Journal of Climate Change, Vol. 9, No. 3 (2023), pp. 15-25.
DOI 10.3233/JCC230020

Trend Analysis of Climatic Variables and their Possible Impact on the Health of People in Himachal Pradesh, India

Himani Narwal, Nisha Rani* and Neha
Department of Environmental Sciences, Himachal Pradesh University, Shimla – 171005
Himachal Pradesh, India
✉ nishaharpal@gmail.com

Received March 24, 2023; revised and accepted July 19, 2023

Abstract: Climate variability has significant implications for human health, necessitating a comprehensive understanding of the relationship between the two. The present study examines the trend analysis of climatic variables, and their possible impacts on health and identifies specific challenges faced by the people of Himachal Pradesh, India. The Mann-Kendall test, a non-parametric test, was used to examine temperature and rainfall trends. A survey was conducted to gauge public awareness regarding climate change and its health risks in the region. The study analysed weather patterns over 10 years, revealing fluctuating temperatures with the hottest years being 2012, 2015-17. Rainfall exhibited irregular patterns with less rainfall in 2012, 2014, 2017 and 2019. Trend analysis showed significant temperature trends in Dharamshala and Kangra. Weather-related incidents and fatalities peaked during 2012-14, while diseases, such as acute respiratory infections (ARI), asthma, cardiovascular diseases, diabetes, hypertension, and vector and water-borne diseases saw an increase over the decade. The survey results showed that the people of this region suffered mostly from respiratory problems, water-borne diseases and mental health issues. This study contributes to the existing knowledge by establishing a possible relationship between climate variability and the health of the people. Furthermore, it also provides a health database, facilitating the formulation of targeted interventions to address health-related challenges arising from the observed changes in weather patterns.

Keywords: Climate change awareness; Mann-Kendall test; Increasing temperatures; Respiratory problems; Vector and water-borne diseases.

Introduction

Climate variability refers to the fluctuations and changes in climatic patterns over time, including natural variations as well as those influenced by human activities. It is characterised by shifting weather patterns, such as changes in temperature, precipitation, humidity, and extreme weather events (WMO, 2022). These variations have significant implications for human health and well-being. Direct impacts arise from extreme weather events, such as heatwaves, heavy rains, floods, and droughts. These events can lead to a range of health complications, including heat-related illnesses such as heatstroke, cardiovascular diseases, skin burns, exhaustion, and dehydration (WHO, 2022). Indirect impacts on health are mediated by the natural systems affected by climate variability.

Changes in temperature and precipitation can influence air quality, water availability, and the distribution of disease vectors, leading to the spread

*Corresponding Author

of vector-borne and water-borne diseases (McMichael et al., 1998). Additionally, altered weather patterns can contribute to mental stress and trauma, occupational hazards, and undernutrition, all of which have implications for human health (WHO, 2022). Global studies have shown that disasters related to extreme weather events, including floods and storms, have significant health consequences, leading to stress, displacement, and the spread of diseases (Ebi et al., 2021). In India, the increasing trend of heatwaves and rising temperatures over the past fifteen years has been associated with various health issues (Kumar et al., 2020). Additionally, wildfires, often exacerbated by climate variability, have severe direct health effects, including burns, injuries, and mental health impacts due to property loss, displacement, and traumatic experiences (Xu et al., 2020).

Understanding the relationship between climate variability and its impacts on human health is crucial for developing effective adaptation and mitigation strategies. National-level plans such as the National Programme on Climate Change and Human Health in India, play a crucial role in evaluating and implementing actions to address these challenges (Kumar et al., 2020). However, to formulate targeted and evidence-based interventions, it is essential to conduct temporal and spatial-specific research that considers local contexts and health data (Mall et al., 2017). In Himachal Pradesh, several initiatives like State Action Plan on Climate Change, Health Adaptation Plan and Disaster Management Framework outline the strategies to enhance adaptive capacity and healthcare infrastructure (SAPCC, 2012; HAP, 2012). In this study, we aim to explore the possible impacts of climate variability on the health of the people of Himachal Pradesh, India. By analysing changing weather patterns and their possible association with health outcomes, we seek to contribute to the understanding of the specific challenges faced by the people. The findings of this study provide us with a health database that can serve as an entry point for interventions to tackle climate-related health issues.

Materials and Methods

Study Area

The study is based in Himachal Pradesh (H.P) which is a hilly state located in the North-West of India. Its climate is diverse and ranges from semi-tropical to semi-arctic. The geographical coordinates i.e., latitude is 30º22.40 N to 33º12.20 N, and longitude is 75º45.55 E to 79º04.20 E. Its altitude ranges from 350 meters to 6975 meters (m) above mean sea level (GoHP, 2014). The population of Himachal Pradesh is 68.65 lakh (Census, 2011). The state is comprised of 12 districts (Figure 1).

