Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Geospatial Assessment of Economic Activity in Manipur Using Night Time Light Data from 2014 to 2023

Taibanganba Laishram
Sharda University
Vipin Solanki
geosolanki@gmail.com
Sharda University
Sajad Nabi Dar
VIT-AP University

Research Article

Keywords: Nighttime light, Economic activity, GSDP, VIIRS, Manipur

Posted Date: June 2nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9633578/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Abstract

Nighttime Light (NTL) data is widely used to assess economic activity, but its reliability at smaller geographic scales is still uncertain. This study analyzes the relationship between NTL intensity and economic activity in Manipur during the period from 2014 to 2023, using VIIRS- derived radiance data along with Gross State Domestic Product (GSDP). A set of complementary specifications is employed in this analysis, including log-log, time-adjusted, and first-difference, in order to investigate the robustness of the relationship between NTL intensity and GSDP. The baseline findings suggest that there is a positive correlation between NTL intensity and GSDP. However, when temporal effects were considered through the use of both a time-adjusted and a first-difference model, the strength of the relationship diminished. In addition, no relationship was evidenced when examining the dependence of GSDP growth based upon NTL intensity, suggesting that the level of association is largely driven by a common temporal trend. The spatial analysis indicates an uneven distribution of economic activity, where there is a persistent concentration of NTL intensity in the central valley of Manipur. This suggests that the NTL data can help identify broad trends and spatial variation with respect to economic activity. However, NTL cannot be used effectively as a measure of economic variation on a short-term basis and should be viewed as such when performing time series analyses of small geographical regions.

Introduction

Regional Development is observed to provide a broad picture of how varied regions grow over time by the measure of economic activity. Gross Domestic Product (GDP) and Gross State Domestic Product (GSDP) are the indicators used to calculate the value of goods and services produced in an economy (Ministry of Statistics and Programme Implementation, 2022). These measurements remain uncertain, especially in developing regions, as they do not show the complete picture of the economy. In many cases, difficulties regarding gathering information, variations in how offices report facts, and the presence of informal activities that are not properly recorded cause regional development data to lose trust when people look at small geographic areas (Henderson, Storeygard, & Weil, 2012; Jerven, 2013).

Researchers have searched for alternative ways to measure economic activity because of these types of problems and have turned to night-time light (NTL) data from satellites, which captures artificial lighting as part of an indirect measure of human activity and settlement patterns (Elvidge, Baugh, Zhizhin, Hsu, & Ghosh, 2017) (Solanki & Joshi, 2017). Previous researchers have also found that areas with higher levels of light generally link with higher population density and increased economic activity (Doll, Muller, & Morley, 2006; Ebener, Murray, Tandon, & Elvidge, 2005). In this way, NTL data can help give an idea about how economic activity is spread, even though it may not show everything (Solanki, 2026).

Many studies have tried to examine the relationship between NTL intensity and economic output. In several cases, NTL serves as a proxy indicator in regions where there exists no reliable economic data (Chen & Nordhaus, Using luminosity data as a proxy for economic statistics, 2011; Henderson, Storeygard, & Weil, 2012). NTL has also been used for comparing economic growth among regions and countries (Alam & Tarananum, 2021) (Keola, Andersson, & Hall, 2015; Pinkovskiy & Sala-i-Martin, 2016). As data processing and calibration improved, NTL has become more applicable to smaller regions (Li, Xu, Chen, & Li, 2013).

Changes have also occurred in the technologies that produce satellite imagery that we utilize for the development of NTL datasets, making them a more reliable source of information. For instance, the Visible Infrared Imaging Radiometer Suite (VIIRS) has greatly increased the resolution of NTL datasets when compared to earlier sources of nighttime light data, such as the Defense Meteorological Satellite Program Operational Line Scanner (DMSP-OLS). Therefore, it is now possible to detect lower levels of lighting much more accurately than before (Elvidge, Baugh, Zhizhin, Hsu, & Ghosh, 2017; Li & Zhou, 2017). Consequently, these new improvements to VIIRS make them an increasingly popular source of data used to evaluate economic activity in both space and over time (Chen & Nordhaus, VIIRS Nighttime Lights in the Estimation of Cross-Sectional and Time-Series GDP, 2019).

Limitations such as light saturation, blooming, and sensor distortions can create erroneous results when using NTL data (Small, Pozzi, & Elvidge, 2005). In addition, because NTL does not capture the real economic activity in places where there is little or no artificial lighting, like rural or low-electricity areas (Gibson, Olivia, & Boe-Gibson, 2020). NTL should best be viewed as a complement to other types of information rather than a substitute for them.

There has been a lack of sub-national analysis using NTL in Northeastern India, specifically with reference to the area of Manipur; this gap is even more noticeable when you consider the broader literature. Most studies concerning the NTL and economic activity relationship primarily focus on larger scales (usually global or national) or are based in developed areas. Therefore, illuminated areas with limited data available have not received significant attention, even though these are the areas where these types of methods could be most valuable. Existing studies applied simple regression or cross-sectional approaches and failed to adequately account for temporal dynamics. Where both NTL and the economic-related variables are increasing at similar rates over time, this will also play a role in the relationship that is observed between the two groups of variables.

