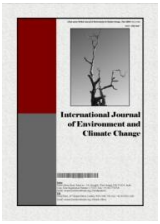

International Journal of Environment and Climate Change

10(12): 110-125, 2020; Article no.IJECC.62402
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Impact of Lockdown amid COVID-19 Pandemic on Temperature and Rainfall in Sub-Himalayan Ranges of Jammu & Kashmir Union Territory, India

Mahender Singh[1], Vishaw Vikas[1*], Sushmita M. Dadhich[2] and Rohit Sharma[3]

[1]Agrometeorology Section, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, India.
[2]Division of Agricultural Engineering, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, India.
[3]AMFU, RARS, Rajouri, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors MS and VV designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SMD and RS managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2020/v10i1230289
Editor(s):
(1) Dr. Gamal Abdel-Hafez Mahmoud Bekhet, King Faisal University, Saudi Arabia.
(2) Dr. Nese Yilmaz, Istanbul University, Turkey.
(3) Dr. Anthony R. Lupo, University of Missouri, USA.
Reviewers:
(1) M.T. Rintis Hadiani, University of Sebelas Maret, Indonesia.
(2) Yonny Martinez Lopez, Federal University of Espírito Santo, Brazil.
(3) J. S. Ojo, Federal University of Technology Akure, Nigeria.
Complete Peer review History: http://www.sdiarticle4.com/review-history/62402

Original Research Article

Received 10 October 2020
Accepted 19 November 2020
Published 11 December 2020

ABSTRACT

The study was conducted to evaluate the effect of lockdown on temperature and rainfall in sub-Himalayan ranges i.e. Foothills of NW Shivaliks and Pir Panjal ranges of Jammu & Kashmir Union Territory, India. The statistical analysis inferred that due to the implementation of complete lockdown in region amid COVID-19 pandemic has brought reductions in day temperature in foothills of NW Shivaliks by 10.29% and 2.20% compared to year 2018 and 2019 respectively. While under Pir Panjal range the reduction in day temperature was found to be significant by 6.08% and 4.13%. Also evaluation of night temperature values revealed the significant reductions

**Corresponding author: E-mail: vishaw.vikas@gmail.com;*

by 10.29% and 2.20% as compared to year 2018 and 2019 in foothills of NW Shivaliks and 10.37%, 5.93% in Pir Panjal. The Rainfall also increased in both sub-Himalayan ranges during this period and it was >100% and 70.25% under foothills of NW Shivaliks, 34.6% and 100% under Pir Panjal range. Hence the present study highlighted a plausible impact of lockdown on the weather parameters of the region, making it an efficient tool to mitigate the pace of regional changing climatic patterns for long term sustainability, productivity and for better soil, plant and animal health.

Keywords: Northwestern foothills of shivaliks; pir panjal; day and night temperature; rainfall; COVID-19; climate change.

ABBREVIATIONS

NW: Northwestern

1. INTRODUCTION

Alarming situations related to environment catastrophe are being noticed everywhere worldwide. An example of which is that, In 2019, more than 40,000 forest fires were reported in Brazilian Amazon forest and still counting in 2020 (Wikipedia). Also, the increasing trend of uncontrolled bush fires in Australia and the recent incident happened in November 2019-January 2020 claimed to have damaged the property worth billion dollars (Wikipedia). The long term exposure of aquatic and terrestrial ecosystems to such incidents not only damage or destroy the existing habitats but also create competition among the survivors for food and shelter thereby affecting the entire food chain and food web. The rising emissions and increasing pollutants have created havoc in almost every developed and developing country, as a result of which incidents like Antarctic ice melting, rising sea levels, submergence of low lying areas, respiratory diseases, poor air quality index and crop yield deviations have been observed globally. From India's context, the population is increasing exponentially with a growth rate of 37.60% having direct impact on rising pollutant emissions and demand-supply ratio. In 2030, India is expected to have a demand of food grains of more than 335 million tonnes (www.consultancy.in), thus a more sustainable approach is required for production in any aspect taking care of soil, plant and animal health. Despite the awareness programmes launched globally to tackle the menace of pollutants, the world still faced 1% increase in CO_2 emissions over previous decade Friedlingstein, P. et al. [1] and Peters, G. P. et al. [2] and the fossil energy also remained in dominating position for surface, air and water transport Solaymani, S. [3]. In overall aspect, the reaction of nature towards our activities today, seems much like fiction movies but is rather a bitter truth and harsh reality of our future. Today, there is a need of immediate action and quick response from human being to reduce the hazardous anthropogenic activities; otherwise the sure negative consequences of these would be going to downgrade the weather uality of the entire country Borunda, [4] and particularly the sub-Himalayan region of Jammu & Kashmir.

Shivaliks has been considered as youngest of all mountains in India and is considered as parallel to Himalaya Sivakumar K., [5]. The Northwestern Shivaliks have been neglected since long time amid the conservation measures were issued in 1895 Agarwal et al. [6]. This covers about 20,000 km^2 area and is in constant threat to erosion and other problems along with the problems arising from industrialization and urbanization. Anthropogenic activities have degraded the ecosystem of the entire area and wildlife is highly threatened. Lack of resources, zero access to essential requirements and changing weather patterns has led to the lop off the entire nomadic population in the area. The declining trend in soil fertility, vegetation cover and changing climatic events has created an alarming situation in the region. In particular to North West Himalayas, the temperature has risen 1.2°C as compared to global average of 0.8-0.9°C in last 100 years and as a result of which we are witnessing faster melting of glaciers DNA India, [7]. Erratic precipitation pattern and unusual warm winters are some of the characteristics of changing weather pattern in lower Himalayan region. The Pir Panjal Range is situated in the Southeast of the union territory of Jammu and Kashmir and extends for more than 320 kms from the Kishanganga River in western occupied Kashmir area (administered by Pakistan), through south western Jammu and Kashmir (administered by India) to the Beas River in Himachal Pradesh state, India Paul Y. [8] Pir Panjal separates Jammu Hills to the south from the vale of

Kashmir beyond which lie Great Himalayas Paul Y. [9]. The challenges of climate change and global warming has continuously threatened the prevailing ecosystem of the region and in this regard the researchers need to evaluate the impact of climate change through continuous weather parameters analysis to reduce vulnerability of systems. Therefore, unless effective counter measures are taken and implement, healthier environment and ecosystem cannot be restored in the region.

