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Urban Land Surface Temperature Variations in Bukuru and Environs, North Central, Nigeria: A Remote Sensing Analysis For 2025

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Abstract- Increasing population and urbanization in sub-Saharan Africa has been changing the local climate, thereby creating the Urban Heat Island (UHI) effect, which places urban residents under a heat stress load. This research examined the spatial distribution of LST and its relationship to land use/land cover (LULC) over the city of Bukuru and surrounding areas in North Central Nigeria for the year 2025. The GIS software enabled us to map the spatial distribution of LST across land cover types and identify thermal hotspots in Bukuru and environs. The results show that the highest recorded LST recorded in built-up areas was 45.17°C. The coolest recorded at waterways was up to 22.81°C, and the mean LST was 37.87°C. The minimum NDVI value was -0.61 and the maximum was 0.78, with the mean being 0.27 (and this value is close to the NDVI values of the built-up areas). The results provide a sound basis for integrating green infrastructure and improved housing standards in Bukuru and environs.

Keywords: Bukuru, Land Surface Temperature, Nigeria, Remote Sensing, Urban

I. INTRODUCTION

While other parts of the world are experiencing rapid urbanisation, nowhere is this more significant than Africa, where estimates are that by 2050, over half of the continent's population will be living in cities and altering the landscape (UN-DESA, 2018; Seto et al., 2012). The rapid and unplanned urbanization of Africa is causing many environmental impacts, among them the impact on local climate and the so-called Urban Heat Island (UHI) effect, where urban areas are significantly warmer than their rural counterparts (Oke, 1982; Arnfield, 2003; Stewart and Oke, 2012).

The most likely mechanism of local warming is the alteration of the land surface from naturally cool surfaces such as grass and soil to more impervious, heat-absorbing surfaces such as concrete, asphalt, and metal roofs (Voogt and Oke, 2003; Kalnay and Cai, 2003). Urban areas experience heightened thermal stress due to the UHI effect, due to the impervious and thermally absorbent surfaces, reduced vegetation, and altered surface energy budgets (Ha et al., 2020). High temperatures lead to increased cooling demand, which puts further strain on the fragile power grid and contributes to emissions (Santamouris et al., 2020; Li et al., 2019). Impaired air quality increases respiratory and heart disease among urban residents, particularly among the elderly, children and chronically healthy (Kovats and Hajat, 2008; Patz et al., 2005; Basu and Samet, 2002).

Nigeria is facing an urban climate challenge. While big cities such as Lagos have received much attention (Balogun and Balogun, 2014; Adebowale et al., 2019; Nwilo et al., 2015), the environmental impact on young secondary cities has been less studied (Güneralp et al., 2017). Bukuru, a part of the Jos-Bukuru metropolitan area in Plateau State, is a perfect study to explore these conditions. At around 1,200 hectares of tin mine, Bukuru has been transformed into a bustling commercial and administrative center. Bukuru's highland elevation (roughly 1,200m) and history of tin mining land make it more vulnerable to changing climate and thermal impacts (Lar and Suleiman, 2018). The state enjoys a cooler climate than many other parts of Nigeria, with average annual temperatures between 18°C and 25°C depending on the season and altitude (Orewere et al., 2019). Its unique climate is being threatened by urbanisation and changes in land cover.

The UHI effect is perhaps one of the most well-documented examples of unintended anthropogenic climate change. Oke (1982) proposed the theoretical framework that city canyon geometry traps longwave radiation and anthropogenic heat from vehicles and buildings increase the urban energy budget. Subsequent research has examined how factors such as urban materials' thermal properties (low albedo, high heat capacity), evaporative cooling surfaces, and the three-dimensionality of the urban form are all key contributors to the UHI effect (Oke et al., 2017; Stewart and Oke, 2012).

Voogt and Oke (2003) reported that during the day, the SUHI rises due to solar heating of dry and impervious surfaces. This is the heat we can feel radiating from the ground and which leads to thermal discomfort.

The main biophysical properties of SUHI include: low surface albedo (high solar absorption), high thermal conductivity, and ultimately low moisture availability for evaporative cooling (Taha, 1997; Akbari et al., 2001).