Keeping this in view, the present study examines the relationship between NTL intensity and economic activity in Manipur for the period 2014–2023. VIIRS-based NTL data are used along with GSDP to assess whether NTL can serve as an indicator of economic activity at the state level. In addition to the baseline analysis, the study also considers the role of time trends and short-term changes in order to better understand the nature of this relationship.

Objectives of the Study

1. To examine the spatio-temporal variation in NTL intensity across Manipur during 2014–2023.
2. To analyse the relationship between NTL intensity and GSDP using correlation and regression-based approaches.
3. To compare the temporal movement of NTL and GSDP to identify whether changes in light intensity reflect changes in economic activity.
4. To evaluate the reliability of NTL as a proxy for economic activity in the context of Manipur.

Study Area

Manipur is one of the northeastern states of India, which is located between 23.83°N and 25.68°N latitude and 93.03°E and 94.78°E longitude (Figure 1). The state shares an international boundary with Myanmar on the eastern and south-eastern side, and it is bounded by Nagaland in the north, Assam in the west, and Mizoram in the south-west. The total geographical area of the state is about 22,327 sq. km. The state is mainly divided into two physical parts: the valley region and the hill region. The valley lies in the central part of the state, and it is comparatively smaller in area, but most of the population is settled in this part. Most of the agricultural activities and other economic activities are also found in the valley area. The hill areas, on the other hand, cover a larger portion of the state, but these areas are not easily accessible, and the population is also less in comparison. This shows that there is a clear difference between the valley and hill areas in terms of settlement and land use (Government of India, 2011; Government of India, 2015). The pattern seen in the region reflects the physical differences across it. Hill districts tend to be less developed than valley districts regarding infrastructure and basic services, which results in differences in the distribution of economic activity throughout the state. (Mishra, Pauntunthang, Marbaniang, & N, 2021). Thus, Manipur serves as an appropriate case for analyzing the relationship between NTL intensity and economic activity in the valley and hill regions of Manipur.

Data and Methodology

Data Sources

Secondary data gathered through satellite observations and published official economic statistics form the foundation of this study. The NTL data are taken from the VIIRS Day/Night Band annual composites derived from the Suomi National

Polar-orbiting Partnership (Suomi NPP) satellite, produced by the Earth Observation Group (Earth Observation Group, 2026), which reports radiance values of artificial illumination. The NTL datasets contain radiance-calibrated, cloud-free measurements of artificial brightness. This brightness, reported as nanowatts of light per square centimetre of area per steradian (nW/cm²/sr), is extensively used in analysing human and economic activities. The economic variable used is Gross State Domestic Product (GSDP) for Manipur, obtained from the 'Handbook of Statistics on Indian States' published by the (Reserve Bank of India, 2024), with values reported at constant prices.

Data Processing

The satellite data were reduced to resemble a time series to compare the two variables. The annual raster layers were extracted by clipping each year's raster data using a boundary shape file and then using the layer's zonal statistics to calculate a single mean value for each year. By averaging these mean brightness values, variations in the amount of NTL produced by local areas are essentially reduced to the average amount of NTL produced by all areas of the state on a state-level basis. Since NTL values are skewed, they were transformed using a logarithmic transformation to make them appropriate for statistical analysis. NTL data were from the calendar year, while GSDP data were from a financial year and needed to be modified to align them with the equivalent calendar year, thus making their usage during the study consistent.

Analytical Framework

In this study, a set of regression models was used to analyze the relationship between NTL and GSDP for the state of Manipur.

The first model (log-log) is shown in Eq. (1),

$$ln\left(GSDP\right) = \beta^{0} + \beta^{1} ln\left(NTL\right) + \epsilon \qquad (1)$$

Where GSDP = total output during the time period t and NTL = corresponding NTL during the same time period. The model also has an error term (ε), which accounts for other potential factors that may affect GSDP. The coefficient (β_1) represents elasticity; therefore, the value of β_1 will indicate the proportionate change in GSDP resulting from a proportionate change in NTL.

It should be noted that both NTL and GSDP have shown a consistent increase in each variable over time; it is only the consistent increase common to both variables that may represent any relationship discovered in Model 1; this may reflect a shared time trend rather than a direct economic relationship between the two variables.

To address this concern, a time variable is introduced, giving Eq. (2),

$$\ln\left(GSDP_t\right) = \beta_0 + \beta_1 \ln\left(NTL_t\right) + \beta_2 t + \epsilon_t \qquad (2)$$

where *t* is a linear time index. The inclusion of β_2 accounts for the general trend common to both variables. Any change in the estimated coefficient of NTL after introducing the time variable indicates whether the relationship observed in Eq. (1) is driven by a shared time trend or reflects a more direct association.

Both Eq. (1) and Eq. (2) are specified in levels and therefore primarily capture long-term relationships (i.e., over the study period). To examine short-term dynamics, the relationship is also expressed in first differences, as shown in Eq. (3),

$$\Delta \ln\left(GSDP_t\right) = \beta_0 + \beta_1 \Delta \ln\left(NTL_t\right) + \epsilon_t \qquad (3)$$

where Δ denotes the change from one year to the next. Also, $\Delta\ln(GSDP_t)$ refers to the growth rate of the economy, while Δln(NTL) captures changes in light intensity. By removing long-term trends and focusing on changes between any two

particular years, it enables examining whether there are any associations between NTL and GSDP in economic activity.