The COVID-19 disease was first reported in Wuhan, China in 2019 which resulted in several million cases worldwide. In response to the abrupt spread of the disease, the WHO declared the COVID-19 as pandemic on 14th March 2020 WHO, [9]. As a measure to control the spread of COVID-19 disease, India imposed countrywide complete lockdown in phases starting from 24th March to 31st March 2020 inhibiting the surface, water and air movement along with closure of industrial sector. These restrictions imposed, no doubt reduced the spread of disease but also had a direct impact on weather parameters i.e. temperature and rainfall thereby creating a new environment friendly and sustainable trend to control emissions specifically in inhabited areas of northwestern foothills of Shivaliks and Pir Panjal range. The changes in temperature and rainfall pattern in the target area of study therefore provide an insight into the deviation of parameters compared to past two years (2018 and 2019) and to assess the usefulness of the lockdown as an alternative strategy for diminution of changing climatic pattern in the target areas.

The objectives of the study are:-

(i) To quantify the change in temperature and rainfall due to the implementation of lockdown regulation during lockdown period,
(ii) To compare and correlate the temperature and rainfall values of the study areas during lockdown period and
(iii) To unveil the level of parameters in the past few years during the same window period.

Focusing on the natural resource management of foothills of Shivaliks and Pir Panjal Range, the study is thought to be a plausible addition to the scientific community and policy makers not only to assess the impacts of lockdown on weather parameters, but also its efficacy as a strategic measure to upgrade the changing climatic pattern within the region with public involvement in future.

2. MATERIALS AND METHODS

The Northwestern Shivaliks lies in between 33.3716° N, 74.3152° E to 32.3863° N, 75.5173° E and Pir Panjal lies in between 33.4370° N, 75.1939° E to 33.3116° N, 75.7662° E in Jammu & Kashmir Union Territory, India. To study the changes in temperature and rainfall of the entire region, the daily data was collected from Agrometeorological observatories in different locations of the study areas i.e. from northwestern foothills of Shivaliks the data was collected from district Rajouri (33.3716°N, 74.3152°E), Jammu (32.7266°N, 74.8570°E), Reasi (33.0804°N, 74.8364°E), Samba (32.5530°N, 75.1108°E) and Kathua (32.3863°N, 75.5173°E) and for Pir Panjal range the data was collected from district Ramban (33.2464°N, 75.1939°E) (Banihal, 33.4370°N, 75.1939°E and Batote, 33.1216°N, 75.3216°E), Doda (33.1457°N, 75.5480°E) and Kishtwar (33.3116°N, 75.7662°E). In order to have a representation of entire population, the data was analyzed using descriptive statistics method to find the Highest, Lowest, Mean, Standard Error, Standard Deviation, Coefficient of Variation, Kurtosis and Skewness values and was run in MS-Excel 2010 along with Pearson Correlation in SPSS 16.0 to find out the significant values and impact of one parameter over another.

Also, to analyze the change in the entire study area, weather parameters were statistically and graphically analyzed fortnightly i.e. from 24th March to 31st May considered as lockdown period, 2020) and during same window period for year 2018 and 2019. Deviation percentage among values was calculated for each parameter to quantify the improvisation in weather parameters during lockdown period compared with previous 2 year data of same timeline.

3. RESULTS AND DISCUSSION

3.1. Variation in Temperature

The descriptive coefficients were analyzed for day temperature variation in Shivaliks as well as for Pir Panjal Range (Table 1). Graphically, significant observations related to day temperature in lockdown were noticed (Fig. 1 and 2). In NW foothills of Shivaliks, it was

observed that restriction measures have deviated the day temperature values in 1st fortnight of lockdown by -20.97% and -16.67% and in Pir Panjal, by –25.41% and -22.66%. In 2nd fortnight of lockdown the day temperature values were deviated by -4.03% and -5.59% compared to year 2018 and 2019 for NW foothills of Shivaliks and -3.16% and -3.97% for Pir Panjal. Likewise in 3rd fortnight of lockdown, the day temperature values were deviated by -9.96% and -8.87% compared to year 2018 and 2019 for NW foothills of Shivaliks and -7.35%, -2.21% for Pir Panjal range. During further analysis of 4th fortnight of lockdown, the deviation observed was -3.03% and -0.85% in relation to year 2018 and 2019 in NW foothill of Shivaliks and -3.43%, -4.14% in Pir Panjal Range. In last fortnight of lockdown, the deviation observed was -9.15% and -6.00% compared to year 2018 and 2019 for NW foothills of Shivaliks and -6.85 %, -3.43% for Pir Panjal range. The cumulative analysis depicted a significant deviation of -9.33% and -6.65% for day temperature in NW foothills of Shivaliks and -6.08%, -4.13% for Pir Panjal Range.

The night temperature values were analyzed and descriptive coefficients were enumerated for NW foothills of Shivaliks as well as for Pir Panjal Range (Table 2). Graphical description signified the night temperature values below normal than year 2018 and 2019 (Fig. 2 and 3). In NW foothill of Shivaliks, the deviation in night temperature in lockdown during 1st fortnight of lockdown compared to year 2018 and 2019 was -18.92% and -8.21 and in Pir Panjal the deviation observed for same window was -37.32% and -25.38%. However, in 2nd fortnight of lockdown the deviation in NW foothills of Shivaliks was -6.12% and -5.19% and -0.11%, -11.08% in Pir Panjal. Similarly in 3rd fortnight of lockdown, the deviation observed for NW foothills of Shivaliks was -12.47% and -2.34%, and for Pir Panjal the deviation was -7.53%, -2.13%. Meanwhile, the 4th fortnight analysis results depicted -8.85% and -1.14% deviation in NW foothills of Shivaliks whereas -4.76% and -0.62% in Pir Panjal compared to year 2018 and 2019 of same window. During 5th fortnight analysis, the deviation observed was -4.52% and -2.17% in NW foothills of Shivaliks whereas -5.42% and -3.83% in Pir Panjal. Cumulative data analysis of entire lockdown period highlighted -10.29% and -2.20% deviation in Shivaliks and -10.37%, -5.93% deviations in Pir Panjal.

