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Shedding Nightlight on Economic Development in Bangladesh

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Abstract: Using satellite-based nightlight data, this article attempts to study the relationship between economic development and energy consumption in Bangladesh. The findings confirm a substantial increase in nightlight intensity between 2011 and 2022, as expected, considering the impressive economic growth of the country over the past decade and reflecting the progression of electrification and economic activities, particularly in urban centres. However, it also uncovers pronounced regional disparities in nightlight intensity, indicating a widely uneven distribution of economic development and energy consumption across districts. These disparities highlight the concentration of economic activities in a few regions, alongside a nationwide trend towards increased energy usage and urbanisation. This policy brief posits that nightlight data can potentially serve as a good proxy for economic activity and thus a useful tool for policymakers. The recommendations call for enhanced investment in power generation and a strategic focus on addressing regional disparities, to foster more balanced and inclusive economic growth. By integrating nightlight intensity data into the policy formulation process, the paper underscores the potential for more targeted and effective development strategies, aiming to ensure equitable access to the benefits of economic progress and energy consumption.

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I. Background

The process of economic development in any country is intricately linked to energy consumption. Over the past decade, Bangladesh's GDP has consistently grown, with substantial development of physical infrastructure and a rapid expansion of the urban landscape being defining features of its ongoing economic transformation.

As Bangladesh's economy expands and urban centers flourish, the demand for energy has surged to power homes, industries, and infrastructures. Energy consumption, a crucial indicator of economic development, has grown in tandem with the country's GDP, underpinning economic activities. The relationship between development and energy consumption is bidirectional in nature, with each fueling the other—economic growth spurs increased energy demand, while access to energy enables further growth and development. Beginning from a low base, energy consumption in Bangladesh has increased significantly although it remains amongst the lowest per capita energy users in the world.

To capture economic development, energy consumption, and factors like regional inequality, economists and policymakers have traditionally relied on data from large-scale socio-economic surveys. These data-gathering exercises are complex tasks that require a significant amount of time, and the information often comes with considerable time lags, lacking real-time insights. Additionally, socio-economic data frequently suffer from quality concerns. Against this backdrop, the relatively new approach of using nightlight data has gained significant traction. This method offers a more immediate and potentially more accurate reflection of economic activity and development trends.

Modern remote sensing technology has offered alternative methods of data analysis, with satellite-based nightlight observations emerging as a fascinating indicator of economic activity. Satellite imagery of night lights offers a unique perspective on global economic transformation. By analyzing the intensity and distribution of artificial lighting captured from space, researchers can track urban expansion, identify areas of economic growth, and pinpoint industrial activities. This method is particularly effective in revealing the dynamics of urban vis-à-vis rural development, as well as in comparing economic progress over time and across different regions or countries.[1]

[1] For instance, Henderson et al. (2012) for sub-Saharan Africa identified a significant positive correlation among GDP growth, electricity usage and nightlight intensity. Singhal et al. (2020) uses nigh time light data to assess regional inequality in India. Li *et al.* (2018) provides an evaluation of the advancement of artificial light sources and the socioeconomic development in Algeria between 1992 and 2012. Hu and Yao (2019) show that the elasticity of night-time lights with respect to real GDP per capita is 2.5 per cent for low-income countries.

Changes in night light patterns also provide valuable insights into the impact and recovery from natural disasters, as well as variations in energy consumption related to economic activities.

Objectives of this article

In this article, by comparing nightlight intensity between 2011 and 2022, an attempt is made to indicate the changes in economic activities in Bangladesh to complement the sustained economic growth narrative that macroeconomic data seem to reveal. Variations in night light intensity are also compared overtime across districts to shed light on regional disparities. One key objective of this article is to demonstrate how nightlights can be a useful tool to provide insights into the patterns of economic development.

II. Methodology of using nighttime light data

Utilizing data from satellite programmes such as NASA and NOAA's Visible Infrared Imaging Radiometer Suite (VIIRS) and the Defense Meteorological Satellite Program (DMSP), the use of nightlight intensity to capture changes in economic activities has increasingly become an important tool in socio-economic research. It can assist in understanding poverty levels, wealth distribution, and the effects of government policies. Moreover, the visual representation of nightlight data not only aids in quantifying economic activity but also in visualizing the extent of human influence on the planet, offering an illustration of the disparities in resource access and utilization around the globe and across regions within a country.

