LUMS | Chaudhry Nazar Muhammad Department of Economics

USING NIGHTLIGHTS DATA TO INFORM URBAN DEVELOPMENT

Measuring Economic Activity using Nightlights: GDP of Khyber Pukhtunkhwa's Districts

Policy Brief: June 2024

Using Night Lights data (NTL) provides several avenues for economic analysis and policy formulation. The spatial information embedded in the nightlights data gives it the unique advantage of providing granularity to the level of 1 sq. km. The research study quantifies economic output of KP districts and finds useful insights on how KP's cities are growing. Major findings include identification of pockets of rapid growth, the extent and pace of urban sprawl, low levels of urbanization overall, and the slow rise of secondary cities. These insights can be utilized by the Government of KP to plan effective, well-targeted public investments that support growth and address regional disparities. Furthermore, the research highlights the long-term benefits of capacity building in utilizing nightlights data in the economic landscape at provincial and district level.

Authors

Syed M. Hasan, Robert C. M. Beyer, Khawaja Hassan

In Collaboration with Sustainable Energy and Economic Development (SEEDS) & Government of KPK

Introduction

Recent technological advancements in satellite imagery and improvement in computational skills have unleashed new avenues of research for incorporating spatial analysis in analyzing economic activity. The element of geographical space has been missing in greater part of mainstream research in economics for most of the last century.

- In general, sampling and data collection in developing countries is often undertaken at the second tier of administrative hierarchy i.e. at provincial level; thus limiting the depth of information and insights about economic activity at a more spatially disaggregated level e.g districts.

- On the other hand, the rapid pace of urbanization in South Asian countries, especially Pakistan, and the growth of cities has the potential to promote future growth. This is because the structure of an urban center tackles the constraints present in achieving high productivity. The spatial distribution and growth of urban clusters over time, thus, are good indicators of how successfully a nation is in achieving high economic growth. However, cautioned by Ellis & Roberts (2015) as they have characterized the current state of South Asian urbanization as "messy" and "hidden", the analysis of cities' economy is critical and needs to be undertaken with great care. Unfortunately, this can not be addressed by national level statistics.

- Moreover, the contribution of various economic agents to final economic aggregate varies by virtue of:
  - Spatial heterogeneity in location choice
  - Existence of place-specific natural advantages (or disadvantages)

Hence, consistent data on economic activity for smaller geographical units is useful in:

- Understanding growth at sub-national levels
- Reliable impact assessment of policies in place
- Robust design of future growth strategies

Nighttime lights data add to our understanding of regional economic development especially in the case of developing countries, which typically lack availability of reliable data. The economic literature has several examples where the researchers have resorted to the use of various proxies generated from satellite imagery. The seminal work by Henderson et al. (2012) estimated the elasticity between GDP growth and growth of lights using data of 180 countries to be 0.3, concluding that nighttime lights are best utilized when augmenting official statistics especially in low and medium developed countries.

Districts are especially important in the administrative hierarchy as they form:
- 3rd tier of administrative structure below provinces and divisions
- Top tier of local government, followed by tehsils and unions

GDP of Khyber Pakthunkhwa Districts:
Measuring Economic Activity Using Nightlights

This comprehensive research is the first study[1] in Pakistan to use this novel approach of nightlights to estimate district and city-level economic activity. It serves as a practical complement to official data as it allows for live feedback on the state of the economy at levels of disaggregation as fine as 1 km, in addition to being readily available, easy to use and inexpensive.

Following objectives are accomplished using datasets mentioned in Table 1 and applying rigorous econometric and spatial analyses.

1. Estimate the sub-national economic development and benchmark provincial economic activity by measuring economic output of KP province and its districts using NTL data as captured by the satellite images of the earth.

2. Quantify regional disparities by analyzing information about KP's economy at provincial and district level, study economic growth rates and districts' contribution to GDP of KP, by combining NTL data with spatial distribution of population.

3. Identify the growth of urban centers and city cores/urban markets by deploying inter-temporal analysis of NTL distribution at various thresholds.

4. Determine inter-city and intra-city growth patterns across more urbanized districts of KP by utilizing land use/land cover maps along with NTL.