SUHI has different magnitudes in different places. In many cities of West Africa, LST has increased above 40°C in dry months in high-density built-up areas (Adebowale et al., 2019); in Ibadan, Nigeria, peak LST was 47.72°C in the city and 39.42°C in the more vegetated parts of the city (Adebayo and Tukur, 2014). In Kano, LST has increased by at least 1.5 degrees C over the past two decades, and only 0.8 degrees C in rural areas (Shaibu et al., 2025). Urbanization is one of the biggest contributors to local warming, with urbanization accounting for a large portion of the increase in LST in Nigerian cities (Ogunjobi et al., 2018). The Plateau State Council of the Society of Landscape Architects of Nigeria (SLAN) has called for the establishment of Landscape Architecture departments in tertiary institutions as a way to combat climate change, and for urban heat islands by planting trees, designing water features, and using heat reflective materials to create appealing walking spaces (Guardian, 2024).

Landsat 8 and 9 are projected to produce a consistent data stream at a higher radiometric resolution in 2025 (Irons et al., 2012; Masek et al., 2020). As demonstrated in the United States, Landsat imagery has been successfully used for the LULC-LST relationship in Lagos (Nwilo et al., 2015), Ibadan (Fashae et al., 2020), Akure (Akinyemi and Adegboyega, 2017), and Kano (Shaibu et al., 2025) for Imo State, Nigeria, finding that the highest variation in LST was between water bodies and vegetation, with the highest LST in Owerri and Mgbidi Town. In the Niger Delta region, a mangrove reduction from 12,991 km2 in 1987 to 9,089 km2 in 2022 leads to a shift in LST from 26.01°C to 28.07°C (Akinyemi and Adegboyega, 2017). Thus, land cover change affecting heatwaves in the region is well-studies that land coverage based on comparisons of NDVI below 0.4 increases in LST varying from 26.01°C to 28.07°C (Akinyemi and Adegboyega, 2017). In Ibadan, study a comparative machine learning approach to evaluate the effect of land cover on the heatwave observed an increase in LST of 12 °C in the Niger Delta where NDVI > 0.44 suggests that the decrease in NDVI is associated with a 95% increase in LST along with a 96% increase in NDVI. In Kano, Shaibu et al. (2025) confirmed the significant increase in built-up area and a 96% increase in LST.

LST retrieval involves several steps. The raw digital numbers are converted to at-sensor spectral radiance and then brightness temperature (Chander et al., 2009). Land surface emissivity is also necessary as different surfaces emit different amounts of heat (Sobrino et al., 2004).

II. STUDY AREA

Bukuru is a major city in Jos South Local Government Area of Plateau State, North Central Nigeria. This paper is concerned with the broad area of Bukuru bounding box (latitudes: 9° 35' N and 9° 55' N; longitudes: 8° 40' E and 8° 59' E). The vast area includes Bukuru, a part of Jos, the peri-urban and rural landscapes, and thus provides an excellent view of urban-rural thermal gradient. Along with the city of Jos, it forms part of the Jos-Bukuru Metropolitan Area.

The Plateau State has an average elevation of 1,200 metres above sea level. It has a mild climate, cooler than the rest of Nigeria. The average annual temperature in Plateau State is 18°C to 25°C depending on the season and altitude (Orewere, et al., 2019).

The Jos Plateau is cooler in summer months and at night can see temperatures as low as 11°C (Adebayo and Tukur, 2014). The high season (March to May) can reach 30°C (Adebayo and Tukur, 2014). In Bukuru, temperatures range from 12°C to 33°C (Leadership, 2025). April is the hottest month with an average high of 32°C and low of 18°C, while December is the coolest month with an average low of 12°C and high of 29°C (Leadership, 2025).

There are wet and dry seasons. In the wet season (April-October), a mean annual rainfall is 1,100 to 1,600 mm, with highest amounts recorded on the Jos Plateau (Adebayo and Tukur, 2014). In the dry season, from November-March, the area experiences cool, dry harmattan winds blown by the Sahara (Orewere et al., 2019).

The Jos Plateau is characterised by the Younger Granites that are extensively weathered, creating a landscape of rolling hills and granite outcrops (MacLeod et al. 1971). Soils are generally sandy loams produced by granite weathering.

Bukuru's history is inextricably connected to tin mining. Intensive mining left traces of mine ponds, abandoned pits and huge spoil heaps (Alexander, 2020; Dung et al., 2018). Although large-scale mining has retreated, abandoned mine lands and their exposed surfaces are part of the contemporary thermal landscape.

