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OBSERVING ECONOMICS THROUGH GEOGRAPHY: COVID-19 AND NIGHT-LIGHT DATA ANALYSIS OF BANGLADESH AND SRI LANKA (2017-2021)

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ABSTRACT

Human activities produce imprints in space and time. In this regard, Night-light data is observed to be reflective of the geographical behaviour of economic activities and many other economic parameters as well. Further, Night-light data measured through radiance through satellites has been gaining immense consideration as a representative of multiple economic analysis. Of the data types available in this regard, Visible Infrared Imaging Radiometer Suite (VIIRS) data has been observed to be less erroneous, cutting edge and spatially more precise than any other data base. The current study is an indirect investigation of economic activities in the developing nations of Bangladesh and Sri Lanka in South Asia over the last five years, out of which two have been reeling under the effects of the life altering COVID-19 pandemic through observations of NOAA-VIIRS satellite data. Results depict a specific pattern of radiance in Bangladesh and a highly fluctuating trend of radiance for Sri Lanka spatially and temporally, indicating a specific and non-specific trend in economic activities respectively.

KEYWORDS: *Bangladesh, Economic, Night-light, NOAA-VIIRS, Spatial, Sri Lanka*

INTRODUCTION

Economic activities operate in space through various processes (Mackinnon & Cumbers, 2014) **[1]** and economic geography indicates how economic activities produce patterns (Saxena, 2013) **[2].** Economic investigation in this regard is a study of regions comprising the economic space and these regions are dissimilar in nature (Combes, Mayer, & Thisse, 2008) **[3].** This also tends to create centres of economic activity in a region in a geographical space (Combes, Mayer, & Thisse, 2008) **[3].** This pattern as observed across, is an outcome of a number of factors and turns spaces into places in which a geographical analysis provides a very strong method of examination (Coe, Kelly, & Yeung, 2020) **[4].**

Of recent, the anisotropic nature of Night-lights (Li, et al., 2019) **[5]** is considered as a representative of economic activities and the method of studying human activities through these has gained an equal and an even more significance than conventional economic assessments (Gibson, Olivia, & Gibson, 2020) **[6].** This data is important further as light can be considered as an indicator of distribution and linkage between different forms of development (Small & Elvidge, 2013) **[7].**

Night-light data has gained a popularity to the extent that it is even taken as an indicator of economic development even in countries where economic data is not properly maintained (Bhandari & Roychowdhury, 2011 **[8]** and Huang, 2019 **[9]**). Extensively utilised in various sub branches of geographical study, this data is forwarded to be supplementary to traditional day time remote sensing besides providing a remarkable information on Night time activities and also light pollution. This is more applicable for urban areas of a region (Li, Elvidge, Zhou, & Changyong , 2017) **[10]** as more lights indicate more urban build up and activities in the area (Cheon & Kim, 2020) **[11].**

Radiance is considered as a better indicator of Night-lights as it provides a more detailed information even at a micro level (Cao & Bai, 2014) **[12].** Stability of Night-lights and the consequent radiance generated forms the basis of this analysis. However, urban and non-urban activities both generate this data (Mellander, Lobo, Stolarick, & Matheson, 2015) **[13]** and there is observed to be an enhanced correlation between radiance generated night time data than the one with stable lights. Reflections on nocturnal data indicates the level of human development also (Elvidge, Baugh, Anderson, Sutton, & Ghosh, 2012) **[14].** However, there also exist some concerns in accepting this data for scrutiny of existing inequalities in space and economy (Sindin, Chen, & Prischepov, 2021) **[15].**

In all these regards, the current analysis becomes relevant and significant in observing the economics of two developing nations of South Asia (Siddique, Salvanathan, & Salvanthan, 2012) **[16]**. The nations of Bangladesh and Sri Lanka are developing economies of South Asia and are dominated by agricultural activities in terms of land use (Puri, 2022;Tinker & Husain, 2022) **[17].** The current study utilises the VIIRS data for these two nations on the basis of a five year period from 2017-2021. This is initiated on an yearly basis for each year from 2017 to 2021. It then observes the average trend of Night-light data for the two nations for the whole period of study. The examination is also extended to the study of yearly trend with respect to each year for the time period.

