INVESTIGATING THE EFFECTS OF LAND COVER ON THE TEMPERATURE OF NYALI - MOMBASA

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Teach Through Expounding of Themes

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ABSTRACT

Land use change is one of the key factors affecting local and regional climate patterns. This study investigates how different land covers (grassy and concrete) impact surface and air temperatures in Nyali area, Mombasa. The research aims to determine temperature variations, assess the role of land cover in temperature regulation, and evaluate contributions to the urban heat island (UHI) effect.

Data was collected using Digital Hygro-Thermometers and Extech Mini IR Thermometers at three different time intervals across selected locations representing the two land cover types. The study found that concrete surfaces exhibited higher temperatures than grassy areas, significantly contributing to urban heat retention. The findings suggest that impervious surfaces increase temperature rise, affecting human comfort and urban climate. The research concludes that urban planning should include more green spaces to mitigate UHI effects and recommends policies promoting sustainable land cover management.

Keywords: *Land use change, temperature variation, urban heat island, climate impact*

RESEARCH QUESTIONS

1. How do surface and air temperatures vary between grassy and concrete land cover areas throughout the day?
2. What is the effect of land cover in regulating surface and air temperatures?
3. How do temperature differences in various land covers contribute to the urban heat island effect?

INTRODUCTION

Literature Review

Land use change impacts local and regional climate greatly by altering surface and air temperatures. Urbanization, which is majorly characterized by increased impervious surfaces such as concrete, modifies thermal properties and contributes to temperature variations. This literature review investigates the relationship between land cover and temperature, the role of vegetation in temperature regulation, and the urban heat island (UHI) effect, with a specific focus on Nyali, which is a rapidly growing area in Mombasa, Kenya.

Temperature Variations in Different Land Covers

Grassy vs. Concrete Surfaces

Nyali has undergone significant land use changes due to urbanization, with increased residential and commercial developments replacing natural vegetation. Grassy and vegetated areas, such as those found in Nyali area, golf course and private gardens, typically exhibit lower surface and air temperatures due to their higher transpiration and evaporative cooling effects (Oke, 1982). Conversely, areas with extensive concrete and paved surfaces, such as City Mall and surrounding commercial zones, experience higher daytime and nighttime temperatures due to heat retention (Taha, 1997). A study on urban climate in coastal cities found that built-up areas in Nyali can be up to 3-5°C warmer than green spaces, especially during peak sunshine hours (Gartland, 2012).

Temperature Variability

The difference in heat absorption rates between grassy and concrete surfaces leads to significant daily variations. The cooling effects of vegetation are noticeable in areas near green spaces, while high-density developments experience prolonged heat retention. Research conducted in similar coastal cities has demonstrated that urban greenery effectively reduces peak daytime temperatures by up to 3-5°C compared to impervious surfaces (Gartland, 2012).

Role of Land Cover in Temperature Regulation

Vegetation and Urban Cooling

Vegetation plays a crucial role in mitigating temperature extremes by providing shade and facilitating evapotranspiration (Bonan, 2008). In Nyali, trees and grass in residential compounds, hotel gardens, and natural reserves help regulate local temperatures. Studies have shown that areas with substantial vegetation cover exhibit lower temperatures compared to built-up regions (Gill et al., 2007). Green infrastructure, including urban parks and tree-lined streets, contributes to localized cooling effects. However, increased deforestation and the conversion of open spaces into commercial developments threaten this natural cooling system. Developments in Nyali area have led to increased heat retention (Bowler et al., 2010).

Impervious Surfaces and Heat Retention

The replacement of natural vegetation with impervious surfaces in Nyali has led to heat retention and microclimatic changes (Li & Bou-Zeid, 2013). With ongoing real estate developments, areas with high-rise buildings, such as Links Road and Beach Road, experience temperature increases compared to less developed sections.

Concrete-dominated areas, such as shopping complexes and business centers, absorb and retain heat longer, contributing to sustained higher temperatures, especially at night. This phenomenon has been observed in satellite temperature readings of Mombasa, which highlight Nyali as a warmer zone compared to surrounding natural areas.

Contribution of Land Cover to the Urban Heat Island Effect

Mechanisms of UHI Formation in Nyali

The urban heat island (UHI) effect is evident in Nyali due to increasing impervious surfaces and decreasing green spaces. Several factors contribute to UHI formation in this area, including:

- Reduced evapotranspiration due to vegetation loss
- Increased absorption and retention of solar radiation by impervious surfaces
- Heat emissions from buildings, vehicles, and industrial activities

Studies indicate that urban areas with extensive concrete surfaces, can experience temperature differences of 3-7°C compared to vegetated areas (Santamouris, 2015).

