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ASSESSMENT OF THE IMPACT OF THE ATANI–OBOSI SECOND NIGER BRIDGE ACCESS ROUTE CONSTRUCTION ON LAND SURFACE TEMPERATURE

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ABSTRACT

Transportation infrastructure is an important catalyst for economic development and regional integration; however, its construction frequently results in environmental modifications that alter local climatic conditions. This study assessed the impact of the Atani–Obosi Access Route of the Second Niger Bridge on Land Surface Temperature (LST) within the surrounding environment. The study employed a geospatial approach integrating remote sensing, Geographic Information Systems (GIS), and meteorological data analysis to evaluate thermal changes across the pre-construction, construction, and post-construction phases of the project. Multi-temporal Landsat imagery and complementary climatic datasets covering the period from 2017 to 2024 were analysed to determine spatial and temporal variations in surface temperature patterns. The findings revealed a consistent increase in LST throughout the study period, with the highest temperatures occurring in built-up and newly developed sections of the corridor. Areas characterized by vegetation cover and water bodies exhibited relatively lower temperatures due to their natural cooling functions. However, progressive land conversion and vegetation stress reduced the capacity of these natural systems to moderate thermal conditions. The observed thermal changes indicate the emergence of localized urban heat island effects associated with infrastructure-induced land-use transformation. The study concludes that while the Atani–Obosi Access Route has enhanced regional accessibility and socio-economic development, its construction has contributed to measurable modifications in local thermal regimes. The study recommends the incorporation of green infrastructure, ecological restoration programmes, and continuous thermal monitoring into transportation planning and environmental management frameworks. The findings provide important insights for sustainable infrastructure development and climate-sensitive planning in Nigeria.

Keywords: Land Surface Temperature, Transportation Infrastructure, Climate Change, Remote Sensing, GIS, Environmental Sustainability.

1.0 BACKGROUND TO THE STUDY

Transportation infrastructure remains a critical driver of economic growth, regional integration, urban expansion, and improved accessibility. In developing countries, road development projects are often undertaken to facilitate the movement of people and goods, stimulate investment, reduce transportation costs, and enhance socio-economic opportunities. However, while such projects contribute significantly to economic development, they frequently generate environmental changes that extend beyond the immediate construction corridor [8].

One of the most important environmental consequences of transportation infrastructure development is the modification of local climatic conditions through alterations in land-use and land-cover characteristics. The construction of roads typically involves vegetation clearance, earthworks, land reclamation, and the replacement of natural surfaces with impervious materials. These activities alter the energy balance of the landscape by reducing evapotranspiration, increasing heat absorption, and modifying surface reflectance properties. Consequently, areas experiencing rapid infrastructure development often exhibit elevated Land Surface Temperatures (LST) and localized urban heat island effects [2, 3].

Land Surface Temperature is widely recognized as a critical environmental indicator because it reflects the thermal state of the Earth's surface and provides valuable information regarding the interactions among vegetation cover, land-use dynamics, and climatic processes. Vegetated surfaces generally exhibit lower temperatures because of evapotranspiration and shading effects, whereas built-up and impervious surfaces retain greater quantities of solar energy and release heat more slowly. As a result, changes in land-cover patterns frequently translate into measurable variations in surface temperature distributions.

Globally, studies have demonstrated that transportation infrastructure can significantly influence thermal environments through vegetation loss, land-use conversion, and urban expansion. Chen et al. [2] reported substantial vegetation disturbance and associated environmental changes resulting from transportation development, while Deljouei et al. [3] observed that road construction activities altered vegetation structure and ecological conditions in forest ecosystems. Contemporary sustainability discourse therefore emphasizes the need to integrate environmental

considerations into transportation planning and infrastructure development to ensure that economic gains are not achieved at the expense of environmental quality [8].

The Atani–Obosi Access Route of the Second Niger Bridge represents one of the most significant transportation projects undertaken in southeastern Nigeria. Constructed to improve regional connectivity and reduce congestion associated with traffic movement across the Niger River corridor, the project traverses wetlands, agricultural lands, vegetated landscapes, riverine environments, and rapidly developing settlements. The scale of land transformation associated with the project raises important questions regarding its influence on local climatic conditions, particularly Land Surface Temperature.

Evidence from the study indicates that LST increased consistently from the pre-construction phase through the post-construction period, with built-up areas recording the highest temperatures while vegetated surfaces and water bodies provided cooling effects. The progressive conversion of natural landscapes into transportation infrastructure and associated developments appears to have altered the thermal characteristics of the study area, suggesting the emergence of localized heat stress conditions. Given the growing importance of climate-sensitive infrastructure planning and environmental sustainability, assessing the thermal implications of the Atani–Obosi Access Route is essential for informing future transportation projects, environmental management strategies, and sustainable development policies within Nigeria and other developing countries.

1.2 Statement of the Problem

Infrastructure development remains essential for economic growth and regional integration. However, the environmental implications of transportation projects often receive less attention than their economic benefits. Existing studies have shown that road construction contributes to vegetation loss, land-use change, ecosystem disturbance, and modifications of local climatic conditions [2, 3]. Among these impacts, increases in Land Surface Temperature are particularly important because they influence environmental quality, ecological stability, and human comfort.