The lowered day and night temperature values during lockdown can be attributed to reduction in particulate matter in air Mandal and Pal [10]. The concentration of pollutants such as NO_2, SO_2, CO, Particulate Matter is considered as dominant reason of increase in air temperature Mandal and Pal [10]; Gupta et al. [11] but lack of vehicular and transportation movement might have resulted in lesser emissions Global Carbon Project 2020) resulting in lowering of temperature values. The restrictions on industrial operations, transportation movement and other mining operations in the region has led to the dramatic reduction on greenhouse gas emissions leading to drop in temperature, the same pattern of decreasing temperature due to reduced emissions has been also noticed in France, Germany, Italy and Spain ESA, [12]. Also, the significant reduction in temperature values in the entire region can be attributed to restriction on anthropogenic movements and activities amid lockdown Singh et al. [13]. Also, declining trend in the economic output, reduced energy consumption, staggered emissions from land usage may have resulted in significant lowering of atmospheric temperature than 2018 and 2019; thus lowering risk of threat to our environment Williams K.D. [14]; Manabe S. [15]. In another study by Bashir et.al. 2020, there was also depiction of a positive correlation between air quality parameters and weather parameters as a result of which it was proven that average temperature, minimum temperature and air quality are significantly associated with COVID-19 in New York, USA. Jerez et.al. 2018; Manabe S. [15] have already reported that the high accumulation of greenhouse gases may lead to surging temperatures and may also affect other climatic components like fog, dew, precipitation etc. Mandal and Pal [10] have also reported reduction in temperature values by 3-5 °c as compared to pre-lockdown period in middle catchment of Dwarka river basin of Eastern India due to reduction in industry and vehicular movement induced energy footprints. Again, a comparison between year 2019, pre-lockdown and lockdown values of land surface temperature has highlighted the reduction in values amid lockdown in major cities of India i.e. Mumbai, Noida, Kolkata and Chennai Ghosh et al. [16]. However, the consistent drop in temperature amid lockdown due to COVID 19 pandemic can be temporary Monserrate et al. [17] but the lockdown has proven to be an effective alternative to tackle the system of emissions and understanding the regional climate signatures.

Table 1. Descriptive coefficients of Day temperature (°C) during lockdown (2020), 2018 and 2019 in North western foothill of shivaliks and pir panjal

		Day Temperature in Northwestern foothills of Shivaliks			Day Temperature in Pir Panjal		
Time Period	**Descriptive Coefficients**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
1st Fortnight Analysis	**Lowest**	27.18	22.63	20.15	19.43	15.60	9.23
	Highest	32.73	32.80	26.65	27.80	28.40	22.97
	Mean	30.36	28.79	23.99	24.24	23.38	18.08
	S.E	0.40	0.81	0.57	0.63	1.00	0.99
	S.D	1.54	3.13	2.21	2.46	3.86	3.82
	C.V (%)	0.05	0.11	0.09	0.10	0.17	0.21
	Kurtosis	-0.21	-0.56	-0.79	-0.51	0.51	0.80
	Skewness	-0.36	-0.62	-0.54	-0.57	-1.01	-0.96
2nd Fortnight Analysis	**Lowest**	25.85	20.38	23.60	12.37	12.77	13.97
	Highest	32.40	32.40	30.90	25.90	27.10	26.93
	Mean	29.01	29.49	27.84	22.43	22.62	21.72
	S.E	0.47	0.88	0.54	1.03	1.10	1.06
	S.D	1.81	3.41	2.10	3.99	4.24	4.10
	C.V (%)	0.06	0.12	0.08	0.18	0.19	0.19
	Kurtosis	-0.46	2.67	-0.55	-0.55	0.29	-0.95
	Skewness	0.18	-1.75	-0.23	-0.52	-0.95	-0.46
3rd Fortnight Analysis	**Lowest**	24.50	29.68	25.90	21.60	18.50	19.30
	Highest	36.70	35.93	33.85	29.47	29.60	28.20
	Mean	33.31	32.91	29.99	26.24	24.86	24.31
	S.E	0.84	0.41	0.47	0.66	0.80	0.59
	S.D	3.24	1.59	1.83	2.57	3.11	2.29
	C.V (%)	0.10	0.05	0.06	0.10	0.13	0.09
	Kurtosis	2.87	0.38	1.55	-1.10	-0.37	0.47
	Skewness	-1.54	-0.14	-0.09	-0.51	-0.39	-0.25
4th Fortnight Analysis	**Lowest**	29.18	28.38	28.80	14.47	17.17	16.83
	Highest	36.60	36.18	36.20	29.37	29.83	29.90
	Mean	33.56	32.82	32.54	25.60	25.79	24.72
	S.E	0.59	0.72	0.56	0.97	0.88	0.75
	S.D	2.30	2.77	2.16	3.76	3.39	2.89
	C.V (%)	0.07	0.08	0.07	0.15	0.13	0.12
	Kurtosis	-0.25	-1.28	-0.62	2.64	0.44	6.67
	Skewness	-0.70	-0.40	-0.28	-1.38	-0.78	-2.07
5th Fortnight Analysis	**Lowest**	37.35	28.80	28.85	28.33	16.33	22.63
	Highest	40.18	39.90	38.18	31.17	31.53	30.47
	Mean	38.57	35.14	35.08	29.89	28.83	27.84
	S.E	0.28	1.16	1.14	0.33	1.66	0.95
	S.D	0.84	3.48	3.42	1.00	4.98	2.85
	C.V (%)	0.02	0.10	0.10	0.03	0.17	0.10
	Kurtosis	0.54	-0.04	-0.59	-1.45	0.13	-0.65
	Skewness	0.69	-0.43	-0.99	-0.09	-0.88	-0.82
Cumulative Analysis	**Lowest**	24.50	20.38	20.15	12.37	12.77	9.23
	Highest	40.18	39.90	38.18	31.17	31.53	30.47
	Mean	32.47	31.54	29.44	24.66	24.16	23.16
	S.E	0.44	0.43	0.52	0.50	0.47	0.55
	S.D	3.67	3.61	4.30	4.13	3.91	4.58
	C.V (%)	0.11	0.11	0.15	0.17	0.16	0.20
	Kurtosis	-0.74	1.04	-0.37	0.51	0.29	0.32
	Skewness	0.18	-0.58	0.01	-0.80	-0.73	-0.74

3.2 Variation in Rainfall

The descriptive coefficients for Rainfall in NW foothills of Shivaliks and Pir Panjal have been stated in Table 3. The graphical representation of variation in rainfall pattern has been depicted in Fig. 3 and 4. The fortnightly analysis has however depicted very erratic rainfall pattern, so to highlight the major deviation we have described only cumulative analysis of data in which the deviation in lockdown was > 100% and 70.25% compared to year 2018 and 2019 in NW foothills of Shivaliks whereas 34.6% and >100 % in Pir Panjal. In results, there is clear postitve impact of lockdown on rainfall and while understanding the correlation values; it is clearly acceptable that during the lockdown period there was significant negative correlation between temperature and rainfall (Tables 4 and 5). So, the precipitation has increased with decrease in temperature and the finding is in line with research done by Patni and Jindal, [18] in which they have analyzed the rainfall intensity has increased in summers from March to May 2020 in between COVID-19 pandemic lockdown. Also, the observations related to rainfall in lockdown period are very fluctuating and the impact of air pollution on rainfall pattern is very uncertain but we can consider the reduced emissions as a major cause of erratic rainfall pattern in the region under lockdown Uchiyama et al., [19]; American Association For The Advancement of Science news, [20]. Also, in another research by Bhat et al. [21] has revealed that unpredicted rainfall patterns have increased as a result of indirect impact of COVID-19 lockdown in Jammu & Kashmir. Also, the erratic rainfall patterns in region can be correlated with a study in which scientists ran a series of model simulations using a range of CO_2 concentrations and temperature in which the effect on extreme climate events was studied by changing CO_2 concentrations which highlighted a significant deviation in precipitation events Harvey C. [22]. At present when governments worldwide are trying to manage the COVID-19 situation, the lockdown has shown a positive impact on rainfall ultimately towards restoring ecosystem and environment.

