Jñānābha, Vol. 49(1) (2019), 1-10

TIME SERIES ANALYSIS OF HEAT STROKE

By

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(*Received : January* 24, 2018 ; *Revised: March* 26, 2019)

Abstract

India in terms of Travel and tourism has been ranked at the 40^{th} globally as per the list of World Economic Forum. Tourism is one of the main source of earning in our country, as it helps in Earning of Foreign Exchange from Tourism (PR) in terms of INR (1 crore=10 million), 135193 crores, Rate of Annual Growth 9.6%, in US$ terms Billion US $ 21.07, Rate of Annual Growth 4.1%, which means a lot for the country and holds good share in GDP of India. The amount of carbon dioxide released by the public transports such as buses, cars and air ways are affecting the air in the atmosphere highly. The rapid increase in the temperature causing deaths due to heat stroke, thus, it is important to take preventive measures to reduce the emission of carbon dioxide to control global warming. The paper studies about the change in the predictability of the temperature using time series analysis for the factors which may affect chaotic situation leading to the increase in death rates due to heat stroke also studying the regression analysis and descriptive statistics of the data of both tourism and temperature. Increase in temperature causes hazardous change in environment in form of Global Warming. Anti-persistence behavior is observed which is alarming due to the chaotic nature thus government may take directives as emphasized by global initiative like Paris Climate Agreement 2015 in direction of controlling the carbon emission and reducing Global Warming.

2010 Mathematics Subject Classification: 37C45

Keywords and phrases: Time Series, Predictability Index, Global Warming, CO emission, Chaos.

1 Introduction

India is a country of flora and fauna with different climate throughout the year as summer, winter, spring, autumn, monsoon. Industry of Tourism is increasing day by day in terms of volume and in terms of its importance economically. Many places have gained attention over past few years as Holiday destination. Despite the fact that now and since past few years the economy of the Holiday destination has become vulnerable as a result of Climate change. Temperature is increasing both globally and regionally as well. Climate change have lead increase in risk of illness across the world which will result in discouragement of Tourism.

As per the suggestion of climate models a future warning of 0.2 0.3 oC per decade and it is expected a rise of 4-10 cm in the sea level per decade. Climate has important role

to play in promotion of tourism for places such as beaches, Hill Station and water sports and the continuous increase in hazardous gases affecting climate and weather is also gravely affecting the other economic activities. The aviation sector is going through tremendous pressure since the intergovernmental panel on climate change (IPCC) and environmental campaign groups have discussed and signed the reason of rise in the global greenhouse gas emissions due to air travels. It has been seen that world-wide, 16000 commercial air ways produces above 600 million tons of CO2 every year, India produces 10 million tons of CO2 from all sectors ranking 5th next to US, China, Russia, Japan. Increase in green-house gas concentration can affect the all over rise in days of rain to an intensity of 1-4mm/day apart of areas in northwest India their rainfall has decreased intensity by 1mm/day. The paper studies about the nature of temperature pattern of every five years from 1901 to 2015 and further the death of human beings due to heat stroke increasing every year. The paper will also study about the increase in the tourism sector and further modes of transportation used which contributes in the emission of CO2 causing global warming, hence increase in the temperature.

Bhardwaj et al [2-8] studied various statistical characteristics, Wavelets and Fractal Methods of various real-life phenomena to forecast weather, rainfall, environment data. Becken et al. [9] studied the impacts of weather on tourist Travel. Bodri [10] applied Rescaled Analysis in order to analyze the Annual mean surface Temperature of different stations in Hungary. Hu. et al. [15] measured destination attractiveness: a contextual approach. Maddison [16] studied the change in the flow of British tourism as an impact of climate change. Morgan et al. [17] calculated climate index for improved user-based beach. Nyaupane et al. [18] studied the impact of climate change on nature-based tourism in the Nepalese Himalayas. Robinson et al. [19] discussed the effects on environment of rise in Carbon Di Oxide. Witt et al. [20] forecasted tourism demand. Wei et al. [23] gave concepts of Time Series Analysis – Univariate and Multivariate Methods. None of the authors have studied the time series, predictability analysis of heat stroke.

2 Methodology

The paper studies different measures of analysis to study the temperature patterns.

2.1 Analysis of Regression:

Analysis of Regression is a method for studying relationship among the dependent and independent variable. regression Analysis is used for the purpose of Forecasting and also to study how dependent and independent variables are related. Equation can be represented as , where Y is the variable which depends (implies ordinate hence Y axis), X is a variable which is independent (implies abscissa hence X axis), b is the slope; y-intercept is denoted as a.

