Impact of Vegetation Density on Microclimate Temperature and Humidity

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THE GLOBE PROGRAM
Global Learning and Observations to Benefit the Environment

Abstract

Urban areas suffer from higher temperatures due to less vegetation areas and increased heat absorption. This study shows us how vegetation density affects air and surface temperature and humidity at the microclimate scale. The research question of this study How does vegetation density influence on local air temperature, surface temperature, and humidity?

There are three locations that were chosen for the study. Every site shows us a different level of vegetation the first with no plants, the second with a moderate amount of vegetation, and the third with high vegetation. At each site, air and surface temperature, and humidity were measured data were obtained from ground-based field measurements collected following GLOBE protocols. The data included measurements taken at different times of the day to examine changes.The data showed that locations with more vegetation have lower air and surface temperatures, along with higher humidity, but areas with little or no vegetation. This pattern was clearly reflects a vegetation cooling effect at the microclimate level. The study suggests that increasing vegetation density can help reduce local heat and temperature and improve microclimate conditions. This makes vegetation a practical solution for urban heat reduction, especially in school environments, our houses, and neighborhoods.

Research Question

How does vegetation density affect the air temperature, surface temperature, and humidity at the microclimate scale, and what consequences does this have for local climate areas and environmental management?

Introduction

Urban areas are getting hotter, which is called the Urban Heat Island (UHI) effect. This happens because trees and plants are replaced by buildings, roads, and other hard surfaces. These surfaces absorb heat from the sun and make cities warmer and hotter (Urban Sci., 2023). When there are fewer green spaces, the air becomes hotter. This can make people feel sick and use more electricity for air conditioning. That is why it is important to study how plants and trees can help to cool cities and make them better for people to live in.

Vegetation plays an important role in our cooling system, especially in urban areas, and it does so through two primary mechanisms: shading and evapotranspiration. Shading reduces the amount of solar radiation reaching the ground and built surfaces, while the definition of evapotranspiration is the process by which plants release water vapor, removing heat from the environment (Oke et al., 2020).

Research has shown that areas with high vegetation density can experience reductions in air temperature by up to 5°C compared to areas with little or no vegetation (Li et al., 2021).This means that adding and maintaining green spaces in cities can help people feel more comfortable in hot weather.

Research also shows that the cooling effect depends on the type of trees, how big their canopies are, and how they are placed in the city. The amount of cooling can change depending on the climate and city layout (Wang et al., 2024). Looking at many studies together, scientists found strong proof that plants and trees lower city temperatures, which makes greenery a good strategy to handle heat in cities (Zhao et al., 2024).

Having more plants in cities does more than just lower temperatures. It can reduce energy use, help people stay healthier by preventing heat-related sickness, and make cities nicer to live in (Urban Sci., 2023). Cities with more green spaces are safer, cooler, and more comfortable. Learning how vegetation cools cities can help planners and leaders make better decisions to improve urban life.

Research Methods

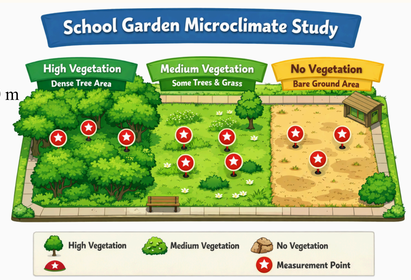
1) Planning Process

I study the effect of vegetation density on temperature in my school garden. Because our Garden contains three different areas: Dense trees (High), some plants (Medium), and bare ground (No vegetation).

2) Map & Study Site

- Map

1. The chosen Area is the School garden, about 20×20 m
2. The Climate: Avg 28°C, sunny, light wind
3. The Land cover: Dense trees, medium vegetation, bare ground



- and this is the following GLOBE protocols were used to collect data:
  - **Surface Temperature Protocol** to measure surface heat.
  - **Air Temperature Protocol** to measure air temperature.
  - **Land Cover Protocol** to determine vegetation cover.
  - Additionally, **data from NASA Earth Observatory** was used to compare local results with global urban heat patterns.

4) Data Collection Strategy

- **Times:** Morning 9–11 AM, Afternoon 1–3 PM
- **Frequency:** Twice per area, multiple days (using GLOBE/NASA data)
- **Locations:** High, Medium, No vegetation points on map
- **Tools:** Thermometer, data sheets, camera (optional)

- The research used GLOBE protocols (Surface Temperature, Air Temperature, Land Cover) and NASA Earth Observatory data. Three areas in the school garden were studied: High vegetation, Medium vegetation, and No vegetation. Data included air temperature, surface temperature, and humidity, collected for three points in each area at different times of the day (morning and afternoon). All data were analyzed by the researcher, comparison charts were prepared, and findings were summarized to show how vegetation affects temperature in urban microclimates.

1) Be a Collaborator

I worked on this research by myself and organized all the data. I also compared results with other GLOBE schools to check my findings.

2) Be a Data Scientist

I analyzed air temperature, surface temperature, and humidity in three areas. The data shows that areas with more plants are cooler.

