



# The Environmental Benefits of Trees in a Changing Climate: A Nigerian Experience

V. N. Ojeh<sup>1\*</sup>, A. Philip-Humshie<sup>1</sup>, H. A. Garba<sup>1</sup>, E. Naabil<sup>2</sup>, E. C. Obiano<sup>3</sup>,  
O. P. Boyitie<sup>4</sup> and K. K. Boyiga<sup>1</sup>

<sup>1</sup>Department of Geography, Taraba State University, P.M.B. 1167, Jalingo, Nigeria.

<sup>2</sup>Department of Agricultural Engineering, Bolgatanga Polytechnic, Box 767, Bolgatanga, Ghana.

<sup>3</sup>Department of Environmental Health Science, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

<sup>4</sup>Department of Meteorology and Climate Change, Nigerian Maritime University, Okerenkoko, Delta State, Nigeria.

## Authors' contributions

This work was carried out in collaboration among all authors. Authors VNO and APH designed the study. Authors VNO, EN and KKB performed the statistical analysis and wrote the protocol. Authors VNO, HAG, ECO and OPB wrote the first draft of the manuscript. Authors VNO, APH and EN managed the analyses of the study. Authors ECO and VNO managed the literature searches. All authors read and approved the final manuscript.

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## ABSTRACT

The paper presents a micrometeorological study on the environmental benefits of trees in the Taraba State University, Jalingo in Nigeria. Temperatures under three different surfaces (under trees and among different tree species, bare-ground and asphalted surfaces) within the campus were measured. The temperature under trees such as Mahogany (*Khaya senegalenses*), Eucalyptus (*Eucalyptus sp.*), Gmalaina (*Gmalaina aborea*), Mango (*Mangifera indica*) found on the University campus alongside bare-ground (no vegetal coverage) and asphalted road surfaces were measured in degree Celsius for a period of three weeks. Additionally, 113 copies of some self-structured questionnaires were administered to the students of the University from the departments of Geography, Agricultural Science, Biological Science, Medical Laboratory Technology as well as

\*Corresponding author: E-mail: drojehvn@tsuniversity.edu.ng;

the Male and Female hostels on campus. Data collected were analysed using frequency, percentage, line graph and pie chart. The study showed that there is a temperature variation under different surfaces. Under the trees recorded lowest mean temperature of 29.5°C followed by bare-ground with 32.5°C whereas asphalt surface recorded the highest mean temperature of 37.5°C. The temperature under different tree species shows that trees with bigger crown and broad leaves had lower temperatures. Mean temperature under the Mango tree was 28°C while under the Neem tree, mean temperature was 32°C. On the benefits of trees to the University campus, trees as a wind breaker constituted the highest benefit as expressed by the respondents (how many in %). The following recommendations were made among others; Students should be encouraged to plant trees by giving those who are willing the seedlings of trees as incentives and water should also be made available and accessible in different in locations order to maintain the planting and maintenance of trees. Cutting down of trees should be discouraged and environmental education on the benefits of trees should be a routine activity. There should be a follow-up study on carbon sequestration in Nigeria based on solid data on benefits.

*Keywords: Benefit of trees; environment; climate change; TSU.*

## 1. INTRODUCTION

The role of trees in the environment, especially as it relates to climate change is one issue that has been emphasized by climate scientist and that is why afforestation is a key component of climate change adaptation. Functions inherent to forests, according to [1] offer solutions to water availability and cooling [1,2,3]. By evapotranspiring, trees recharge atmospheric moisture, contributing to rainfall locally and in distant locations [1] Cooling is unequivocally entrenched in the capacity of trees to capture and redistribute the sun's energy [4]. Furthermore, trees' microbial flora and biogenic volatile organic compounds can directly promote rainfall [1]. Trees enhance soil infiltration and, under suitable conditions, improve groundwater recharge. Precipitation filtered through forested catchments delivers purified ground and surface water [5,6]. Urban vegetation is very important for people's living because it not only provides visual joy for people, but also influences directly or indirectly, urban environment through its physical characteristics [7]. For example, it influences urban environmental conditions and energy fluxes by selective reflection and absorption of solar radiation and by modulation of evapotranspiration [8]. Thus, a reliable measure of the distribution of urban vegetation is getting more significant. At present, several studies have pointed to urban green spaces as a resource in promoting public health and providing valuable ecosystem services to urban dwellers [9,10,11,12,13].

Yilmaz [14] noted that plants improve the aesthetic quality of the environment and, in addition to their aesthetic aspects; Plants play

important roles in urban ecosystems by providing canopy effect, water vapour to the environment through evapotranspiration process, air pollutant reduction, carbon emission reduction, storage structural heating, and cooling cost reduction. [14] carried out detailed research to determine the temperature difference between asphalt, concrete, soil, and grass surface in the city of Erzurum, Turkey. This was done in a bid to infer that grasses, in addition to their aesthetic aspects, also plays an important role in urban ecosystems by providing canopy effect, air pollution reduction, etc. The study showed that asphalt/concrete surface has an average of 28.74°C for the whole period. Soil surface was warmer, with an average of 22.24°C, then the grass surface which had an average of 16.95°C. This shows that grass surface is most advantageous for temperature lowering because of its high reflectivity. [15] observed that grass (depending on the type) like every other cultivated green plant, requires the right soil environment, soil structure, soil pH, and nutrient conditions for it to grow. However, despite these benefits, there are scanty studies on the environmental benefits of trees in Nigeria. Where they exist, there are largely based on observation and perception as only a few are based on micrometeorological measurement. For example, [16], used 1,200 copies of questionnaires in Ekiti State in Southwest Nigeria to look for reasons why people plant trees. Similarly, the study of [17] utilized semi-structured questionnaires to survey the trees in the city of Ibadan Southwest Nigeria and the people living close to the trees or working in the locations where the trees are sighted to determine the socioeconomic benefits. A total of 65 trees (0.14 trees/km<sup>2</sup>) of *M. excelsa* were sighted. As observed in the city, the