Along with descriptive statistics, Pearson's correlation coefficient was analyzed in order to find any impact of one weather parameter over another in fortnightly interval for both the study regions (Tables 4 and 5).

Table 2. Descriptive coefficients of night temperature (°C) during lockdown (2020), 2018 and 2019 in north western foothill of Shivaliks and Pir Panjal

		Night Temperature in Northwestern foothills of Shivaliks			Night Temperature in Pir Panjal		
Time Period	**Descriptive Coefficients**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
1st Fortnight Analysis	**Lowest**	12.92	10.10	10.65	7.50	5.47	3.63
	Highest	16.51	16.38	13.38	13.53	11.20	9.03
	Mean	14.74	13.02	11.95	9.94	8.35	6.23
	S.E	0.31	0.50	0.23	0.46	0.48	0.39
	S.D	1.19	1.95	0.88	1.78	1.85	1.52
	C.V (%)	0.08	0.15	0.07	0.18	0.22	0.24
	Kurtosis	-1.04	-0.72	-1.23	-0.28	-1.12	-0.05
	Skewness	-0.09	-0.05	-0.05	0.47	-0.20	-0.09
2nd Fortnight Analysis	**Lowest**	13.18	12.50	11.95	5.07	6.33	6.10
	Highest	18.00	17.50	18.40	11.77	13.50	12.03
	Mean	15.52	15.49	14.57	8.99	10.10	8.98
	S.E	0.39	0.43	0.48	0.46	0.50	0.53
	S.D	1.53	1.66	1.87	1.78	1.93	2.06
	C.V (%)	0.10	0.11	0.13	0.20	0.19	0.23
	Kurtosis	-1.10	-1.04	-0.11	0.22	-0.26	-1.50
	Skewness	0.20	-0.51	0.62	-0.33	-0.19	0.06
3rd Fortnight Analysis	**Lowest**	15.47	15.20	14.43	9.93	8.93	7.13
	Highest	21.25	18.70	18.75	12.93	13.43	14.23
	Mean	18.59	16.66	16.27	11.42	10.79	10.56
	S.E	0.43	0.25	0.32	0.25	0.31	0.48

		Night Temperature in Northwestern foothills of Shivaliks			Night Temperature in Pir Panjal		
Time Period	**Descriptive Coefficients**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
	S.D	1.67	0.96	1.23	0.96	1.20	1.84
	C.V (%)	0.09	0.06	0.08	0.08	0.11	0.17
	Kurtosis	-0.62	0.01	-0.11	-0.93	1.78	0.35
	Skewness	-0.31	0.30	0.44	-0.10	1.32	0.35
4th	**Lowest**	17.04	16.38	16.45	7.97	9.97	9.13
Fortnight	**Highest**	21.69	20.55	19.45	13.60	13.20	13.00
Analysis	**Mean**	19.87	18.32	18.11	11.76	11.27	11.20
	S.E	0.35	0.30	0.20	0.42	0.23	0.33
	S.D	1.37	1.16	0.77	1.61	0.90	1.29
	C.V (%)	0.07	0.06	0.04	0.14	0.08	0.12
	Kurtosis	0.49	-0.23	0.82	0.84	0.23	-1.11
	Skewness	-1.09	0.24	-0.19	-1.00	0.74	-0.34
5th	**Lowest**	19.64	16.75	18.03	10.70	10.47	10.23
Fortnight	**Highest**	24.19	21.33	22.83	14.77	13.80	13.60
Analysis	**Mean**	21.67	21.15	20.69	12.72	12.51	12.03
	S.E	0.52	0.50	0.48	0.47	0.41	0.34
	S.D	1.57	1.49	1.43	1.41	1.24	1.02
	C.V (%)	0.07	0.07	0.07	0.11	0.10	0.08
	Kurtosis	-0.90	-0.97	0.45	-1.32	-1.34	2.63
	Skewness	0.43	-0.10	-0.52	0.10	0.16	-1.47
Cumulative	**Lowest**	12.92	10.10	10.65	5.07	5.47	3.63
Analysis	**Highest**	24.19	21.33	22.83	14.77	13.80	14.23
	Mean	17.77	16.30	15.94	10.79	10.28	9.67
	S.E	0.35	0.31	0.37	0.24	0.23	0.32
	S.D	2.88	2.57	3.09	2.00	1.89	2.64
	C.V (%)	0.16	0.16	0.19	0.19	0.18	0.27
	Kurtosis	-1.00	-0.03	-0.85	-0.14	0.33	-0.76
	Skewness	0.10	-0.51	0.08	-0.41	-0.55	-0.40

Table 3. Descriptive coefficients of rainfall (mm) during lockdown (2020) , 2018 and 2019 in North Western foothill of shivaliks and Pir Panjal

		Rainfall in Northwestern foothills of Shivaliks			Rainfall in Pir Panjal		
Time Period	**Descriptive Coefficients**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
1st	**Lowest**	0.00	0.00	0.00	0.00	0.00	0.00
Fortnight	**Highest**	4.10	0.75	77.30	9.23	4.07	96.27
Analysis	**Mean**	0.33	0.07	6.62	1.14	0.31	10.31
	S.E	0.27	0.05	5.12	0.74	0.27	6.31
	S.D	1.05	0.20	19.82	2.85	1.04	24.42
	C.V (%)	3.20	2.91	2.99	2.50	3.36	2.37
	Kurtosis	14.19	10.17	14.04	5.19	14.58	13.13
	Skewness	3.74	3.16	3.71	2.50	3.80	3.54
2nd	**Lowest**	0.00	0.00	0.00	0.00	0.00	0.00
Fortnight	**Highest**	10.70	15.85	17.25	27.10	14.33	41.10
Analysis	**Mean**	2.91	2.42	1.78	10.16	2.27	5.53
	S.E	0.94	1.33	1.14	2.71	1.10	2.86
	S.D	3.65	5.13	4.42	10.50	4.26	11.08
	C.V (%)	1.25	2.12	2.49	1.03	1.88	2.00
	Kurtosis	1.02	3.91	12.73	-1.61	4.36	8.07
	Skewness	1.40	2.25	3.49	0.31	2.18	2.73