A combination of such analysis provides a descriptive of pattern and operation of activities in these economies at the macro level. The study also holds significance as it covers the pre COVID-19, COVID-19 pandemic year of 2020 and post COVID-19 time period to check the changes in Night-light data after the pandemic. The attempt is to see whether the COVID-19 year of 2020 observed any significant change in light data and activities as exhibited in spatial concentration of light data. A comparison pre-2020 and post-2020 will be very helpful in discussing these trends and also in discovering the changes as a proxy to COVID-19 impacts economically and spatially.

Study Area

The study area comprises of the countries of South Asian countries of Bangladesh and Sri Lanka as show in Figure 1. They are chosen for analysis with regards to specific features of their location and economic concerns. While Bangladesh has constantly been applauded for its economic growth even after COVID- 19 pandemic (Sharma, 2020; Bank A. D., 2021; and Bank T. W., 2021 **[18,19,20]**), Sri Lanka has been badly affected by the pandemic (Moramudali, 2022) and is facing one of its 'worst' economic concerns (Moramudali, 2022) **[21].** Bangladesh is located in the deltaic region of river Ganga and Yamuna bordered by India on three sides and Myanmar in the east (Tinker & Husain, 2022) **[22].**

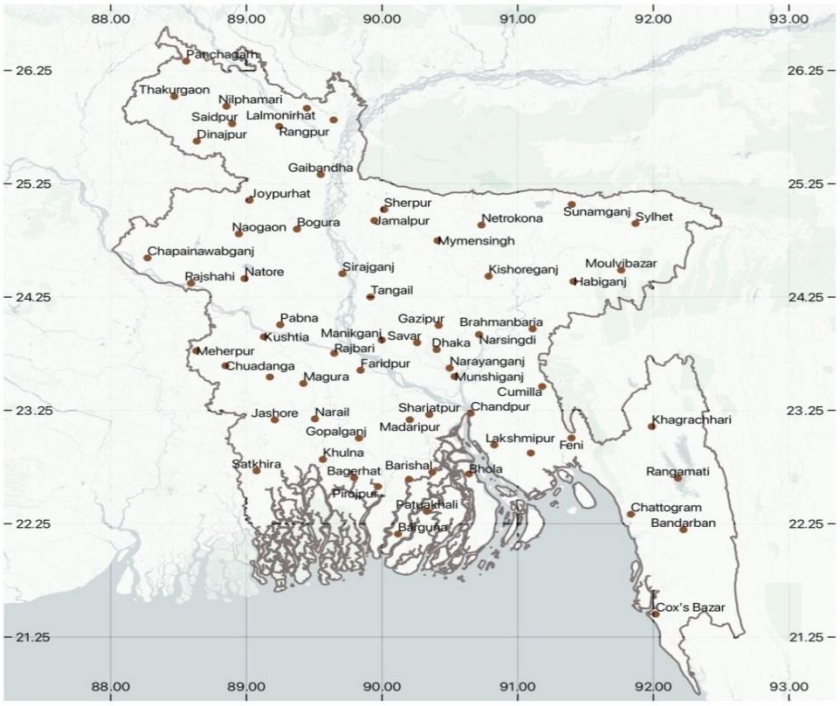
It is one of the most densely populated countries of the world (Tinker & Husain, 2022) **[22]** with about 1265 persons per sq. km. inhabitation (Worldometer, 2022) **[23]**. Its population in March 2022 is 167,546,220 (Worldometer, 2022) [**23**]. Although its Gross Domestic Product (GDP) has been fluctuating but post COVID-19, there has been an improvement in its economy (IANS, 2022) **[24].** Its current GDP is expected to grow at 6.8% in 2022 as compared to 5.5% in 2021. Pre COVID-19, it was 8.9% in 2019 (Bank A. D., 2021) **[19].**

In 2002, its GDP growth was slided at -7% while in 2019 it was the seventh fastest growing economy in the world (Sharma, 2020) **[18].** Bangladesh's growth even during COVID-19 crisis has been recognised in Bloomberg's COVID-19 resilience ranking and its economy has been observed to grow by 271 times in the last 50 years and many specific initiatives have been attributed to this (Sharma, 2020) **[18].** Its export of ready-made garments, export diversification and stability in economy are attributed to this growth (Bank, 2021) **[19].** A strong growth has been observed in its economy in the last five years from 2017 to 2022 (Foundation, 2022) **[25].**