benefits of the tree species were categorized as: environmental, medicinal, economic, spiritual and ecological services. Provision of shade that creates a 'microclimatic environment' in the form of cooling effects from the heat of the day was mentioned by about 95% of the respondents as the major benefit obtained from the trees [17]. No temperature measurements or comparison was carried out. [18] study was conducted to investigate the tree species diversity in two cities in Nigeria ascertain their biodiversity conservation potentials using both semi-structured questionnaire and inventory of tree species in Abuja and Minna of Nigeria in the North central geopolitical zone of Nigeria. No temperature measurements were also made in this study. In the study of [19], the potential of *Moringa oleifera* tree was reviewed, emphasizing its nutritional applications for humans, industrial uses and its propagation methods, as not everyone knows the enormous benefits it has. [20] was aimed at finding the impacts of different tree species and individual trees of different sizes on species richness, diversity, and composition of the herbaceous layer in Guinea Savannah Ecological Zone of Nigeria. In [21], the socioeconomic impact of commercial production of Rosewood (*P. erinaceus*) in Taraba State, Nigeria was reported through the use of the interview schedule and discussion with forestry officials, local community members and key informants in the study area. The findings of the study show that this high exploitation of *P. erinaceus* is like a 'rush for gold' in which the activity is highly organized into a coordinated network that have defied all existing forestry regulations in the State. The exploitation of the log wood provided employment opportunity for many young unemployed youths in the area, thereby alleviating poverty of the rural communities grappling with endemic poverty [21]. An assessment of the economic contribution of the *Pterocarpus erinaceus* Tree (Madrid) in the livelihood sustenance of the rural people of the Southern Taraba State, Nigeria was reported by [22] where they used purposive sampling to select three Local Government Areas. Their findings revealed that *Pterocarpus erinaceus* play an important role in the lives of many people, especially the rural people through the provision of food, medicine, wood, food for roofing and firewood, livestock feed, Source of income to many by reducing the poverty level of the rural people across the ages. It is evident from the literatures, that there is an obvious lack of an empirical study on the environmental benefits of trees in urban environments in Nigeria

and by extension Taraba State in the Northeast region of the country.

There has been a level of confusion as to whether most communities know the values of trees planted or even appreciate them. For instance, in Taraba State University, Jalingo (TSUJ), the trees seen in the University community were inherited from the former College of Education which has been relocated to another town. There have not been any plans of planting or replacing the ones that have been cut down in order to erect other structures. The benefits of trees are not only well recognized by the academic community, but by municipalities and institutions around the country and the world [23]. However, even when general benefits of trees are understood and desired, it is difficult to manage and maximize their benefits without quantitative information on the direct benefits of an urban forest [24].

Without trees, the world would be bleak, and life as it is known would be impossible. Man is already acquainted with the vast importance of trees to his survival. Primitive people were dependent on trees for food. Fossilized products of trees like coal (carbonized and fossilized wood) supply fuel for the energy needs of man. Modern man is no less dependent upon trees, particularly the soaring demand for tree products in the manufacture of newsprint and in the manufacture of papers as well as cardboard and similar packaging. Trees also serve as screens to secure privacy, to reduce noise and they provide shade, unfortunately, little or no value or priority has been placed on tree planting in Taraba State University (TSUJ) and Nigeria as a whole.

Also, trees serve as wind breaks, however, only few stands are currently standing in TSUJ campus as the environment is characterized by a lot of open space which make windstorms one of the major natural disasters in the area. Two of such instances are the reported episodic rainstorm events of April 18, and May 5 in 2018 which destroyed building/properties worth thousands of dollars, including loss of life during the raining season [25]. The results of the study by [25] showed that the 2-day rainstorm extreme event came with a high wind speed of over 600 knots (327 m/s) and caused devastating damages to building infrastructures in with the university campus and other locations within the Taraba State. Roofs of institutional and household buildings, including the mast of

Globacom Telecommunication were badly damaged leading to the death of five people with several others sustaining diverse degrees of injuries in 17 communities in Jalingo and Wukari. As a consequence of the devastating effects of the storm about 62% of those affected were forced to vacate their residential houses to take refuge outside their homes for over three days while others spent more than 10 days. For institutional buildings, the affected offices were relocated till the damaged facilities were fixed. It is on this basis that the study was embarked on to assess the environmental benefits of trees in the university campus of the Taraba State University, Jalingo, Nigeria.

Trees are not a taxonomic group, but include a variety of plant species that have independently evolved a woody trunk and branches as a way to tower above other plants to compete for sunlight. Trees tend to be long-lived, some reaching several thousand years old. Trees have been in existence for 370 million years. It is estimated that there are just over 3 trillion mature trees in the world [26]. Trees help in greening the environment. Greening environment is often used as a catchall term referring to resource protection and practices which emphasize certain core concepts, such as resource efficiency (notably balancing consumption with nature's ability to replenish these resources) and the need to protect the natural systems upon which humans and other species depend [27]. However, deforestation as caused by multiple drivers and pressures, including conversion for agricultural uses, infrastructure development, wood extraction [28,29] agricultural product prices, and a complex set of additional institutional and location-specific factors [30], have led to the loss of trees which can be extremely important in certain localities such as Jalingo.

Notable drivers of the loss of tree species in most developing countries are social amenities such as roads, hospital, and water plants etc. which are provided by the government and or the communities themselves. Most times without proper planning, primary forests are cleared to site such project. In Nigeria sites presently occupied by Petrochemicals, Refineries, Fertilizer Companies and Liquefied Natural Gas Plants where sometime, naturally occurring forest ecosystems [31].

Trees play important roles in maintaining a virile and sustainable environment. Trees provide the

means of paying "carbon debt", this is done as it absorbed carbon IV oxide ( $\text{CO}_2$ ) and gives out oxygen. When most of these trees are destroyed and used as fuel wood, planks for building, etc we have more carbon IV oxide circulating in the air causing more havoc [32]. Too much carbon IV oxide in the atmosphere causes more heat to be trapped within the atmosphere which contributes immensely to global warming and climate change [33,34].

Trees are indicators of a community's ecological health. When trees are large and healthy, the ecological systems – soil, air and water – that support them are also healthy. In turn, healthy trees provide valuable environmental benefits [16]. The greater the tree cover and the less the impervious surface, the more ecosystem services are produced in terms of reducing storm water runoff, increasing air and water quality, storing and sequestering atmospheric carbon and reducing energy consumption due to direct shading of residential buildings [32].

The Taraba State University campus has many buildings of architectural excellence and more are being constructed as the years go by but plans for greening the environment seem not to be in the pipeline as trees are cut down to put up more faculties and office blocks. It is on the basis of this that the study accessed the environmental benefits of the few remaining trees-stands by measuring temperatures under these trees and on two other surfaces devoid of trees; bare-ground and asphalted surfaces (tarred roads).

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The Taraba State University is situated along longitude  $11^\circ 18'50.35''\text{E}$  and latitude  $8^\circ 53'51.50''\text{N}$  and is located in Jalingo the capital city of Taraba State which lies approximately between longitudes  $11^\circ 09'\text{E}$  to  $11^\circ 30'\text{E}$  and latitude  $8^\circ 47'\text{N}$  to  $9^\circ 01'\text{N}$  (Fig. 1 and Fig. 2) [35]. The Local government lies in the north of Taraba state. It is bounded to the north by Lau L.G.A, to the east by Yorro L.G.A, and to the south and west by Ardo-Kola L.G.A. Jalingo has a total land mass of about  $195.071 \text{ km}^2$ .