2.2 Hurst exponent:

Hurst exponent refers to the index of dependence. Hurst exponent value ranges between 0 and 1. H equals to 0.5 implies true random walk (that is time series which is Brownian). When H is in range of 0.5 to 1 persistence response (positive autocorrelation) exists. H is in range of 0 and 0.5 then anti-persistence response (non-positive autocorrelation) exists. A cyclic response is seen as Increase will be followed by decrease and vice-verse. Mean Reversion term used for this behavior.Algorithm for the calculation on Rescaled Range:

1. Average of the Series is Calculated by:
$$\bar{y} = \frac{1}{n}\Sigma_{i=1}^{n} y_i. \tag{2.1}$$
2. Generate a Series of Adjusted Averages:
$$Z_t = Y_t - \bar{y}, t = 1, 2, 3, ..., n. \tag{2.2}$$
3. Now, Generating Series of deviated Sum:
$$X_t = \Sigma_{i=1}^{n} Z_t, t = 1, 2, 3, ..., n. \tag{2.3}$$
4. Series of Range is Generated as R:
$$R_t = max(a_1, a_2, ..., a_n) - min(a_1, a_2, ..., a_n), t = 1, 2, 3, 4, ..., n. \tag{2.4}$$
5. Generate Series of Standard Deviation S:
$$S_t = \sqrt{\frac{1}{t}\Sigma_{t=1}^{n}(X_i - \bar{x}(t))}^{2}, t = 1, 2, 3, 4, ..., n, \tag{2.5}$$
where, $\bar{x}(t)$ is denoted as the average of Series 't'
6. Obtaining the rescaled range series (R/S)
$$(\frac{R}{S})_t = \frac{R_t}{S_t}, t = 1, 2, 3, 4, ..., n. \tag{2.6}$$

2.3 Fractal Dimension:

Fractal dimension is a method of studying how completely fractal fill in the space, as expanded to superior to superior scale. Dimension of Fractal is the Haussdrof Dimension
$$D_H = \lim_{\phi \longrightarrow \infty} [\frac{ln[X(\phi)]}{(ln[\phi])}],$$
where $[X(\phi)]$ is denoted as number of radius of open balls to complete the whole set.

Now, as per the above calculations of Hurst exponent; further calculations can be done.

2.4 Predictability Index:

It analyzes the nature of series of time. Predictability Index (P.I.) is given by
$$P.I = 2|D - 1.5|.$$

The value of P.I. rises resulting in D more or less than 1.5. If value comes near 0 then it is called Brownian motion and hence non-predictable.

3 Results

Foreign Tourist arrival is the major source of income in the tourism sector as every year we have increasing number of tourists visiting India to the India monuments, Beaches, Hill stations. The main source of transportation used by the tourists is Airways whose fuel emits CO2 and other hazardous gases which hence leads to increase in the temperate, Humidity, weather changes and further climate changes such as late monsoon, unexpected rainfall. Table 3.1 shows the number of FTAs per year in India. Global warming is affecting the tourism in other way, the number of FTAs is not even throughout the year the peak months are May, June, July [18].

May and June are the lean months as they are the hottest months of the year and as a result FTAs are lesser in these months. The months of highest attraction are January, March and December. The most opted mode of transportation by the tourists is air ways and then followed by the land and then sea.

Table 3.1: Number of FTAs in India since 1981-2015

Year	FTAs in India	Year	FTAs in India
1981	1279210	1999	2481928
1982	1288162	2000	2649378
1983	1304976	2001	2537782
1984	1193752	2002	2384364
1985	1259384	2003	2726214
1986	1451076	2004	3457477
1987	1484290	2005	3918610
1988	1590661	2006	4447167
1989	1736093	2007	5081504
1990	1707158	2008	5282603
1991	1677508	2009	5167699
1992	1867651	2010	5775692
1993	1764830	2011	6309222
1994	1886433	2012	6577745
1995	2123683	2013	6967601
1996	2287860	2014	7679099
1997	2374094	2015	8027133
1998	2358629		

Table 3.2: Descriptive statistics of Temperature and Tourism

STATISTICAL MEASURES	TEMPERATURE	TOURISM
MINIMUM VALUE	29.050	1193752
MAXIMUM VALUE	30.030	8027133
QUARTILE 1	29.363	1714391.750
QUARTILE 3	29.818	4922919.750
MEDIAN	29.710	2379229
MEAN	29.649	3259631.118
VARIANCE (n-1)	0.116	4255831032363.020
STANDARD DEVIATION (n-1)	0.340	2062966.561

Now, The Statistical measurements made in the above table are necessary in order to analyze central tendencies of data. Mean gives the expected average value about which the data is supposed to be symmetrically distributed while the standard deviation gives information about the deviation of data points from the mean. Variance shows the deviation in the data from the mean. Quartile is middle value such as Q1 is the middle number between the smallest number and the median of the data set; Q3 is the middle value between the median and the highest value of the data set. Median is the value which is average of the middle most value of the data set.