Sri Lanka has a population of 21,567,655 persons in March 2022 (Worldometer, 2022) **[23].** Located in the Indian Ocean, it has a population of around 22 million as of March 2022 (Worldometer, 2022) **[23]** and a population density of around 348 persons per sq. km.(Sri Lanka, 2020). Its GDP growth has been fluctuating from 5.0% in 2015, 3.6% in 2017, 2.3% in 2019 (Sri Lanka, 2020) **[26]** and -3.6% in 2020 (Bank T. W., 2022) **[27].** The COVID-19 pandemic has put a dent in its economy with economic problems reaching at an unprecedented height in the form of debts, inflation and unemployment (Bank T. W., 2021) **[19].**

In the background of all these contemporary concerns, the examination of Night-light data can provide a supplementary and complementary overview of the economic activities and their relative fluctuations in these economies at the geographical scale. It can help in identifying as to which regions have experienced more of these changes in the respective countries and to what extent.

Figure 1. Location of Bangladesh with Major Cities



Source- Authors, 2022

Figure 2. Location of Sri Lanka with Major Cities

Source- Authors, 2022

With this background, the exploration of Night-light data is done for both the countries from the NOAA-VIIRS database.

Database and Methodology

The database for the study is VIIRS Stray Light Corrected Nighttime Day/Night band Composites Version 1to gather spatial data for the parameter of average radiation. Night time light data currently is generated by two data sources- Operational Line Scan (OLS) system on board Defense Meteorology Satellite Program (DMSP) and VIIRS on board the SUOMI- NPP (SNPP) and NOAA-20 satellites in the Joint Polar Satellite System (JPSS) (Nechaev, et al., 2021) **[28].** This database provides average Day Night Band (DNB) radiance values measured in nanoWatts/sq.cm/sr ranging from a minimum of -1 and a maximum value of 193564.92 nanoWatts/sq.cm/sr with a resolution of 468.83 meters. It is provided by the Earth Observation Group, Payne Institute for Public Policy, Colorado School of Mines. The group is highlighted as a leader in providing highest quality data till date in the field of Night-light data.

The approach of generating this data is defined as a new one with the derivation done from monthly cloud free mean radiance generated monthly and annually by excluding the impact of stray light, lightning, lunar gleam, and cloud cover. Version I database covers 75N to 65S latitudes (Mines, 2022) **[29].** The impact of radiance outliers is removed. The data is in processed form with the removal of cursory lights and non-lights from the images. Data extraction is from Google Earth Engine Code Editor and processed in QGIS 3.16 software. The image CRS is EPSG:4326. The methodology involves the following steps:

a. Extraction- The extraction of annual average radiance imageries for Bangladesh and Sri Lanka from 2017-2021 respectively for each year has been the first step for examination. This is followed by analysing the difference in average radiance between 2017 and 2021. The data source is VIIRS Stray Light Corrected Nighttime Day/Night Band composites Version I extracted from the Google Earth Engine Code Editor(Engine , 2022) **[30]** which is processed in QGIS 3.16 software.

b. Analysis- It involves observing the spatial and temporal extent and variation of trends in average radiance for both the countries from 2017-21. The attempt is diversified to observe the yearly variations in average radiance and analyse them particularly in the context of COVID-19 pre 2020 and post 2020.