Jalingo has a tropical continental climate well marked by wet season, which begins in April and ends in October and a dry season begins in November running through March [25]. The dry season is characterized by the prevalence of the

North-East trade winds from the Sahara desert. Jalingo has a mean annual rainfall of about 1200 mm and mean temperature of about 29°C [25].

The Taraba State University, Jalingo was established on 24th January 2008 by law No. 4, passed by the Taraba State House of Assembly. The (then) executive Governor, Pharm. Danbaba Suntai accepted the law on 28<sup>th</sup> January 2008 [36].

The Taraba State University has a land area of about 1084 Hectares [37]. The University comprises of two campuses; the Main campus and the Mini campus, this study cover only the main campus where the Senate building, eight academic faculties, and the Departments are located and activities takes place. Developments on the campus include a land mass of about 5.93

kilometres in the perimeter and 238 hectares in area (Google Earth Delineation). The campus was regarded as 'the fastest growing university in North-East Nigeria' as at 2012 [38].

## 2.2 Methods

The research design adopted for this study is field survey in which self-structured questionnaires were administered to one hundred and thirty three respondents in the study area. We also used a temperature measuring handheld sensor (RF-20) to measure the temperatures under three surfaces which include under a tree, bare ground and asphalted surface for a period of three weeks covering all days of the week except Sunday because Sunday, was a worship day and active school activities takes place on that day. The measurements were