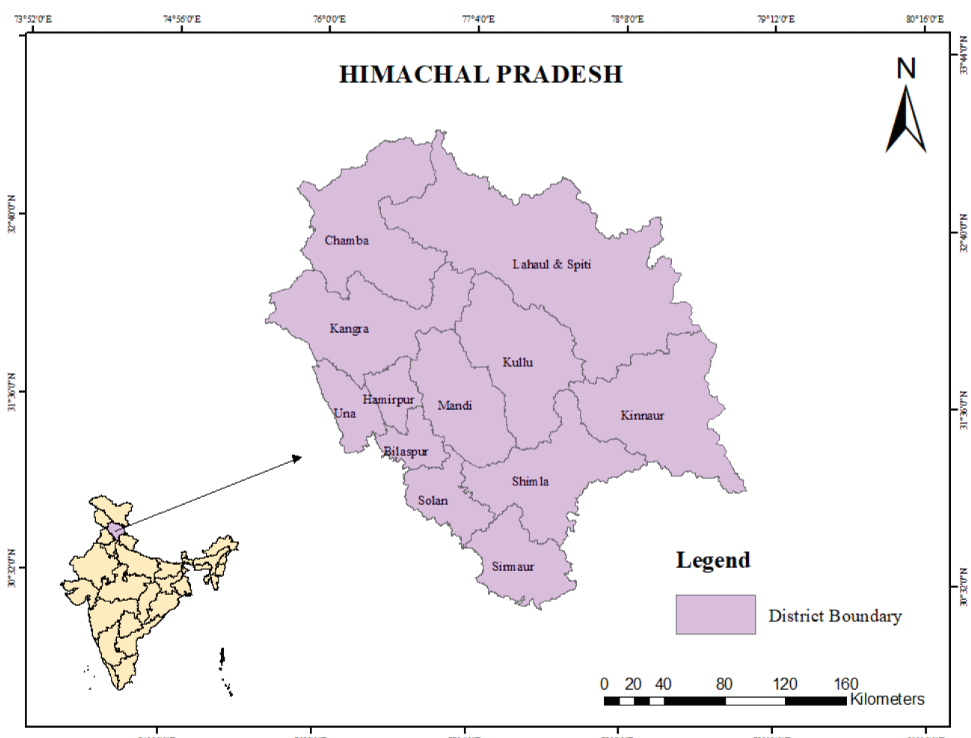


Figure 1: Himachal Pradesh with its district boundaries.

Survey Studies

A survey was conducted to understand the awareness of climate change and the health risks associated with it in the people of Himachal Pradesh. The questionnaire was distributed to the people through online applications from July to October 2021. 255 people from different age groups responded to it. The study was time-sensitive and was done during the ongoing pandemic, hence the "Convenience Sampling" method was used. It is a type of non-probability sampling where a particular group of people, especially those who are easy to reach represents the whole population.

Database Creation

Monthly meteorological data of 10 different places in Himachal (Shimla, Solan, Kangra, Dharamshala, Una, Sundernagar, Nahan, Keylong, Kullu and Kalpa) for the period 2010 to 2020 was obtained from Meteorological Centre, Shimla. Reports on Accidental Deaths and Suicides in India (ADSI) uploaded by the National Crime Records Bureau (NCRB) on the Ministry of Home Affairs website were considered to obtain data on accidental deaths caused due to forces of nature for the period 2010-2020. Statistical data on cloudburst and landslide incidents and related deaths was provided by Himachal Pradesh State Disaster Management Authority (HPSDMA). The statistics of deaths caused due to various diseases were derived from the reports on Medical Certification of the Cause of Death (MCCD) of the Government of India for the base period 2010-2019. National Health Profiles (NHP, 2010-2019) by the Central Bureau of Health Intelligence provided us with necessary statistical data on common health conditions, communicable and non-communicable diseases of Himachal Pradesh.

Trend Analysis Using the Mann-Kendall Test

Analysis of meteorological trends has been done using the "Mann-Kendall test" which is a non-parametric test (Hamid et al., 2014). It is used for the detection/analysis of significant trends in maximum temperature ($T_{\max}$), minimum temperature ($T_{\min}$) and rainfall. In the Mann-Kendall test, each value of the time series is compared with the remaining data in sequential order. The Mann-Kendall Statistic S is the sum of all counting:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sgn(x_j - x_k) \qquad (1)$$

$$\text{sgn}\,(x_j - x_k) = \begin{cases} 1\, if\, (x_j - x_k) > 0 \\ 0\, if\, (x_j - x_k) = 0 \\ -1\, if\, (x_j - x_k) < 0 \end{cases} \qquad (2)$$

where x_j and x_k are the sequential data values, n is the length of the data set. The value of S shows the direction of the trend. The upward trend is indicated by the positive value of S and the downward trend is indicated by a negative value. The test is conducted using a normal distribution with the mean and variance as follows.

$$E(S) = 0$$

$$\text{Var}\,(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{q} t_p (t_p - 1)(2t_p + 5) \right] \qquad (3)$$

where t_p is the number of data points in the p^{th} tied group and q is the number of tied groups in the data set. The standardised test statistics (Z_{mk}) is calculated as:

$$Z_{mk} = \begin{bmatrix} \dfrac{S-1}{\sqrt{Var}(S)} & if & S > 0 \\ \dfrac{S+1}{\sqrt{Var}(S)} & if & S < 0 \\ 0 & if & S = 0 \end{bmatrix} \qquad (4)$$

where the value of Z_{mk} is the Mann-Kendall test statistics. It follows a standard normal distribution with a mean of zero and a variance of one.