		Rainfall in Northwestern foothills of Shivaliks			Rainfall in Pir Panjal		
Time Period	**Descriptive Coefficients**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
3rd Fortnight Analysis	**Lowest**	0.00	0.00	0.00	0.00	0.00	0.00
	Highest	9.83	6.30	6.90	24.97	11.10	16.63
	Mean	0.90	0.24	0.97	2.55	2.86	3.21
	S.E	0.65	0.49	0.53	1.37	1.07	1.67
	S.D	2.53	1.90	2.06	6.46	4.14	5.30
	C.V (%)	2.83	7.93	2.12	2.53	1.45	1.65
	Kurtosis	13.27	2.94	4.78	12.20	-0.19	2.27
	Skewness	3.58	1.83	2.31	3.40	1.17	1.75
4th Fortnight Analysis	**Lowest**	0.00	0.00	0.00	0.00	0.00	0.00
	Highest	6.00	17.05	7.10	18.33	22.33	15.00
	Mean	0.71	2.12	0.80	3.03	3.47	1.50
	S.E	0.45	1.14	0.50	1.45	1.45	1.00
	S.D	1.72	4.43	1.95	5.63	5.61	3.87
	C.V (%)	2.44	2.09	2.45	1.86	1.62	2.57
	Kurtosis	6.84	10.46	8.53	3.82	10.39	12.48
	Skewness	2.69	3.12	2.86	2.13	3.03	3.46
5th Fortnight Analysis	**Lowest**	0.00	0.00	0.00	0.00	0.00	0.00
	Highest	0.00	3.25	5.10	0.67	36.83	11.87
	Mean	0.00	0.64	0.88	0.11	5.61	3.87
	S.E	0.00	0.43	0.56	0.08	4.05	1.51
	S.D	0.00	1.29	1.69	0.24	12.15	4.52
	C.V (%)	0.00	2.00	1.92	2.09	2.16	1.17
	Kurtosis	0.00	1.27	5.99	3.36	7.17	0.05
	Skewness	0.00	1.70	2.41	2.02	2.63	1.20
Cumulative Analysis	**Lowest**	0.00	0.00	0.00	0.00	0.00	0.00
	Highest	10.70	17.05	77.30	27.10	36.83	96.27
	Mean	1.05	1.36	2.32	3.69	2.67	4.97
	S.E	0.29	0.40	1.16	0.87	0.70	1.57
	S.D	2.44	3.35	9.60	7.23	5.82	13.01
	C.V (%)	2.32	2.47	4.13	1.96	2.18	2.62
	Kurtosis	8.00	13.23	56.70	2.96	18.49	36.85
	Skewness	2.87	3.58	7.27	2.02	3.86	5.58

Table 4. Correlation of coefficients among temperature and rainfall during lockdown period in Northwestern foothills of Shivaliks

Correlation	Day Temp.	Night Temp.
Night Temp.	0.88**	
Rainfall	-0.33**	-0.24*

***Correlation is significant at 1% level of significance*
**Correlation is significant at 5% level of significance*

Table 5. Correlation of coefficients among Temperature and Rainfall during Lockdown period in Pir Panjal

Correlation	Day Temp.	Night Temp.
Night Temp.	0.87**	
Rainfall	-0.51**	-0.38**

***Correlation is significant at 1% level of significance*

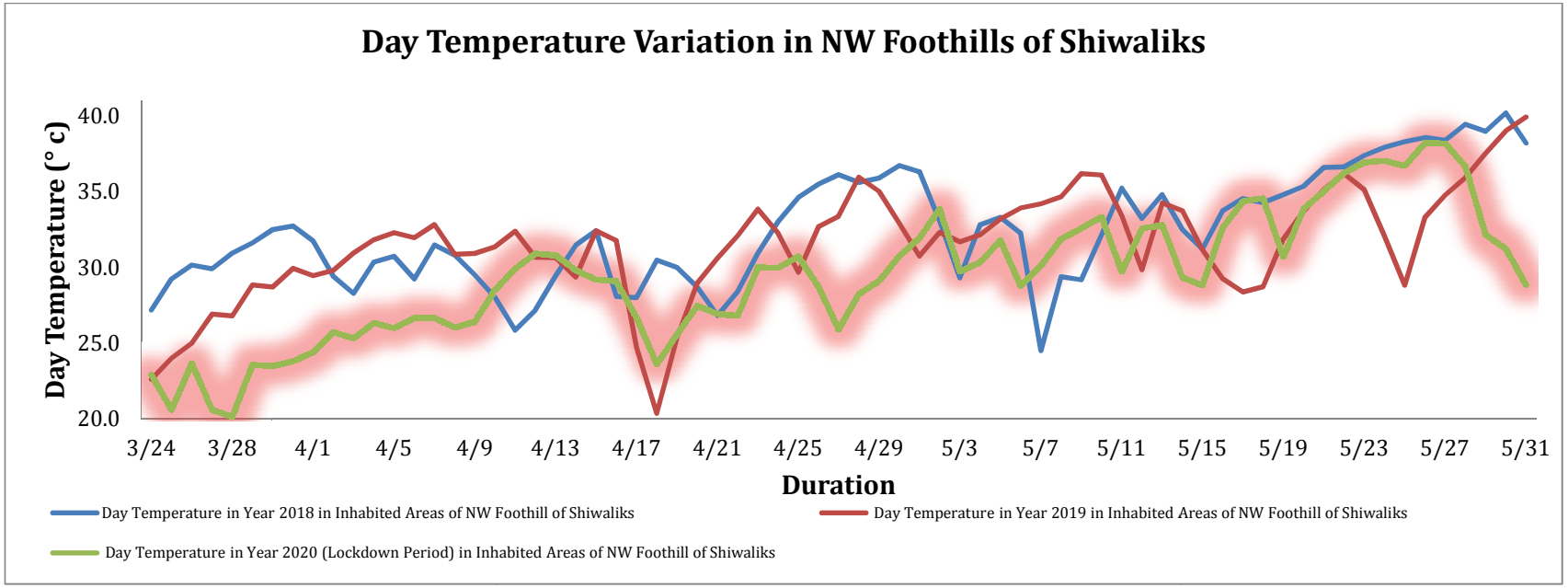

Fig. 1. Effect of complete lockdown on day temperature (°C) variation compared to Year 2018 and 2019 in North Western foothills of Shivaliks

