# Assessment of Tree Canopy Cover on Urban Heat Island Effect in Owerri Metropolis, Nigeria

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**ABSTRACT:** Cities are facing rising temperatures due to global warming and fast urban growth. This study focused on the Owerri metropolis in Imo state, Nigeria, seeking to examine the influence of tree canopy cover on urban heat island effects and to comprehend the local community's perception of tree canopy cover. Two hundred fifty semi-structured questionnaires were administered to participants in sampled locations within the Owerri urban area through purposive and random sampling techniques. The results of the research indicate that planting trees (42.3%) strategically, including various species such as native (34.5%)), exotic (12.8%), fruit (42.6%), and ornamental species, helps reduce high temperatures to levels of comfort as perceived by 23.6% of the respondents. Trees are vital for providing shade, which helps lower Urban Heat Island effects, decrease energy usage, improve air quality, and aid evapotranspiration to cool the surrounding air. To increase tree canopy coverage in residential areas across the state, it is recommended that governmental entities, NGOs, and key stakeholders create and execute tree planting policies, as indicated by 80.4% of survey participants. Establishing precise yearly goals for tree planting projects can be a successful tactic to increase tree coverage, ultimately leading to a better quality of life for city residents.

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## INTRODUCTION

Heat island effects form when a significant portion of natural land cover in an area is replaced by built surfaces, trapping solar radiation during the day and re-radiating it at night (Enete and Alabi, 2012). This slows the cooling process, thus, keeping the nighttime air temperature higher compared to less urban areas (Gunawardena *et al.,* 2017). This increase in urban air temperature compared to surrounding suburban and rural temperatures is known as the heat island effect. Tree shading reduces the amount of heat stored within urban surfaces (Rahman, 2021).

Heat island effects of varying extent and magnitude have been observed in most urban areas (Enete and Alabi, 2012). The tree canopy creates shade through its foliage geometry, the crown of trees formed by branches, leaves and twigs provides shade and reduces wind speed (Zheng *et al.*, 2018). The shade cast by the tree reduces glare and blocks the diffused light from the sky and surrounding surfaces thereby altering the heat exchange between the building and its surroundings. As trees cast their shade during the day, they not only provide a cooling canopy overhead but also reduce the surface temperature of the surrounding environment, thereby minimizing the amount of heat that enters nearby buildings (Armson *et al.*, 2012).

Trees can minimize environmental problems such as thermal stress (Shahidan *et al.,* 2010; Raman *et al.,* 2021). Thus, the tree canopy is a major component which significantly influences the microclimatic environment. Several strategies have been proposed in recent decades to mitigate urban heat. These include cooling streets by installing reflective surfaces (Santamouris, 2014; Yang *et al.,* 2015) along with nature-based solutions, such as planting trees and constructing green walls and roofs to increase vegetation cover (Speak *et al.,* 2020; Wujeska-Klause and Pfautsch, 2020). The impact of urban development in central urban regions, such as the heat island effect, has pointed out the importance of diverse microclimate regulation roles provided by trees. These roles include - horizontal cooling, air humidification, soil cooling disparities between sunny and shady sites, vertical cooling adjustment, and radiation interception (Yan *et al.,* 2012; Sanusi *et al*., 2016). There are three prevailing hypotheses aimed at explaining the significant variations in microclimate regulation among trees within the same urban area. One of these hypotheses centers on forest characteristics, stating that the inherent nature of the forest ecosystems mostly influences microclimate regulations. This theory states that factors such as tree species (De Abreu-Harbich *et al.,* 2015; Sanusi *et al.,* 2017), tree size, and community features (Zhang *et al.,* 2017a) play an important role in shaping microclimate regulation. However, recent published research is scarce in the study area investigating the impact of tree canopy and abundance.

