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Source: Environmental Health Insights, 16(1)

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/11786302221131467>

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Effect of Seasonal Land Surface Temperature Variation on COVID-19 Infection Rate: A Google Earth Engine-Based Remote Sensing Approach

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Environmental Health Insights
Volume 16: 1–4
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DOI: 10.1177/11786302221131467



ABSTRACT: This study aims to identify the effect of seasonal land surface temperature variation on the COVID-19 infection rate. The study area of this research is Bangladesh and its 8 divisions. The Google Earth Engine (GEE) platform has been used to extract the land surface temperature (LST) values from MODIS satellite imagery from May 2020 to July 2021. The per-day new COVID-19 cases data has also been collected for the same date range. Descriptive and statistical results show that after experiencing a high LST season, the new COVID-19 cases rise. On the other hand, the COVID-19 infection rate decreases when the LST falls in the winter. Also, rapid ups and downs in LST cause a high number of new cases. Mobility, social interaction, and unexpected weather change may be the main factors behind this relationship between LST and COVID-19 infection rates.

KEYWORDS: COVID-19, land surface temperature, public health, MODIS, Google Earth Engine

RECEIVED: July 1, 2022. **ACCEPTED:** September 21, 2022.

TYPE: Short Report

FUNDING: The author(s) received no financial support for the research, authorship, and/or publication of this article.

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Introduction

Covid-19 first appeared in late 2019 and slowly spread around the world. The World Health Organization (WHO) later declared it an epidemic on March 11, 2020, due to deteriorating conditions. Among various ecological triggers of COVID-19, environmental components were viewed as significant indicators from the start of the pandemic because COVID-19 is like other infections, which are by large connected with climatic inconstancy. Environmental factors such as temperature, humidity, and wind speed can affect the viability of viruses.^{1,2}

Numerous studies have suggested that the seasonal cycle of environmental variables might impact COVID-19 transmission.³ In order to create effective public health measures, it is crucial to comprehend how land surface temperature affects the COVID-19 pandemic.^{3,4} According to the epidemiological triangle, for an infection to occur, the agent must be able to infect the host, and this depends on whether the environment is conducive to the agent's survival and transmission as well as on the host's susceptibility.⁵ So, the patterns of the COVID-19 pandemic may have been impacted by weather circumstances affecting the susceptibility of the host.^{3,5} LST plays a significant role in climate change discussions since it affects other variables like hydrology and the urban environment directly or indirectly.^{6,7} Additionally, researchers state that the prevalence of LST can significantly affect COVID-19, whether it is low or high.^{6,8} Furthermore, it has been widely believed from the outbreak's start that COVID-19, like other respiratory viral illnesses, maybe a seasonal phenomenon.³ According to research, several climatic conditions, such as temperature and humidity, might impact the coronavirus's transmissibility. These parameters also affect the virus's survivability in the routes of transmission.^{3,9,10} Although these conclusions are debatable, several epidemiological and

laboratory experiments have investigated the connection between COVID-19 transmission and climatic conditions.^{3,11} Additionally, most research that has been done so far on how weather elements affect the dynamics of COVID-19 transmission under actual circumstances has relied on linear and non-linear statistical analysis.^{3,12,13} For instance, by influencing the duration of coronaviruses' survival on surfaces, the temperature may raise or lower the chance of transmission.^{12,14} Therefore, it makes sense to investigate how temperature affects the transmission of this novel coronavirus.¹²

Air temperature and humidity have been indicated to affect COVID-19 transmission significantly. Different research has assumed that temperature is one of the important reasons for an increase or decrease in the COVID-19 infection rate in different regions worldwide.^{15,16} Several factors change according to the ups and downs of LST over the years, like social interaction and the probability of falling into illness. These mercurial factors are also related to COVID-19 infection, which eventually relates LST with COVID-19. This article studies the LST fluctuation and COVID-19 infection rate over the years in several divisions of Bangladesh and explains the possible relationship among them.