The methodology involves using the province-level share of Sum of Lights to estimate the manufacturing and services share, and provincial rural population share to estimate the agricultural contribution of province in the national GDP. Furthermore, to understand growth of urban centres, each city is spatially divided into five different sub-regions involving: low, medium-low, medium, medium-high, and high night-time lighting areas and then analyzed. The high NTL area corresponds to the city core whereas the low NTL is the rural area of the district.

1. Conducted in collaboration with Sustainable Energy and Economic Development (SEEDS) program in Khyper Pakhtunkhwa in 2021. Later, in 2022, government of AJ&K also conducted a similar exercise.

DATASETS	AREA COVERAGE	TIME COVERAGE
Population Census	National, Provincial, District	1998, 2017
Labor Force Survey	Provincial	2003-04 to 2017-18
Agriculture-Census	National	2010
Crop Survey	Provincial, District	Multiple Years
National Accounts	National	1992 to 2020
Regional Accounts	Provincial	1992 to 2005 2018 - 2020
LandScan (GIS)	100-meter grid	2000 to 2019
MODIS (GIS)	National, Provincial, District	2002 to 2020
Census Population Grid (GIS)	National, Provincial, District	1998
World Development Indicators	National	Multiple Years
CIESIN Gridded Population	Spatial-1 km	Multiple Years
Nightlights Datasets 1. Defense Meteorological Satellite Program (DMSP/OLS)	Global	1992-2013
2. Visible Infrared Imaging Radiometer Suite (VIIRS)	Global	2013 – 2020

Table 1 Datasets Used in Research Study

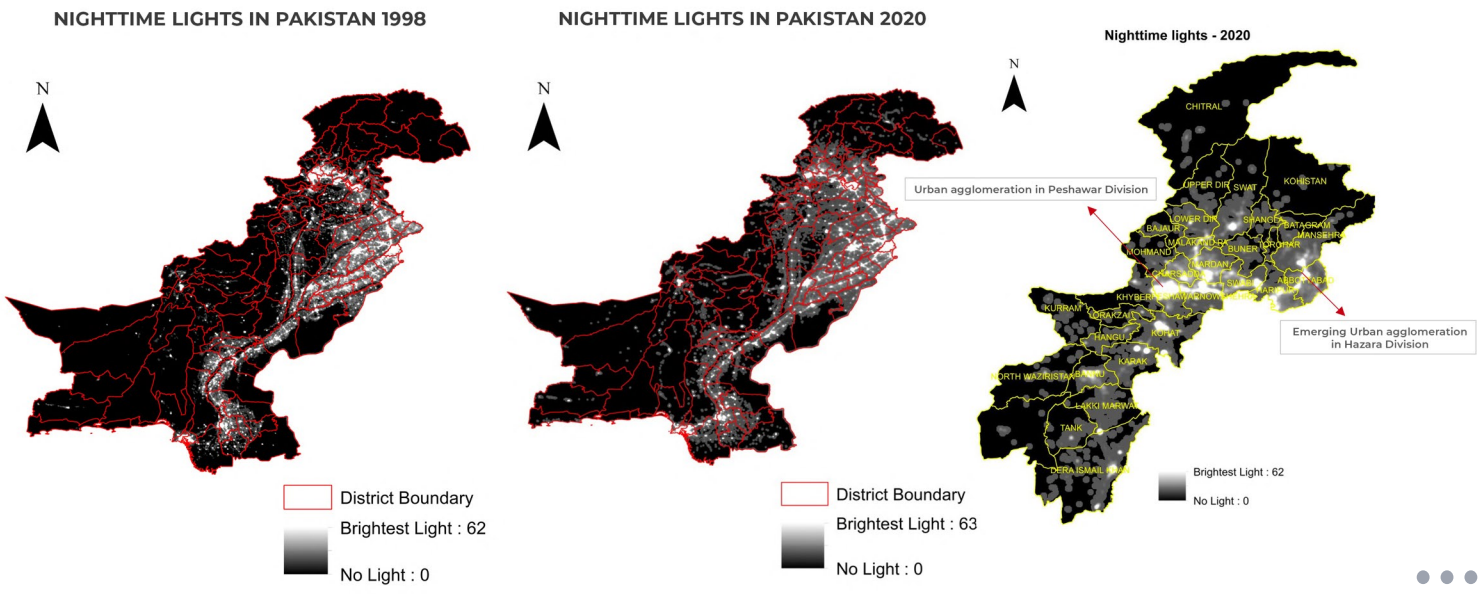

Figure 1: Pakistan Map with NTL and District Boundary (1998 and 2020)