Many studies (De Abreu-Harbich *et al.,* 2015; Deng *et al.,* 2022; Wu *et al.,* 2022; Feng *et al.,* 2023) have been carried out to assess and quantify the role of tree design in shaping landscape character and microclimatic temperature regulation. These studies indicate that trees have a significant influence on environmental temperatures. The lack of tree canopy cover has led to significant environmental problems globally, particularly in developing countries like Nigeria (Ahmed and Olaitan, 2024). National governments and the United Nations are working to raise awareness about environmental issues such as air and water pollution, deforestation, desertification, greenhouse gas emissions, global warming, and climate change (Ibimilua and Ayiti, 2024). This has led to various summits, conferences, conventions, and declarations, including the Rio Declaration on Environment. At the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, Principle 10 highlighted the importance of awareness, access to information, and public participation in environmental matters (IPPC, 2007). Despite these efforts, progress in finding lasting solutions has been limited due to insufficient knowledge and ineffective tree-planting campaigns.

This study aims to assess the effect of tree canopy cover on Urban Heat Island within, Owerri metropolis, (Imo state) Nigeria. Therefore, it is important to study the microclimate between tree-cover and no-tree-cover homes in the study area to update knowledge and to encourage home tree planting in the study area.

## MATERIALS AND METHODS

### Description of the study area

Owerri metropolis is an area in the capital city of Imo state, Nigeria. The study area is located between latitude $5^0$24’0” N and longitude $7^0$1’0” E. The geology of the area is predominantly composed of coastal plain sand. The study area falls within the subequatorial climate region of Nigeria with a total rainfall varying from 1,500mm to 2,200mm (60 to 80 inches). The study area experiences two major seasons, the rainy and the dry seasons. The rainy season lasts from March to October while the dry Season starts in November and ends in February.

Humid tropical weathering of the sediments especially the carbonate is pronounced under this climate region. The rainy season is marked by heavy rainfall, thunderstorms, lighting water infiltration and percolation, leaching and sometimes flooding. The rainy season is divided into peaks. The first peak lasts from April to July while the second lasts from September to October. The dry season is divided into the cold dry season (harmattan) and the hot dry season.

The mean annual atmospheric temperature within the study area is about $28^0$c maximally. It is usually at its peak from February toward the end of the dry season but hardly exceeds $3^0$C. The mean annual pressure ranged from 1010 to 1012.9 millibars. The average daily pressure value at mean sea level (MSL) is about 109mb - 10mb during the dry season. The geology and topography of the area of studied have some influence on the drainage characteristic

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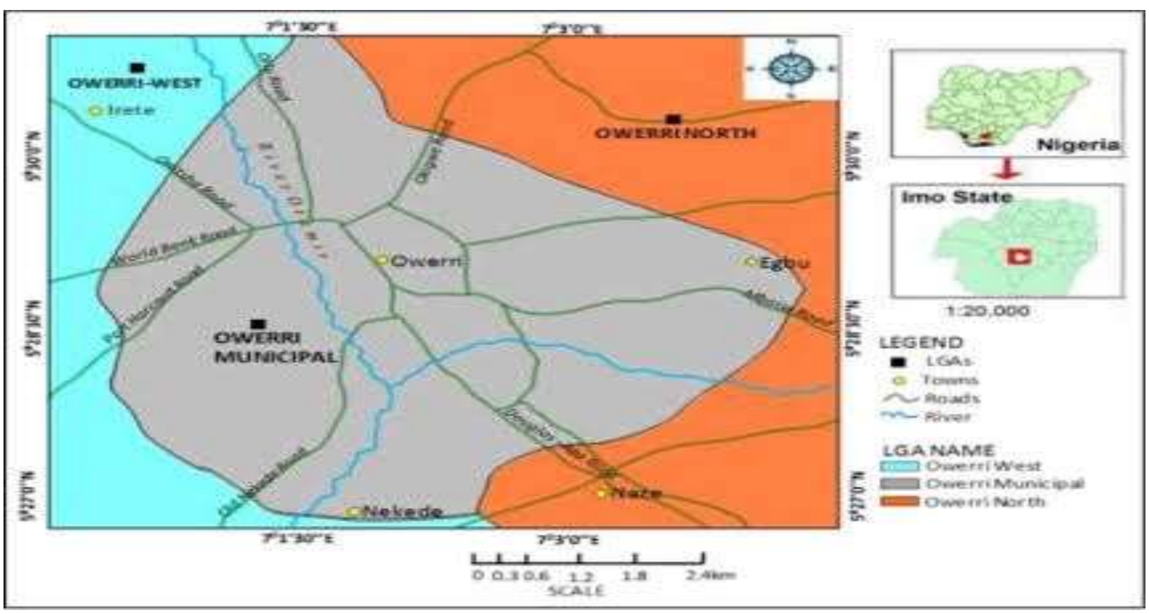