Nightlight data reflects the concentration of human activity through nocturnal light emissions, and it is widely regarded to be positively correlated with economic parameters such as GDP as well as energy consumption (Henderson et al., 2012). Nightlight refers to the visible light on Earth's surface during the nighttime, as detected in satellite imagery. Generally, each pixel in these images records the light per square kilometre area. Bright, concentrated light in cities shows that there are busy economic hubs while dim, scattered light implies an area being less developed or rural. Moreover, the nightlight intensity can also reflect not only energy consumption but also population density as well as the quality of infrastructure development.

For this study, we employed harmonised global nightlight images, as compiled and presented in the research conducted by Li et al. (2020). Generally, two platforms were used to collect nightlight data. The first was the Defense Meteorological Satellite Program (DMSP)-Operational Linescan System (OLS), which supplied annual data from 1992 to 2013. The second was the Visible Infrared Imaging Radiometer Suite (VIIRS), which has been providing monthly nightlight data since 2013. However, the discrepancy in data frequency, among other factors such as the impact of cloud density and stray light, posed a challenge for researchers in utilising nightlight data over an extended period. To overcome this obstacle, Li et al. (2020) developed a method to harmonise the DMSP-OLS and VIIRS nightlight data, filling a significant gap in the field. The images are supplied in a raster format, which

They also find that find that GDP per capita measures are less precise for middle- and low-income countries and nighttime lights can play a bigger role in improving such measures.

consists of a pixel matrix. Each pixel within this matrix captures the nightlight of a specific geographical area. For the purpose of extracting data at a sub-national level, we employed the district shapefile of Bangladesh. In the course of this analysis, we calculated the nightlight intensity by dividing the aggregate nighttime luminosity of a district by the respective district's area, measured in square kilometres. This calculation facilitated a standardised measure of nightlight intensity, thereby enabling a more accurate comparison across the subnational level. Data from harmonised images allow researchers to conduct more comprehensive and continuous analysis.

III. Findings on Bangladesh

A significant rise in nightlight intensity

First, we compare nightlight intensity through simple visualization. Between 2011 and 2021, the proportion of households in Bangladesh with access to electricity increased from 59.6 per cent to 99 per cent. Along with this, extensive infrastructure development has taken place, prompting economic activities. The increase in nightlight intensity in Bangladesh, as depicted in Figure 1, aligns with our understanding of the country's economic growth and development. Within the cartographic representation, regions with elevated nightlight intensity are denoted by a brighter orange hue, while areas with lower nightlight intensity are signified by a darker shade. Notably, regions marked in deep blue represent the highest levels of nightlight intensity. The illuminated areas during the night likely to represent urban regions and places experiencing a rise in economic activities over the decades. For example, the nightlight map of Bangladesh from 2011 reveals that the Sunamganj district was predominantly darker, indicating a lower level of economic development. However, there was a noticeable improvement in the same district within the decade. Simultaneously, the districts situated in the southern region demonstrated a significant enhancement in their economic activities compared to their status in 2011. Economic development was dispersed throughout the country in 2011, but a decade later, it exhibited considerable improvement, which can be attributed to the advancements in energy generation. The deep blue regions provide insight into the clustering of economic activities particularly within the districts that are centered around Dhaka. It can be estimated that Between 2011 and 2022, Bangladesh experienced about 12 per cent average annual growth in nightlight intensity.[2]

It is important to note that growing electrification and rising night light intensity have been a global phenomenon. A similar comparison with West Bengal, India, is given in Figure 2. A close look at Figures 1 and 2 would suggest that by 2022, most of the regions of West Bengal had become noticeably brighter at night in comparison with Bangladesh. Furthermore, West Bengal have more areas with very intense nightlight as marked by deep blue coloured regions.

[2] It is worth pointing out that between 2009 and 2018, the number of power plants in the country increased from 27 to 118 (CRI, 2018). The total electricity generation in the country increased from 4,942 megawatt in 2011 to 23,548 megawatt in 2022.