Evaluation of trends using the Mann-Kendall test depends on two important statistical metrics – the significance level of the trend or the p-value and the trend slope (β) (Hamid et al., 2014). A significant trend is indicated by the p-value. 1%, 5% and 10% significance levels were chosen for a two-sided test. A p-value < 0.01 indicates that the trend is statistically significant at a 1% level of significance, p-value < 0.05 indicates that the trend is statistically significant at a 5% level of significance, whereas a p-value < 0.1 indicates that the trend is statistically significant at a 10% level of significance. Hence, the null hypothesis of no trend to the alternate hypothesis of the existence of a trend in data is checked by the Mann-Kendall test. This is valid when the number of observations $n \geq 10$.

Results and Discussion

Trends in the Weather Patterns of H.P.

The study focused on examining the temperature and rainfall patterns of several places in different districts of Himachal Pradesh over a ten-year period. The analysis aimed to gain insights into the changes in weather patterns during the time frame. The year was divided into two seasons: March to August representing the summer months, and September to February representing the winter months. The average values of the highest minimum temperature (T_{min}), highest maximum temperature (T_{max}), and monthly total rainfall were calculated spanning from 2010 to 2020.

Variations in the Temperature

From 2010 to 2011, most places recorded a decrease in temperatures in the summer months, except for Una, Dharamshala, and Keylong, which saw a slight increase. In the summer of 2012, Kangra had a significant drop, while Dharamshala witnessed a sharp rise in T_{min} (Figure 2a). In winter, Una experienced decreasing T_{min} and T_{max} until 2015, followed by an increase in the following years. Kangra's T_{min} also declined until 2013 and then gradually rose until 2017 (Figure 2b). Overall, temperature fluctuations were observed in different periods, with the hottest years identified as 2012, 2015, 2016, and 2017.