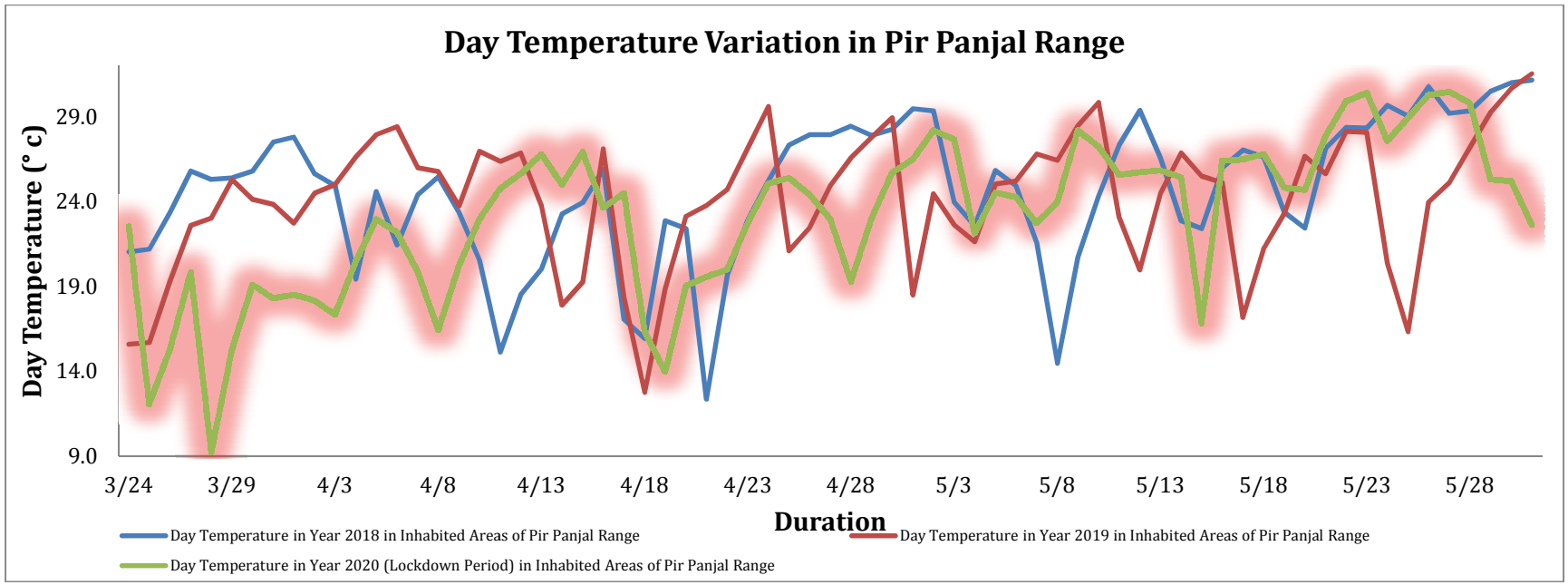

Fig. 2. Effect of complete lockdown on day temperature (°C) variation compared to Year 2018 and 2019 in Pir Panjal

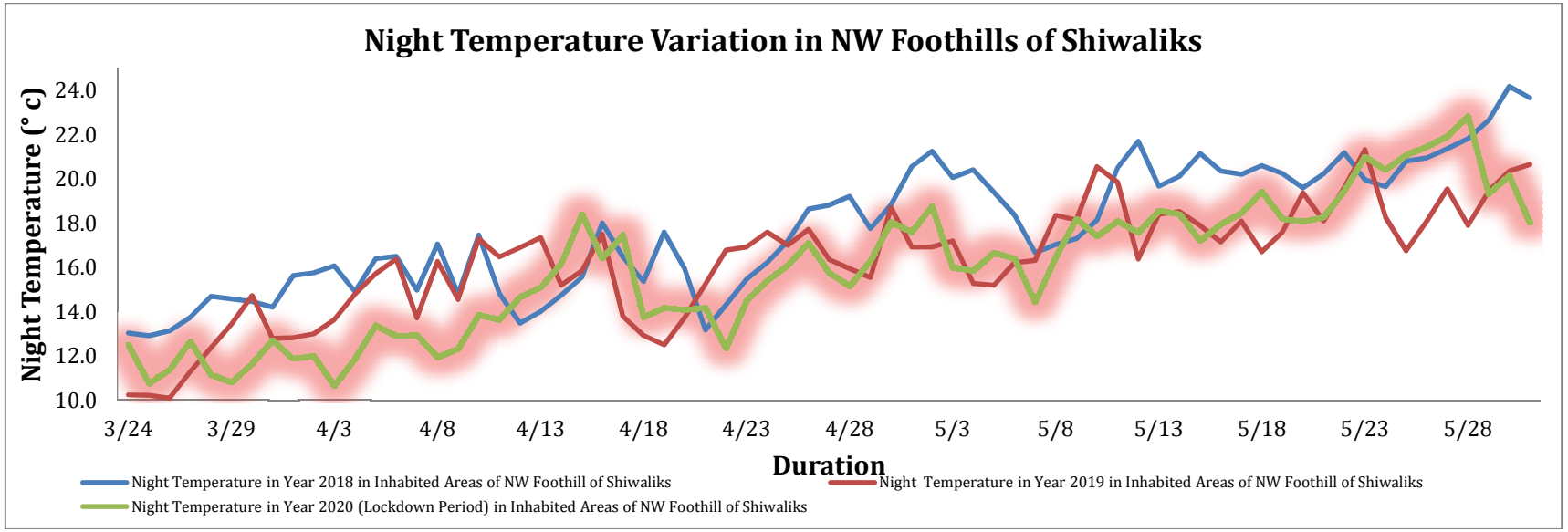

Fig. 3. Effect of complete lockdown on night temperature (°C) variation compared to Year 2018 and 2019 in North Western Foothills of Shivaliks