Impact on Nyali and Coastal Climate

Coastal cities experience amplified UHI effects due to high humidity levels, which intensify thermal discomfort (Sailor & Fan, 2002). Nyali, being a high-end residential and commercial hub, has seen rapid urbanization, reducing natural cooling elements. The combination of increasing urbanization, limited green spaces, and high solar radiation intensifies temperature differences across various land covers. Research in similar equatorial coastal environments has shown that increasing urban vegetation can significantly mitigate UHI effects (Weng et al., 2004).

Land use change has a profound impact on temperature dynamics in Nyali, Mombasa. Vegetated surfaces exhibit lower temperatures due to their cooling effects, while impervious surfaces contribute to heat retention and UHI formation. Understanding these variations is critical for sustainable urban planning and climate resilience in Nyali. Future studies should explore the potential of green infrastructure and land use policies to mitigate temperature increases in this rapidly urbanizing region.

Problem Statement

The increase in built-up areas and reduction in vegetation in Nyali area, Mombasa have led to local temperature variations, impacting public health, energy consumption, and ecological balance. The study investigates how different land covers influence temperature patterns and how this knowledge can be applied to sustainable urban development.

Community Relevance

Hot temperatures can be dangerous for both people and nature. When it gets too hot, people can suffer from heatstroke, dehydration, and breathing problems, especially young children and older adults. Many families and businesses use fans and air conditioners to stay cool, but this uses a lot of electricity, making power bills go up and adding more pollution to the air. A smart way to keep cities cool is by planting more trees, creating parks, and using special materials that reflect heat. These simple steps can help make cities more comfortable and safe for everyone.

This study helps city leaders understand how land use affects temperature. By planning better, they can make sure all neighborhoods have green spaces and shady areas, not just the rich ones. In Mombasa, where it is both hot and humid, these ideas are especially important to keep people healthy and happy. If cities use smart designs, they can protect nature, keep people cool, and make life better for everyone.

RESEARCH METHODS

Study Site Selection

Nyali, a coastal urban area in Mombasa, Kenya, features a mix of residential, commercial, and recreational spaces. Its tropical coastal climate is characterized by warm temperatures ranging from 24°C to 32°C, high humidity, and significant rainfall during the rainy seasons. The proximity to the Indian Ocean helps moderate temperatures, but urbanization has led to localized warming.

The area's land cover includes built-up infrastructure such as roads, apartments, and commercial buildings, which contribute to heat absorption. However, green spaces, tree-lined streets, and gardens provide cooling effects. Sandy beaches and the oceanfront also influence temperature regulation by reflecting solar radiation and promoting airflow. With rapid urbanization reducing natural vegetation, Nyali faces increased risks of localized heating and urban heat island effects. Two study sites were selected to represent different land covers: a grassy field and a concrete-paved surface.

Figure 1: A map of the study Site - Nyali area in Mombasa County.

Equipment and materials

- Digital Air Temperature Sensor/Thermometer
- GLOBE Atmosphere Protocol Thermometer
- Hygrometer
- Mobile GPS App
- Field Notebook & Data Sheets
- GLOBE Observer App
- Weather Station Data
- GLOBE Visualization System
- Maps and Satellite Images (Google Earth Pro)
- Digital Camera and Smartphone

Data Collection Procedures

To answer the research questions, the study utilized GLOBE Atmosphere Protocols; the *Surface Temperature* and the *Air Temperature Protocols*. These protocols provided standardized methods for measuring and comparing temperature variations across different land cover.

Locations of the Study Site

The research was conducted in two distinct land cover types within the school:

- **Grassy Area** – Representing vegetated land cover.
- **Concrete Surface** – Representing built-up, impervious surfaces.

Sampling Method

- Measurements were taken at the same point within each land cover type to ensure a representative dataset.
- Data was collected at three different times of the day: morning, midday and evening to capture temperature fluctuations.
- The study spanned eight weeks, allowing for reliable trend identification.

Measuring Air Temperature

Air temperature was measured using a Digital Hygro-Thermometer at the various locations. To ensure accuracy, the measurements were taken at a standard height of 1.5 meters above the ground, following the guidelines set by GLOBE protocols. Regular recordings were made to track temperature variations over time. In addition to temperature, humidity levels were also measured to understand their influence on temperature changes.

