ekiti. An understanding of air and non air quality ecosystem services provided by urban trees will help Government in greening of cities as trees provides support to human health, improve economic and environmental benefits and also assist in the process of landscaping which gives beauty to the environment.

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