The Atani–Obosi Access Route traverses environmentally sensitive landscapes characterized by wetlands, agricultural lands, riverine systems, and natural vegetation. During construction,

substantial land clearing and earthworks were undertaken, resulting in the replacement of natural surfaces with transportation infrastructure. Such transformations have the potential to alter local thermal conditions through changes in surface reflectance, heat storage, and vegetation cover.

Despite the strategic importance of the project, limited empirical evidence exists regarding its effects on Land Surface Temperature. Existing Environmental Impact Assessments are often focused on regulatory compliance and short-term project approval requirements rather than long-term climatic monitoring. Furthermore, few studies within southeastern Nigeria have employed geospatial techniques to evaluate thermal responses to transportation infrastructure development. This gap limits the ability of planners and policymakers to incorporate climate-sensitive considerations into future infrastructure projects. Consequently, there is a need for a comprehensive assessment of the thermal impacts associated with the Atani–Obosi Access Route.

1.3 Aim and Objectives

Aim

To assess the impact of the construction of the Atani–Obosi Second Niger Bridge Access Route on Land Surface Temperature within the study area.

Objectives

1. To determine the spatial and temporal patterns of Land Surface Temperature before, during, and after the construction of the Atani–Obosi Access Route.
2. To evaluate the relationship between land-use changes and variations in Land Surface Temperature within the study corridor.
3. To assess the thermal influence of built-up surfaces, vegetation cover, and water bodies on the observed temperature patterns.
4. To determine the implications of infrastructure-induced thermal changes for environmental sustainability and climate-sensitive planning.
5. To provide recommendations for mitigating adverse thermal impacts associated with future transportation infrastructure projects.

3.0 STUDY AREA AND METHODOLOGY

3.1 Study Area

The study was conducted along the Atani–Obosi Access Route of the Second Niger Bridge located within Anambra State, southeastern Nigeria. The access route forms a major transportation corridor linking the bridge to the Onitsha–Owerri Road and adjoining settlements within Idemili North and Ogbaru Local Government Areas. The project traverses environmentally sensitive landscapes comprising wetlands, riverine environments, agricultural lands, natural vegetation, floodplains, and rapidly urbanizing settlements.

The study area extends from the Obosi Interchange through Okpoko and Odekpe to Atani and adjoining communities within the Niger floodplain. The area is strategically important because it serves as a major gateway linking southeastern Nigeria with other parts of the country through the Second Niger Bridge transportation network. The corridor has experienced substantial environmental modification resulting from road construction activities, land reclamation, sand filling, vegetation clearance, and associated urban development.

Geographically, the area lies within the humid tropical rainforest zone of southeastern Nigeria and is characterized by a warm climate with distinct wet and dry seasons. Annual rainfall is generally high, while the extensive wetlands and river systems exert considerable influence on local microclimatic conditions. Prior to construction, large portions of the corridor were dominated by natural vegetation, agricultural lands, wetlands, and seasonally inundated areas.

The study area is drained by several rivers and tributaries, including portions of the Idemili River system and associated floodplain environments. The presence of wetlands, water bodies, and vegetated landscapes previously contributed to temperature moderation through evapotranspiration and surface moisture retention. However, road construction activities involving vegetation clearance, earthworks, and conversion of natural land surfaces have altered the physical characteristics of the area and potentially influenced local thermal regimes.

The selection of the study area was informed by the strategic importance of the Atani–Obosi Access Route as one of the largest transportation infrastructure projects undertaken in southeastern Nigeria in recent years and the need to understand its environmental implications, particularly concerning Land Surface Temperature dynamics.