Figure 2: Students at Shree Swaminarayan Academy taking air temperature measurements

Measuring Surface Temperature

Surface temperature was measured using Extech Mini IR Thermometer to assess the temperatures of different materials (grassy field and a concrete-paved surface). To ensure consistency, the device was held at a 90-degree angle to the surface during each measurement.

Figure 3: Students at Shree Swaminarayan Academy taking Surface Temperature measurement

School: Shree Swaminnarayan Academy
Site: outside SSA Building

Measurements | Data Counts | School Info | Site Info | Photos

Atmosphere Site

Activated At	2024-11-13 12:00:42.477065
Obstacles	There are trees and buildings nearby.
Buildings	The buildings are 10 metres
Surface Cover	concrete
Thermometer Type	digital: single-day

Surface Temperature Site

Activated At	2024-11-13 12:00:42.477096
Homogenous Site Short Length (m)	10.0
Homogenous Site Long Length (m)	10.0
Surface Cover Type	concrete

School: Shree Swaminnarayan Academy
Site: Shimo La Tewa A

Measurements | Data Counts | School Info | Site Info | Photos

Activated At	2025-01-29 07:37:50.903883
Obstacles	buildings
Buildings	10m
Surface Cover	short grass
Thermometer Type	digital: single-day
Thermometer Height	120

Surface Temperature Site

Activated At	2025-01-29 07:37:50.90393
Homogenous Site Short Length (m)	10.0
Homogenous Site Long Length (m)	10.0
Surface Cover Type	short grass

Figure 4: Data Extract from the GLOBE Site

RESULTS

The study examined how different types of land cover (grass and concrete) affect surface and air temperatures throughout the day. The findings highlight significant temperature differences between these surfaces, showing the impact of land use on urban climate and the importance of green spaces in cooling cities.

Figure 5: Picture showing different Land Covers - Grassy and Concrete surfaces

Variation of surface temperatures in different land cover

According to the study, temperatures varied significantly based on land cover. Concrete surfaces heated up the fastest and reached the highest temperatures during midday, often exceeding 40°C. Grass-covered areas remained the coolest throughout the day, with surface temperatures staying lower due to moisture retention and shading effects.

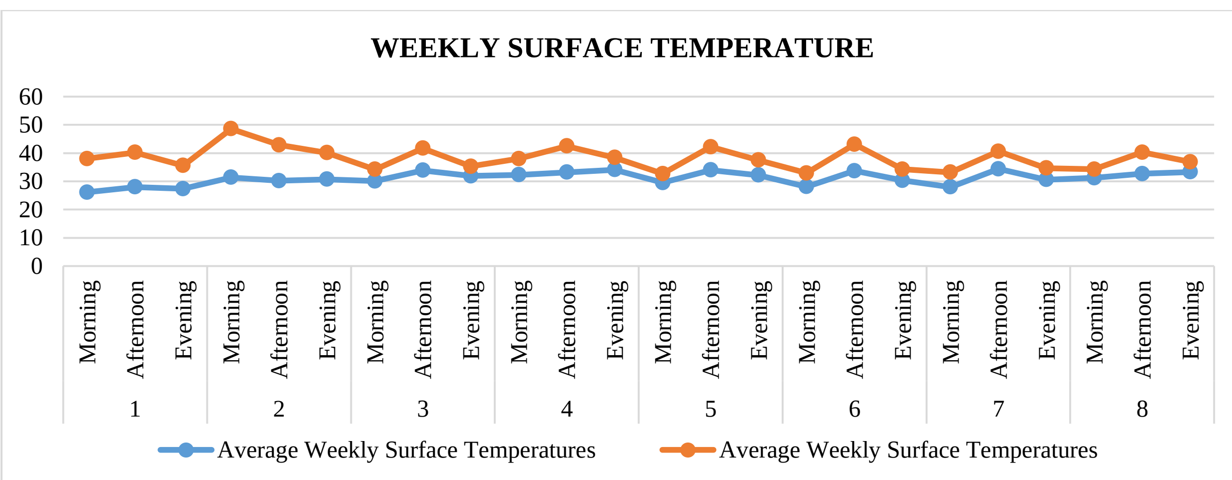

Figure 6: Graph showing the weekly average temperature for Grassy and Concrete area