These models are not mutually exclusive; they offer complementary views on the relationship between NTL and GSDP, as well as allow an assessment of whether the relationship between NTL and GSDP is constant, whether the two variables share common trends, or whether the relationship disappears when considering only short-term changes.

Justification of Study Period

The study period of 2014–2023 was established because of the availability and consistency of the data used in this study. VIIRS nighttime light data are typically available and more consistent starting in 2014; therefore, 2014 was the starting year for this study. The ending year for this study was established by the availability of GSDP data; thus, the only selection criterion is that GSDP and NTL data be in the same years. By having GSDP (financial year) data correspond with NTL (calendar year) data, both sets of data are usable across the entire study timeframe.

Results

Trend and Spatial Patterns

The NTL intensity has a general upward trend from 2014 to 2023 and follows closely the same upward trend as GSDP, seen in the time-series graph (Figure 2). There are, however, several fluctuations in their growth, but the direction of overall movement is positive for both sets of data. As a result of this observation, NTL intensity likely reflects economic development on the aggregate level due to both exhibiting upward trends; however, this is likely due to both displaying common time effects as opposed to having direct or independent associations with each other.

NTL spatial patterns are uneven across the state, with most of the central valley having higher NTL intensity. Illumination remains clustered in the central valley and remains low in the surrounding hill areas (Figure 3). The persistence of the patterns over time demonstrates that the spatial increases in NTL are not representative of broad-scale economic growth but instead exemplify a localized increase in activity.

Association between NTL and GSDP

The scatter plot (Figure 4) demonstrates a positive correlation between ln (NTL) and ln (GSDP), implying that they experience an upward trend together. Because of the similar upward movement of the two variables through time (in Figure 2), both may be subjected to a common temporal influence rather than being directly related to each other. The visual distribution, therefore, warrants additional investigation via regression analysis.

Descriptive Statistics and Regression Results

Table 1 represents descriptive statistics for ln(NTL) and ln(GSDP) over time. The ln(NTL) data have a moderate range of variation throughout the studied period, whereas ln(GSDP) has a limited range of variation; therefore, it can be concluded that ln(NTL) has an unstable growth path, whereas ln(GSDP) has a stable growth path. The disparity between the two study variables is pertinent when determining if there is a substantive relationship between NTL and economic activity.

Table 1: Descriptive Statistics of ln(NTL) and ln(GSDP)

Variables	Mean	Std. Deviation	Minimum	Maximum
ln (NTL)	9.81	0.437	9.06	10.20
ln (GSDP)	14.40	0.12	14.20	14.60

Source: Calculated by Author

Table 2 shows the results of a regression analysis that helps to assess the link between NTL and GSDP. Results from Model 1 (baseline log-log) show a positive relationship between NTL and GSDP ($\beta = 0.241$, $p < 0.01$). Overall, given the high R^2 (0.773), at least part of the variation in GSDP can be explained through this model.

Table 2: Regression Results (Models 1–3)

Variables	Model 1: Baseline (Log-Log Model)	Model 2: Time-Adjusted Model	Model 3: First-Difference Model
ln(NTL)	0.241***	0.037	
	(0.046)	(0.081)	
Time		0.032**	
		(0.012)	
Δln(NTL)			0.011
			(0.122)
Constant	12.072***	13.892***	0.044
	(0.453)	(0.739)	(0.025)
Observations	10	10	9
R^2	0.773	0.892	0.001
Adjusted R^2	0.745	0.861	

Notes: Standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Source: Calculated by Author

The relationship appears to have significantly weakened due to the greater significance of the time variable in Model 2 and the greater insignificance of the ln(NTL) variable (Table 2). This indicates that much of the association observed in Model 1 is primarily due to a common time trend. This is more clearly illustrated in Model 3, in which the coefficient for the variable represents insufficient statistical significance and explains very little of the variance in the dependent variable (the R^2 value of the model is approximately 0.001). Thus, short-term variations in NTL do not correspond to changes in GSDP. Ultimately, these findings suggest that NTL intensity and GSDP are correlated over time at the overall level, but this correlation is diminished when accounting for time, and does not hold true when considering short-term fluctuations.

Discussion

The findings show that there is a positive relationship between the intensity of NTL and the GSDP of Manipur in the initial estimation. The models also show evidence of this relationship not consistently being present in all of the models. The elasticity estimated (0.241) and relatively high explanatory power ($R^2 = 0.773$) for the baseline model imply that NTL corresponds with overall levels of the economy when viewed in levels. However, there does not appear to be a statistically significant relationship when the time variable is added, although the time trend continues to show significance. This suggests that what has appeared to be a measurable relationship between the two is more likely reflective of an overall long-term upward trend rather than a causal relationship. The first-difference analyses further demonstrate that changes in NTL do not demonstrate statistically significant relationships with changes in GSDP, and overall prediction remains modest. Collectively, these results indicate that NTL and GSDP have a long-term correlation, and do not show persistence in their short-term correlation.