Bukuru has risen to become an important business and administration centre over the years with the secretariat of Jos South Local Government Area, a large main market, many schools, and a growing commercial area. The growth has been unplanned and has led to informal settlements and the conversion of green spaces into built-up areas. The city's population has grown rapidly, which has pushed housing and infrastructure needs further away. Around 85% of the surroundings of the city center are paved with hard landscape elements such as asphalt, interlocks and concrete which create heat islands around buildings (Orewere et al., 2019).

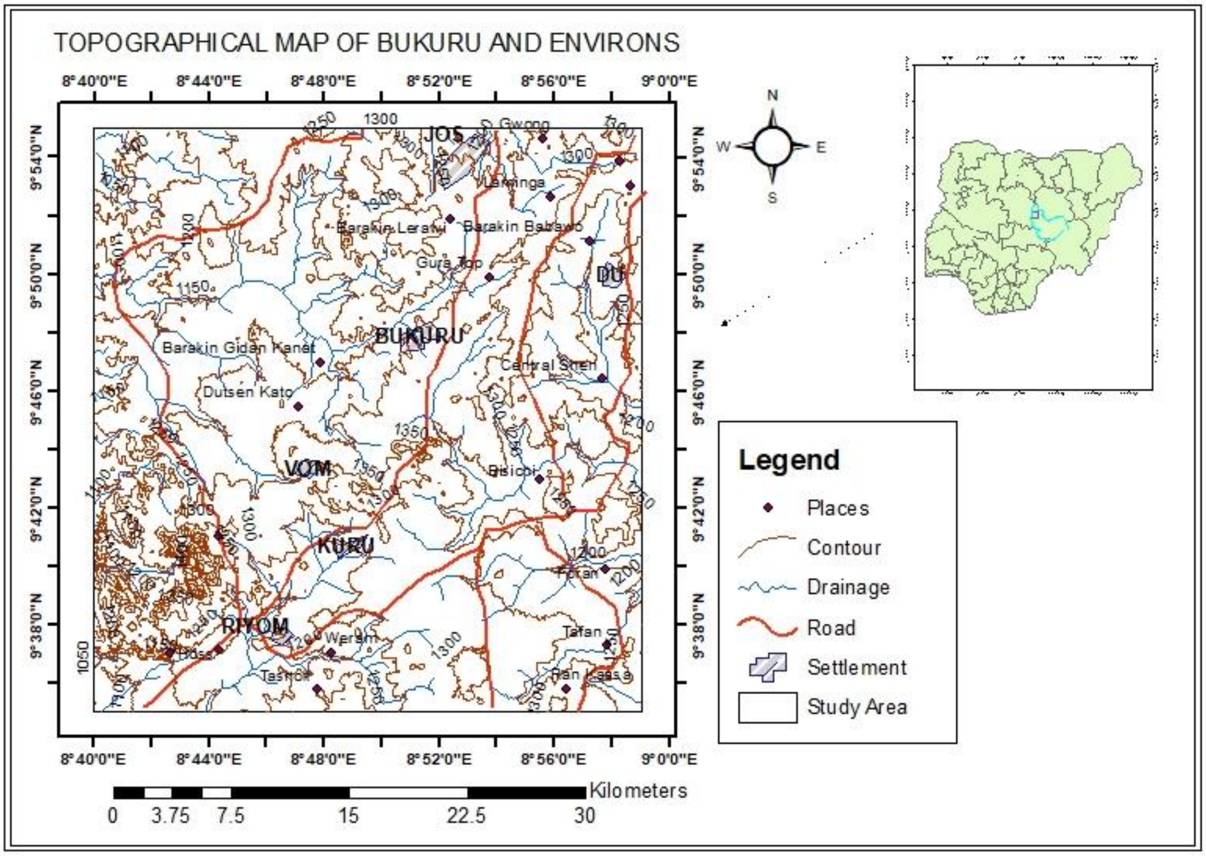

Figure 1 Topographic map of Bukuru and environs, showing major towns and roads.