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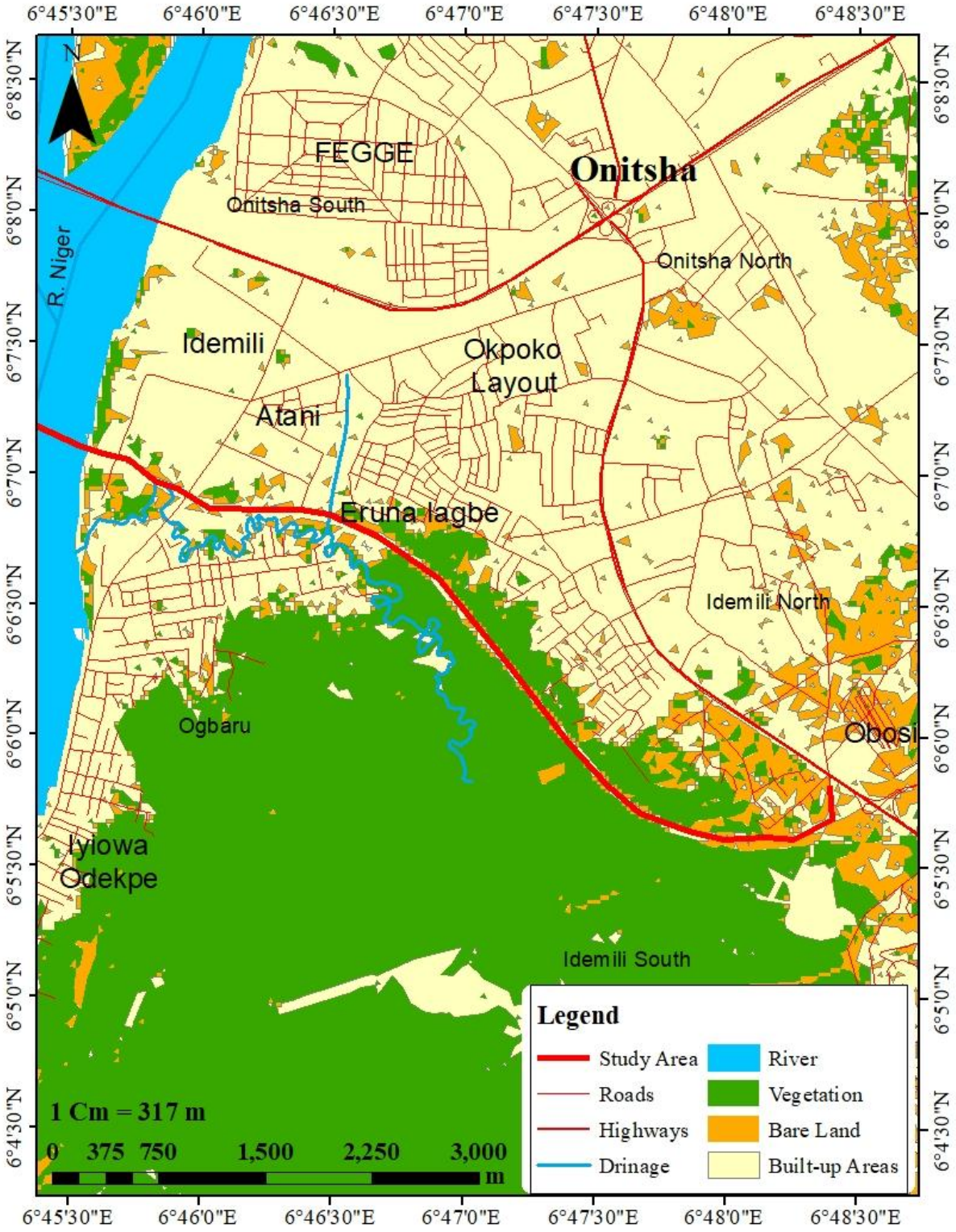

Figure 3. 1: Map of the Study Area.

3.2 Methodology

3.2.1 Research Design

This study adopted a geospatial and environmental assessment approach integrating remote sensing, Geographic Information Systems (GIS), and climatic data analysis to evaluate the impact of the Atani–Obosi Access Route construction on Land Surface Temperature. The approach enabled the investigation of spatial and temporal variations in thermal conditions before, during, and after the construction of the project.

The study employed a longitudinal environmental monitoring framework using multi-temporal satellite imagery and climatic datasets covering the pre-construction, construction, and post-construction phases of the project. This approach facilitated the assessment of thermal responses associated with land-use transformation resulting from infrastructure development.

3.2.2 Data Sources

The study utilized both primary and secondary datasets.

Secondary datasets included:

- Multi-temporal Landsat satellite imagery obtained for selected years representing pre-construction, construction, and post-construction conditions.
- Meteorological datasets including temperature, rainfall, and relative humidity records obtained from relevant meteorological stations.
- Existing maps and geospatial datasets used for image processing and environmental analysis.

Primary data included field observations conducted within the study corridor to validate environmental conditions and support interpretation of satellite-derived outputs.

3.2.3 Image Processing and Analysis

Satellite images were subjected to preprocessing procedures including geometric correction, radiometric correction, image enhancement, and clipping to the study area boundary. Image processing was undertaken within a GIS and remote sensing environment to ensure consistency and comparability across different time periods.

Land Surface Temperature was derived from thermal infrared bands of the Landsat imagery using standard radiometric conversion procedures. The processing involved:

1. Conversion of Digital Numbers (DN) to Spectral Radiance.
2. Conversion of Spectral Radiance to Brightness Temperature.
3. Correction for surface emissivity.
4. Computation of Land Surface Temperature.

The resulting LST maps were generated for the selected study years and subsequently compared to identify thermal changes associated with the construction of the access route.

3.2.4 Spatial Analysis

Spatial analysis was performed using GIS techniques to evaluate temperature distributions and identify thermal hotspots within the study area. The analysis included:

i. Temporal Analysis

Temporal comparisons were conducted to determine changes in Land Surface Temperature across the pre-construction, construction, and post-construction periods.

ii. Land Use–Temperature Relationship Analysis

Land Surface Temperature outputs were compared with land-use characteristics to determine the influence of vegetation cover, built-up surfaces, wetlands, and water bodies on observed thermal patterns.

iii. Buffer Zone Analysis

Buffer analysis was conducted to assess temperature variations at varying distances from the road corridor. This enabled the identification of potential road-effect zones and the spatial extent of thermal impacts associated with the project.

iv. Trend Analysis

Trend analysis was employed to determine the direction and magnitude of temperature changes throughout the study period.