Variations in the Rainfall

Dharamshala had the highest rainfall in both the

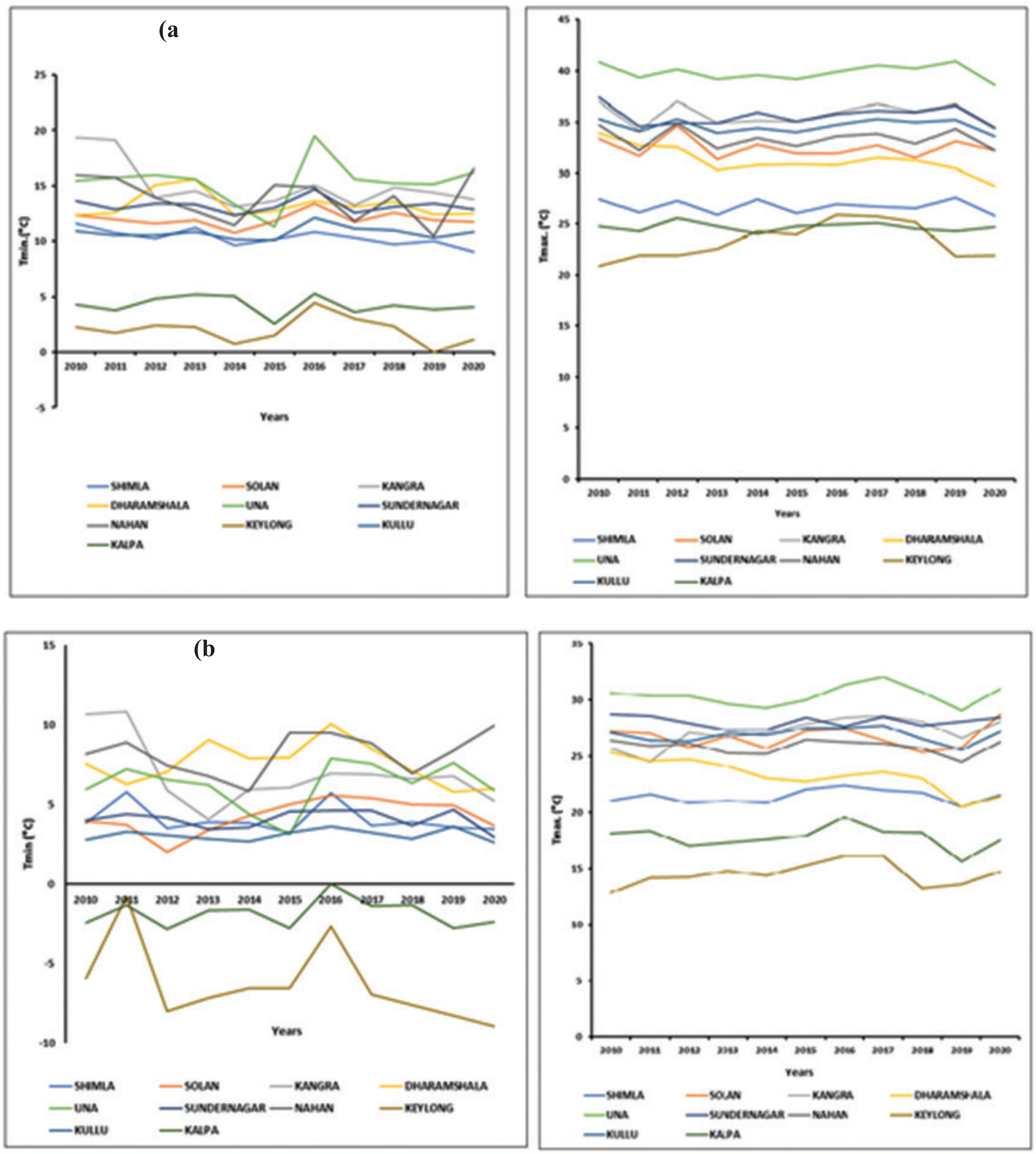


Figure 2: Variations in the minimum temperature (T_{min}) and maximum temperature (T_{max}) of the summer months (a) and the winter months (b).

summers and winters of 2012, followed by a decline in 2014. Kangra also experienced heavy showers in 2012, 2015, 2018-19. In 2013, rainfall was high in Nahan during summers (Figure 3a) but in the winters of 2011, rainfall was low (Figure 3b). Shimla too had heavy rainfall in 2014 and 2018 (Figure 3a) but the showers decreased in 2019 (Figure 3b). Sundernagar observed heavy rainfall between the summers of 2013 and 2016 but lower precipitation in the winters of 2016 and 2019. Kullu observed varying summer and winter rainfall, with maximum rainfall in 2011 and minimum rainfall in 2019. Overall, there was reduced rainfall in the summers of 2012, 2014, 2017, and 2019, whereas, in the winters of 2011, 2016, 2018, and 2020, constant rain was observed. The findings highlight the very irregular nature of rainfall patterns in Himachal Pradesh.

Trend Analysis of Temperature and Rainfall

The analysis of trends of seasonal temperature and rainfall for the decade 2010-2020 was carried out using the Mann-Kendall non-parametric test. Statistically significant trends have been indicated by the values in bold.

Table 1 describes the trends in seasonal T_{max} at different locations for the decade (2010-20) and indicates four stations with an increasing trend in their T_{max} while six stations showed a decreasing trend during the summers. However, in winter, the same number of stations showed increasing and decreasing trends. Dharamshala showed a statistically significant decreasing trend in its T_{max} at 5% and 10% levels of significance during both the summers (p = 0.043) and winters (p = 0.03). Kangra, on the other hand, showed a statistically significant increasing trend in its T_{max} at a 5% and 10% level of significance in winters (p = 0.043).

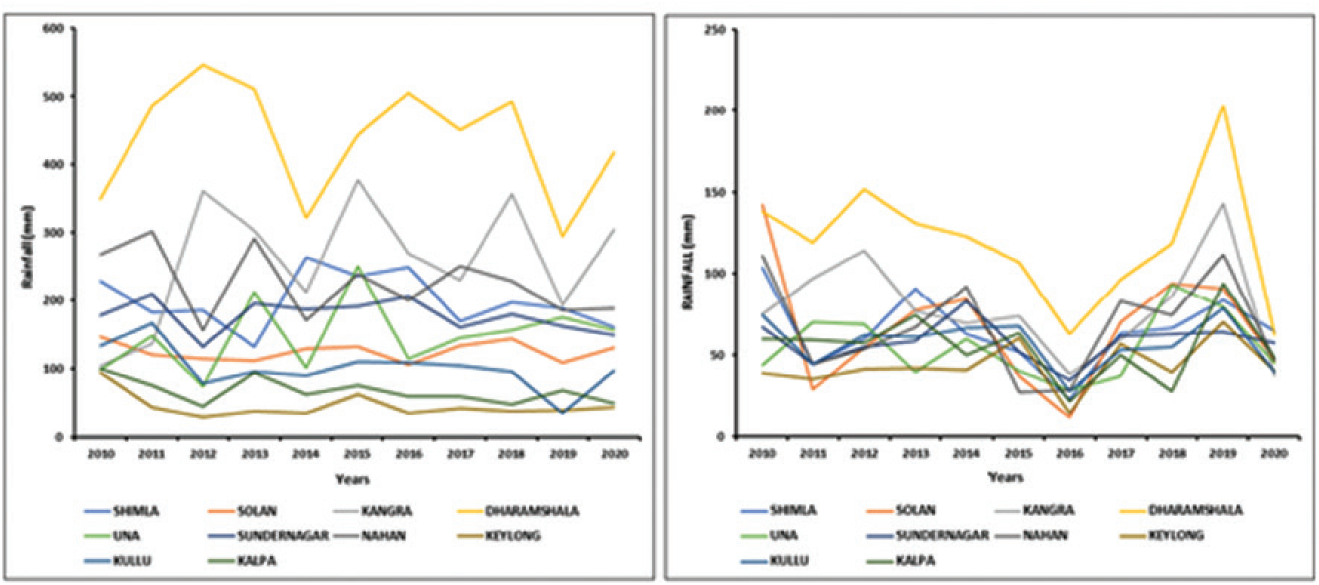
Table 2 shows the trends in seasonal T_{min}. During the summers, two stations showed an increasing trend in their T_{min} while eight stations showed a decreasing trend. However, during the winters the number of stations with increasing trends outnumbered the stations with decreasing trends in their T_{min}. Shimla showed a statistically significant decreasing trend in its T_{min} at 5% and 10% levels of significance (p = 0.029) during the summers. Keylong showed a statistically significant decreasing trend in its T_{min} at only a 10% level of significance during the winters (p = 0.062).