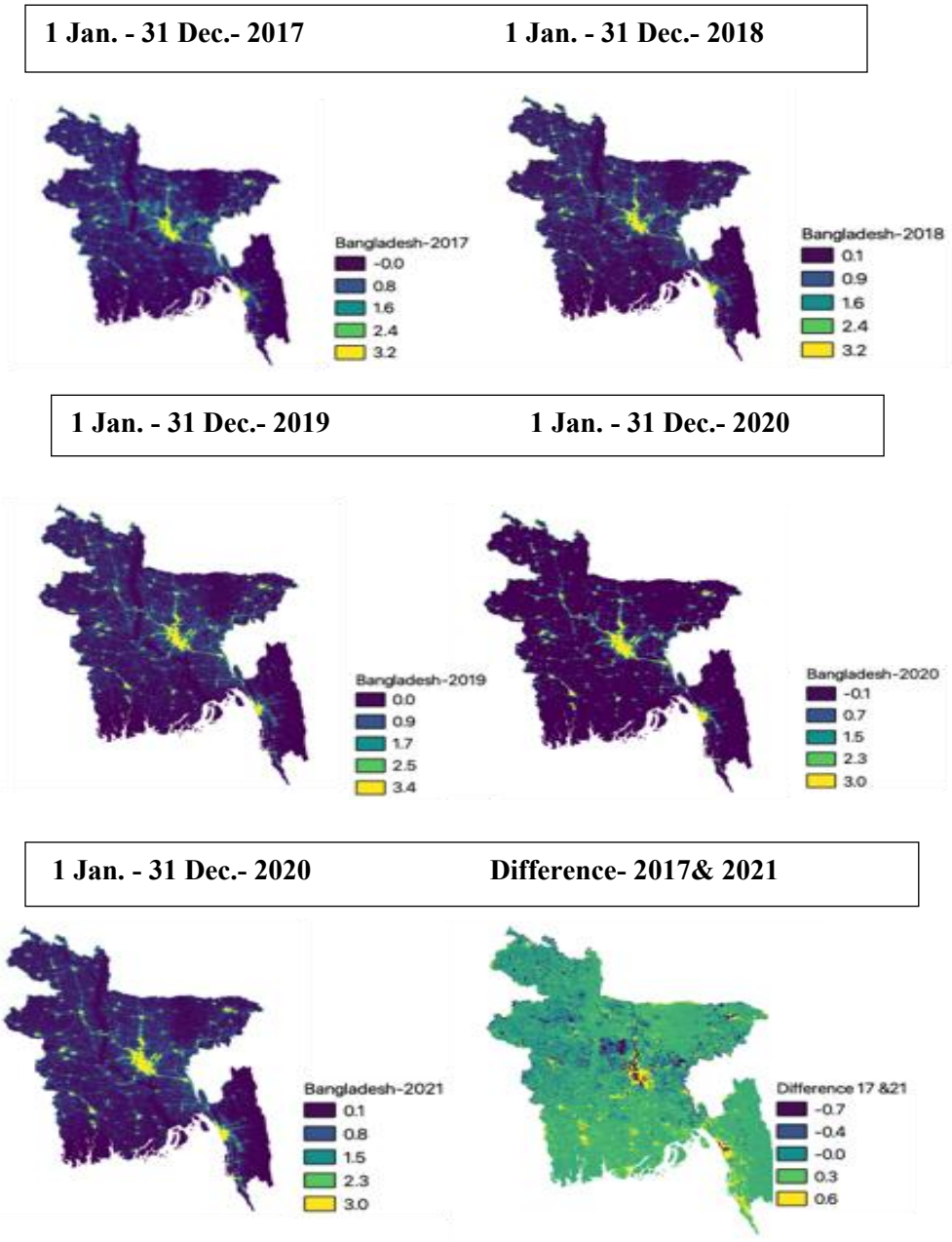
RESULTS AND DISCUSSIONS

Following observations were recorded:

Spatial Trend-Figure 3. highlights the observations in Bangladesh. The years 2017 and 2018 saw stability in average radiance trends indicating a probable stability in economic activities. In 2019, there was a slight increase in average radiance. In 2020, which was the pandemic year, there was an overall decrease in the spatial trend of average radiance in the country. It went to negative value of the minimum of -0.1.This is indicating a decrease. In 2021, there was a slight improvement in the rate of average radiance in certain geographic locations. Overall, the capital city of Dhaka with surrounding urban centers in the central part of the country, exhibit the maximum values of average radiance indicating its significance as the focus of economic activities. Chattogram port in the far east is the second major center where maximum radiance

values are observed for the country. The regions with minimum radiance are geographically distinct such as the mangrove areas in the south, forested areas in the east sharing border with Myanmar and the agricultural land spread throughout in the country (Puri, 2022) **[17].** The year 2020 indicates a marked decline in radiance geographically for the country with maximum regions coming under least average radiance category, except Dhaka.