Figure 1: Nightlight map of Bangladesh

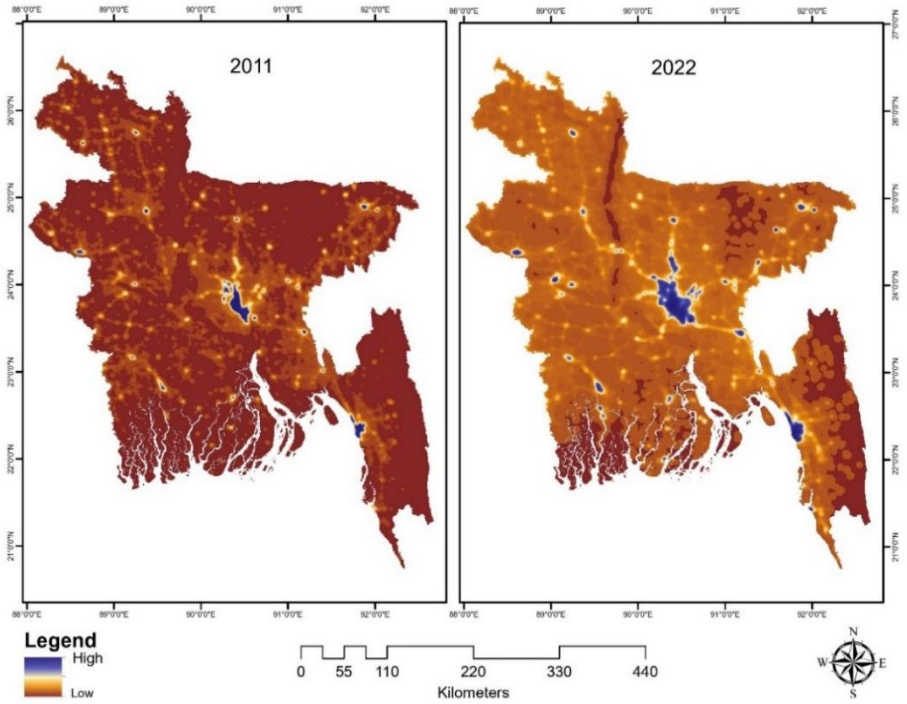
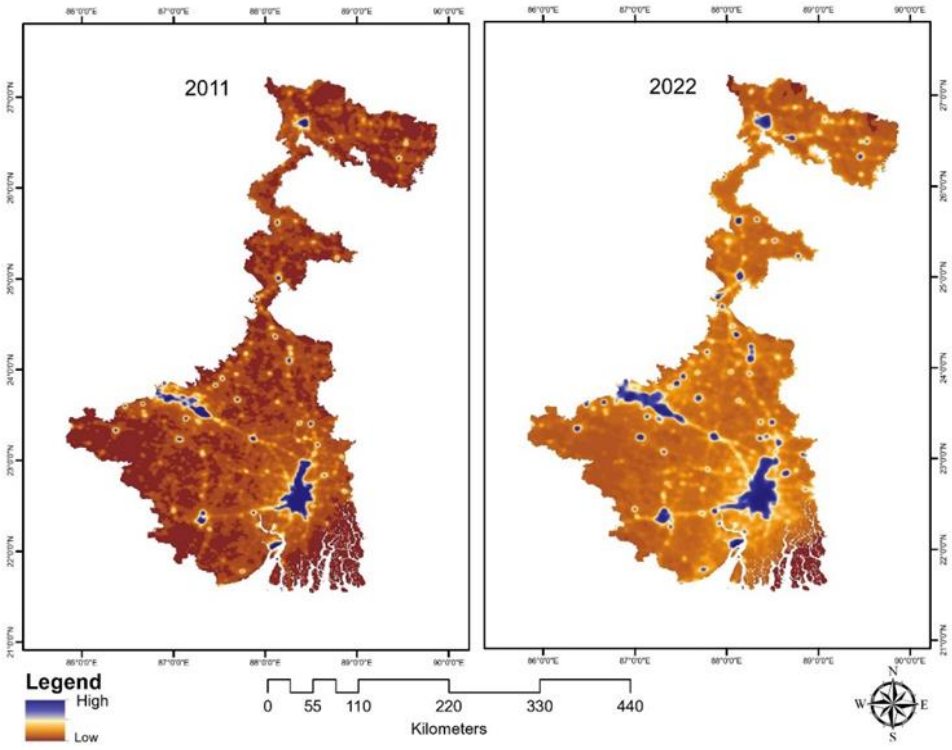