The number of stations with decreasing trends was more than the number of stations with increasing trends in rainfall during the summers (Table 3). However, during the winters, the same number of stations showed increasing and decreasing trends in rainfall.

Trend analysis of seasonal temperature in a study revealed that the warming was much more in winters as compared to the summers (Hamid et al., 2014). Such analysis and assessment of trends help in the identification and minimisation of vulnerable disasters (Pal et al., 2017).

Weather-Related Incidents and Deaths

The majority of weather-related incidents and deaths occurred during the period 2012 to 2014 (Table 4).



(a) (b)

Figure 3: Variations in the rainfall (mm) of summer (a) and winter (b) months.

Table 1: Trends in seasonal T_{max} at different locations for the decade (2010-20)

Sr. No.	Stations	Summers			Winters		
		Z	Slope	P	Z	Slope	P
1.	Solan	-0.15	-0.027	0.876	-0.15	-0.040	0.876
2.	Kangra	0	0	1.000	2.02	0.274	**0.043**
3.	Dharamshala	-2.02	-0.334	**0.043**	-2.95	-0.368	**0.003**
4.	Una	0.15	0.003	0.876	0.15	0.035	0.876
5.	Sundernagar	0.54	0.085	0.585	-0.23	-0.017	0.815
6.	Nahan	-0.15	-0.027	0.876	-0.7	-0.040	0.482
7.	Shimla	-0.62	-0.050	0.533	0	0.020	1.000
8.	Keylong	1.24	0.470	0.213	1.24	0.120	0.213
9.	Kullu	-0.46	-0.011	0.640	0.39	0.017	0.696
10.	Kalpa	-0.39	-0.012	-0.39	-0.15	-0.008	0.876
	No. +	4			5		
	No. -	6			5		
	No. Sig +	0			1		
	No. Sig -	1			1		

Table 2: Trends in seasonal T_{min} at different locations for the decade (2010-20)

Sr. No.	Stations	Summers			Winters		
		Z	Slope	P	Z	Slope	P
1.	Solan	-0.31	-0.013	0.755	1.01	0.175	0.310
2.	Kangra	-1.24	-0.217	0.213	-0.46	-0.081	0.640
3.	Dharamshala	0	0.007	1.000	-0.31	-0.063	0.755
4.	Una	-0.15	-0.021	0.876	0.15	0.028	0.876
5.	Sundernagar	-0.39	-0.030	0.696	0.62	0.023	0.533
6.	Nahan	-0.93	-0.233	0.350	0.77	0.113	0.436
7.	Shimla	-2.18	-0.155	**0.029**	-1.09	-0.056	0.276
8.	Keylong	-0.62	-0.080	0.533	-1.86	-0.260	**0.062**
9.	Kullu	0	0.004	1.000	0	0.000	1.000
10.	Kalpa	-0.31	-0.025	0.755	0.15	0.010	0.876
	No. +	2			6		
	No. -	8			4		
	No. Sig +	0			0		
	No. Sig -	1			1		

From 2017 to 2019, Himachal Pradesh experienced significant periods of heavy rainfall (Figure 3), which contributed to an increased occurrence of landslides. Over the past decade, approximately 1.2 billion people have been exposed to hydrometeorological hazards, highlighting the widespread impact of such events (Hashim and Hashim, 2016). In 2019, global disasters resulted in numerous fatalities worldwide, with Asia being the most affected continent. Asia accounted for 40% of total extreme weather events, 40% of total deaths, and 74% of other damages, underscoring the region's vulnerability to these hazards (Ebi et al., 2021).