**Figure1: Map of Imo State, showing the Study Area**

### 3.2 Data Collection and Analysis

Stratified and multi-stage sampling techniques were adopted for the study. In the first stage, warehouse, and Control areas of Owerri west, Imo State was stratified into different council wards based on existing council wards. In the second stage, fifty percent (25%) of council wards were randomly selected. In the third stage, each council ward was further stratified into different locations; streets were randomly selected in each of the locations, and in each of the selected streets, residential houses with tree canopy covers were purposively selected.

Primary data were collected for the study using a questionnaire. One hundred and fifty copies of questionnaires were randomly administered to respondents in the study area. Detailed explanations were given to the respondents to get authentic information. All filled questionnaires were collected and analyzed using SPSS version 20.0. Data collected were subjected to descriptive statistics (such as frequency and percentage) and a Likert scale of rating was used to rate the responses by the respondents.

## RESULTS

The result in Table 1 shows the number of genders, age-bracket(years), occupation and years of residence of respondents who responded to the questionnaires given to them. For the gender 43.2% were males while females were 56.8% respondents. The age-bracket (in years) between 18-25 were 58.8%, this was followed by 22.3% between the age bracket of 35-45 years while 26-35 had 18.9% of the respondents. The occupations of the respondents as shown in the table indicate that majority of the respondents (64.9%) were students, followed by civil servant while farmers were 2% among the respondents. Results on the years of residence showed that most of the respondents (60.1%) had been residing in the area for less than 5 years. This was followed by 19.6% of the respondents who had resided for 11-15 years, 17.6% have been in the area for 5-10 years while 2.7% resided for more than 15 years in the study area.

**Table 1: Socio-economic Attributes of the Respondents in Owerri Metropolis, Nigeria**

| Variables | | Frequency | Percentage |
|---|---|---|---|
| Gender | Male | 64 | 43.2 |
| | Female | 84 | 56.8 |
| | **Total** | **148** | **100.0** |
| Age bracket (years) | 18-25 | 87 | 58.8 |
| | 26-35 | 28 | 18.9 |
| | 35-45 | 33 | 22.3 |
| | **Total** | **148** | **100.0** |
| Occupation | business/trading | 13 | 8.8 |
| | civil service | 36 | 24.3 |
| | Student | 96 | 64.9 |
| | Farming | 3 | 2.0 |
| | **Total** | **148** | **100.0** |
| Years of residence | <5 | 89 | 60.1 |
| | 5-10 | 26 | 17.6 |
| | 11-15 | 29 | 19.6 |
| | >15 | 4 | 2.7 |
| | **Total** | **148** | **100.0** |

The result in figure 2, shows the responses on the existence of trees in neighborhood within the study area. Based on the result, 85.1% of the respondents reported that yes here were existence tree species in Owerri metropolis, while 14.9% reported that, there were no trees around their neighborhood in the study area.

Table 2 provides estimations of tree canopy cover in respondents' neighborhoods within Owerri Metropolis, represented in percentages. The data reveals that approximately 20.9% of respondents perceive their neighborhoods to have a tree canopy cover of 25%, while a larger portion, constituting 39.2%, estimate the canopy cover to be between 25% and 50%. Furthermore, 28.4% of respondents believe that their neighborhoods possess a tree canopy cover ranging from 51% to 75%, whereas a relatively smaller fraction, about 4.1%, feel that their neighborhoods boast a tree canopy cover of 75% or more.

Regarding the knowledge of tree canopy cover's role in mitigating urban heat island effects, the results indicate that 23.6% of respondents are aware of this aspect, while the majority, accounting for 76.4%, do not possess such knowledge. This finding highlights the potential for educational and awareness programs to emphasize the significance of tree canopy cover in mitigating the urban heat island effect, especially among those lacking awareness within the study area.