3.2.5 Statistical Analysis

Descriptive statistics were used to summarize temperature variations across different years and land-use categories. Trend analysis techniques were applied to evaluate temporal changes in Land Surface Temperature. Comparative analyses were also conducted to assess differences between pre-construction, construction-phase, and post-construction thermal conditions. Where applicable, inferential statistical procedures contained in the thesis were used to determine the significance of observed temperature changes.

3.2.6 Ethical Considerations

This study complied with established ethical requirements for environmental research. The research relied primarily on remotely sensed and secondary environmental datasets, thereby minimizing risks to human participants.

Where field observations were undertaken, no personal information was collected. All environmental and geospatial data were used strictly for academic and research purposes. Data acquisition and processing were conducted in accordance with relevant institutional and professional standards.

4.0 PRESENTATION OF RESULTS

The analysis of Land Surface Temperature (LST) over the study period highlights the thermal dynamics and changes associated with land use and land cover (LULC) modifications due to the construction of an access route. The study spans three distinct phases: Before Construction (2017), During Construction (2018–2023), and After Construction (2024); as encapsulated in figures 4.1 to 4.4.

Before Construction (2017)

In 2017, the study area represented a relatively undisturbed environment with minimal anthropogenic activities. The LST patterns during this period serve as a baseline for assessing the impact of construction on the thermal characteristics of the area. The minimum LST recorded was 20.09°C, while the maximum reached 34.87°C, resulting in a mean LST of 27.48°C. These values indicate a relatively stable thermal environment, with no significant thermal hotspots. The water bodies in the area exhibited the lowest LST range, from 20.09°C to 22.87°C. This reflects the high heat capacity and evaporative cooling effect of water, which moderates temperatures in its vicinity.

The LST for vegetated areas ranged from 22.88°C to 28.42°C, showcasing the natural cooling effect of vegetation. Dense vegetation cover helps in reducing surface heating by providing shade and promoting evapotranspiration. Built up area displayed higher LST values, ranging from 28.42°C to 34.78°C. The presence of impervious surfaces such as asphalt and concrete contributed to localized heating, often referred to as the urban heat island effect. Bare land was not recorded in 2017, indicating that land clearing activities had not yet begun, and the area remained largely covered by vegetation and other natural features. This period demonstrates the thermal equilibrium of the environment before the onset of construction activities.

During Construction (2018–2023)

The construction phase, spanning from 2018 to 2023, marked significant changes in the thermal environment due to land clearing, vegetation removal, and the introduction of impervious surfaces. In 2018, initial construction activities, such as vegetation clearing and bare land exposure, began to influence LST patterns. The minimum LST increased to 24.75°C, while the maximum rose to 38.87°C, resulting in a mean LST of 31.81°C. These changes signify the early thermal impacts of construction. LST for water bodies increased to a range of 24.75°C to 25.31°C. This slight rise may be attributed to the reduced vegetative buffer around water bodies, which exposed them to

higher solar radiation. Vegetated areas showed an increase in LST to 25.32°C–29.89°C, reflecting thermal stress caused by vegetation loss and fragmentation.

Newly cleared areas emerged with LST values ranging from 29.89°C to 32.43°C. The exposure of bare soil surfaces, which absorb more heat than vegetation, contributed to higher LSTs. Built-Up Areas recorded LSTs between 32.43°C and 38.87°C, highlighting the growing extent of construction and associated thermal effects. By 2020, construction activities had intensified, leading to further thermal changes. The minimum LST rose to 26.01°C, while the maximum reached 39.09°C, with a mean LST of 32.55°C. LST for water bodies increased to 26.01°C–27.55°C, reflecting the cumulative effects of warming in the surrounding environment.

The LST for vegetated areas increased to 27.56°C–29.72°C, indicating continued thermal stress and the diminishing extent of vegetation. LST for bare land ranged from 29.72°C to 33.12°C, slightly higher than in 2018. This was due to prolonged exposure to solar radiation and the absence of vegetative cover. Built-Up Areas recorded the highest LST range, from 33.12°C to 39.09°C, driven by the expansion of impervious surfaces and increased human activity.

In 2023, the access route construction neared completion, resulting in significant thermal changes. The minimum LST rose to 27.77°C, while the maximum soared to 43.42°C, with a mean LST of 35.59°C. The LST for water bodies increased marginally to 27.77°C–28.23°C, showing continued warming. Vegetation exhibited an LST range of 28.24°C–31.04°C, reflecting the impact of further vegetation loss. With bare land being converted into built-up areas, the LST peaked at 31.05°C–43.42°C, representing the highest thermal footprint recorded during the study period.

Bare land was no longer recorded in 2023, as most of it had been converted to the access route and other infrastructure.

After Construction (2024)

By 2024, the construction activities were completed, and the area had stabilized. However, the thermal impacts of the built-up environment persisted. The minimum LST increased to 28.21°C, while the maximum reached 45.89°C, resulting in a mean LST of 37.05°C. These values reflect the lasting impact of impervious surfaces on the thermal environment. LST for water bodies increased slightly to 28.21°C–29.11°C, indicating the influence of urban heat from surrounding built-up areas.