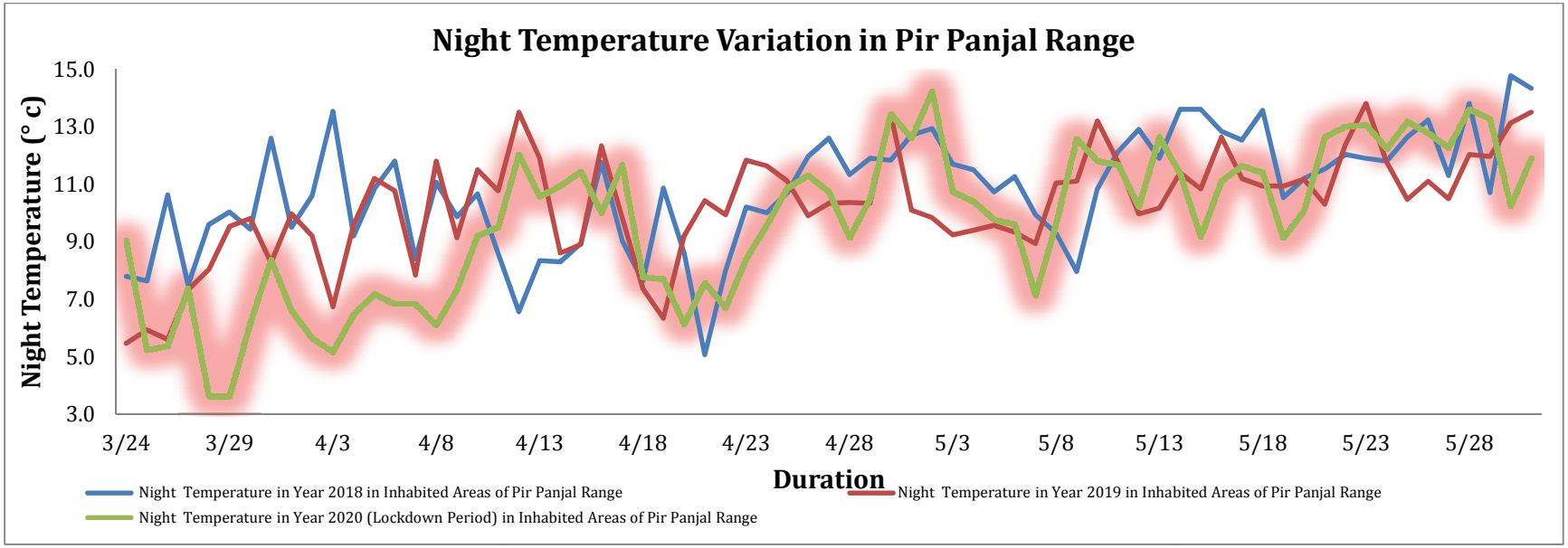

Fig. 4. Effect of complete lockdown on night temperature (°C) variation compared to Year 2018 and 2019 in Pir Panjal

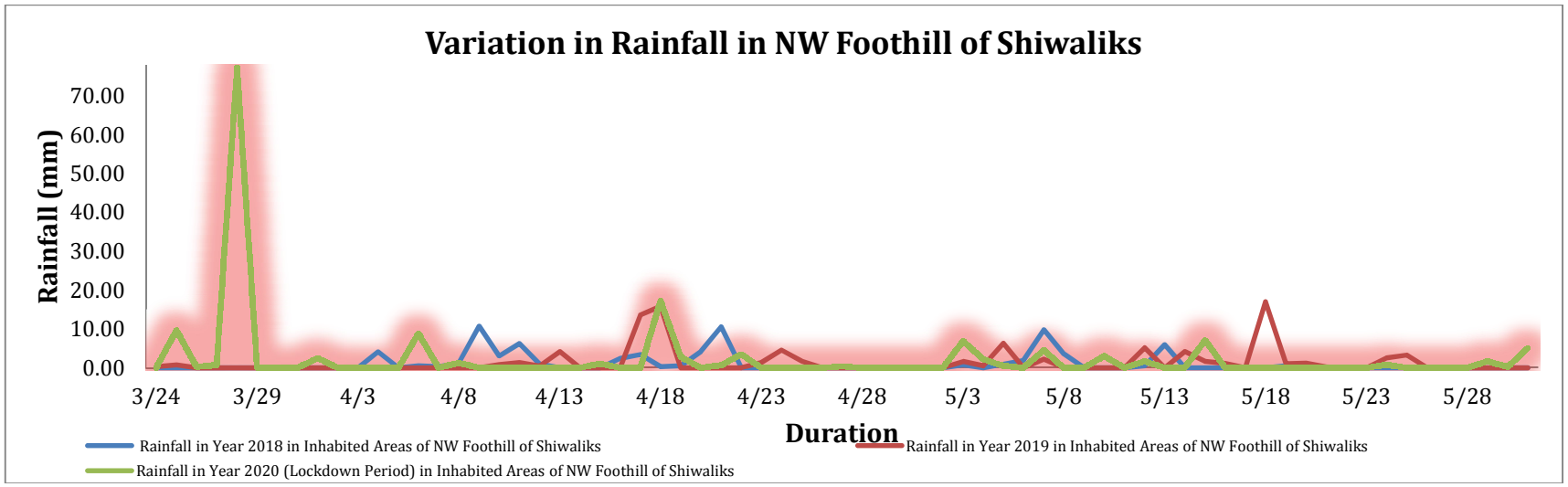

Fig. 5. Effect of complete lockdown on rainfall (mm) variation compared to Year 2018 and 2019 in North Western Foothills of Shivaliks

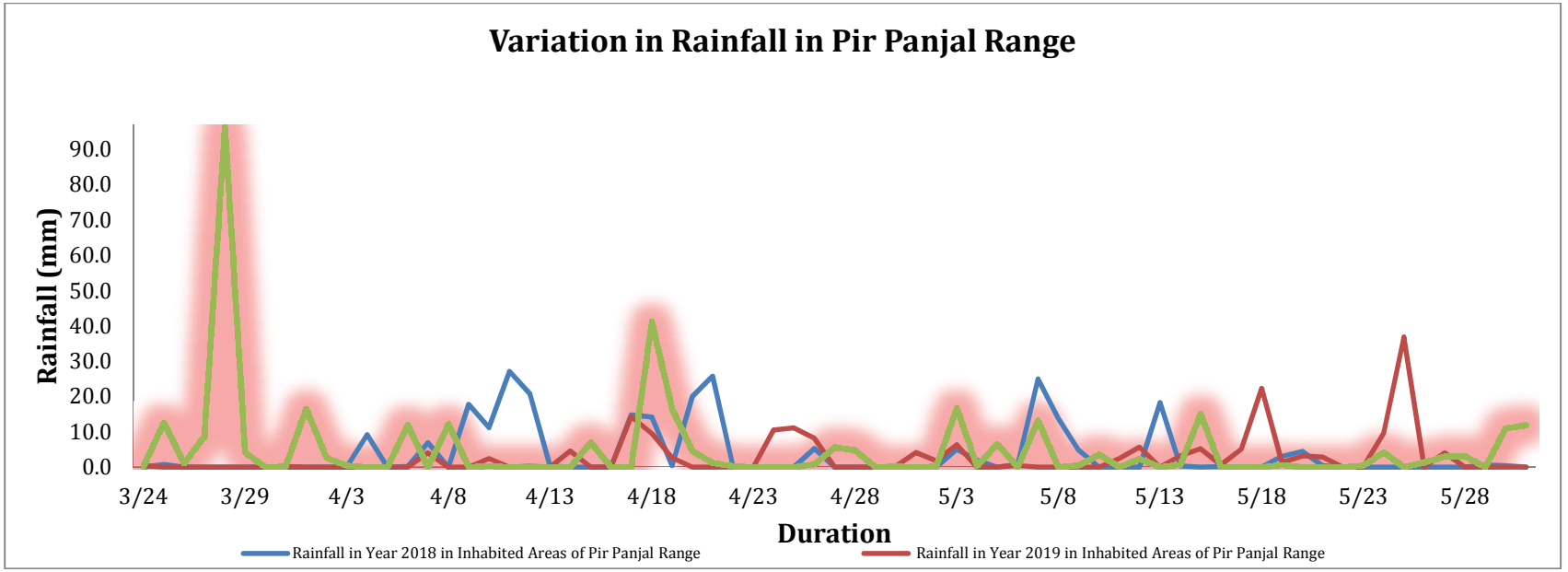

Fig. 6. Effect of complete lockdown on rainfall (mm) variation compared to Year 2018 and 2019 in Pir Panjal