Methods

The research has been based on 8 divisions of Bangladesh. It is a densely populated, low-lying, mainly riverine country located in South Asia with a coastline of 580 km on the northern littoral of the Bay of Bengal & it has a tropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures, and high humidity.¹⁷ The primary reason for selecting Bangladesh is its seasonal variation and LST variation according to geographical location. Also, Bangladesh faced



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noticeable ups and downs in COVID-19 infection rates over the years, which is suitable for this study.

Dhaka, the country's capital, is a densely populated city. The principal maritime city and trade center in southeastern Bangladesh is Chittagong, where humidity is aerial. The third biggest city in Bangladesh is Khulna, with a 700 per kilometer square population density. The weather is soggy and warm during summer and bland and tranquil in winter. Sylhet is the fourth-largest municipality in Bangladesh which is placed northeastern in Bangladesh and belongs to a subtropical climate and vigorous highlands territory. The cleanest and most verdurous city among the cities of Bangladesh is Rajshahi, located on the north shore of the Padma River. The coldest place is Tetulia in Bangladesh, situated in the division of Rangpur. Barishal is a vital division that lies on the coast of the Kirtankhola River in south-central Bangladesh. The last administrative division is Mymensingh, where the weather is indifferent from rainy to dry. Hence, the dry season is more vivid and precise than the wet season.

MODIS satellite data has been used to collect the LST over the years. MOD11A2 V6 offers an average 8-day land surface temperature (LST) grid of 1200×1200 km. Each MOD11A2 pixel value is a simple average of all the MOD11A1 LST pixels gathered over those 8 days. The 8-day compositing time was selected since it is twice the duration of the Terra and Aqua platforms' specific ground track repetition period. Along with the daytime and nighttime surface temperature bands and their associated quality indicator (Q.C.) layers, this package includes MODIS bands 31 and 32 and 8 observation layers.¹⁸ The Google Earth Engine platform has been used to collect and manage the LST dataset from May 2020 to July 2021. Algorithm 1 shows the GEE code for extracting LST data from MODIS.

ALGORITHM 1

```
1 var start = ee.Date('2020-05-01')
2 var dateRange = ee.DateRange(start, start.
  advance(1, 'year'))
3 var LST = MOD.select('LST_Day_1km').
  filterDate(dateRange)
4 var cel_LST = LSTmap(function(img){
5   return img.multiply(0.02).subtract(273).clip(ROI)
6   .copyProperties(img, ['system:time_start',
    'system:time_end'])});
```

The data for new COVID-19 cases have been collected from COVID-19 Dynamic Dashboard for Bangladesh supported by the District Health Information System.¹⁹ This data has been synced with the LST data, collected over 8 days, just on the date that the MODIS LST data is available.

Results

Descriptive analysis of COVID-19 infection rate and LST

Figure 1 shows the LST variation and ups and downs in per day new COVID-19 cases from the very beginning of

the pandemic for each division. The upper part illustrates the continuous LST data, and the lower part shows the COVID-19 new cases data. As the capital, Dhaka has the most population in the country, and the COVID-19 infection rate is highest compared to other divisions. Then there is Chittagong, followed by Rajshahi and Khulna. The variation of the COVID-19 infection rate is similar for most of the divisions. New cases started to rise from the middle of May 2020 and continued till mid-July. After that, a slight decrease in infection rate can be observed, which continued till September. A slight rise can be seen in the middle of October, which is less than May's. A drastic decrease in COVID-19 new cases can be seen in November and December 2020, and January 2021. January 2021 has the lowest infection rate till now. However, the infection rate started to rise significantly from the end of January. In March 2021, the total number of new cases for Bangladesh was 10 119, which is around 10 times greater than the new cases in February 2021. A sudden drop in new cases can be seen in April and May 2021. Nevertheless, after May, the infection rate rose beyond the previously recorded score, with 39 221 new cases in July.