The results of this study confirm previous research that showed a positive relationship between NTL and the amount of economic output in an area (Henderson, Storeygard, & Weil, 2012; Chen & Nordhaus, VIIRS Nighttime Lights in the Estimation of Cross-Sectional and Time-Series GDP, 2019), but those studies assessed much larger areas and often used cross-sectional or aggregate data sources; therefore, the ability to detect variations in those studies was much greater than it would be in a single state over time. This may explain why the relationship between NTL and economic activity was diminished when time factors were considered in this paper (Li, Xu, Chen, & Li, 2013; Gibson, Olivia, & Boe-Gibson, 2020). The spatial analysis revealed that NTL remained concentrated in the central valley area with a continuing low level of NTL in the outlying hill areas; therefore, the spatial disparities are still evident. Thus, the results suggest that NTL is better at depicting spatial differences than temporal changes. However, further limitations exist; not all economic activities create NTL, and differences in electricity access, light efficiency, and infrastructure characteristics may cause differences in observed NTL radiance and are therefore not necessarily indicative of economic activity (Chen & Nordhaus, Using luminosity data as a proxy for economic statistics, 2011; Gibson, Olivia, & Boe-Gibson, 2020). Overall, the findings of this study show that NTL can serve as a useful but proxy for measuring the level of economic activity in Manipur, especially when conducting time-series analyses on smaller geographic units where the presence of common trends and limited variation greatly diminishes NTL's ability to be used as a proxy.

Gross State Domestic Product (GSDP) and Night-Time Light (NTL) satellite imagery

Gross State Domestic Product (GSDP) is the most widely accepted macroeconomic indicator for assessing the economic performance of Indian states. It is conventionally estimated through the production approach as:

$$GSDP = SVABP + ProductTaxes - ProductSubsidies$$

where **SVABP** represents State Value Added at Basic Prices. While this framework is statistically robust, it depends heavily on administrative records, sectoral reporting systems, tax databases, and institutional continuity. In conflict-affected regions such as Manipur, especially during the prolonged ethnic unrest and political instability witnessed between 2014 and 2023, these conventional sources may underrepresent real-time economic conditions. Market shutdowns, curfews, road blockades, displacement, destruction of infrastructure, internet suspensions, and informal sector contraction often remain partially invisible in official estimates.

Reconceptualizing GSDP: A Data-Driven Paradigm Integrating Satellite-Derived Indicators

In this context, **Night-Time Light (NTL) satellite imagery** offers a novel proxy for economic activity. Artificial illumination observed from space has been widely linked with urbanization, electricity consumption, industrial output, transport intensity, and income generation. Unlike conventional statistics, NTL data provide high-frequency, spatially explicit, and independently observable evidence of economic vitality. Changes in luminosity can reflect economic slowdowns during violence, recovery after disturbances, spatial shifts in commercial centres, and resilience of urban systems.

Therefore, this study proposes to integrate NTL dynamics into the GSDP estimation framework by augmenting the conventional identity with an economic activity proxy:

$$GSDP^* = SVABP + ProductTaxes - ProductSubsidies + \beta\ (NTL)$$

where **β(NTL)** represents the calibrated contribution of Night-Time Light intensity to state-level economic performance. This does not replace official GSDP methodology but supplements it through a remote sensing-based resilience indicator.

NTL is employed as a complementary proxy indicator to assess latent economic resilience and temporal-spatial deviations from officially reported GSDP.

Conclusion

The relationship between economic activity in Manipur (GSDP) and the NTL intensity from 2014 to 2023 was examined by using official GSDP data and satellite-based NTL (radiance) data. It was determined that while both NTL and GSDP showed a positive relationship when measured in the baseline model, the significance of the relationship weakened once temporal effects were included in the analysis. Furthermore, NTL and GSDP showed no significant statistical relationship when using the first-difference measure, indicating that levels of these two variables were predominantly attributed to a common trend in time and not to an independent relationship between NTL and GSDP.

The results support the view that NTL is useful only when applied consistently. In Manipur, NTL shows long–term patterns and is useful for determining the distribution of economic activity throughout the state based on the persistent concentration of NTL intensity in the central valley area compared to the peripheral hilly regions. However, NTL does not represent short–term variability in the level of economic activity nor provide consistent relationships with GSDP after accounting for time. Therefore, NTL can complement other measures of economic activity, but it is not adequate on its own as a time–series measure of economic activity at the State level. Therefore, researchers should consider scale and timing when interpreting NTL measures of economic activity.

Declarations

1. Acknowledgments: Not Applicable.

2. Author contributions: T.L. conceptualized the study, collected and processed the night-time light data, performed data analysis, and drafted the initial manuscript. V.S. supervised the research work, contributed to the study design, interpretation of results, and critically revised the manuscript. S.N.D. assisted in methodology development, geospatial analysis, visualization, and manuscript editing. All authors reviewed and approved the final version of the manuscript.