Following key district level findings form the basis of policy recommendations:

1. The presence and annual variation in the scale of informal economy is indicated by the the difference[2] between the actual and estimated GDP.

2. Even though the overall economy of Peshawar district is the largest in the KP province, Haripur district has the highest per-capita income followed by Nowshera and Abbottabad. In terms of per-capita GDP, the lowest figure is for Kohistan district preceded by Torgarh district[3].

3. Figure 2 shows results from the analysis based on city division into sub-regions. These numbers signify the urban growth pattern indicating the densification in the case of Peshawar (maximum percentage growth is in 'High' areas) and urban sprawl in the case of Mardan (maximum percentag growth in Medium-low areas).

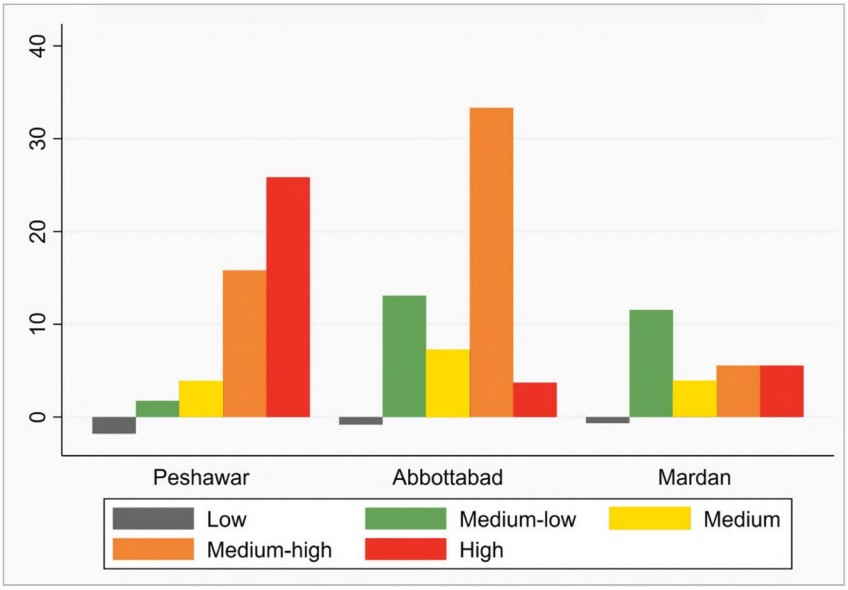

Figure 2: Annual Percentage Change for Peshawar, Abbotabad and Mardan

4. Overall, NTL data shows a common trend demonstrating urban sprawl as observed from population growth in large cities of KP such as Peshawar, Mardan, Nowshera, and Abbottabad. Apart from Peshawar, there is dimming of nightlights at the core of the city and more growth on the periphery which highlights the concerns related to horizontal urban growth.

5. The data further shows that both tehsils of Abbottabad district – Abbottabad and Havelian as well as locations in the Galiyat region are experiencing new low density urban development which is often considered an inefficient use of land.

6. GDP of FATA region was also quantified. It was found that districts belonging to the FATA region except Mohmand and North Waziristan have nearly null share in the manufacturing and services sector as assessed by the NTL, indicating that most economic activity in the region relates to the farming sector. Using the NTL share and the rural population share, our calculations show that the region has a GDP that is around 1.03% of the national GDP.

2. Though differences in methodology can also be a contributing factor.
3. These findings were further validated from Multidimensional Poverty Index (UNDP) and GPI (Gender Parity Index) from Development Statistics.