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The LST for vegetation ranged from 29.12°C to 31.78°C, reflecting the residual thermal stress on the remaining vegetation. The LST for built-up areas peaked at 31.78°C–45.89°C, highlighting the enduring urban heat island effect. Bare land was no longer present, as it had been entirely replaced by built-up areas.

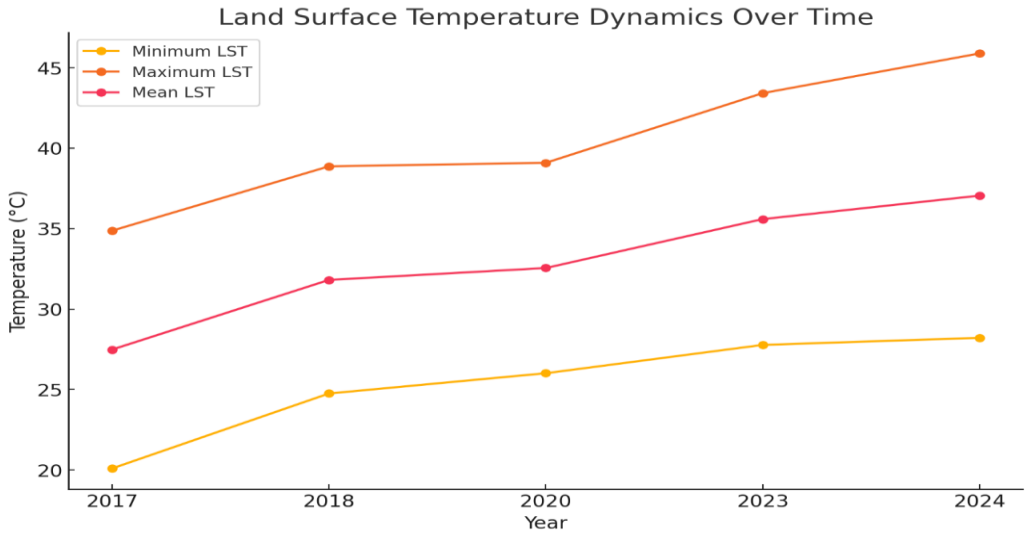

Figure 4.1: Distribution of LST Dynamics Between 2017 and 2024

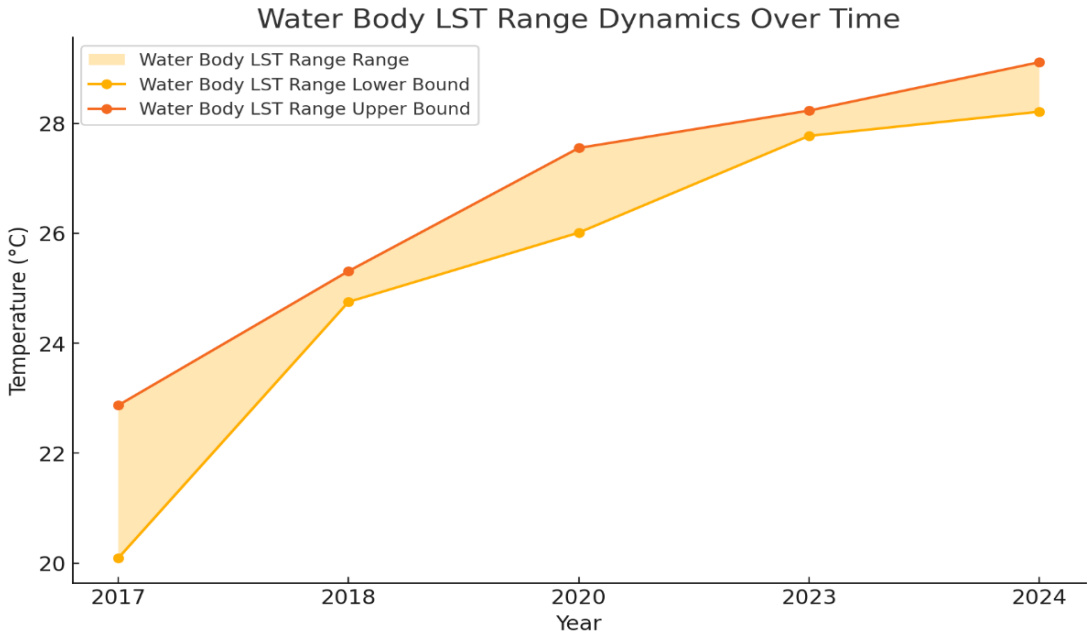

Figure 4.2: Distribution of LST Dynamics of the Water Body Between 2017 and 2024