3. Clinical trial number: Not Applicable.

4. Consent to participate: Not Applicable.

5. Consent to publish: Yes

6. Conflicts of interest: The authors declare no conflict of interest regarding the publication of this manuscript.

7. Ethical approval: Not Applicable.

8. Data availability statements: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

9. Ethical statement: The research is based exclusively on remote sensing data, secondary sources, and publicly available spatial datasets. No human participants or animals were involved in the study; therefore, ethical clearance was not required. The authors affirm that **ChatGPT (OpenAI, GPT-5)** was used solely to refine grammar, improve readability, and ensure consistency in terminology to enhance the overall clarity and presentation of the manuscript. All conceptualization, data analysis, interpretations, and conclusions were independently conducted and verified by the authors, in accordance with Springer's AI disclosure guidelines.

10. Human Participants: Not Applicable

11. Declaration of Funding

The authors declare that no financial support, grant, or funding was received from any public, commercial, or non-profit funding agency for the research, authorship, and/or publication of this article.

References

1. Alam, M. J., & Tarananum. (2021). Socio-Economic Impact Of E-Governance On Agricultural Growth In India: A Case Study Of Western Uttar Pradesh. *PalArch's Journal of Archaeology of Egypt, 18*(10), 265–275. Retrieved from

https://archives.palarch.nl/index.php/jae/article/view/9764

2. Chen, X., & Nordhaus, W. D. (2011, May). Using luminosity data as a proxy for economic statistics. *Proc Natl Acad Sci U S A*. doi:10.1073/pnas.1017031108
3. Chen, X., & Nordhaus, W. D. (2019). VIIRS Nighttime Lights in the Estimation of Cross-Sectional and Time-Series GDP. (9), 1057. doi:10.3390/rs11091057
4. Doll, C. N., Muller, J.-P., & Morley, J. G. (2006). Mapping regional economic activity from night-time light satellite imagery. *Ecological Economics, 57*(1), 75-92. Retrieved from https://doi.org/10.1016/j.ecolecon.2005.03.007
5. Earth Observation Group. (2026). *VIIRS night-time light annual composites*. Retrieved January 2026, from Earth Observation Group: https://eogdata.mines.edu/nighttime_light/annual/
6. Ebener, S., Murray, C., Tandon, A., & Elvidge, C. C. (2005). From wealth to health: modelling the distribution of income per capita at the sub-national level using night-time light imagery. *International journal of health geographics*. Retrieved from https://doi.org/10.1186/1476-072X-4-5
7. Elvidge, C. D., Baugh, K., Zhizhin, M., Hsu, F. C., & Ghosh, T. (2017). VIIRS night-time lights. *International Journal of Remote Sensing, 38*(21), 5860-5879. doi:10.1080/01431161.2017.1342050
8. Ghosh, T., Powell , R. L., Elvidge, C. D., Baugh, K. E., Sutton, P. C., & Anderson, S. (2010). Shedding Light on the Global Distribution of Economic Activity. *The Open Geography Journal, 3*, 147-160. doi:10.2174/1874923201003010147
9. Gibson, J., Olivia, S., & Boe-Gibson, G. (2020). NIGHT LIGHTS IN ECONOMICS: SOURCES AND USES1. *Journal of Economic Surveys*, 955-980. Retrieved from https://doi.org/10.1111/joes.12387
10. Government of India. (2011). *Manipur*. Retrieved March 4, 2026, from Know India: https://knowindia.india.gov.in/states-uts/manipur.php
11. Government of India. (2015). *State profile of Manipur 2014–15.* Ministry of Micro, Small and Medium Enterprises, Development Commissioner. Retrieved from https://dcmsme.gov.in
12. Henderson, J. V., Storeygard, A., & Weil, D. N. (2012, April). Measuring Economic Growth from Outer Space. *American Economic Review, 102*(2), 994-1028. doi:10.1257/aer.102.2.994
13. Jerven, M. (2013). Poor Numbers: How We Are Misled by African Development Statistics and What to Do about It. *Cornell University Press*. Retrieved from http://www.jstor.org/stable/10.7591/j.ctt1xx4sk
14. Keola, S., Andersson, M., & Hall, O. (2015). Monitoring Economic Development from Space: Using Nighttime Light and Land Cover Data to Measure Economic Growth. *World Development, 66*, 322-334. doi:10.1016/j.worlddev.2014.08.017
15. Li, X., & Zhou, Y. (2017). A Stepwise Calibration of Global DMSP/OLS Stable Nighttime Light Data (1992–2013). *Remote Sensing, 9*(6). Retrieved from https://doi.org/10.3390/rs9060637
16. Li, X., Xu, H., Chen, X., & Li, C. (2013). Potential of NPP-VIIRS Nighttime Light Imagery for Modeling the Regional Economy of China. *Remote Sensing, 5*(6), 3057-3081. Retrieved from https://doi.org/10.3390/rs5063057
17. Ministry of Statistics and Programme Implementation. (2022). *Gross State Domestic Product at Constant Prices*. Retrieved from data.gov.in: https://www.data.gov.in/catalog/gross-state-domestic-product-constant-prices
18. Mishra, P. S., Pauntunthang, N., Marbaniang, S. P., & N, A. K. (2021). Geographical divide led inequality in accessing maternal healthcare services between hills and valley regions of Manipur state, India. *Clinical Epidemiology and Global Health, 11*.
19. Pinkovskiy, M., & Sala-i-Martin, X. (2016). LIGHTS, CAMERA . . . INCOME! ILLUMINATING THE NATIONAL ACCOUNTS-HOUSEHOLD SURVEYS DEBATE. *The Quarterly Journal of Economics, 131*(2), 579-632. Retrieved from https://www.jstor.org/stable/26372649
20. Reserve Bank of India. (2024). *Handbook of statistics on Indian states.* Reserve Bank of India. Retrieved from https://rbi.org.in/
21. Small, C., Pozzi, F., & Elvidge, C. (2005). Spatial analysis of global urban extent from DMSP-OLS night lights. *Remote Sensing of Environment, 96*(3-4), 277-291. Retrieved from https://doi.org/10.1016/j.rse.2005.02.002