Table 3: Trends in seasonal rainfall at different locations for the decade (2010-20)

Sr. No.	*Stations*	*Summers*			*Winters*		
		Z	*Slope*	*P*	*Z*	*Slope*	*P*
1.	Solan	0	-0.365	1.000	0	1.350	1.000
2.	Kangra	0.77	9.873	0.436	0.93	-3.283	0.350
3.	Dharamshala	-0.77	-6.052	0.436	-1.55	-5.487	0.119
4.	Una	1.4	7.284	0.161	0	-0.533	1.000
5.	Sundernagar	-1.09	-3.850	0.276	0.31	0.880	0.755
6.	Nahan	-1.09	-7.896	0.276	0.15	0.244	0.876
7.	Shimla	-0.46	-2.969	0.640	0.31	0.407	0.755
8.	Keylong	0.15	0.056	0.876	0.93	1.000	0.350
9.	Kullu	-1.09	-4.087	0.276	-0.46	-1.280	0.640
10.	Kalpa	-1.55	-3.375	0.119	-0.93	-1.247	0.350
	No. +	3			5		
	No. -	7			5		
	No. Sig +	0			0		
	No. Sig -	0			0		

Table 4: Accidental deaths in H.P due to natural disasters for the decade (2010-20)

Sr. No.	*Causes of death*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
1.	Avalanche	1	1	5	5	-	-	-	-	-	4	-
2.	Exposure to cold	13	21	36	37	32	23	9	15	13	3	-
3.	Flash floods/ Cloudburst	5	9	30	10	19	1	10	-	2	7	-
4.	Heat/Sunstroke	-	1	2	-	1	-	-	-	-	-	-
5.	Landslides	63	33	29	42	22	21	12	71	19	45	20
6.	Torrential rain	-	-	-	-	-	-	-	1	16	-	-
7.	Forest fire	-	-	-	-	-	1	3	11	-	8	2

Common Health Conditions

Table 5 illustrates the percentage of deaths in Himachal Pradesh caused due to common health conditions over the last decade.

In Himachal Pradesh, diabetes mellitus caused a significant number of deaths annually from 2010 to 2019, with air, water, and soil pollution playing a precipitating role. Climate change also contributed to the development and progression of diabetes (Raman, 2016). The state experienced its highest temperatures in 2012 and from 2016 to 2019 (Figure 2), coinciding with a peak in deaths due to epilepsy, a neurological disorder triggered by environmental factors such as temperature and infectious agents (Todorova et al., 2006). From 2010 to 2013, the state recorded the highest number of deaths related to malnutrition, mental and behavioural disorders, diabetes, asthma, respiratory diseases, and genitourinary system diseases. However, heart diseases and cerebrovascular diseases saw a significant increase in reported deaths from 2015 onwards. Asthma, a major consequence of air pollution and forest fires, along with other respiratory diseases, accounted for a high number of deaths in Himachal Pradesh, particularly in 2010, 2011, and 2012, aligning with the elevated temperatures during those years (Figure 2). Ecosystem changes and increased levels of pollen, fungi, and pollutants act as triggers for respiratory and allergic diseases (Demain, 2018).

From 2015 to 2018, there was a significant increase in cases of diabetes and hypertension, indicating a growing health concern (Table 6). Similarly, cardiovascular diseases experienced a tremendous surge in 2018 compared to 2015. In 2019, the incidence of common cancers reached its highest level. Lifestyle changes,

Table 5: Medically certified deaths for important diseases in H.P for the decade (2010-19)

Sr. No.	*Causes of Death*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
1.	Malnutrition	-	-	-	5	3	2	-	1	-	-
2.	Diabetes mellitus	223	240	164	235	97	134	191	212	219	241
3.	Mental and behavioural disorders	-	-	4	3	21	27	76	67	80	95
4.	Alzheimer's disease	-	-	4	6	1	-	-	-	1	-
5.	Epilepsy	18	14	54	14	9	19	46	39	45	39
6.	Ischemic heart diseases	222	278	567	346	612	649	593	669	691	684
7.	Pulmonary heart diseases	138	113	316	296	335	314	424	356	465	546
8.	Cerebrovascular diseases	139	127	374	208	237	276	338	330	339	379
9.	Upper respiratory tract diseases	21	51	6	26	57	16	7	7	9	61
10.	Lower respiratory diseases	383	344	510	695	397	458	475	453	440	554
11.	Asthma	119	97	93	47	48	33	46	29	18	53
12.	Influenza	-	-	-	-	1	18	6	8	6	3
13.	Diseases of genitourinary system	119	117	149	253	162	191	190	161	181	208