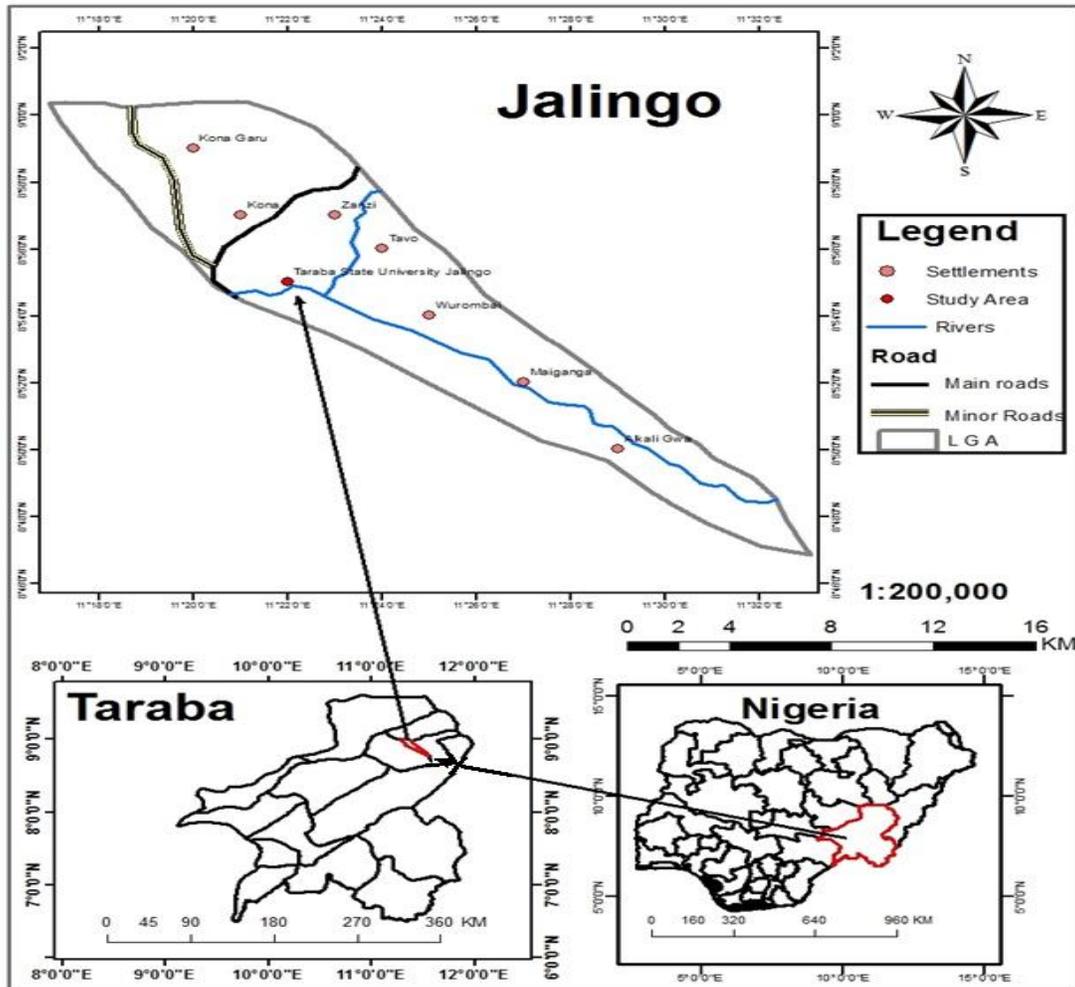


Fig. 1. Map of Nigeria showing Taraba and Jalingo

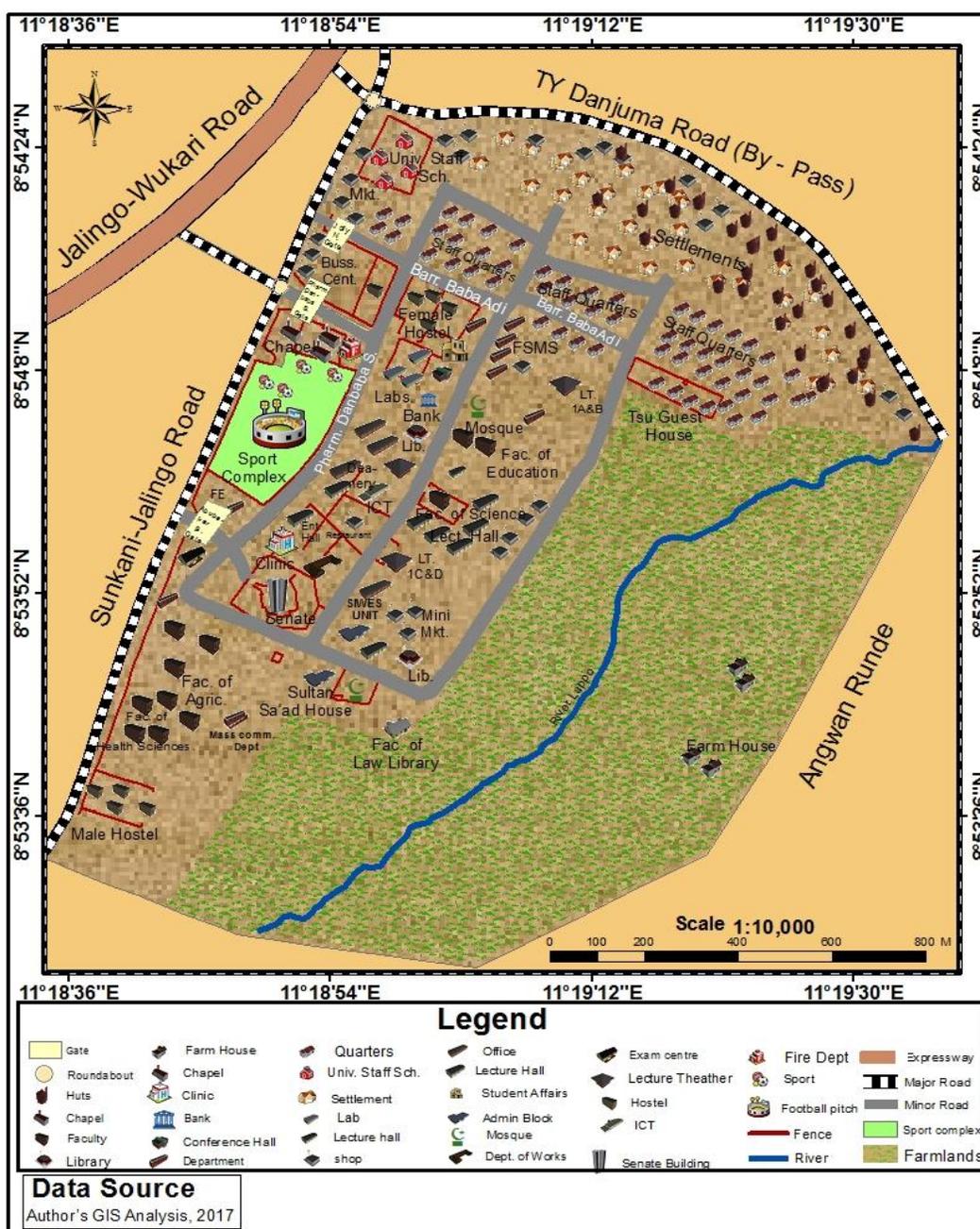


Fig. 2. Map of Taraba State University

made between 10.00am to 1.00pm local time for the period of study. Additionally, measurements were also made under tree species such as Mahogany (*Khaya senegalenses*), Eucalyptus (*Eucalyptus sp.*), Gmalaina (*Gmalaina aborea*), Mango (*Mangifera indica*) within the University. The consent of respondents was sought via a written letter from the office of the Head of Department of Geography, Taraba State

University at the start of the study and they all willingly gave their consent to be part of the research. Subsequently, self-structured questionnaires were administered randomly to the staff and students from department of the Geography, Agricultural Science, Biological Science, Medical Laboratory Technology and male and female hostels. The choice of the departments was borne out of the fact that in way

or the other, their study involves the environment and trees or plants. The trees sampled are located around the football pitch, male and female hostels, Geography, Agricultural Science, Biological Science and Medical Laboratory Technology departments. The entire study was done during the dry season. The temperature measurements were taken and instantly recorded in a field note and later transferred to the computer for the analysis.

### 3. RESULTS AND DISCUSSION

#### 3.1 Tree Species Found on Taraba State University Campus and Location

Chart 1 presents the various trees in the Taraba State University campus. It recorded trees that dominant in the different locations. The study recorded about 14 species of trees that are found in the Taraba State University. The study observed that the trees are sparsely distributed in these locations and no orderliness in their arrangement. This could be the result that the trees were largely inherited and the initial tertiary institution, the College of Education which has been relocated to another location didn't take expansion future expansion of the environment into consideration.

#### 3.2 Temperature Difference under Different Tree Species

Fig. 3 shows the temperature of bare ground, under trees and on tarred road. The mean

temperature computed for bare ground, under trees and tarred roads reveals 32°C, 29.6°C and 39.5°C respectively. The result is a proof of the environmental benefit of trees in the campus environment especially in the northeast region of Nigeria where most of the land mass is devoid of natural vegetation, thus leading to extremely hot weather during the dry season months of November to April. At this period, one could feel the heat directly from asphalted surfaces during the day.

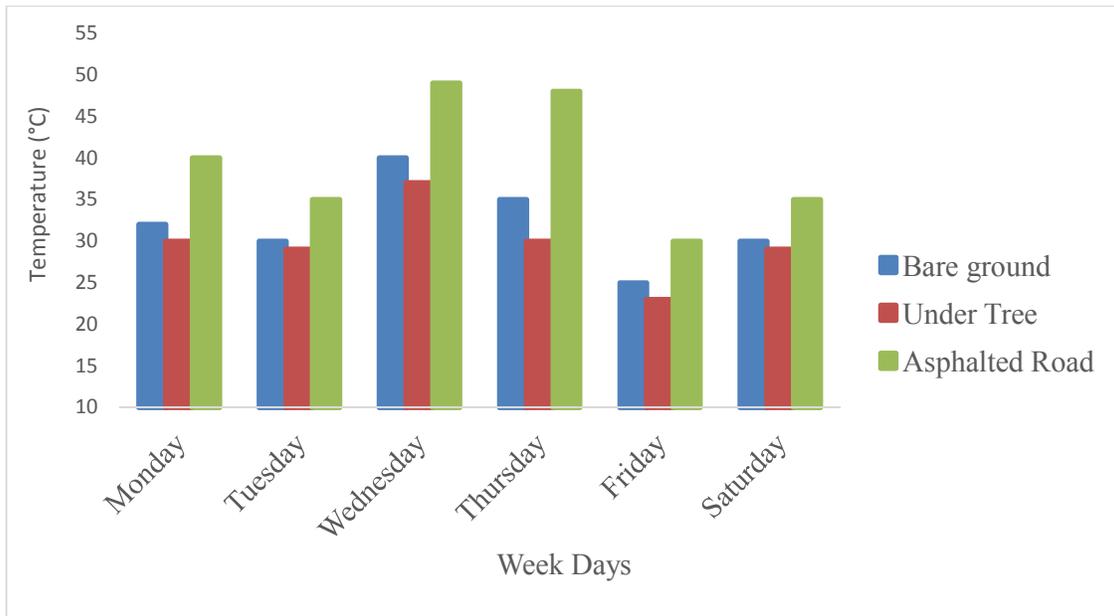
Fig. 4 shows the temperature of bare ground, under trees and on tarred road. The mean temperature computed for bare ground, under trees and tarred roads reveals 31°C, 28.67°C and 37.3°C respectively. The trend of temperature in the second week was similar to the result obtained during the first week of the study. There is a consistency of higher temperature on asphalted surfaces over bare ground and under trees.