22. Solanki, V. (2026). The anthropogenic destruction of wetlands: exploring the need for a legal framework against “Wetcide”. *Environmental Reviews, 34*, 1-10. doi:dx.doi.org/10.1139/er-2025-0111
23. Solanki, V., & Joshi, A. (2017). Disappearing Wetland: A Study of Basai Wetlands, Haryana (India). *International Journal of Economic Research*, 681-691.
24. Survey of India. (n.d.). *Administrative Boundary Data Base*. Retrieved Feb 2026, from Survey of India: https://surveyofindia.gov.in/
25. Sutton, P. C., Elvidge, C. D., & Ghosh, T. (2007). Estimation of Gross Domestic Product at Sub-National Scales using Nighttime Satellite Imagery. *International Journal of Ecological Economics and Statistics, 8*, 5-21. Retrieved from https://api.semanticscholar.org/CorpusID:15222774

Figures

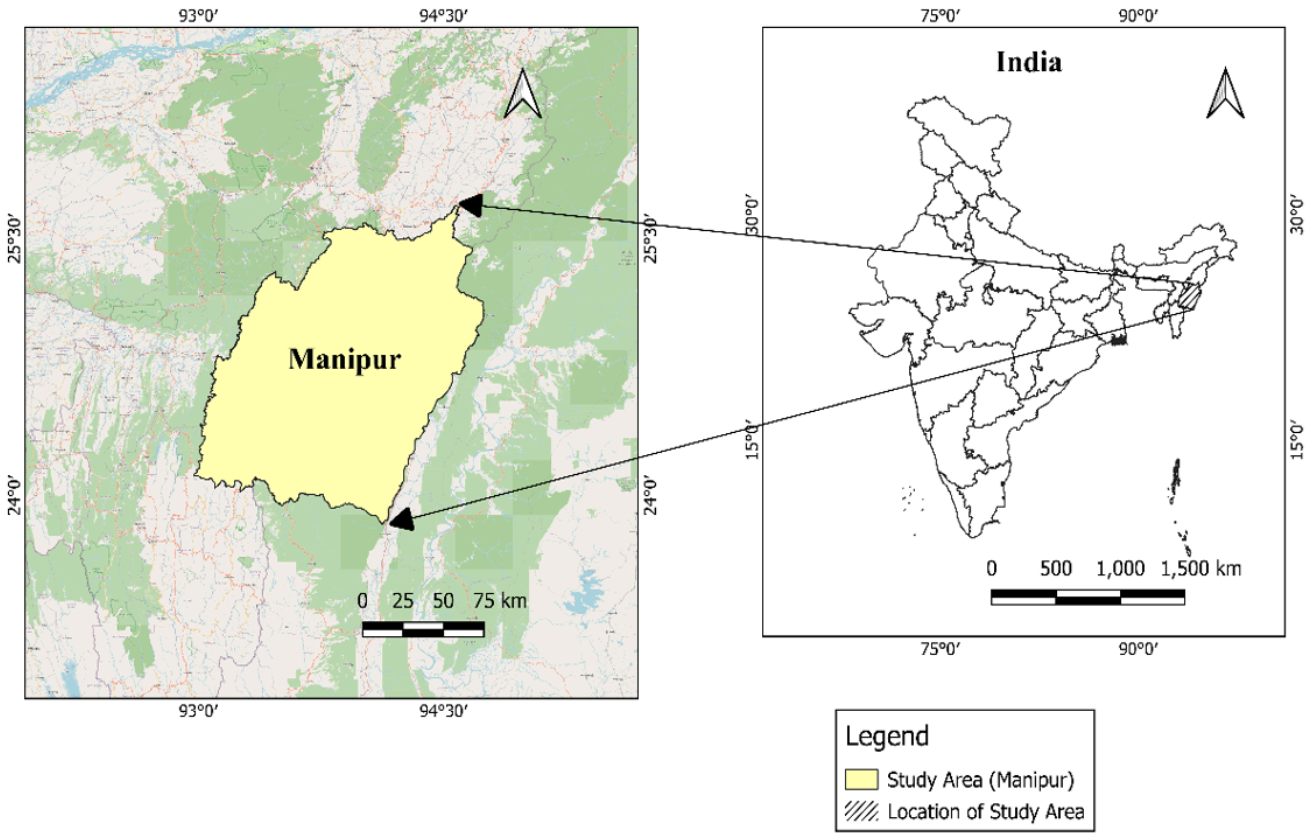


Figure 1

Location of the Study Area, Manipur

Source: Survey of India, digitized in QGIS 3.44.7

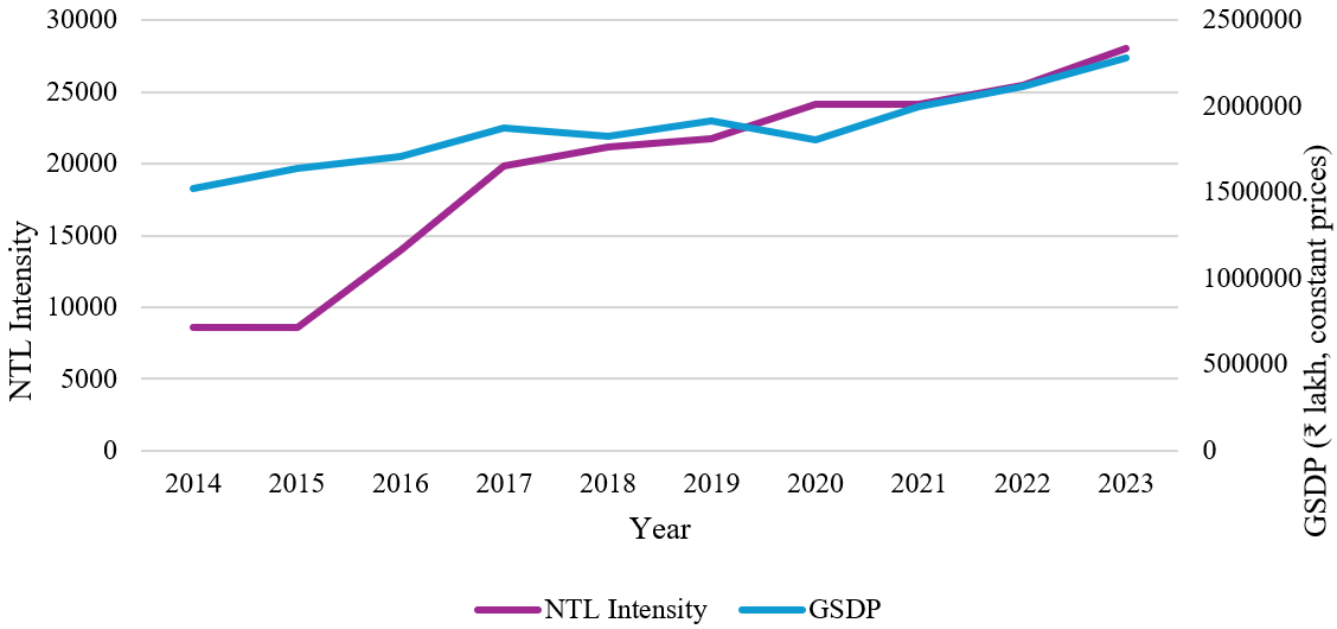


Figure 2

Time-Series Graph of NTL Intensity and GSDP (2014–2023)