Table 6: Number of cases of common diseases in H.P for five consecutive years

Sr. No.	*Types*	*2015*	*2016*	*2017*	*2018*	*2019*
1.	Diabetes	5831	48274	58636	77845	31310
2.	Hypertension	6478	46511	74662	99432	51060
3.	Cardiovascular diseases	58	1842	1210	2150	627
4.	Stroke	-	-	116	213	110
5.	Common cancers	2	210	642	453	4503
	Total	12369	96837	135266	180093	87610

migration, social practices, and cultural factors play a substantial role in the development of heart diseases, even in the absence of genetic changes (Bhatnagar, 2017). Climate change contributes to health risks by exposing individuals to harmful UV radiation, air pollutants, toxic chemicals, poor water and food quality, and infectious agents, thereby providing pathways to certain cancers and increasing the overall cancer risk in populations (Hiatt and Beyeler, 2020).

Communicable Diseases

Communicable diseases are transmitted through respiratory droplets, vectors, water and food.

Over the last decade (2010-2019), there has been a notable increase of 27% in cases of acute respiratory infection (ARI), which are often triggered by climatic variability and airborne respiratory droplets (Table 7). These changes in climate make individuals more susceptible to such diseases, altering the immune response of the body.

Additionally, water and food contamination contributes to the transmission of water-borne and food-borne diseases. Cases of acute diarrhoeal diseases (ADD) and enteric fever (typhoid) have increased by 26% and 27%, respectively, from 2010 to 2019 in the state. The years 2014 and 2019 stand out as having the highest number of reported cases of water and foodborne diseases, coinciding with heavy rainfall during those periods (Table 8 and Figure 3). Increasing temperatures and climate change have disrupted water availability and quality, leading to an increase in water-borne diseases, affecting dissolved oxygen and carbon nitrate levels (Kumar and Singh, 2021).

Table 7: Diseases caused due to airborne respiratory droplets in H.P. during the decade (2010-19)

Sr. No.	*Types*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019 (Prov.)*
1.	Acute respiratory infection (ARI)	1364166	1484149	1484315	1631779	1523572	1591505	1649023	1551213	1594743	1730783
2.	Pneumonia (All causes)	31466	29357	26039	23409	22471	22157	20157	13648	12785	12138
	Total	1395632	1513506	1510354	1655188	1546043	1613662	1669180	1564861	1607528	1742921

Table 8: Water and food-borne diseases in H.P. during the decade (2010-19)

Sr. No.	*Type*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019 (Prov.)*
1.	Acute diarrhoeal diseases (ADD)	284548	310227	338708	349904	350459	334168	310749	314463	300059	359321
2.	Enteric fever (typhoid)	24417	28074	40041	37128	48786	40639	38093	39692	25821	31072
3.	Viral hepatitis (all causes)	2566	1248	1310	2023	2808	1739	2716	1001	1035	1663
	Total	311531	339549	380059	389055	402053	376546	351558	355156	326915	392056

In hilly areas like Himachal Pradesh, vector-borne diseases, including dengue and malaria (Table 9), have shown prevalence and are highly influenced by climatic conditions such as high temperatures and rainfall. Dengue cases saw a significant increase in 2018 compared to 2012, with an outbreak observed in the state during the monsoon of 2018 (Figure 3). The worst affected districts were Bilaspur, Solan, Mandi, and Kangra. This outbreak resulted in approximately 10 times more cases than in 2017, with a total of 4,672 reported cases. The changes in temperature and rainfall patterns create ideal breeding conditions for mosquitoes, impacting the transmission of these diseases (Medlock and Leach, 2015).

Awareness and Health Risks in the People of H.P.

A survey was conducted to check the awareness about climate change, changing weather patterns and its observed impacts on the health of the people of Himachal Pradesh. About 50.2% of females and 49.8% of males participated in this survey. A maximum number of participants in the survey were of an average age group of 18-27 years.

The survey as shown in Figure 4 revealed that 80.7% of respondents expressed concern about the changing weather patterns and pollution in the state. Depletion of natural resources, overpopulation, food and water scarcity, wildfires, and congestion were also noted. Health impacts included mental health effects, allergies and asthma, heat stress, respiratory and heart diseases, injuries from extreme weather events, waterborne diseases, and malaria and dengue. Individual responsibility for addressing climate change was acknowledged by many individuals. These findings reflect widespread concern about climate change, its possible influence on health, and the desire for proactive measures to tackle this global challenge. Natural disasters, global warming and climate change also affect the mental health of people as much as their physical health by triggering aggression, suicidal tendencies, stress disorders, psychological distress, and depression in them (Padhy et al., 2015).

Table 9: Vector-borne diseases in H.P. during the decade (2010-19)

Sr. No.	*Types*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019 (Prov.)*
1.	Malaria	210	247	216	141	102	60	106	96	98	109
2.	Dengue	3	-	73	89	2	19	322	452	4672	344
	Total	213	247	289	230	104	79	428	548	4770	453

Figure 4: Responses of the participants.