Table 1: Showing changes in Surface Temperature in Grassy and Concrete areas

Week	Time	Average Weekly Temperature		
		Grassy Area (℃)	***Concrete Area*** (℃)	***Difference (℃)***
1	Morning	26.1	38.0	11.9
	Midday	28.0	50.2	22.2
	Evening	27.4	35.6	8.2
2	Morning	31.4	48.6	7.2
	Midday	30.2	52.9	22.7
	Evening	30.7	40.1	9.4
3	Morning	30.1	34.2	4.1
	Midday	33.9	51.7	17.8
	Evening	31.9	35.3	3.4
4	Morning	32.3	38.0	5.8
	Midday	33.2	52.5	19.3
	Evening	34.1	38.4	4.3
5	Morning	29.5	32.7	3.2
	Midday	34.0	52.2	18.2
	Evening	32.2	37.5	5.3
6	Morning	28.1	32.9	4.8
	Midday	33.7	53.1	19.4
	Evening	30.3	34.3	3.0
7	Morning	28.0	33.2	5.2
	Midday	34.4	50.6	16.2
	Evening	30.6	34.7	4.1
8	Morning	31.2	34.3	3.1
	Midday	32.7	50.3	17.6
	Evening	33.3	36.9	3.6

Effect of Land Cover type on temperatures

Data collected from grassy, and concrete surfaces revealed significant differences in how each land cover type influences temperature regulation. Measurements taken at different times of the day showed that concrete surfaces showed the highest temperatures, averaging over 40°C at midday, while grassy areas maintained lower temperatures around 29°C. These findings indicate that land cover plays an important role in surface heat absorption and retention.

Grassy areas had lower surface temperatures due to their ability to cool through evapotranspiration and shading. Vegetation helped moderate air temperatures by releasing moisture and reducing heat buildup. In contrast, concrete absorbed and retained more heat, leading to higher temperatures, especially in the afternoon. This difference demonstrates that areas with more vegetation can help regulate urban temperatures and reduce the intensity of heat islands. The findings support the importance of integrating green spaces into urban planning to enhance climate resilience and improve thermal comfort in cities like Mombasa.

Temperature Differences and the Urban Heat Island Effect

The study confirmed that areas with more concrete had higher temperatures than those with grass and trees. This temperature difference led to the urban heat island (UHI) effect, where cities became significantly hotter than nearby rural areas. The findings suggest that increasing green spaces in urban areas can help lower temperatures and improve comfort for city residents.

DISCUSSION

Urban environments with extensive hard surfaces such as concrete tend to experience higher temperatures compared to surrounding rural areas. This phenomenon, known as the urban heat island (UHI) effect, occurs due to the ability of these materials to absorb and retain solar heat. The accumulated heat results in elevated temperatures, making urban areas significantly warmer, especially during the daytime and early evening. A key strategy to mitigate the urban heat island effect is the integration of vegetation within city landscapes. Trees and plants provide natural cooling through two primary mechanisms: shading and evapotranspiration. Shading reduces direct exposure to solar radiation, thereby preventing excessive heat buildup on surfaces like roads and buildings. Meanwhile, evapotranspiration—a process in which plants release water vapor into the air—contributes to cooling, similar to how perspiration regulates human body temperature.

Despite the clear benefits of urban greenery, studying its impact presents several challenges. Variations in the amount and distribution of shade across different locations can lead to inconsistencies in temperature measurements. Additionally, external factors such as changing weather patterns, human activity, and nearby construction can introduce variations that may affect data accuracy. These challenges highlight the complexity of accurately assessing the full impact of vegetation on urban temperatures.

The findings from this study reinforce the importance of incorporating green spaces into urban planning. Increased vegetation coverage can significantly contribute to reducing urban heat, improving thermal comfort, and enhancing the overall livability of cities. As urban areas continue to expand, prioritizing sustainable designs that integrate parks, tree-lined streets, and rooftop gardens will be crucial in mitigating the adverse effects of the urban heat island effect and promoting environmental resilience.

CONCLUSION

This study shows how different types of land cover affect temperature in Nyali, in Mombasa. The results found that concrete surfaces get the hottest, while grassy areas stay cooler because plants release moisture into the air. Since Nyali has many houses, businesses, and recreational places, the study proves that urban areas can become much hotter than natural areas. To reduce this heat, city planners should add more green spaces like parks and trees to make the area cooler and more comfortable. These findings are important, especially for coastal cities like Mombasa, where rising temperatures affect people’s health, electricity use, and the environment. Future research should also look at other factors like humidity and wind to better understand how cities heat up. This study can be repeated in other cities worldwide to help leaders make better decisions about urban planning.

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