Compared to the COVID-19 infection rate, the LST has more variations. Also, unlike COVID-19 new cases, a difference in LST variation can be seen between different divisions. Khulna and Chittagong faced a higher temperature (27.76°C and 28.32°C average) than Barishal and Mymensingh (27.41°C and 26.63°C average). Temperature is highest in April, May, and June (close to 30°C average) as these months are summer in Bangladesh. Temperature decreases in July and August (25.85°C average) for the rainy season, but a moderate temperature comes with autumn and late autumn from mid-August to mid-November. LST is lowest in December and January (23.24°C average) for the winter season. The temperature starts to moderate from mid-February with the end of spring. The overall LST increases in 2021 compared to 2020 (around 1.5°C average increase), which is expected as global warming hits.

Multiple relationships can be observed for LST and COVID-19 infection rates. A high infection rate can be seen after and during the summer season. For 2020, the highest infection rate was in June and July, where the average LST was 29.06°C in April and May. In June and July, the LST dropped close to 26°C , and a slight decrease in new cases can be observed in late August and September. LST increased again in September and October (around 28°C average), which leads to a slight increase in new cases for early November. But as the winter came, a dramatic decrease in new cases can be observed. For 2021, the pattern was quite similar. LST raised high early this year, in late February and March (close to 28°C average). The sudden decrease of new cases can be explained by the early summer rain, which causes temperature down. But with a high increase in temperature in the summer of 2021, the number of new cases started to peak.