Fig. 5 shows the temperature of bare ground, under trees and on asphalted (tarred road). The mean temperature computed for bare ground, under trees and tarred roads reveals 32°C, 29.5°C and 37.5°C respectively. This indicates that asphalted surfaces have higher temperature because of heat absorption of the tar. Albedo level for asphalted surface is 0.05-0.20 [38]. Albedo is the fraction of solar radiation reflected by a surface or object. It plays an important role in the thermal behaviour of pavements and other ground surfaces and their resultant impacts on humans and the environment.

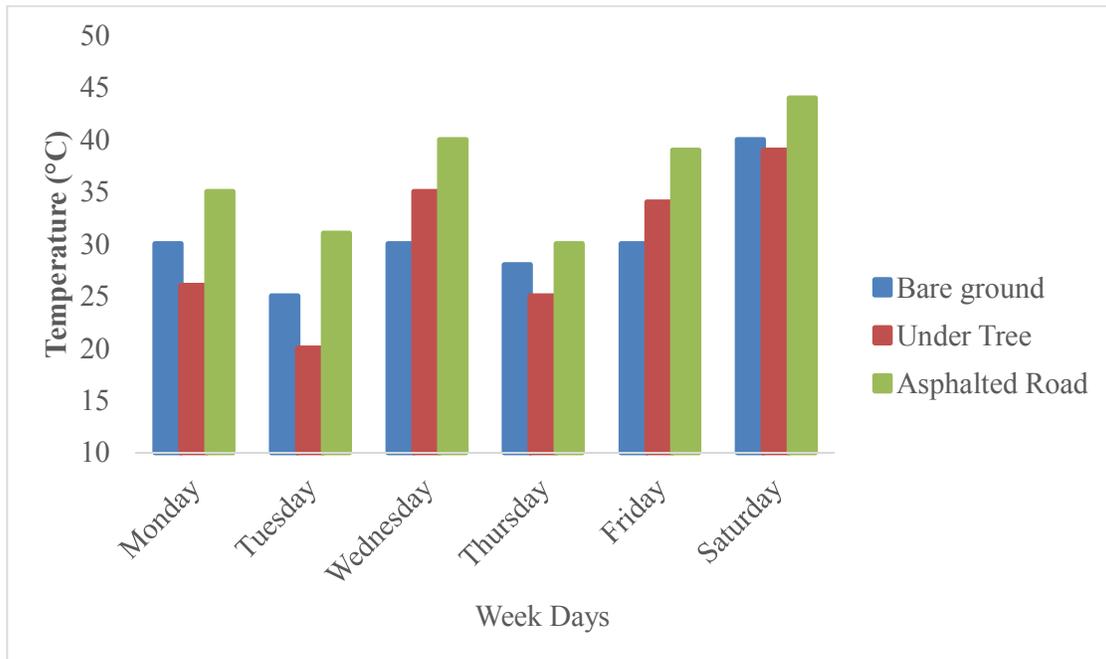
Chart 1. Tree species in taraba state university

S/No	Common names	Scientific names	Location
1.	Neem Tree	<i>Azadirachta indica</i>	Economics Department
2.	Gmalina	<i>Gmalina aborea</i>	Football pitch
3.	Yellow geisha	<i>Durata erecta</i>	Student affairs
4.	Dogon Yaro	<i>Eucaleptus camaldulensis</i>	ICT center
5.	Shear Butter	<i>Vitellaria paradoxa</i>	Law Department
6.	Cashew Tree	<i>Anacadium accidetali</i>	Sick bay
7.	Locust beans	<i>Pakia buglunbusa</i>	Faculty of Education
8.	Wattles	<i>Accacia hockey</i>	Biology Department
9.	Mango Tree	<i>Mangifera indica</i>	Female hostel
10.	Mahogany	<i>Khaya senegansis</i>	Behind Law Department
11.	Baobab Tree	<i>Adasonia digitata</i>	Male hostel
12.	Flambouyant Tree	<i>Delonix regia</i>	Biology Laboratory
13.	Tamarid	<i>Tamarindus indica</i>	Female hostel
14.	Drum stick	<i>Moringa oleifera</i>	Football pitch

Source: Field Survey, 2018



**Fig. 3. Bar chart showing temperature of bare ground, under tree and on asphalted road (week one)**



**Fig. 4. Bar chart showing temperature differences between bare ground, under tree and asphalted road (week two)**

Table 1 shows that week 1 recorded the highest temperature on Wednesday at 37°C and the lowest temperature at 23°C on Friday. Week 2 recorded the highest temperature at 39°C on Saturday and the lowest temperature at 20°C. Week 3 also shows its highest temperature at 40°C and the lowest temperature at 20°C. This temperature variation is related or associated with rainfall. The days that had rainfall indicates low temperatures, but

days that are sunny and dry show high temperatures.

Table 2 shows the result of respondent's perception of temperature expected under different tree species in the area of study. From the table, 37% of the respondent's perceive temperature under the Cashew tree to be cooler.

Similarly, 21% of the respondents perceive the Guava tree to be cooler. However, 11.5% perceived the mango tree, 16.6% perceived the Baobab tree while 12.8% perceived the Neem tree to be cooler respectively. These perceptions are drawn from the respondents' thermal comfort subjective experiences under these trees over time on campus.