III. MATERIALS AND METHODS

Landsat 8 OLI/TIRS imagery of 2025 was used in order to map the spatial distribution and relationship of LST with land cover in Bukuru and its environs. The image is a cloud-free Landsat 8 OLI/TIRS scene (Path/Row: 188/053) for the study area, acquired 15th December 2025 in the dry season (to minimise atmospheric interference and seasonal variation). We downloaded the image as a Collection 2 Level-2 Science Product from the USGS EarthExplorer portal. The collection 2 products provide atmospherically corrected surface reflectance and surface temperature which eases the processing process and improves accuracy. The thermal band (Band 10) was used to calculate LST. The image was clipped to the study area (latitudes 9° 35' N to 9° 55' N, longitudes 8° 40' E to 8° 59' E) using the Clip Raster tool in ArcGIS 10.8.

Surface Temperature Band (ST_B10.TIF) is included with Level-2 Landsat 8 products. These values are scaled Kelvin values. For conversion to degrees Celsius, the following formula was used in ArcGIS 10.8 Raster Calculator: LST_Celsius = ST_B10 * 0.00341802 + 149.5 - 273.15.

NDVI was calculated for surface reflectance bands (Band 4 - Red, Band 5 - Near Infrared) using the standard formula: NDVI = (Band5 - Band4) / (Band5 + Band4). We did this in ArcGIS 10.8 with the Raster Calculator. The NDVI raster was clipped to the study area extent.

LULC classes in the study area include Built-up Area, Vegetation, Bare Land and Water Bodies. Training samples are based on interpretation of the high resolution imagery in Google Earth Pro and field knowledge of the area. The classification was implemented in ArcGIS 10.8 using the Image Classification toolbar. The accuracy of the classification is measured by an error matrix generated from independent validation points.

IV. RESULTS AND DISCUSSION

LST map of Bukuru and environs for 2025 (Figure 2) shows a well-developed Surface Urban Heat Island with wide spatial variability in temperature. Temperature variation from city centre to peri-urban and rural areas is evident, with the highest temperatures in the densely built-up areas of Bukuru and Jos.

Minimum LST is 22.81°C (over a deep mine pond in the peri-urban area), while the maximum LST is 45.17°C (over the central market area and high density informal settlements in Bukuru). Mean LST is 37.87°C. The highest LST values are found in the urban core of Bukuru (central market and slums), where the buildings are tightly packed, covered with corrugated metal roofs, paved, and with little vegetation.

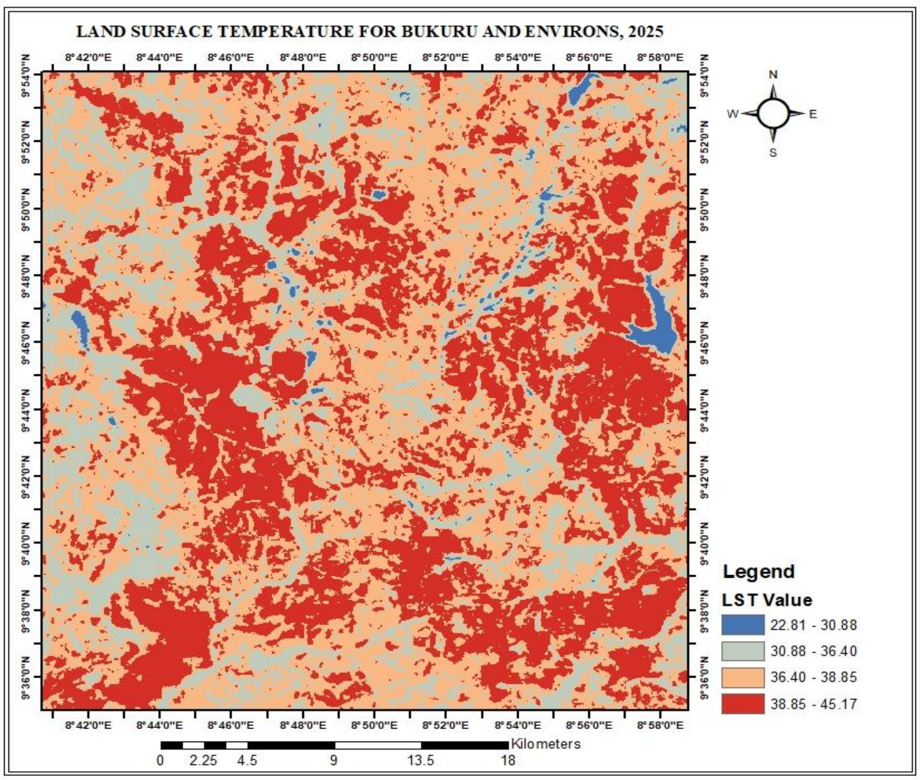

Figure 2 LST map of Bukuru and environs, 2025.