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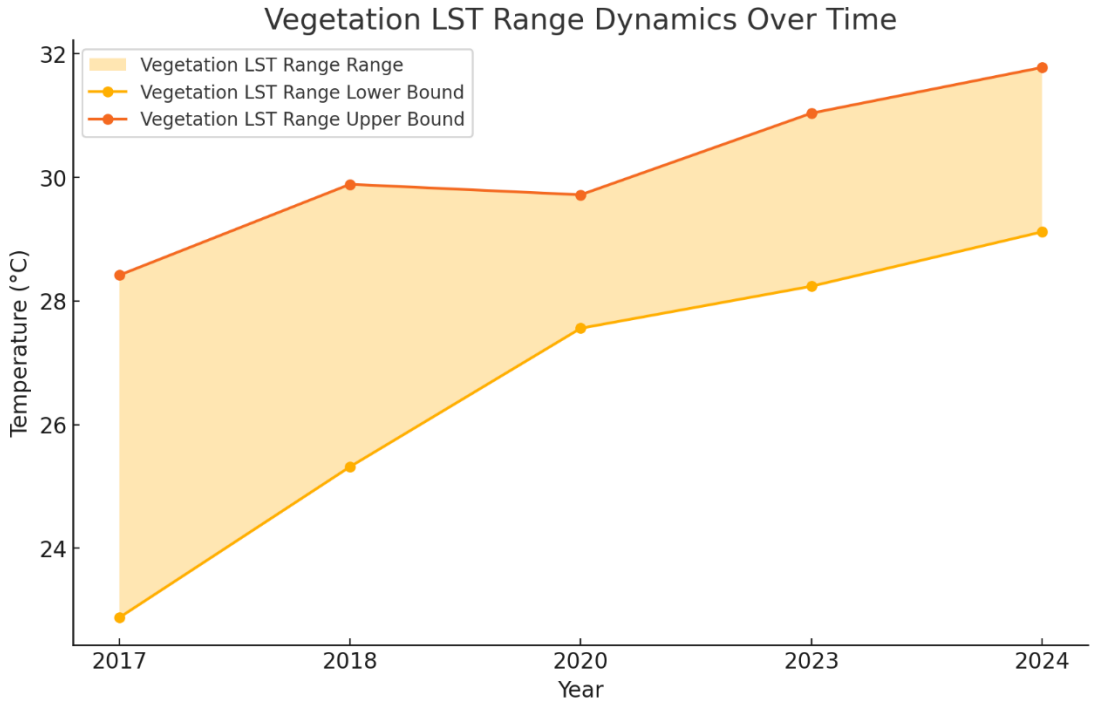

Figure 4.3: Distribution of LST Dynamics of Vegetation Between 2017 and 2024

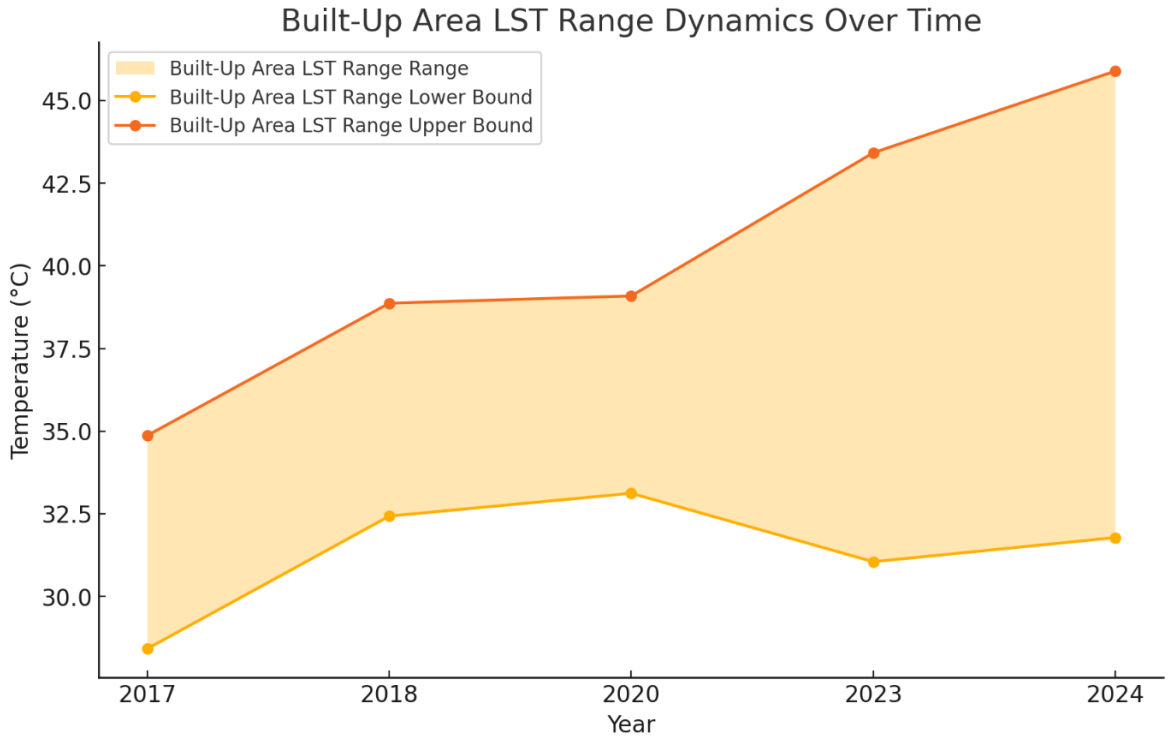

Figure 4.4: Distribution of LST Dynamics of Built-Up Area Between 2017 and 2024

The study reveals a consistent increase in LST over the years, driven by construction activities and land-cover changes. The removal of vegetation and the introduction of impervious surfaces contributed significantly to higher LSTs.