Figure 3. Bangladesh- Night Light Data (2017-2021)

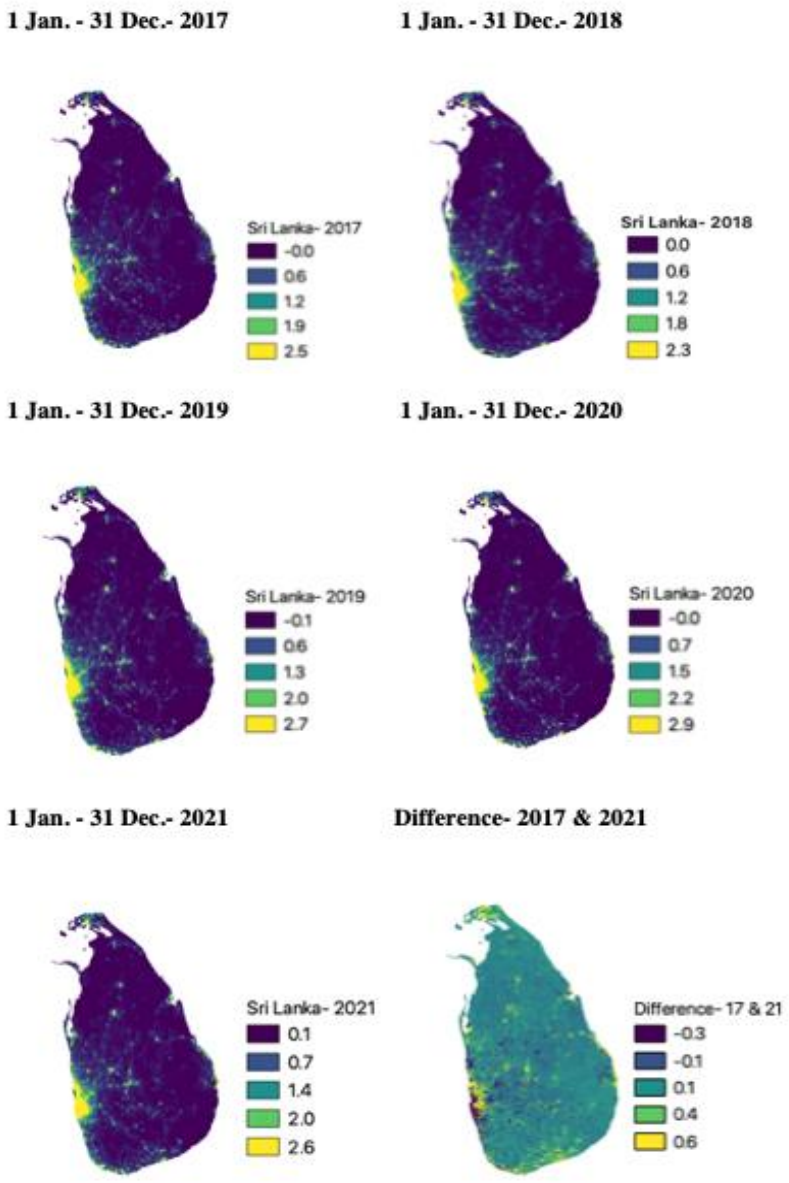


Unit of data- Average radiance (nanoWatts/sq.cm/sr)

Source- Derived by Authors from Google Earth Engine Code Editor, 2022

The year 2021 exhibits a marked recovery as is observed in the spatial distribution of radiance in the country. Overall, the 2017 and 2021 difference indicated an overall increase in average radiance in the country. This can be taken as a probable indicator of economy's robustness as is indicated by data as well. The city of Dhaka and locations in the south and eastern part of the country exhibit the highest positive increase in average radiance. Negative and declining trend in the data was observed in scattered form particularly in the northern part of the country.