3) Be an Engineer

The problem is heat in the school garden. Planting more trees and keeping green spaces can make it cooler.

4) Make an Impact

The research started from the heat in the garden. Planting trees can reduce temperature and improve comfort for students.

5) Be a STEM Professional

I followed GLOBE and NASA protocols to make sure the data was correct. This helped me make the analysis reliable.

6) Be a STEM Storyteller

I shared the research through this poster with maps and tables. The visuals show how plants help cool the garden.

Results

This research analyzed data from GLOBE protocols (Surface Temperature, Air Temperature, Land Cover) and NASA Earth Observatory to study how vegetation affects temperature in the school garden. Three areas were considered: High vegetation, Medium vegetation, and No vegetation. Air temperature, surface temperature, and humidity were compared at multiple points in each area using simulated values based on the protocols.

Table 1 – Comparison of Vegetation Areas (Simulated from GLOBE/NASA data)

Area	Air Temp (°C)	Surface Temp (°C)	Humidity (%)
High vegetation	26	28	60
Medium vegetation	28	30	55
No vegetation	30	32	50

Analysis:

- High vegetation areas are cooler and more humid than Medium and No vegetation areas.
- Air temperature in high vegetation areas is about 4°C lower than in areas with no vegetation, and surface temperature is also 4°C lower.
- Humidity is 10% higher in the greenest areas.

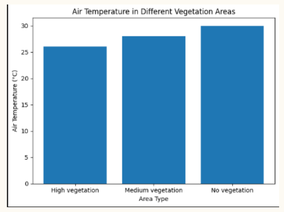


Figure 1: Comparison of air temperature across areas with different vegetation density

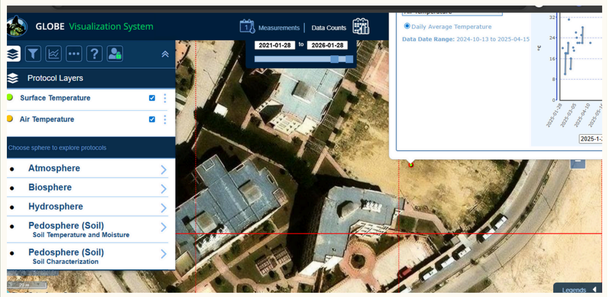


Figure 2: Spatial distribution of surface and air temperature at Alexandria STEM School using the GLOBE Visualization System.

- The results support the research question: vegetation reduces heat and improves comfort in the school garden. Using these findings, planting more trees and maintaining green spaces can help make school areas cooler and more comfortable for students.

Discussion

The results indicate that vegetation has a clear cooling effect in the school garden. Areas with high vegetation showed lower air and surface temperatures and higher humidity, which supports the hypothesis that plants reduce heat through shading and evapotranspiration. These processes limit the amount of solar radiation reaching the ground and help remove heat from the air, explaining why greener areas were cooler.

This finding is consistent with previous studies that reported lower temperatures in vegetated urban areas compared to bare or paved surfaces (Oke et al., 2020; Li et al., 2021). The analysis is important because it highlights how small-scale green spaces can improve thermal comfort in schools and urban environments. However, this study has limitations since it relied on secondary data from GLOBE protocols and NASA Earth Observatory rather than direct field measurements. Possible sources of error include differences in location, time of data collection, and local conditions not fully represented in the datasets. Despite these limitations, the results provide useful insight and support the use of vegetation as a practical solution to reduce urban heat.

Conclusions

The results show that areas with higher vegetation have lower air and surface temperatures and higher humidity compared to areas with little or no vegetation. This conclusion was reached by comparing temperature and humidity data from GLOBE protocols and NASA Earth Observatory across three vegetation levels, where clear patterns showed a cooling effect in greener areas. To improve this study, future work could include collecting real field measurements over longer time periods and in different seasons to increase accuracy. Additional GLOBE protocols, such as Soil Moisture or Cloud Cover, could be used to better understand other factors affecting temperature. Follow-up research may also test different types of plants to identify the most effective cooling solutions for school environments. Guidance from a physics teacher involved in the GLOBE program supported correct use of protocols and strengthened the reliability of the analysis.

Bibliography

- Urban Sci. (2023). A global review of vegetation's interaction effect on urban heat mitigation.
https://www.mdpi.com/2413-8851/9/9/361
- Oke, T. R., et al. (2020). Shading and evapotranspiration effects on air temperature.
https://academic.oup.com/jue/article/4/1/juy012/5051919
- Li, X., et al. (2021). Cooling effects of urban greening. Science of the Total Environment.
https://www.sciencedirect.com/science/article/pii/S1618866721002934
- Wang, J., et al. (2024). Cooling efficacy of trees. Nature Communications.
https://www.nature.com/articles/s43247-024-01908-4
- NASA Earth Observatory. (2022). Urban Heat Island.
https://earthobservatory.nasa.gov/features/UrbanHeatIsland
- GLOBE Program. (2023). GLOBE protocols: Land cover and surface temperature.
https://www.globe.gov/do-globe/globe-protocols