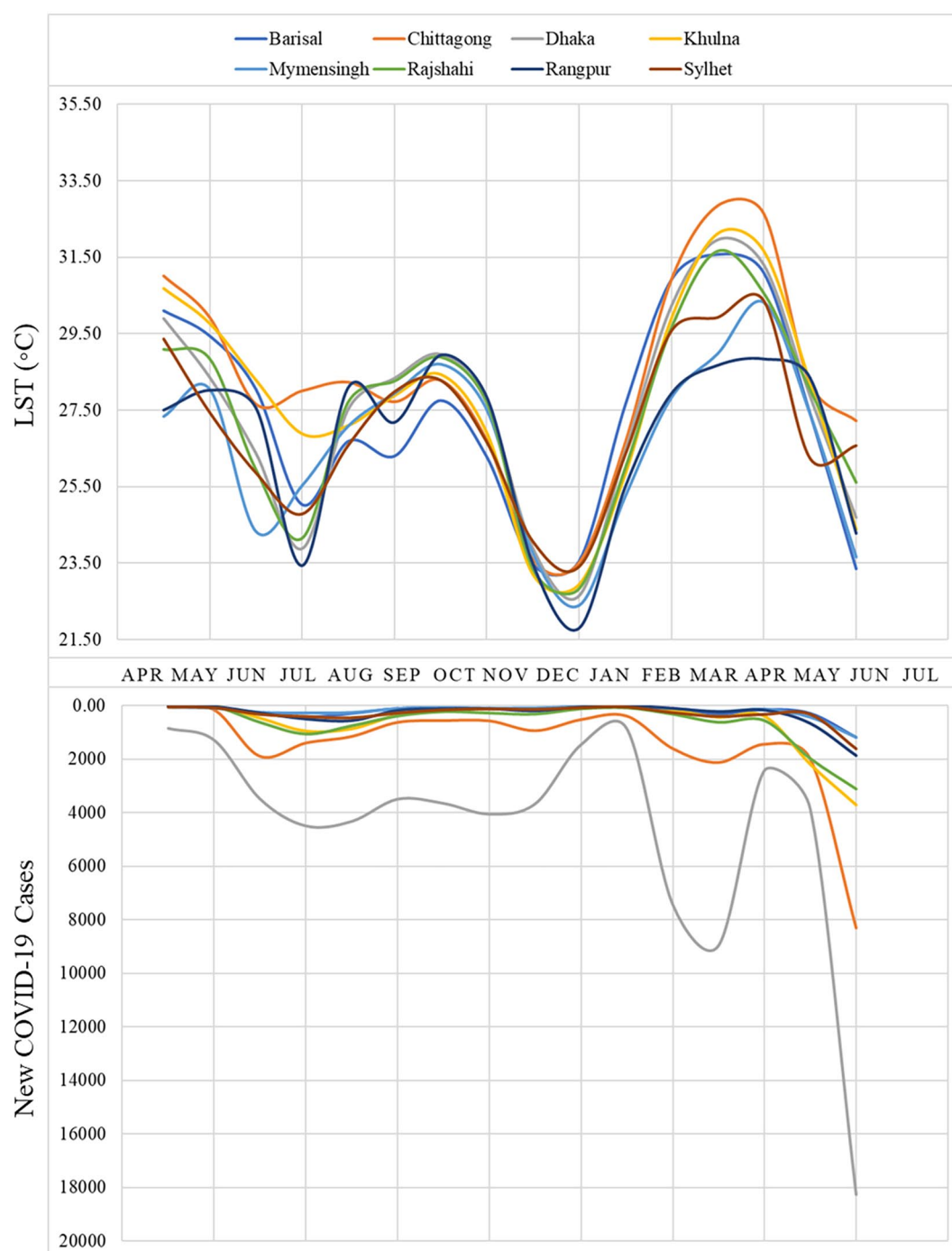


Figure 1. Average LST and COVID-19 new cases scenario from May 2020 to July 2021.

Correlation

The Pearson correlation values for total infection cases per day and LST is shown in Table 1. As seen in Figure 1, the effect of LST becomes apparent after 2 months. After 2 months of summer, the infection rate rises and falls after 2 months of winter. To guarantee a 2-month interval, the new cases data were taken from June 2020 to July 2021, and the LST data were taken from April 2020 to May 2021. Except for Dhaka, the table shows several highly associated values. This was an anticipated exception since Dhaka has a high infection rate and new cases, which are

difficult to correlate with short-range data like LST. The mean and maximum LST correlation value is more than .5 in the Khulna division. Khulna is followed by Mymensingh, Rajshahi, and Rangpur, all of which have significant correlation values for mean and maximum LST. One striking observation is that the correlation value is greatest with maximum LST, and there is no division in which minimum LST is significantly correlated with new cases. Because the lowest LST is from winter and the greatest LST is from summer, this indicates that new cases are significantly associated with the end of the summer season.

Table 1. Pearson correlation values for total new cases and LST.

| DIVISIONS | MEAN LST | MAXIMUM LST | MINIMUM LST |
|------------------|----------|-------------|-------------|
| Barisal Cases | -0.232 | 0.37* | 0.084 |
| Chittagong Cases | 0.364* | 0.255 | -0.156 |
| Dhaka Cases | 0.159 | 0.07 | -0.08 |
| Khulna Cases | 0.551* | 0.513* | 0.235 |
| Mymensingh Cases | 0.436* | 0.426* | 0.211 |
| Rajshahi Cases | 0.49* | 0.5* | 0.152 |
| Rangpur Cases | 0.396* | 0.327* | -0.009 |
| Sylhet Cases | 0.364* | 0.243 | 0.243 |

*Significantly correlated.

Conclusion

This study reveals a transparent scenario of LST change and COVID-19 infection rate, concluding that the number of new cases increases after experiencing a high LST. The probable reason behind this relationship can be the mobility of the people and social interaction.²⁰ In summer, when the days are long and staying at home becomes difficult for extreme heat, people's mobility, and social interaction increase, eventually increasing new cases after a month. This also explains fewer new cases after the winter as the days are shorter in winter, and people stay home to enjoy the warmth. Also, the summer season of Bangladesh has a sudden drop in temperature with rain. This makes everyone vulnerable to diseases like colds and coughs, which can potentially spread COVID-19. So, the summer should be the primary focus for reducing the COVID-19 infection rate. The public health administrations and government should take extra precautions about this fact. Also, adequate measures should be taken after the high-temperature season to mitigate unexpected life loss.

Author Contributions

Sk. Nafiz Rahaman: Conceptualization; Data curation; Formal analysis; Methodology; Software; Supervision; Validation; Visualization; Roles/Writing – original draft; Writing – review & editing; Tanvir Shehzad: Conceptualization; Data curation; Investigation; Resources; Roles/Writing – original draft; Maria

Sultana: Conceptualization; Data curation; Investigation; Resources; Roles/Writing – original draft.

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