Source: Calculated by Author

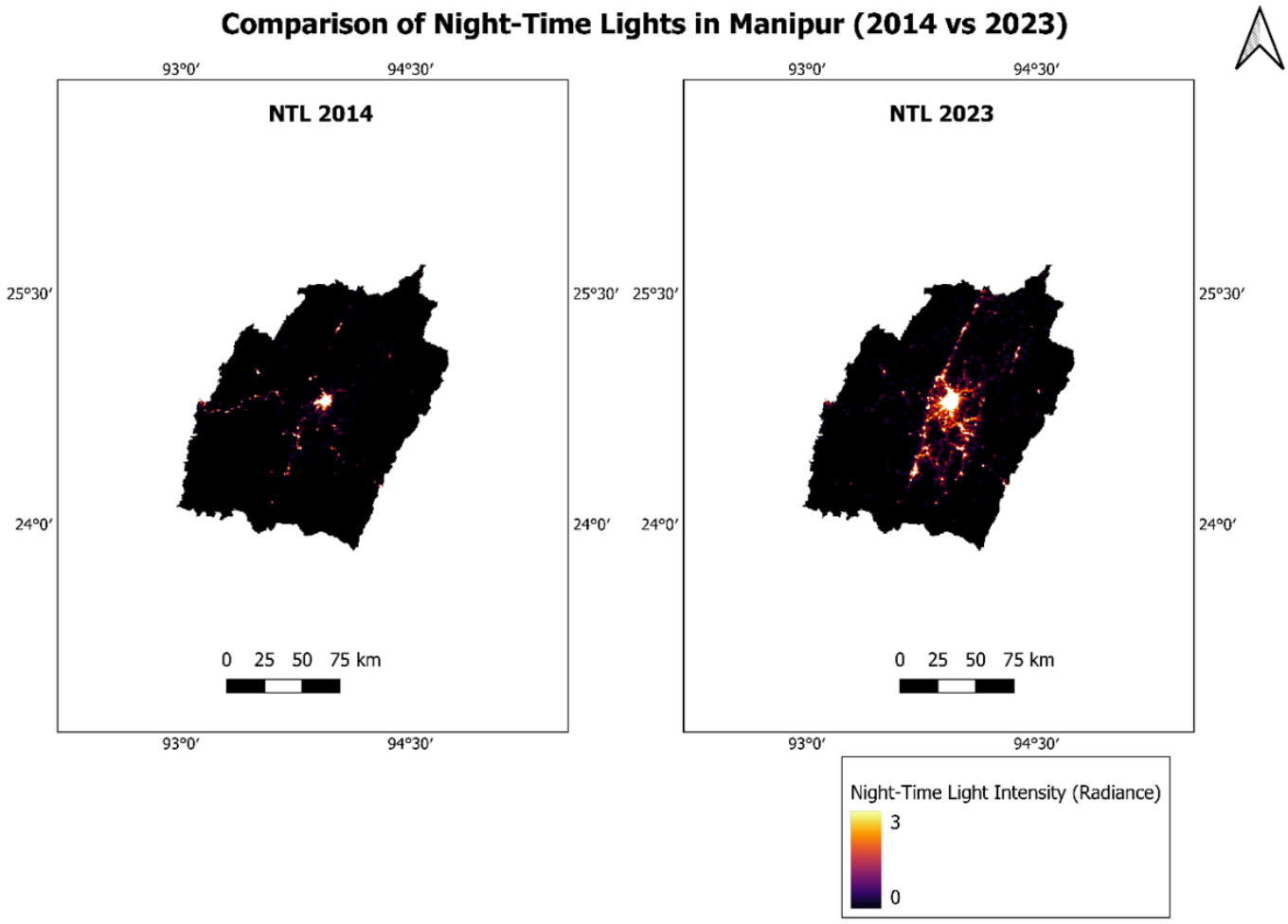


Figure 3

Spatial Distribution of NTL

Source: VIIRS Night-Time Light Data (Earth Observation Group), digitized in QGIS 3.44.7

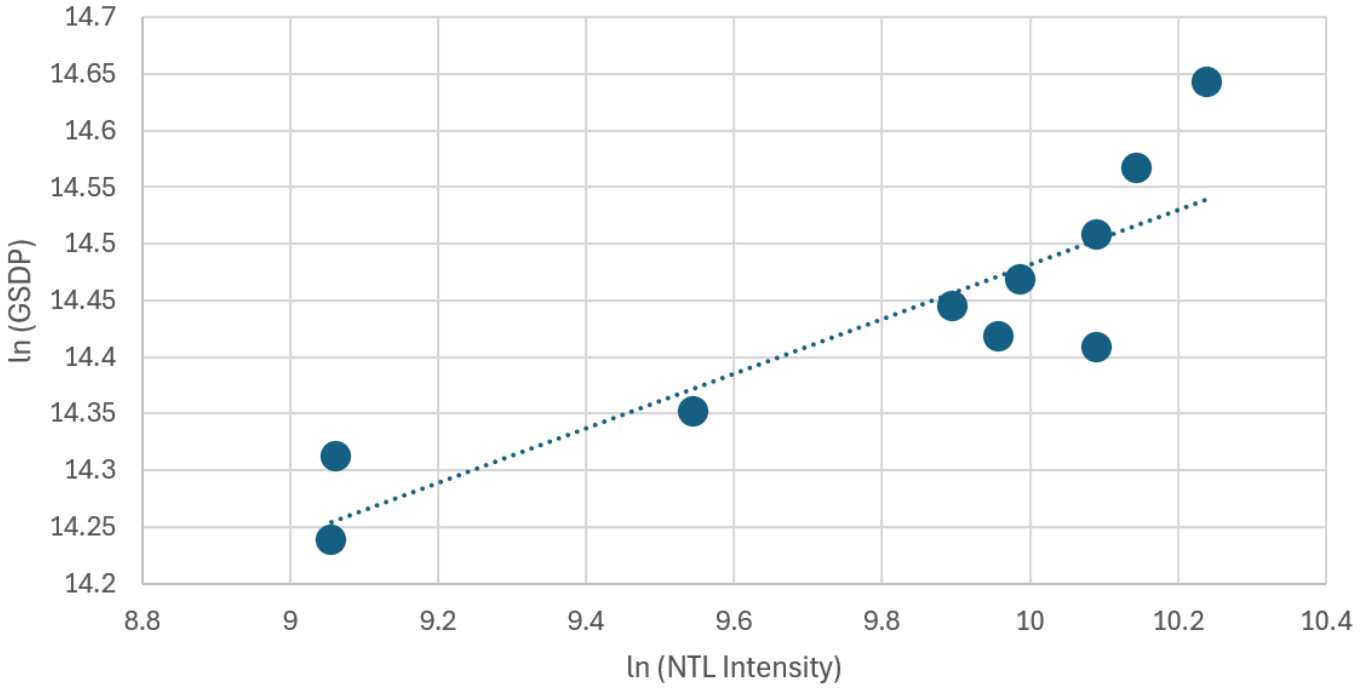


Figure 4

Scatter Graph of ln(NTL) and ln(GSDP)

Source: Calculated by Author