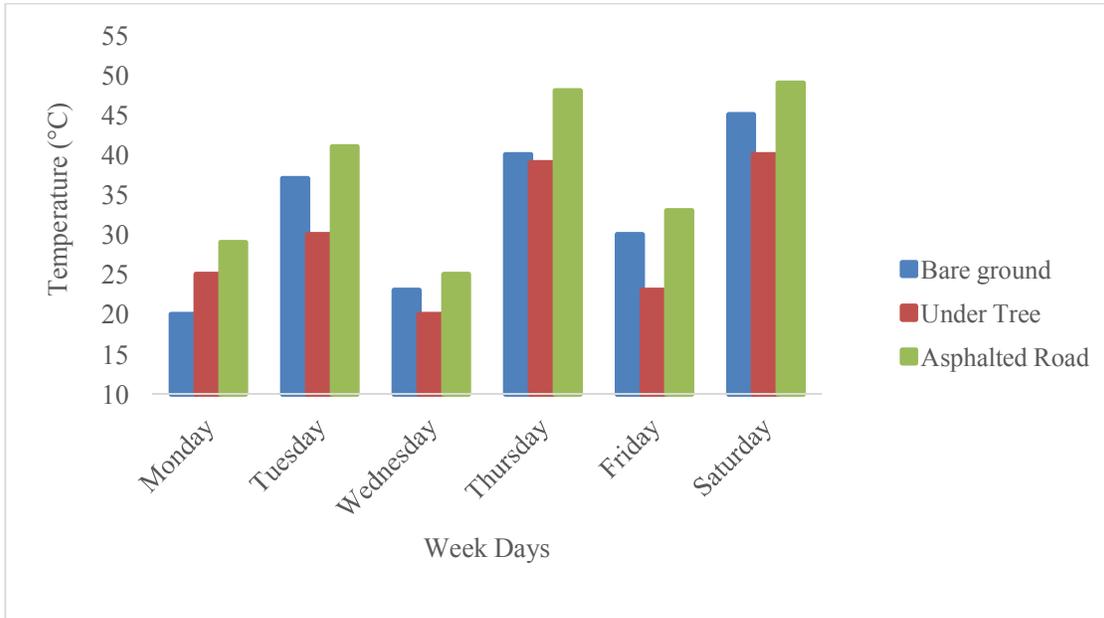


Fig. 5. Bar chart showing the temperature on bare ground, under trees and asphalted road (week 3)

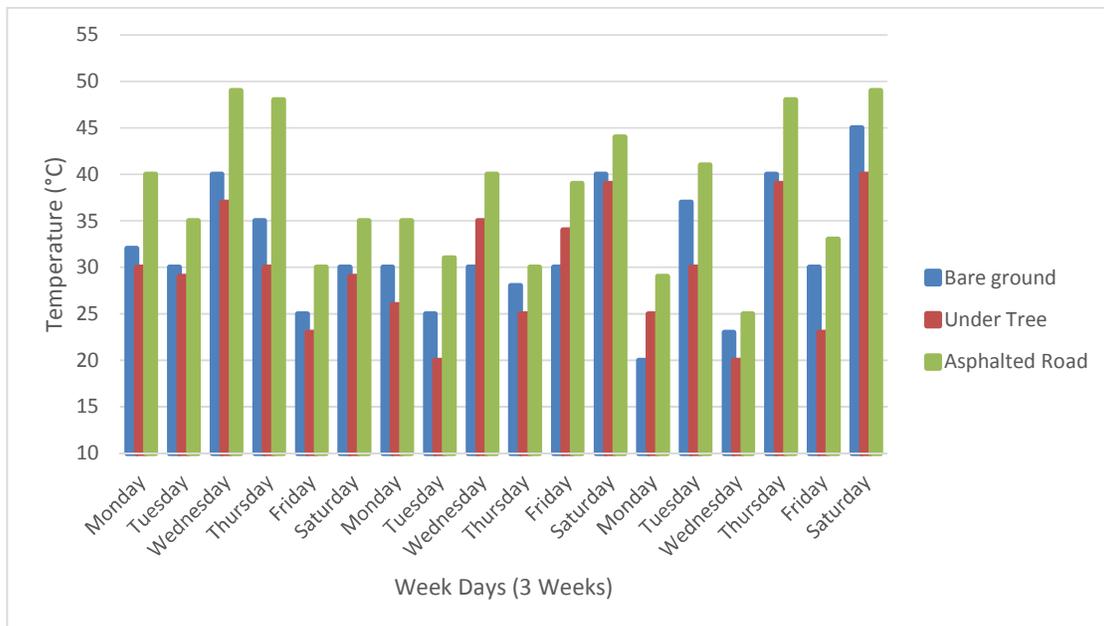


Fig. 6. Daily temperature record for under different surface

**Table 1. Daily temperature record for bare ground, under tree and asphalted road**

Days	Bare ground	Under tree	Asphalted road
<b>Week One</b>			
Monday	32	30	40
Tuesday	30	29	35
Wednesday	40	37	49
Thursday	35	30	48
Friday	25	23	30
Saturday	30	29	35
Mean Temperature	32	29.7	39.5
<b>Week Two</b>			
Monday	30	26	35
Tuesday	25	20	31
Wednesday	30	35	40
Thursday	28	25	30
Friday	30	34	39
Saturday	40	39	44
Mean Temperature	30.5	29.8	36.5
<b>Week Three</b>			
Monday	20	25	29
Tuesday	37	30	41
Wednesday	23	20	25
Thursday	40	39	48
Friday	30	23	33
Saturday	45	40	49
Mean Temperature	32.5	29.5	37.5

Source: Field Survey, 2018

**Table 2. Respondents perception of temperature expected under different tree species within Taraba State University, Jalingo campus**

Variables	Frequency	Percentage (%)
Neem	10	12.8
Baobab	13	16.6
Mango	9	11.5
Guava	17	21.8
Cashew	29	37.2
Total	78	100

Source: Field Survey, 2018

Fig. 7 shows the species of trees that the respondents know and identified in the Taraba State University environment. 10 respondents representing 13% identified Neem tree, another 13 respondents representing 17% knew and identified Baobab tree present in the school premises while 9 respondents representing 11% could identify Mango trees. Meanwhile, 17 respondents representing 22% identified Guava while 29 respondents representing 37% identified cashew. This result shows that a great number of the respondents identified the Cashew tree as the most common tree species in the school. In reality, the study area has more Neem trees than other species. The implication of this result is that though many individuals interact with the trees in

the environment daily, most people cannot accurately identify the names and types of trees. Meaning that there's a need for the trees on campus to be given their appropriate scientific and local names for ease of identification.

In Table 3, the challenges of tree planting in the area of study are presented. From the table, it is evident that the lack of technical knowledge of trees and what trees do in the environment is the most critical challenge with 39.1% of responses. Similarly, the lack of credible information on tree types which are best suited for the environment with 33.1% responses is another factor although 27.8% of the respondents still recognized the lack of land, or secure land tenure or cultivation

rights for the cultivation right as a factor. There are empty lands but no one seems to know if he has the right to plant trees for the benefit of man and the environment without being confronted by the authorities. This poses a big challenge for individuals' initiatives to plant trees because of the bureaucratic processes involved in obtaining permission. From the result, it can be deduced that the greatest challenge of tree planting in Taraba State University is lack of technical knowledge about growing, planting and maintaining trees. This finding agrees with the work of [39] which stated the challenges of tree

planting to be lack of credible information about the benefits of tree planting. If people do not believe that planting trees will be beneficial, there is little motivation for them to become involved in planting.