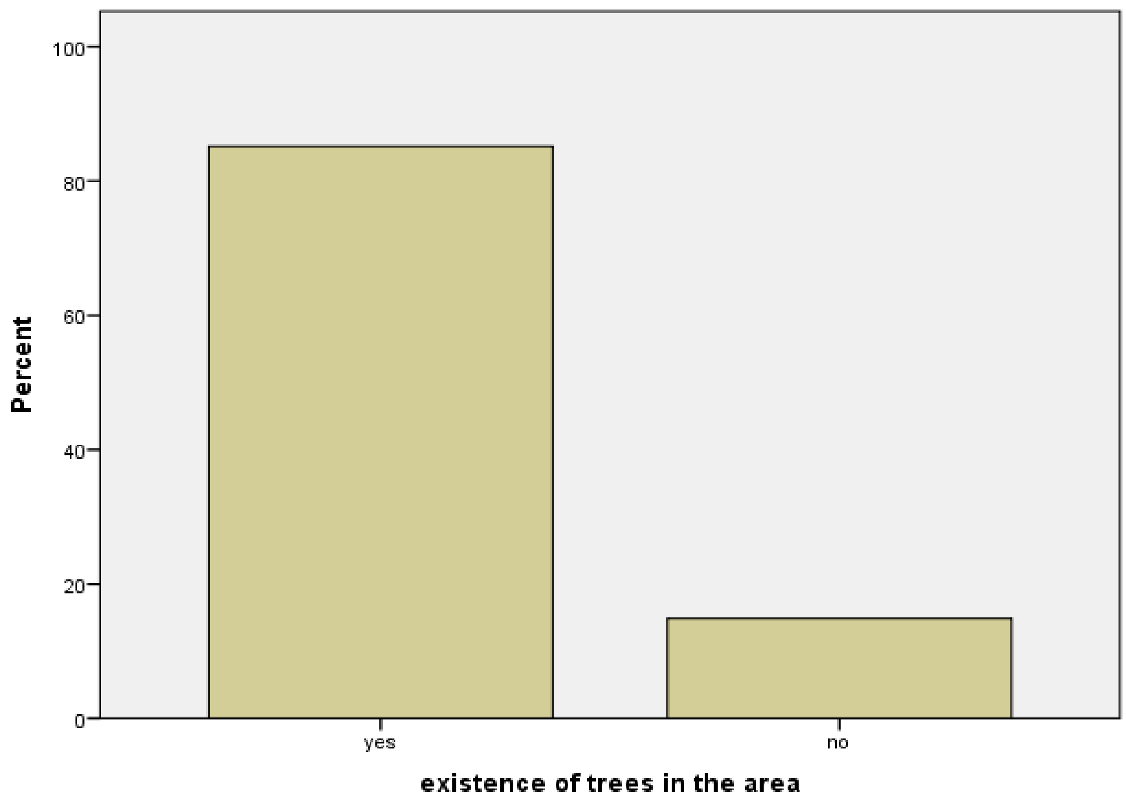


**Figure 2: Existence of Trees in neighborhood in Owerri Metropolis**

**Table 2: Respondents' Perception on Trees Canopy Cover in the Study Area**

| Variables | Frequency | Percent |
|---|---|---|
| Estimated level of tree canopy cover in the study area | | |
| < 25% | 31 | 22.6 |
| 25-50% | 58 | 42.3 |
| 51-75% | 42 | 30.7 |
| >75% | 6 | 4.4 |
| **Total** | **137** | 100.0 |
| knowledge on role of tree canopy cover in mitigating the urban heat island effects | | |
| Yes | 35 | 23.6 |
| No | 113 | 76.4 |
| **Total** | **148** | **100.0** |

Table 3 presents the types of trees available in the area, represented as percentages. Among the respondents, native tree species constitute 34.5%, making them the most prevalent tree type in the area. Exotic species, on the other hand, represent a smaller proportion at 12.8%. Ornamental tree species account for 10.1% of the respondents' perceptions of tree types available. Notably, fruit trees have a significant presence, with 42.6% of respondents recognizing them in the area.

This distribution of tree types in the area is indicative of a diverse urban forest with a mix of native and exotic species, as well as those chosen for ornamental purposes and the production of fruits. Such diversity can contribute to ecological resilience, aesthetic appeal, and potentially provide additional environmental and nutritional benefits to the community.