A progressive rise in minimum, maximum, and mean LST values was observed across all phases of the study. Built-up areas consistently recorded the highest LST values, underscoring the urban heat island effect.

Vegetation and water bodies demonstrated natural cooling properties but were increasingly affected by thermal stress due to construction activities. Bare land emerged as a significant thermal hotspot during the construction phase but was eventually replaced by built-up areas, amplifying thermal impacts. While the area stabilized post-construction, the high LST values associated with built-up areas highlight the need for mitigation strategies.

Test of Hypothesis

H_0: There is no significant trend in land surface temperature (LST) due to the construction of the access route.

Statistical tool: Mann–Kendall trend test with Sen's slope estimator (non-parametric trend detection). LST time series often violate normality and contain outliers or non-linearities; Mann–Kendall is the standard non-parametric test for monotonic trends in environmental time series, and Sen's slope gives an interpretable rate of change per year. The thesis used this test for the LST series.

Decision rule: At $\alpha = 0.05$, reject H_0 if the Mann–Kendall Z statistic > 1.96 (positive trend) or < -1.96 (negative trend).

Test and results: The Mann–Kendall result directly for the LST series: $Z = 3.41$, Sen's slope $\approx +0.23$ °C yr^{-1}, $p = 0.001$. The mean LST values in the study increased from ~27.8 °C to ~32.6 °C over the multi-year record.

Decision

Reject H_0. There is a statistically significant upward trend in LST associated with the construction and post-construction period. The detected upward trend supports the idea that conversion to impervious surfaces and loss of vegetation increased the surface thermal signature (consistent with

EKC early-phase arguments in the thesis). The Sen's slope (+0.23 °C yr^{-1}) is substantial for a local corridor and matches other findings that road/urbanization raises LST (Nwachukwu 2019; Chen et al. cited in the thesis). Implication: without mitigation (green buffers, high-albedo materials), LST increases will continue to amplify heat stress.

5.0 DISCUSSION OF RESULTS/FINDINGS

5.1 Spatial and Temporal Variations in Land Surface Temperature

The analysis revealed substantial spatial and temporal variations in Land Surface Temperature across the Atani–Obosi Access Route corridor. Comparison of pre-construction, construction-phase, and post-construction datasets demonstrated a progressive increase in temperature within areas directly affected by road construction and associated land-use transformation.

The observed increase in Land Surface Temperature corresponded with periods of intensive construction activities characterized by vegetation clearance, sand filling, earthworks, and expansion of impervious surfaces. These findings suggest that infrastructure development altered the thermal characteristics of the study area through modification of natural land-cover conditions, this is in agreement with the findings of Giunta [4].

The results indicate that the highest temperatures were consistently recorded within built-up areas, construction zones, and exposed surfaces, whereas lower temperatures were observed in wetlands, vegetated areas, and water bodies. This pattern reflects the influence of land-cover characteristics on heat absorption, storage, and release processes. The findings support the assertion that vegetation and water bodies perform critical temperature-regulating functions through evapotranspiration and surface moisture retention. Their removal or degradation therefore contributes to increased surface temperatures and localized heat stress conditions [5, 6].

5.2 Relationship Between Land Use Change and Land Surface Temperature

The study established a strong relationship between land-use transformation and observed thermal changes within the study area.

The conversion of vegetated surfaces to transportation infrastructure and associated developments resulted in increased exposure of bare surfaces and impervious materials, thereby enhancing heat absorption and storage. Areas experiencing significant vegetation loss exhibited corresponding increases in Land Surface Temperature.

These observations align with the findings of Chen et al [2], who reported substantial environmental modifications associated with transportation infrastructure development, and Deljouei et al. [3], who identified significant ecological disturbances resulting from road construction activities.

The findings further indicate that natural vegetation served as an important thermal regulator before project implementation. The reduction of vegetation cover therefore weakened the natural cooling capacity of the landscape.

5.3 Thermal Influence of Built-Up Areas, Vegetation and Water Bodies

The spatial distribution of temperature values demonstrates distinct thermal behaviour among major land-cover categories.

Built-up areas and construction zones recorded the highest temperatures due to the presence of asphalt surfaces, concrete materials, and exposed soils. These surfaces possess high heat storage capacities and low evapotranspiration potential, resulting in elevated thermal conditions.

Vegetated areas exhibited comparatively lower temperatures because of shading effects and evapotranspiration processes. Wetlands and water bodies recorded the lowest temperatures, highlighting their role as natural cooling elements within the study area.

The progressive replacement of these natural cooling systems with transportation infrastructure contributed significantly to the observed thermal changes. This supports the findings of Mansuroglu et al [7].

5.4 Implications for Environmental Sustainability

The increase in Land Surface Temperature observed within the Atani–Obosi corridor has important implications for environmental sustainability.

Elevated temperatures can influence ecosystem functioning, biodiversity conservation, hydrological processes, and human comfort. Prolonged increases in temperature may also contribute to changes in vegetation productivity and ecological resilience.