Conclusion

Climate variability, characterised by shifting weather patterns, has significant implications for human health and well-being. It affects human health through direct impacts of extreme weather events and indirect impacts on natural systems. By analysing changing weather patterns and their association with health outcomes, the study aimed to contribute to the understanding of the specific challenges faced by the people. However, the analysis shows only a suggestive relationship between the two variables and this study can be used as a seed to carry out future studies in a more scientific manner. The findings highlight the need for targeted interventions and evidence-based decision-making to address climate-related health risks. It also provides a valuable health database that can serve as a foundation for future interventions.

Acknowledgement

We are very thankful to the Chairperson, Department of Environmental Sciences, Himachal Pradesh University, Shimla; Meteorological Department, Shimla and Himachal Pradesh State Disaster Management Authority, Shimla for their support and assistance.

References

Bhatnagar, A., 2017. Environmental determinants of cardiovascular disease. *Circulation Research*, **121(2):** 162-180.

Demain, J.G., 2018. Climate change and the impact on respiratory and allergic disease: 2018. *Current Allergy and Asthma Reports*, **18:** 22.

Ebi, K.L., Vanos, J., Baldwin, J.W., Bell, J.E. et al., 2021. Extreme weather and climate change: population health and health system implications. *Annual Review of Public Health*, **42:** 293-315.

Government of Himachal Pradesh, 2012. Health Adaptation Plan. Retrieved from http://dest.hp.gov.in/

Government of Himachal Pradesh, 2014. Retrieved from https://himachal.nic.in/

Government of Himachal Pradesh, 2021. State Action Plan on Climate Change (SAPCC). Retrieved from http://dest.hp.gov.in/

Hamid, A.T., Sharif, M. and Archer, D., 2014) Analysis of temperature trends in Satluj river basin, India. *Journal of Earth Science and Climatic Change*, **5(8):** 222.

Hashim, J.H. and Hashim, Z., 2016. Climate change, extreme weather events, and human health implications in the Asia Pacific Region. *Asia-Pacific Journal of Public Health*, **28(2):** 8S-14S.

Hiatt, R.A. and Beyeler, N., 2020. Cancer and climate change. *The Lancet Oncology*, **21(11):** e519-e527.

Kumar, A. and Singh, D.P., 2021. Heat stroke-related deaths in India: An analysis of natural causes of deaths, associated with the regional heatwave. *Journal of Thermal Biology*, **95:** 102792.

Kumar, A., Mahajan, N.P., Sorokhaibam, R., Sunthlia, A., et al., 2020. National programme on climate change and human health-India, 2019. *Journal of Communicable Diseases*, **52(3):** 43-48.

Mall, R.K., Singh, N., Prasad, N., Tompkins, A. and Gupta, A., 2017. Impact of climate variability on human health: A pilot study in tertiary care hospital of Eastern Uttar Pradesh, India. *Mausam*, **68(3):** 429-438.

McMichael, A.J., Patz, J. and Kovats, R.S., 1998. Impacts of global environmental change on future health and health care in tropical countries. *British Medical Bulletin*, **54(2):** 475-488.

Medlock, M.M. and Leach, S.A., 2015. Effect of climate change on vector borne disease risk in the UK. *The Lancet Infectious Diseases*, **15(6):** 721-730.

Office of the Registrar General & Census Commissioner, India, 2011. Census of India. Retrieved from https://censusindia.gov.in/

Padhy, S.K., Sarkar, S., Panigrahi, M. and Paul, S., 2015. Mental health effects of climate change. *Indian Journal of Occupational and Environmental Medicine*, **19(1):** 3-7.

Pal, A.B., Khare, D., Mishra, P.K. and Singh, L., 2017. Trend analysis of rainfall, temperature and runoff data: A case study of Rangoon watershed in Nepal. *International Journal of Students' Research in Technology and Management*, **5(3):** 21-38.

Raman, P.G., 2016. Environmental Factors in Causation of Diabetes Mellitus. *In:* Environmental Health Risk - Hazardous Factors to Living Species, Larramendy, L.M. and Soloneski, S. (eds.). IntechOpen, London, UK, 231-245p.

Todorova, M.T., Mantis, J.G., Le, M., Kim, C.Y. and Seyfried, T.N., 2006. Genetic and environmental interactions determine seizure susceptibility in epileptic EL mice. *Genes, Brain, and Behavior*, **5(7):** 518-527.

World Health Organization (WHO), 2022. Retrieved from https://www.who.int/

World Meteorological Organization (WMO), 2022. Retrieved from https://public.wmo.int/en

Xu, R., Yu, P., Abramson, M.J., Johnston, F.H., Samet, J.M., Bell, M.L., Haines, A., Ebi, K.L., Li, S. and Guo, Y., 2020. Wildfires, global climate change, and human health. *The New England Journal of Medicine*, **383(22):** 2173-2181.