Table 4 presents the findings of this research on the benefits of tree planting as 24 respondents representing 18% asserted that furniture, firewood and provision of timber for building constructions are the benefits of tree planting, another 78 respondents representing 58.6% said that the benefits of tree planting erosion

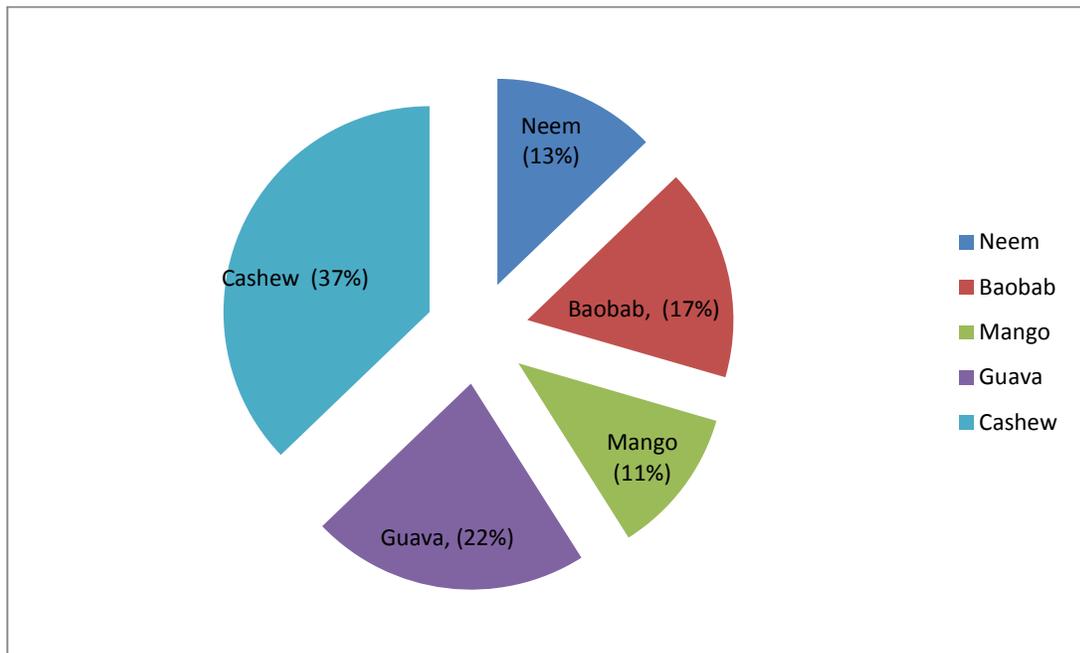


Fig. 7. Pie chart showing trees species identified by respondents in Taraba State University

Table 3. Challenges of tree planting in Taraba State University, Jalingo

Variables	Frequency	Percentage (%)
Lack of credible information	44	33.1
Lack of technical knowledge	52	39.1
Lack of land for cultivation right	37	27.8
Total	133	100

Source: Field Survey, 2018

Table 4. Benefits of tree planting

Variables	Frequency	Percentage (%)
Furniture, firewood, building materials	24	18.
Prevention of erosion and Wind breakers	78	58.6
Provision of food, Shade, and for agricultural research	31	23.3
Total	133	100

Source: Field Survey, 2018

prevention and wind breakers while 31 respondents representing 23.3% sees the benefits of tree planting to include provision of food, shade and for research purposes. Majority of the respondent posits that the benefit of tree planting is for erosion control and also serving as wind breakers. Knowing the benefits of trees without actual engagement in tree planting to enjoy the inherent benefits is costing us our infrastructures, human life in the face of episodic extreme climate events exacerbated by climate change. In March of 2018, several buildings and other infrastructures at the Taraba State University were badly damaged as a result of a two day windstorm that cost millions of naira to fix and brought hardship to students and staff as office blocks including that of the vice chancellors' and many lecture blocks had their roofs blown off [25]. It was observed that buildings which had trees nearby were spared than those without nearby trees.

Table 5 presents the respondent's views on how the students of the university could be encouraged to plant trees in the university community. Twenty three (23) respondents representing 17.3% suggested that land should be made readily available for students to plant trees in the University. Sixty three (63) respondents representing 47.4% suggests that cash donations, as a kind of incentives should be given to students to encourage active participation in tree planting. Thirty-one (31) respondents representing 23.3% suggested that seedlings should also be made available to make tree planting easy for students while sixteen (16) respondents representing 12.0% opined that water should be made available for planting especially during the dry season. The implication of this result is the willingness of students to be engaged, howbeit, making the some resources available will serve as a morale boost to them. For instance, staff of the university in many departments purchase water from water cart pushers (water vendors) popularly called "Mai ruwa" for the conveniences located within their departments. Students who want to help with

tree planting cannot afford to also buy water to keep the environmental moisture needed for the trees to thrive.

Table 6 presents other benefits of tree planting, twenty two (22) respondents representing 16.54% opined that it has the capacity to provide jobs to some people from the time of planting to the maintenance of the tree. Eighty (80) respondents representing 60.15% are of the opinion that tree planting beautify the environment while thirty one (31) respondents representing 23.30% opined that tree planting provide source of raw materials for medicinal supplies. This is related to the findings of [14] noted that plants improve the environment aesthetics. In addition to their aesthetic aspects, plants play important roles in urban ecosystems by providing canopy effect, water vapor to the environment through evapotranspiration process, air pollutant reduction, carbon emission reduction, storage structural heating, and cooling cost reduction.

In Fig. 8, the result shows respondents' suggestion for alternative source of energy (biomass gas) to reduce irrational and indiscriminate falling of trees in the study. A hundred and seven (106) respondents representing 83% said yes that alternative sources of energy should be provided to residents of the university community to encourage them to look away from falling trees in order to provide fuel for cooking amongst the peasants. However, twenty seven (27) respondents representing 17% said no, that there is no need. It could be inferred that these 17% falls within the population of dwellers who do not understand the benefits of trees for the protection of the environment and human life.