Figure 4. Sri Lanka-Night- Light Data (2017-2021)



Unit of data-Average radiance(nanoWatts/sq.cm/sr)

Source- Derived by Authors from Google Earth Engine Code Editor, 2022

As can be observed from Figure 4., for Sri Lanka, there is a distinct and clear dominance of the capital, port city and the urban center of Colombo located on the western coast with regards to radiance values and consequent economic activites. It exhibits the maximum values of average radiance throughout the time period of the study. Outside Colombo, there is a radial pattern of decreasing average radiance but the linkage with the city is clearly strong and visible with cities surrounding Colombo being highlighted as other focal points of economic activity.

This is a probable indicator of the extreme dominance of the capital city in the economy of the country. Jaffna peninsula in the north is another region of significant radiance throughout the time period of the study. It also specifically recorded an increased radiance from 2017 to 2021. This can be due to its strategic defence location as well as economic activities.

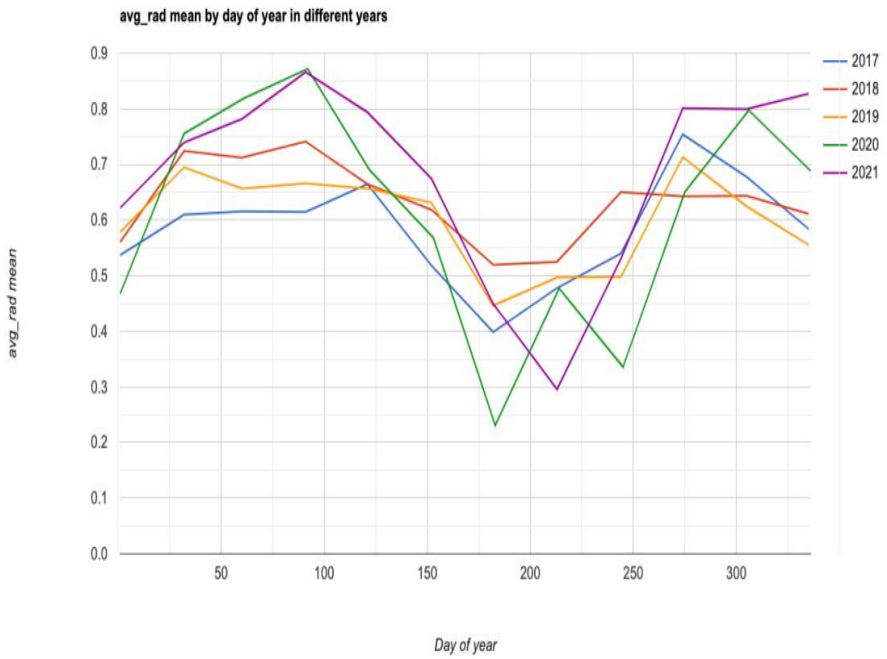
On the whole, average radiance has shown a fluctuating trend for the country. Strangely, in 2020, there was an increase in average radiance which was the maximum for the selected time period. The year 2019 showed the maximum decline in the trend and it was at the minimum value of -0.1 for many parts of the country. It further declined significantly for few geographic regionsin 2020. The year 2021, however, does not indicate a recovery as the minimum values of average radiance were lesser compared to 2020. This corroborates with the economic decline being faced by the country.

However, it is also important to note that on a composite of difference from 2017 and 2021, maximum decline was observed along the city of Colombo followed by the regions immediately next to it which were earlier exhibiting next highest average radiance. Further, majority of the country experienced a negative trend in average radiance for the time period, which is a strong indicator of a decline in economic activities. On the whole, the country exhibited a fall in average radiance which is a sturdy barometer of a fall in economic activities in many forms. This trend along the capital city does not provide robust indication for economic upliftment of the troubled region.

Temporal trend-The analysis is carried further to check the temporal trend of the spatially observed values. The temporal trend of Night-light data for both the countries is depicted in Figures 5. and 6. respectively. The stability of data for Bangladesh is visible for the majority of the time period of study. There is a slight period of decline in data for about three months for the country which is a probable sign of a cyclical economic activity. Two peaks are observed in the data set in the first quarter and last quarter of the years.

This is highly significant in correlating the spatial data and provides strength to the analysis. Bangladesh clearly exhibits a well-established pattern of average radiance for all years of the study. Temporally, as can be observed from Figure 5., that for about the first 150 days of an year, there is a constancy in the average radiance values. Towards the end of the year in the time period of study, activities again pick up and the trend in radiance is upward. To add to this, the year on year growth is observable in the country. In fact, COVID and post COVID years have depicted the highest average radiance.