The findings are consistent with the Environmental Kuznets Curve perspective presented in the theoretical framework, which suggests that environmental degradation often accompanies early stages of infrastructure-driven development before mitigation measures and environmental management interventions are introduced.

The results further support the Systems Dynamics perspective by demonstrating how transportation infrastructure influences environmental conditions through interconnected feedback mechanisms involving land-use change, vegetation degradation, and thermal modification.

The observed thermal changes therefore underscore the importance of integrating climate-sensitive planning principles into transportation infrastructure development to ensure long-term environmental sustainability.

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study assessed the impact of the construction of the Atani–Obosi Access Route of the Second Niger Bridge on Land Surface Temperature (LST) using remote sensing, GIS, and environmental analytical techniques. The findings demonstrated that the project significantly altered the thermal characteristics of the study area through extensive land-use and land-cover modifications associated with road construction activities.

The study established that Land Surface Temperature increased progressively throughout the pre-construction, construction, and post-construction phases of the project. Areas characterized by

intensive construction activities, built-up developments, exposed surfaces, and transportation infrastructure consistently exhibited higher temperature values than vegetated surfaces, wetlands, and water bodies. The observed temperature increases were closely associated with vegetation clearance, land reclamation, soil exposure, and the replacement of natural landscapes with impervious surfaces.

The findings further demonstrated that vegetation cover and wetlands performed important ecological functions by moderating surface temperatures through evapotranspiration, shading, and moisture retention processes. Consequently, the removal or degradation of these natural environmental components reduced the thermal regulation capacity of the landscape and contributed to the emergence of localized heat accumulation zones within the corridor.

The study also established a direct relationship between transportation infrastructure development and thermal environmental change. The observed temperature increases indicate that road construction projects may contribute to localized climatic modification, particularly in environmentally sensitive landscapes characterized by wetlands, floodplains, and extensive vegetation cover.

From a sustainability perspective, the findings suggest that while the Atani–Obosi Access Route has significantly improved regional accessibility, transportation efficiency, and economic opportunities, the environmental consequences associated with increasing Land Surface Temperature require proactive management. Failure to address these thermal impacts may contribute to ecological degradation, reduced environmental resilience, and increased vulnerability to climate-related stresses in the future.

The study therefore concludes that transportation infrastructure development should not be evaluated solely on the basis of economic and mobility benefits but must also incorporate comprehensive environmental considerations. Sustainable infrastructure planning requires the integration of climate-sensitive design principles, ecological conservation strategies, and long-term environmental monitoring systems capable of minimizing adverse thermal impacts while maintaining developmental objectives.

6.2 Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. Climate-Sensitive Infrastructure Planning: Future transportation projects should incorporate climate-sensitive design approaches during planning, design, construction, and operational phases. Environmental considerations relating to thermal regulation, vegetation conservation, and ecosystem protection should be integrated into project decision-making processes from inception.

2. Establishment of Green Infrastructure Corridors: Roadside green infrastructure programmes should be implemented along transportation corridors through the planting of indigenous tree species and the restoration of disturbed vegetation. Green corridors will help reduce heat accumulation, improve carbon sequestration, and enhance biodiversity conservation.

3. Protection of Wetlands and Natural Cooling Systems: Wetlands, floodplains, and natural water bodies should be protected from unnecessary encroachment during infrastructure development. These ecosystems play critical roles in regulating local temperatures and maintaining ecological balance within transportation corridors.

4. Continuous Thermal Monitoring: Government agencies and environmental regulators should establish continuous Land Surface Temperature monitoring programmes using GIS and remote sensing technologies. Such programmes will facilitate the early detection of environmental changes and support evidence-based environmental management.

5. Strengthening Environmental Impact Assessment Procedures: Environmental Impact Assessments (EIAs) should be expanded beyond compliance requirements to include long-term post-construction environmental monitoring. Thermal assessments should become a mandatory component of major transportation infrastructure projects, particularly in environmentally sensitive landscapes.

6. Integration of Nature-Based Solutions: Future transportation projects should incorporate nature-based solutions such as green buffers, urban forests, ecological restoration initiatives, permeable

surfaces, and sustainable drainage systems to mitigate infrastructure-induced temperature increases.

7. Adoption of Sustainable Transportation Policies: Policy makers should develop and implement sustainable transportation policies that balance economic development objectives with environmental sustainability goals. Such policies should promote environmentally responsible infrastructure development while minimizing adverse climatic impacts.

6.3 AI Declaration

Artificial Intelligence (AI) tools, specifically ChatGPT, were utilized solely as editorial support tools during the preparation of this manuscript. The role of AI was limited to improving the organization, language structure, readability, and presentation of the manuscript. All data acquisition, analysis, interpretation of findings, methodological decisions, and scientific conclusions were derived exclusively from the original research conducted by the author(s).

The author(s) assume full responsibility for the integrity, originality, accuracy, and scholarly content of the work presented in this manuscript.

6.4 Conflict of Interest

The author(s) declare that there are no financial, professional, institutional, or personal conflicts of interest that could have influenced the design, execution, analysis, interpretation, or reporting of this study. The research was conducted independently, and all findings presented are based solely on the evidence generated during the investigation.

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