Table 4 presents responses regarding urban heat island effects in the study area, expressed as percentages. In terms of noticing urban heat island effects in their neighborhoods, 54.1% of respondents have observed these effects, while 45.9% have not. Concerning awareness of the potential causes of urban heat island effects, a majority, comprising 60.1% of respondents, are knowledgeable about these causes. In contrast, 36.5% do not possess such awareness, and a smaller proportion, 3.4%, remain undecided.

These findings suggest that a significant portion of the surveyed population has noticed urban heat island effects in their neighborhoods and is aware of their potential causes. However, there is still a substantial percentage that either hasn't observed these effects or lacks knowledge about their underlying causes. These results underscore the importance of further education and awareness campaigns to address urban heat issues and their contributing factors in the study area.

Figure 3 graphically shows the percentage number of people that were familiar with the term urban heat in Owerri metropolis, 60% of the individuals from the study area are aware while 40percent individuals had no idea.

**Table 3: Tree Types Available in the Area**

| Variables | Frequency | Percentage |
|---|---|---|
| native species | 51 | 34.5 |
| exotic species | 19 | 12.8 |
| ornamental species | 15 | 10.1 |
| fruit trees | 63 | 42.6 |
| Total | 148 | 100.0 |

**Table 4: Responses on Urban Heat Island effect in the Study Area**

| Response | Frequency | Percent |
|---|---|---|
| If noticed the Urban Heat Island effects in the neighbourhood | | |
| Yes | 80 | 54.1 |
| No | 68 | 45.9 |
| **Total** | **148** | **100.0** |
| aware of potential causes of the urban heat island effect | | |
| Yes | 89 | 60.1 |
| No | 54 | 36.5 |
| Undecided | 5 | 3.4 |
| **Total** | **148** | **100.0** |

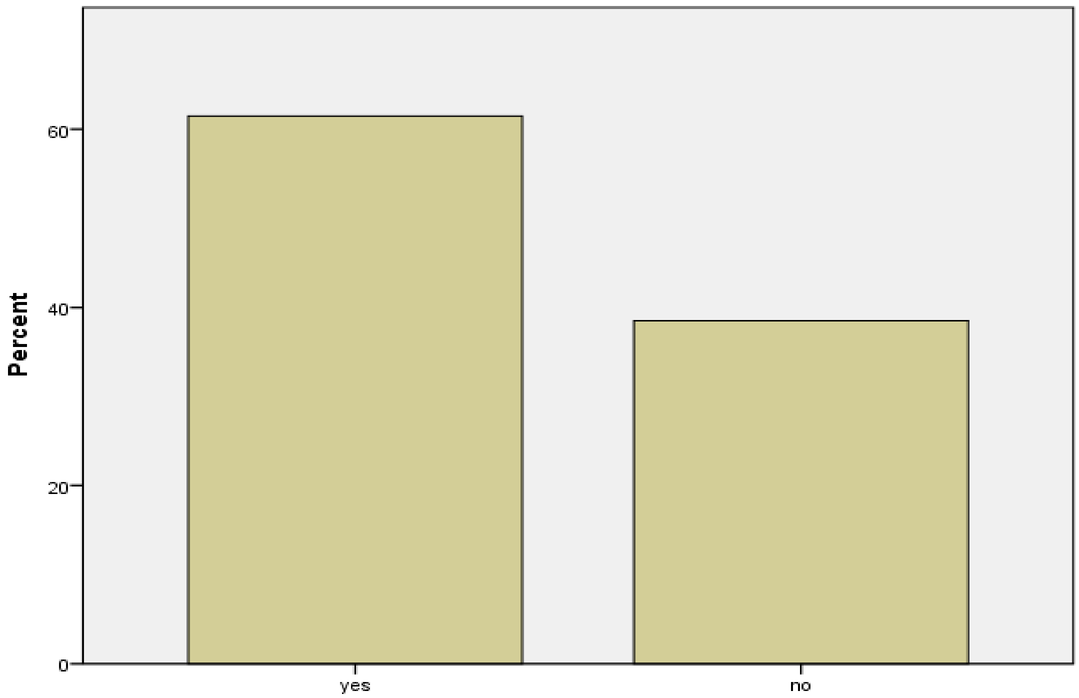


**Figure 3: If Respondents were Familiar with the term "Urban Heat" in Owerri Metropolis**

Figure 4 depicts the distribution of responses regarding perceptions of the intensity of urban heat island effects within Owerri metropolis. A substantial 24.3% of individuals characterize the effects as "very high," while 25.7% describe them as "high." In contrast, a considerable 45.3% of respondents express uncertainty about the intensity of these effects. A minor 4.7% of participants deem the effects to be of "low" intensity.