Figure 2: Nightlight map of West Bengal, India



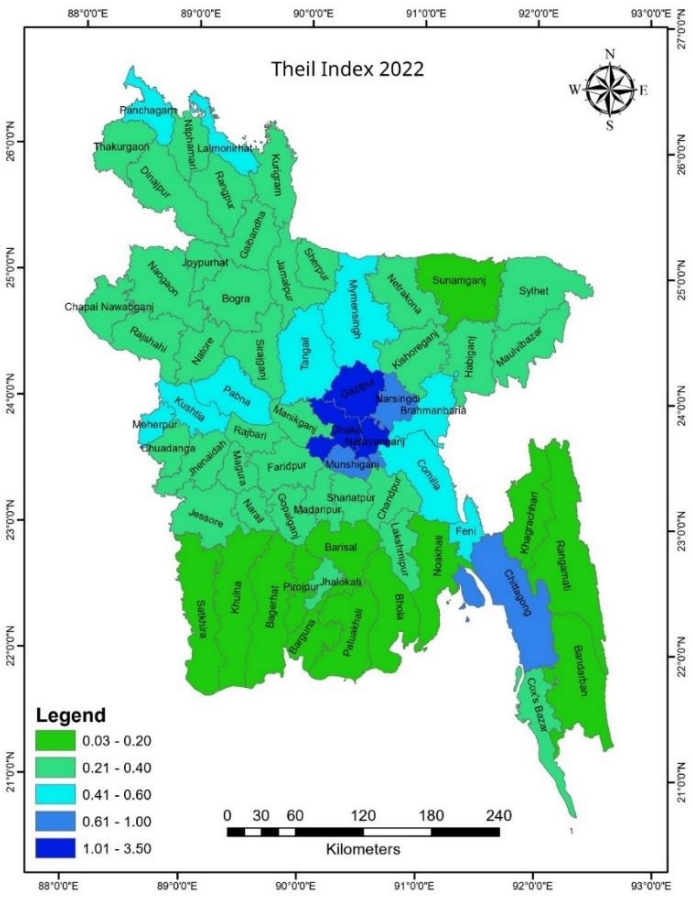
Widespread variations in nightlight intensity across districts

The variation in nightlight intensity across districts is indicative of differing levels of economic activity and energy usage. To evaluate disparities in energy consumption and economic development at the district level, we employed the Theil T index, utilizing nightlight intensity as a proxy measure. This index quantifies the deviation of a district from an ideal egalitarian scenario, where economic prosperity is evenly distributed. A higher Theil T index value for a district suggests a more pronounced concentration of energy consumption relative to other regions, signaling disparities in economic development.

$$T_i = \frac{k_i}{\tilde{k}} \log\left(\frac{k_i}{\tilde{k}}\right)$$

Here, T_i is the Theil index of district i. k_i represents the nightlight intensity of district i and $\tilde{k}$ is the median nightlight intensity of all districts.[3]

Figure 3: Theil T index for nightlight across districts, 2022



Source: Authors' presentation based on Theil T-index calculations.

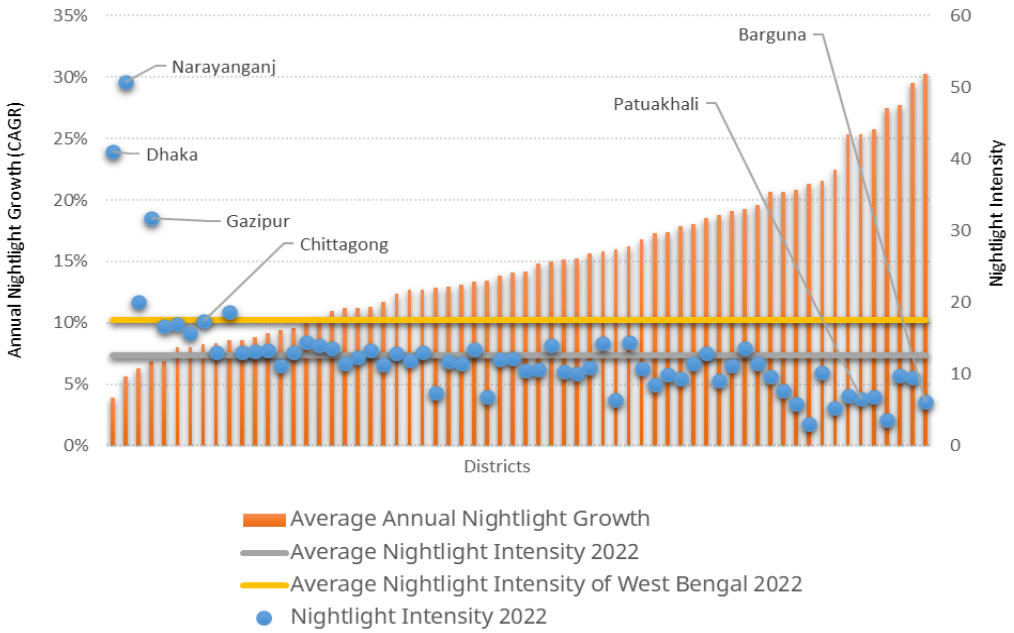
[3] The Theil T-equation is decomposed for individual districts in order to examine the concentration at the subnational level.