POLICY RECOMMENDATIONS

The utilization of satellite imagery, in particular nightlights, is a relatively new concept and is still evolving as researchers find novel ways to use it to understand development. Following policy recommendations arise out of the in-depth analysis conducted in this research study:

1 **Economic Indicators**

Estimation of sub-national GDP to the level of a district or a tehsil yields an economic indicator that can be extensively used for policy planning and evaluation. Nightlights have uses in the following areas:

1. Obtain reliable estimates of poverty
2. Create wealth and other development indices
3. Validate district per capita income values obtained from Labor Force Surveys
4. Calculate regional inequality measure
5. Understand urban crime patterns, etc.

2 **Informal Economy**

These differences between GDP calculations using nightlights and official numbers underscore the need to focus more on capturing the informal economic activity in the official estimates.

3 **Addressing Regional Disparities**

The understanding of inter-district disparities in the scale of economic activity can assist in adopting place-based interventions to uplift lagging districts. Identifying the regions with sub-optimal urban development and inefficient resource allocation helps in devising policies to uplift these districts and realize their growth potential.

4 **Tax Collection**

Linking district level economic activity from industry and service sectors with tax collection figures can help in determining potential revenue generation.

5 **Program Assessment**

Nightlights data can be used in assisting program assessment of development related experiments in the domain of health, governance, local finances, etc. by providing statistics bifurcated along the lines of various smaller administrative and geographical unit.

6 **Urban Planning**

Identification of pattern, pace and direction of urban growth (e.g. horizontal versus vertical), pace has implications for infrastructure planning and efficient provision of urban amenities (roads, transportation, utilities, crime control, waste disposal, mitigation of environmental degradation). This in turn will ease the bottlenecks that prevent cities from becoming efficient and environmentally sustainable contributors to the provincial economy.

7 **Road Infrastructure Planning**

The research findings have specific usage in road infrastructure planning to improve the connectivity of existing economic clusters (for example to connect vibrant economic clusters and industrial parks).

8 **Addressing Stagnating Urbanization**

Insights into stagnating levels of urbanization in KP overall point to underutilized growth potential of cities. This has direct implications for urban planning, especially in planning secondary cities and in addressing pockets of stagnation to ensure that development is inclusive and that all areas of KP are able to become a part of KP's growth story.

9 **Real-Time Impact Assessment**

In situations where economic impact assessment is required in near real-time and at high spatial granularity, nightlight data can be used. Comparison of changes in light intensity before and after lockdowns indicates the impact on local economic activity and hence provides useful information for policymakers. This approach could be useful not just to measure COVID impacts but also to assess the impact of natural disasters or other policy measures, in a sense allowing the policymaker a way to continually monitor the pulse of economic activity in a specific region.

> The study of economic activity at a granular level is important because much of the success of public policy instruments depends on economic conditions immediately surrounding the targeted group of people.

In addition to these immediate insights, once the capacity to understand and leverage nightlights data is developed in KP, it opens the doors to a reliable, live, and inexpensive source of information on future topics where official data is usually silent. Given the range of applications in the policy regime, it is an opportune time for KP (and other provinces) to develop the expertise to analyze and utilize this rich source of information to help achieve their development targets.

However, it is also critical to be mindful of certain limitations of NTL data usage. The nightlight data is best suited to providing a broad overview of spatial patterns of urban growth and expansion within a country. Owing to various measurement errors associated with the NTL data, it should not be taken as providing precise quantitative results for any one given urban area. Moreover, data based on satellite imagery such as NTL is not appropriate to estimate the agriculture sector's contribution to the economy or for regions with low output density, hence the need to use other data sources.

LUMS ECONOMIC POLICY OUTLOOK SERIES

A Publication prepared by
Rabia Saeed (Research Fellow)
Urwa Fatima (Research Assistant)

For information or collaboration,
please reach out at **rabia.saeed@lums.edu.pk**

The source publication can be accessed **here**.

Beyer, Robert & Hassan, Khawaja & Hasan, Syed. (2021). GDP Of Khyber Pukhtunkhwa's Districts - Measuring Economic Activity Using Nightlights.