Table 5 presents data on factors contributing to urban heat island effects in the study area, expressed as percentages. Among the factors identified, "Lack of green spaces" is the most prominent, contributing to 20.9% of the urban heat island effect, followed by "Urbanization & infrastructure" at 16.9%. "Deforestation" accounts for 14.2%, while "Heat-retaining materials" contribute 8.1%. "High population density" is comparatively lower, at 4.1%. These percentages highlight the varying degrees of influence these factors have on urban heat island effects in the study area.

Regarding the question of whether "increasing tree canopy cover can reduce the urban heat island effect in Owerri Municipal," only 80.4% of respondents agreed, while the few, comprising 3.4%, disagreed. A notable 16.2% of respondents were unsure about the potential impact. These percentages reveal a degree of skepticism among respondents about the effectiveness of increasing tree canopy cover in mitigating urban heat island effects in Owerri Municipal. Further education and awareness efforts might be necessary to address these perceptions.

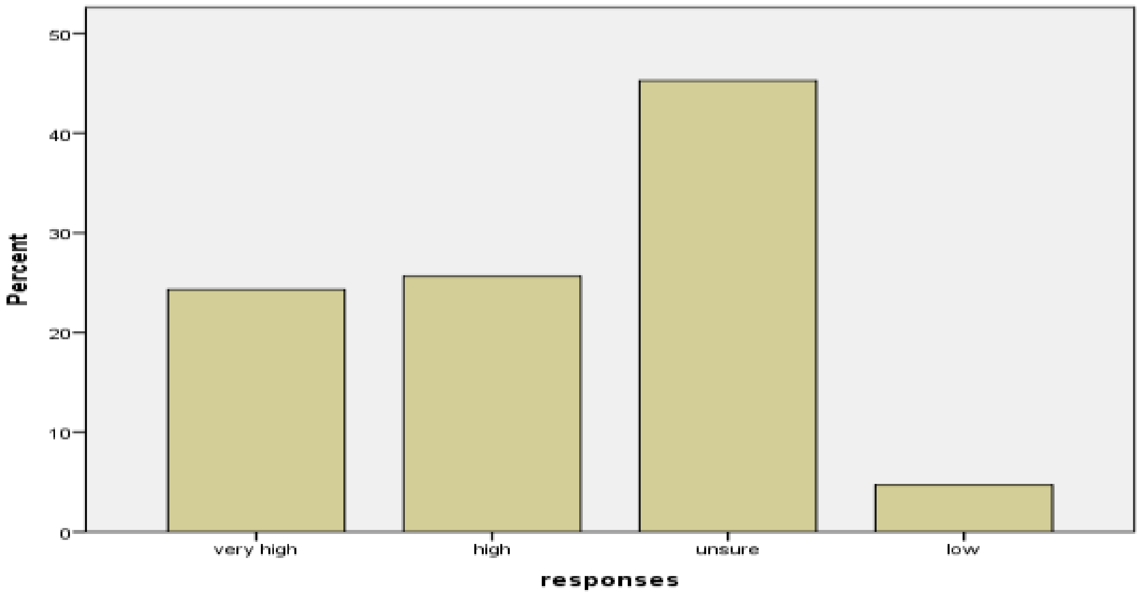


**Figure 4: Respondents' Perception on the Intensity of the Urban Heat island effect in the Study Area**

**Table 5: Factors that Contributes to Urban Heat island effect in the Study Area**

| Options | Frequency | Percent |
|---|---|---|
| High population density | 6 | 4.1 |
| Lack of green spaces | 31 | 20.9 |
| Deforestation | 21 | 14.2 |
| Urbanization & infrastructure | 25 | 16.9 |
| Heat-retaining materials | 12 | 8.1 |
| **Total** | **95** | **64.2** |
| **increasing tree canopy cover can reduce the urban heat island effect in Owerri Municipal** | | |
| Yes | 119 | 80.4 |
| No | 5 | 3.4 |
| Unsure | 24 | 16.2 |
| **Total** | **148** | **100.0** |

## DISCUSSION

The high percentage of students and young adults (58.8%) indicate that the survey's findings are more representative of the views and experiences of younger people, while most (60.1%) of the respondents being relatively new to the area may suggest that they have different perceptions and experiences compared to long-term residents. Many (56.8%) of the respondents were female, schooling and working in the area.