Figure 5. Bangladesh- Yearly Trend of Night Light Data (2017-2021)

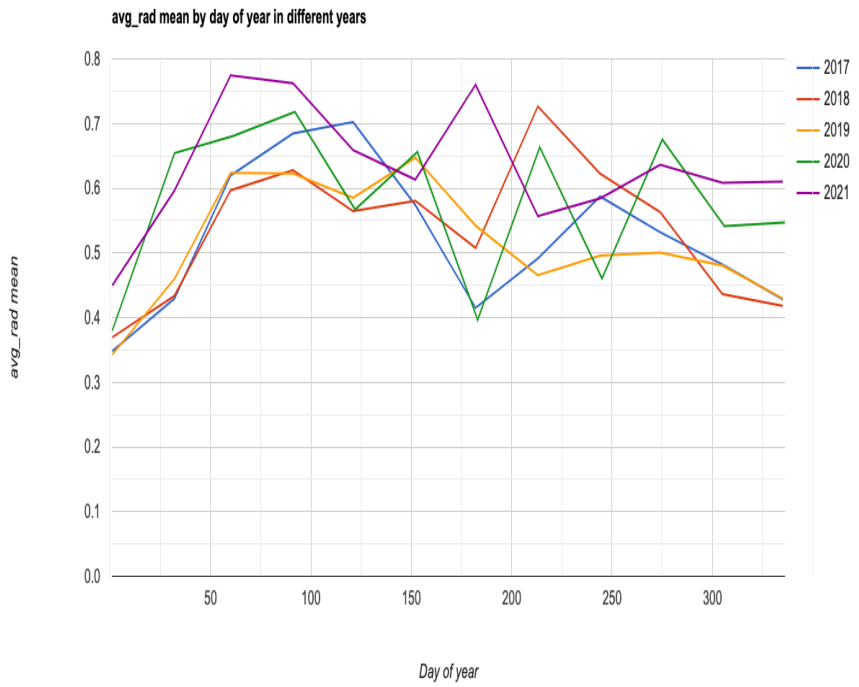


Source- Derived by Authors from Google Earth Engine Code Editor, 2022

The years of 2020 and 2021, both have been the ones with maximum values of the data when the peaks were observed for the country while they have also been the years with maximum decline when seen in the declining trend of radiance in the middle of the year as outlined above. What is most important in this regard is the fact that, the major period of the COVID and post COVID year of 2021 has experienced the maximum average radiance, which can be taken as a probable indicator of the picking up of economic activities in the country. In fact, these were also the most fluctuating years for the country as is observed from Figure 5. The regularity of trend in average radiance is a probable indicator of a pattern of the country's economy.

Figure 6. exhibits the trends for Sri Lanka on yearly basis. Here, a lot of fluctuation is observed in average radiance which strongly indicates a fluctuating level of economic activities. The maxima is observed for the year 2021, post COVID which probably indicates an enhanced economic activity during night- time; particularly around mid-year. This is the maximum for the country for the whole dataset for the selected time period.

Figure 6. Sri Lanka- Yearly Trend of Night- Light Data (2017-2021)



Source- Derived by Authors from Google Earth Engine Code Editor, 2022

But no broad trend can be highlighted for the country as a whole, which strongly leads to put forward that there is no specific patterning of activities and economic activities cannot be taken as an exception to this. There do not exist any pattern of radiance values for the country.

CONCLUSIONS

The above observations lead to the conclusion that the existing economic trends of both the countries match to a great extent with the current analysis through Night-light data. While Bangladesh's economy indicates an uplift and growth, for Sri Lanka the case is opposite. Human activities are the source of this radiance and can range into multiple categories from urbanisation to lightening, creation of new infrastructure, railways, roadways, airways, recreation and many other. So, in the current examination as well, the rise and decline of such activities can be suggested to be reflected in the information mapped and discussed. It can be forwarded that the Nigh-light data is helpful not only in the economic analysis of activities but also their geographical spread. This also helps in identifying how economies also create geographies.

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