4. CONCLUSION

In current situation, where we are struggling hard to curb emissions and climate change worldwide, the weather parameters during lockdown amid COVID-19 pandemic has changed quickly globally, depicting sensitivity towards reduced emissions and anthropogenic activities. However to implement complete lockdown throughout the year or for a certain time period is not possible taking care of the economical aspect but consideration of the other forms of restrictions like lockdown in phases, weekend lockdown, selective or stepwise lockdown like policies can reduce the pace of changing climate and weather worldwide. In the current study where the significant variation in temperature and rainfall in both NW foothills of Shivaliks and Pir Panjal has highlighted the effect of imposed restriction on industrialization and anthropogenic activities, there is a need to frame policies based on the impacts observed to conserve the natural resources and to reduce the impact on climate for sustainable livelihood and long term healthy effects on soil and plant quality. Thus, it can be concluded that complete lockdown amid COVID-19 pandemic emerged as an efficient tool in terms of restoring regional climate change and mitigating the pace of climate change.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Friedlingstein P. et.al. Supplemental data of the Global Carbon Budget 2019: ICOS-ERIC Carbon Portal; 2019. Available:https://doi.org/10.18160/gcp-2019.
2. Peters G, PCorinne Le Quéré, Robbie M. Andrew, Josep G. Canadell, Pierre Friedlingstein, Tatiana Ilyina, Robert B. Jackson, Fortunat Joos, Jan Ivar Korsbakken, Galen A. McKinley, Stephen Sitch, Pieter Tans. Towards real-time verification of CO2 emissions, Nat. Clim. Change. 2020;7:848–850. Available:https://doi.org/10.1038/s41558-017-0013-9.
3. Solaymani S. CO2 emissions patterns in 7 top carbon emitter economies: The case of transport sector. Energy. 2019;168:989–1001.
4. Borunda A. Climate change is roasting the Himalaya region, threatening millions, Over 200 scientists collaborated on a report that forecasts a hot future for the high mountains of Asia. NGC; 2019. Available:www.nationalgeographic.com
5. Sivakumar K, Sathyakumar S, Rawat GS. A preliminary review on conservation status of shiwalik landscape in northwest India. India Environment Portal; 2010. Available:http://www.environmentportal.in/files/Shivalik.pdf
6. Agarwal DK, Farooquee NA, Samal PK, Sharma S, Palni LMS. Siwalik Development Strategy I. Action Plan. G.B. Pant Institute of Himalayan Environment and Development, almora; 2002.
7. J&K beats global warming average; 2017. Available:https://www.dnaindia.com/india/report-jk-beats-global-warming-average-2344622
8. Paul Yash. Economic potential of Pir Panjal region in J&K state. International Journal of Advanced Research and Development. 2017;2(6):499-502.
9. WHO. Coronavirus disease 2019 (COVID-19) Situation Report–63; 2020. Availableat:.https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200323-sitrep-63-covid-19.pdf?sfvrsn=b617302d_4.
10. Mandal Indrajit, Pal Swades. COVID-19 pandemic persuaded lockdown effects on environment over stone quarrying and crushing areas. Sci Total Environ. 2020;732:139281.
11. Gupta N, Tomar A, Kumar V. The effect of COVID-19 lockdown on the air environment in India. Global Journal of Environmental Science and Management. 2020;6(SI):31-40.
12. ESA; 2020. Available:https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-5P/COVID-19_nitrogen_dioxide_over_China
13. Singh Mahinder, Vikas Vishaw, Sharma Charu, Sharma Rohit. Effect of Lockdown amid COVID-19 Pandemic on Weather Parameters of Mid Hill Region of Jammu District of J&K, UT. International Journal of Environment and Climate Change. 2020;10(9):53-77.
14. Williams KD. Greenhouse effect: Greenhouse gases and their impact on global warming. Journal of Scientific Research & Reports. 2017;17(6):1-9.

15. Manabe S. Role of greenhouse gas in climate change. Dynamic Meteorology and Oceanography. 2019;71(1):1-13.
16. Ghosh Sasanka, Das Arijit, Hembram Tusar Kanti, Saha Sunil, Pradhan Biswajeet, Alamri Abdullah M. Impact of COVID-19 Induced Lockdown on Environmental Quality in Four Indian MegacitiesUsing Landsat 8 OLI and TIRS-Derived Data andMamdani Fuzzy Logic Modelling Approach. Sustainability. 2020;12:5464.
DOI:10.3390/su12135464.
17. Monserrate Manuel A. Zambrano, María Alejandra Ruano, Luis Sanchez-Alcalde. Indirect effects of COVID-19 on the environment. Science of the Total Environment. 2020;728:1-4.
18. Patni Kiran, Jindal Manoj Kumar. A positive perspective during COVID-19 related to groundwater crisis. Groundwater for Sustainable Development. 2020;11:1-2.
19. Uchiyama R, Okochi H, Katsumi N, Ogata H. The impact of air pollutants on rainwater chemistry during "urban-induced heavy rainfall" in downtown Tokyo, Japan. J. Geophys. Res. Atmos. 2017;122:6502–6519.
Available:https://doi.org/10.1002/2017JD026803.
20. American Association for the advancement of Science. Air Pollution Can Prevent Rainfall. Science Daily; 2020.
Available at: www.sciencedaily.com/releases/2000/03/000 314065455.htm. (Accessed 18 May 2020).
21. Bhat Bilal Ahmad, Kumar Parmil, Riyaz Shazia, Manzoor Shazia, Geelani SNZ, Tibetbaqal Aadil, Ashraf Syed Sabahat, Sultan Mir Misba. Local perception of climate change, COVID-19 and their impact on birds in Jammu and Kashmir. International Journal of Science and Healthcare Research. 2020;5(2):183-192.
22. Harvey C. CO2 can directly impact extreme weather, Research Suggests; 2018.
Available:www.scientificamerican.com

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/62402