Most of the respondents (76.4%) lack awareness about the importance of tree canopy cover in reducing urban heat island effects. This discovery aligns with Nwakaire *et al*. (2020) study, which reported on the necessity for educational and awareness initiatives to tackle urban heat island impacts. Furthermore, the study's findings on the types of trees available in the area show the importance of urban forestry in mitigating urban heat island effects. The prevalence of native tree species (34.5%) and fruit trees (42.6%) indicates a diverse urban forest, which can contribute to ecological resilience and aesthetic appeal (Almas and Conway, 2016). The factors contributing to urban heat island effects include lack of green spaces (20.9%), urbanization and infrastructure (16.9%), and deforestation (14.2%) (Hu *et al*., 2019; Soltani and Sharifi, 2019).

Based on the result of this finding, planting tree species for fruit and ornamental purposes helps to minimize ambient temperature and contributes to the maintenance of thermal comfort limits. Trees play an important role in upholding the well-being of urban environments, with mature trees holding an inherent value that cannot be readily substituted by newly planted ones (Sjöman *et al.,* 2024). Tree stands contribute to increased shade coverage, which helps to lessen the Urban Heat Island (UHI) effects, thereby reducing energy costs and enhancing air quality (Wang and Akbari, 2016). Their presence also offers vital ecosystem services, including providing habitats, controlling erosion, improving water quality, promoting human health, and contributing to the visual aesthetics of urban areas (Liang and Huang, 2023). This result aligned with the report of Pugh *et al.* (2020) who reported that vegetation can reduce summer temperatures and improve climate comfort in surrounding outdoor spaces, thereby reducing the UHE phenomenon in parts of the city. This result aligned with the report of Akbari *et al.* (2009), and Pugh *et al*. (2020), who reported that the temperature reduction and climate comfort benefits of vegetation. Urban areas tend to be warmer, due to the urban heat island effect which can be mitigated by tree shading (Rahman, 2021). Shading decreases late afternoon tree temperature by 3℃, while trees provide shade and evaporative cooling through transpiration, reducing ambient temperature and UHE effects (Armson *et al*., 2012). Trees also purify the air by absorbing carbon dioxide and releasing oxygen through photosynthesis, contributing positively to air quality (Isaifan and Baldauf, 202). Thus, this finding reveals that increasing tree canopy cover can help reduce urban heat island effects, however, respondents' limited awareness of its effectiveness pointed out the need for further education and outreach efforts to promote the importance of urban trees.

## CONCLUSION

The results from this finding show a significant presence of young adults (18-25 years), and a prominent student demographic. Most of the respondents have recently moved to the area. The canopy coverage of urban trees is unquantifiable, with the majority (85.1%) of respondents confirming their existence in the study area. Also, the result revealed that trees in urban settings are not only for aesthetic purposes. Also, for their ability to mitigate urban heat island effects. Most of the respondents perceive that their neighbourhoods had significant tree canopy cover, ranging from 25% to 75%. However, a need for education regarding the role of tree canopy cover in mitigating urban heat island effects is evident among a portion of the respondents. There is a diverse native and exotic tree species for fruits and ornamental purposes. This diversity has the potential to enhance ecological resilience and provide numerous benefits to the community.

It is recommended that the government, NGOs, and other stakeholders should make policy relating to tree planting strategies to ensure that trees are present in every residential area in the state. The development of specific annual tree planting targets can be used to guide efforts to increase the overall tree canopy cover in the state and ensure a thermal comfort environment. It is also important to emphasize the diversity of urban tree species as a significant component of urban ecosystem since it influences the provision of many environmental and social services that contribute to the quality life.

Addressing these limitations and challenges requires comprehensive urban planning, stakeholder collaboration, and adaptive management strategies. By considering these factors, cities can maximize the potential of covered tree canopy as a tool for mitigating UHEs and creating more sustainable and livable urban environments.

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