Dhaka, Gazipur, and Narayanganj recorded values exceeding one, while Chittagong, Munshiganj, and Narsingdi secured the second-highest positions. This suggests a heavy concentration of economic activities in these districts, also indicating disparity across the subnational level. Despite a 12 percent nationwide annual rise in nightlight intensity over the past decade, the southern districts lag significantly behind other regions.

Among the 64 districts in the country, merely four districts – Dhaka, Gazipur, Narayanganj, and Chittagong – host the majority of readymade garment (RMG) factories (Mapped in Bangladesh, 2023). Apart from RMG units, other industries also exhibit a strong concentration in these four districts, highlighting that a notable portion of energy consumption is confined to these districts.

Figure 4 reveals that districts with lower annual growth in nightlight tend to have relatively high nightlight intensity in 2022[4]. For example, both Dhaka and Narayanganj have a nightlight intensity exceeding 20, yet their annual growth is less than 8 per cent. In contrast, Barguna exhibits the highest nightlight growth at 30 per cent, but it ranks among the lowest in terms of nightlight intensity. This phenomenon can be explained by the fact that districts with initially very low levels of electricity consumption experiencing faster growth in intensity. This is due to the extremely low base of initial intensity.

Figure 4: Average annual nightlight growth (left vertical axis) vs nightlight intensity in 2022 (right



Source: Authors' presentation based on district-wise nightlight statistics.

[4] The annual growth rates (CAGR) for each district are arranged in ascending order, with the district axis indicating the respective districts. The growth rate has been calculated between the year 2011 and 2022.

Most districts in Bangladesh display nightlight intensities below the national average. This suggests that, despite an overall increase in nightlight brightness, economic activities and energy consumption are highly concentrated in certain specific regions. Furthermore, when comparing these nightlight levels to the average in West Bengal, the majority of Bangladeshi districts remain below this benchmark. According to BP statistics, Bangladesh has one of the lowest per capita energy consumptions in the world[5]. This underscores the significant disparities in energy usage and economic development both within the country as well as in comparison with other global economies.

IV. Policy Recommendations

There are some significant policy implications that arise from our analysis above.

- Bangladesh's significant strides in electricity generation and increased nightlight intensity pave the way for further amplifying overall electricity consumption to sustain its economic growth. The per capital energy consumption remains low in the country, and thus more investment in power generation will be needed.
- The high concentration of nightlight intensity in a few districts suggests that economic activities in Bangladesh are heavily centralised. Addressing these regional disparities could be vital to promote balanced economic development so that more people can benefit from the economic growth taking place.
- Rather than relying only on socio-economic surveys—that are often irregular and maybe subject to various limitations—incorporating nightlight intensity data offers a complementary and perhaps more immediate method to identify lagging regions. This approach allows for a clearer assessment of where policy attention is most needed, ensuring that the needs of people living in these areas are effectively met and aiding in the equitable distribution of the country's economic growth.
- To harness the full potential of night light data for more informed policymaking, policymakers and the research community should invest in the relevant capacity-building initiatives. These should focus on enhancing access to and analysis of nightlight data, thereby empowering decision-makers with the tools necessary for more effective and data-driven policy development.

[5] BP Statistical Review of World Energy reveals that energy consumption per capita in Bangladesh is 9.9 gigajoules which is lowest in the world after Africa. In comparison, Pakistan consumes 17.1 gigajoules, the Philippines consumes 17.6 gigajoules, and India consumes 25.4 gigajoules. In contrast, the average energy consumption per capita is 167.9 gigajoules for OECD countries, while non-OECD countries average is 56.2 gigajoules.

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