NDVI map (figure 3) shows vegetation cover in the area of study. Areas of water bodies have a mean NDVI value of -0.38, while built-up, bareland and vegetation have mean NDVI values of 0.12, 0.25 and 0.36 respectively.

LULC classification in 2025 (figure 4) shows that urban areas dominate the northeastern, southeastern and the central parts of the study area with decreasing urbanization on the outskirts.

The areal coverage of the land cover types within the study area are: built-up 20.58 Km2, vegetation 449.47 Km2, bareland 801.98 Km2 and water bodies 8.97 Km2, with their percentage coverage being 1.6%, 35.1%, 62.6% and 0.6% respectively.

The extent of built-up area, which has risen rapidly over the past decade, is the primary cause of elevated LST in the urban core. Vegetation in the periphery and river corridors provides important cooling functions. The bare land class includes active mining sites, abandoned mine spoils, and construction sites, which all exhibit elevated LST due to their exposed, dry surfaces.

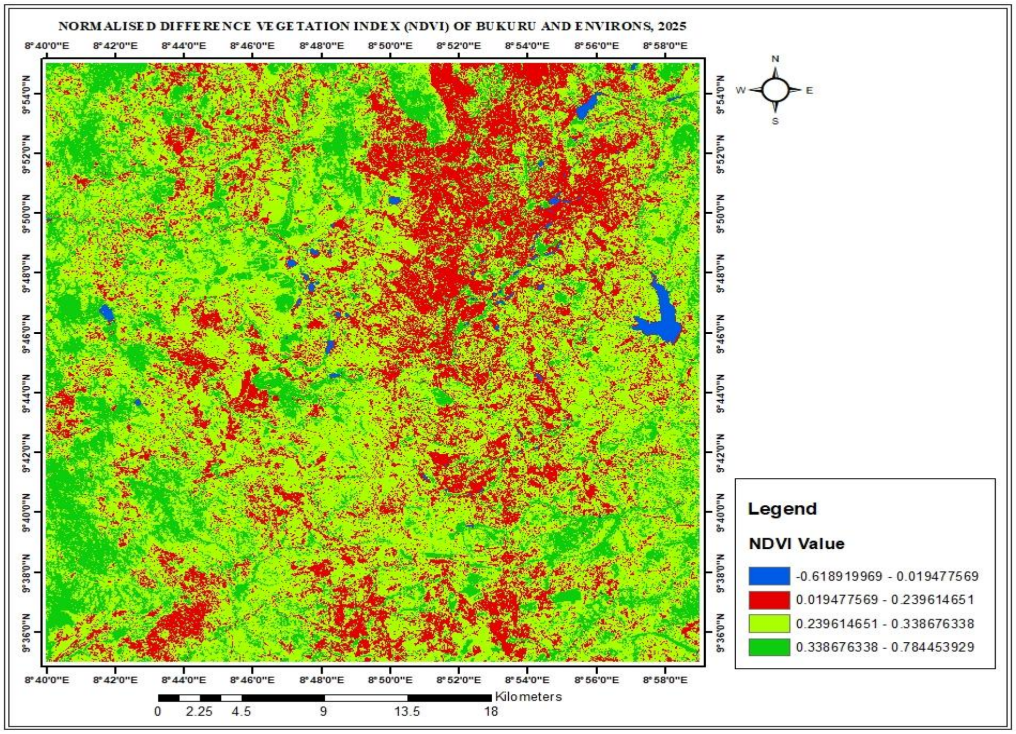

Figure 3 NDVI map of Bukuru and environs, 2025.