Table 7 shows the suggestions of respondents on the various policies that could be made for tree planting in the University. The study reveals 47 respondents representing 35.3% suggested that each students should plant a tree, while 24 respondents representing 18.0% opined that ten

**Table 5. How to encourage students to plant trees**

<b>Variables</b>	<b>Frequency</b>	<b>Percentage (%)</b>
Making available land for tree planting	23	17.3
Making cash donation to motivate students	63	47.4
Seedlings should be made available	31	23.3
Water should be available for watering trees	16	12.0
Total	133	100

Source: Field Survey, 2018

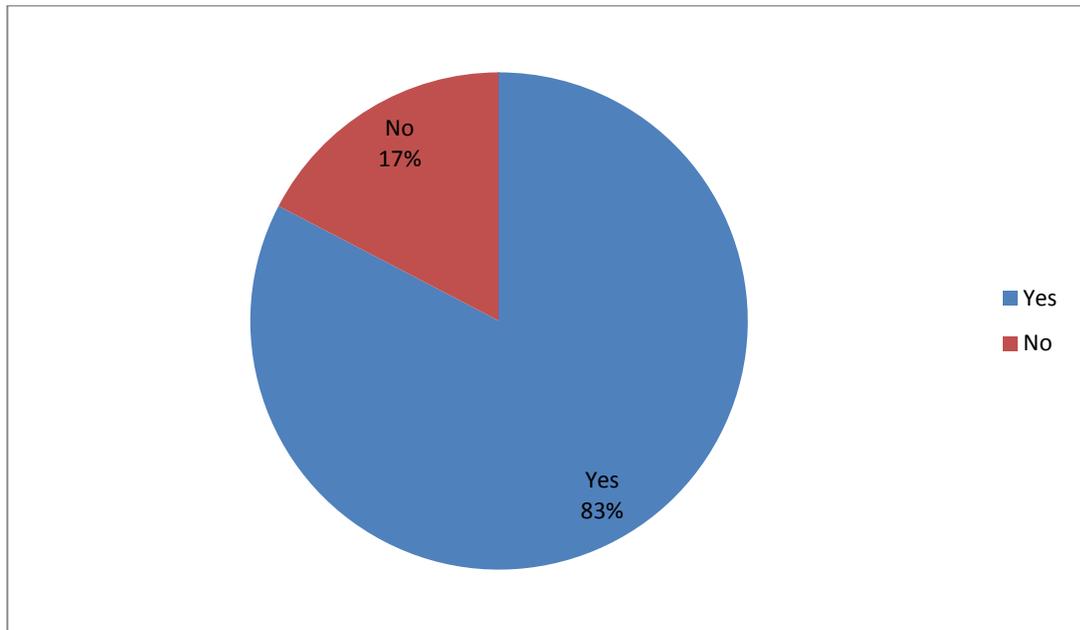
students should plant a tree in each class while 62 respondents representing 46.6% suggested that students of Ecology and Conservation should be responsible for planting and sustaining

trees in the University. With these suggestions, the University is left with the onus to take appropriate decision in the interest of the environment.

**Table 6. Other benefits of tree planting**

Variables	Frequency	Percentage (%)
Job Provision	22	16.54
Beautification of the environment	80	60.15
Provision of source of raw materials for medicine	31	23.30
Total	133	100

Source: Field Survey, 2018



**Fig. 8. Alternative source of energy to reduce the falling of trees**

**Table 7. Suggested policy for the university on tree planting**

Variables	Frequency	Percentage (%)
One student should plant one tree	47	35.3
Ten students should plant a tree in each class	24	18.0
Students of ecology and conservation should responsible for sustenance of this policy	62	46.6
Total	133	100

Source: Field Survey, 2018

**Table 8. How the university can also encourage tree planting**

Variables	Frequency	Percentage (%)
Reward staff who discourage tree planting	6	4.5
Reward students who will plant trees.	89	66.9
Reward communities who take initiative to maintain trees	38	28.6
Total	133	100

Source: Field Survey, 2018

**Table 9. Number of trees and their locations in TSU**

<b>Locations</b>	<b>Number of trees</b>
Female Hostel	5
Fire Service	6
Biology Laboratory	5
Faculty of Engineering	2
Students Affairs	3
Political Science and Sociology	28
Geography and Accounting	45
Destiny Restaurant	2
ADM and Mana	1
Mosque	2
Skye Bank	82
Faculty of Education	59
Library	43
Biological Science	20
Lecture Theater 1E	14
Administrative Block	14
First Role	40
Second Role	50
Vice Chancellor's Office	4
Zenith	7
Sick Bay	4
Engineering	10
Football Pitch	31
Integrated Class room Complex	0
Total	477

Source: Field Survey, 2018

Table 8 shows how the university can also encourage tree planting as 89 respondents representing 66.9% suggested that students who plant trees should be rewarded, 38 respondent representing 28.6% opined that communities who will take initiatives in maintaining trees should also be rewarded while 6 respondents representing 4.5% were of the opinion that staff who discourage tree planting should be rewarded.

The Table 9 shows that there are 477 trees within the Jalingo Campus of the Taraba State University. These trees play diverse role in providing shade which is vital in maintaining the temperature of the environment. More so, these trees in the University environment serves as wind breakers which prevent buildings and other valuable infrastructures from being damaged by wind storm which is a popular weather phenomenon that occurs during the rainy season each year. It was observed that areas with few trees received greater impacts of wind storms while those with much trees had minimal impacts of the wind storm. It therefore be said that trees around the school play a significant role in the environmental protection.

#### **4. CONCLUSION AND RECOMMENDATION**

The study was conducted to evaluate the environmental benefits of trees in a changing climate using the Taraba State University, Jalingo as a case. The objectives were to examine temperature differences under three (3) different surfaces which include "under trees", bare ground and asphalted surfaces. Also, we evaluated in addition temperature differences under different tree species on campus such as: Gmalaina, Eucalyptus, Mango, Mahogany trees.

The study shows that there is temperature variation between the three variables measured which were bare grounds, under tree and on asphalt surface. It was observed that temperatures under trees were lower compared to bare grounds and tarred surfaces. This was expressed from the means of temperature collected for three weeks. The recorded temperature for first week indicated 32°C, 29.6°C and 39.5°C for bare floor, under trees and 39.5°C respectively. That of the second week shows 31.6°C, 28.67°C and 37.3°C respectively while that of the third week indicated 32°C,

29.5°C and 37.5°C respectively. The work also covered the benefits of tree planting in the University community, and it was shown that the benefits include the following: Furniture making, firewood and provision of timber for building constructions and serving as wind break which is capable of protecting houses and properties from being wrecked by wind storm. Other benefits include provision of food, shade and for research purposes. Some of the respondents opined that tree planting has the capacity to provide jobs and beautify the surroundings. The study observed that trees play a significant role in breaking the velocity of wind thereby preventing it from destroying buildings and other infrastructures and strongly noted that if there were trees around Hall 22 and the Faculty of Science, the impact of wind storm that wreaked havoc those structures in 2018 as revealed by the study of [25] would have been drastically minimized. Based on the findings of the study, the following recommendations are made:

- i. Creation of awareness for tree planting among the students, staff of the Taraba State University and people living around the University community should be intensified,
- ii. Students should be encouraged to plant by incentivizing the process to encourage students to engage in planting trees in the University,
- iii. Seedlings of trees and water should also be made available in order to maintain the planting and maintenance of trees.
- iv. The environment should utilize the environmental day demonstrate practical tree planting in the school.
- v. There should be a follow-up study on carbon sequestration in Nigeria based on solid data on benefits.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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