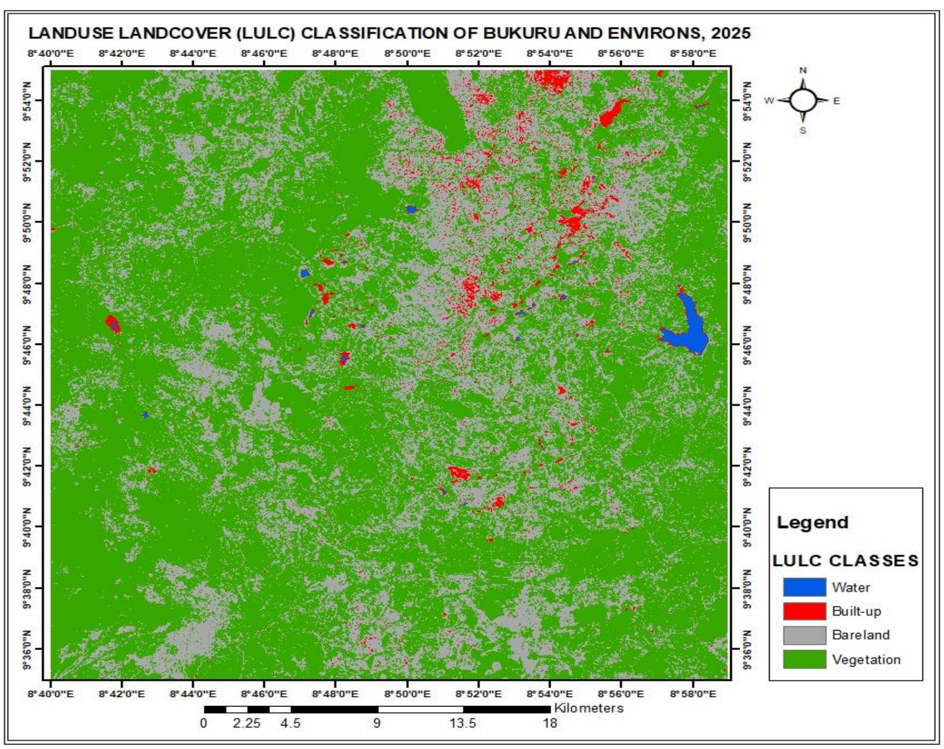

Figure 4 LULC map of Bukuru and environs, 2025 showing built-up, vegetation, bareland and water bodies.

Bukuru and environs may experience increasing temperatures primarily due to urban expansion and changes in land cover in the coming years. This shows that bukuru is under heat stress from increased temperatures caused by urban development. The maximum LST recorded at 45.17°C in the city centre is alarming because this is about the same level as in other cities in Nigeria (e.g., Ibadan, peak LST 47.72°C (Adebayo and Tukur, 2014), Kano with its large built-up areas and 95% increase in LST (Shaibu et al., 2025). It also accounts for the high LST in the study area: 85% of the hard landscape elements in Jos's city centre (Orewere et al., 2019) contribute to the increased LST in the study area.

The thermal contrast between the different types of land cover is stark. The difference of about 22°C between the coolest water body (22.81°C) and the hottest built-up area (45.17°C) indicates the dramatic change in surface energy balance caused by urbanisation. As can be seen from the results, replacing cooling, evaporating surfaces with heating, radiating surfaces raises local temperature (Oke, 1982; Voogt and Oke, 2003). Idi et al. (2022) show that LST can be higher than 43°C at Lamurde hot springs in northeastern Nigeria at certain geological features. This suggests that natural factors are also associated with higher LST values along with urbanisation.

The results have implications for public health and urban planning in Bukuru and its environs. As housing quality is poor and electricity supply is limited, there are a lot of informal settlements that experience high temperatures, and suffer from heatstroke, dehydration, and heat exhaustion (Kovats and Hajat, 2008; Patz et al., 2005).

V. CONCLUSION

This study examined the spatial distribution of land surface temperature over Bukuru and its surrounding areas using Landsat 8 OLI/TIRS imagery in 2025. It confirmed that the Jos-Bukuru region experience large UHI impact with maximum LST at 45.17°C in the city center, and there is a significant negative relationship between vegetation cover (NDVI) and LST (as areas that are densely vegetated and with high NDVI values have low LST values). The results from this study provide a key data-driven basis on which to prepare policies to reduce heat and maintain public health. Local planning, afforestation, and GIS-based monitoring, as advocated by Shaibu et al. (2025), will help to reduce urban heat and promote resilient communities in rapidly urbanized areas.

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