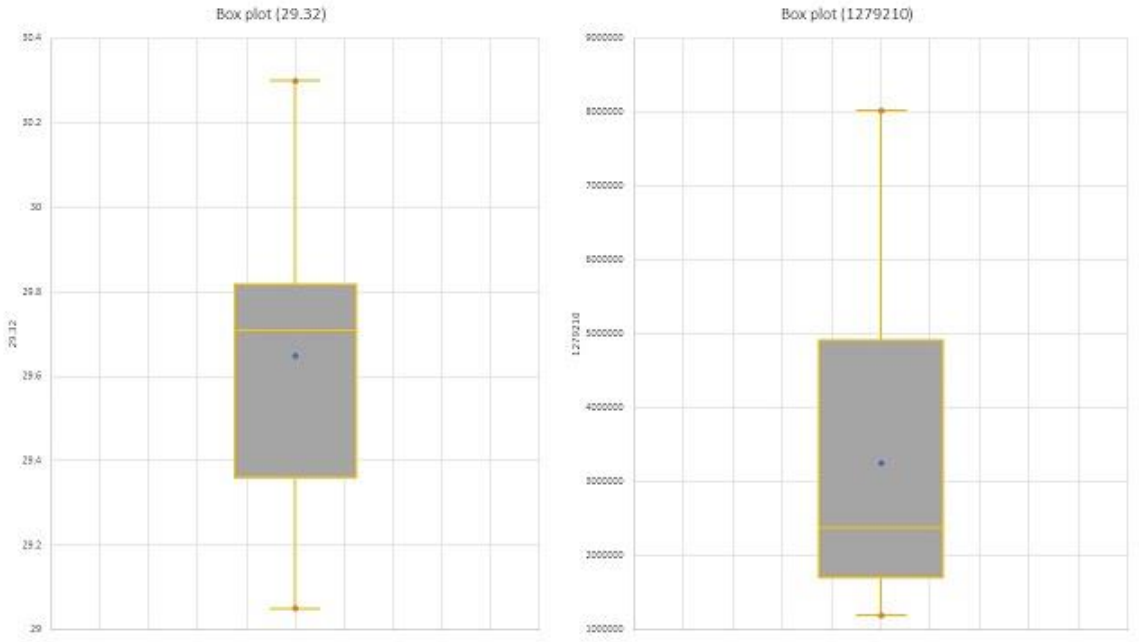

Figure 3.1: Graph 1: Box plot of Temperature and Tourism

Further, regression calculation has been done as follows; where X is temperature the independent variable and Y implies tourism the dependent variable:

Table 3.3: Regression calculation of Temperature and Tourism

REGRESSION	XY
MULTIPLE R	0.529277
R SQUARED	0.280134
STANDARD ERROR	0.292363

As per study it can be seen that there are certain months which are peak months of FTA and few are Lean month; such as U.S, U.K, Bangladesh, Canada, Malaysia, Australia, Russia, Singapore and Pakistan have peal months as December with a share of 14%, 9.4%, 12.2%, 13.7%, 10.5%, 18.2%, 19.5%, 12%, 11.9% respectively. March has FTAs with a share of 10.7%, 12.6% from Sri Lanka and Germany. January shares 10.8%, 10% share of FTAs from Japan and France and for October and November the FTAs arrival from Nepal and China is 11.7% and 11.2%. With peak months there are some Lean months too; the months in which the FTA arrival is lesser such as 4.2%, 4.5%, 5.1%, 4.8%, 1.7%, 6.7% of Bangladesh, Canada,

Australia, Germany, Russia, Pakistan and 6%, 4.8%, 6.3% share of May of the countries Sri Lanka, France, China. April shows 6.5% 6.7%, 6.7% for Malaysia, Nepal, Singapore. For January, July, September share is 6.5% U.K, 6.8% Japan, 4.9% U.S.

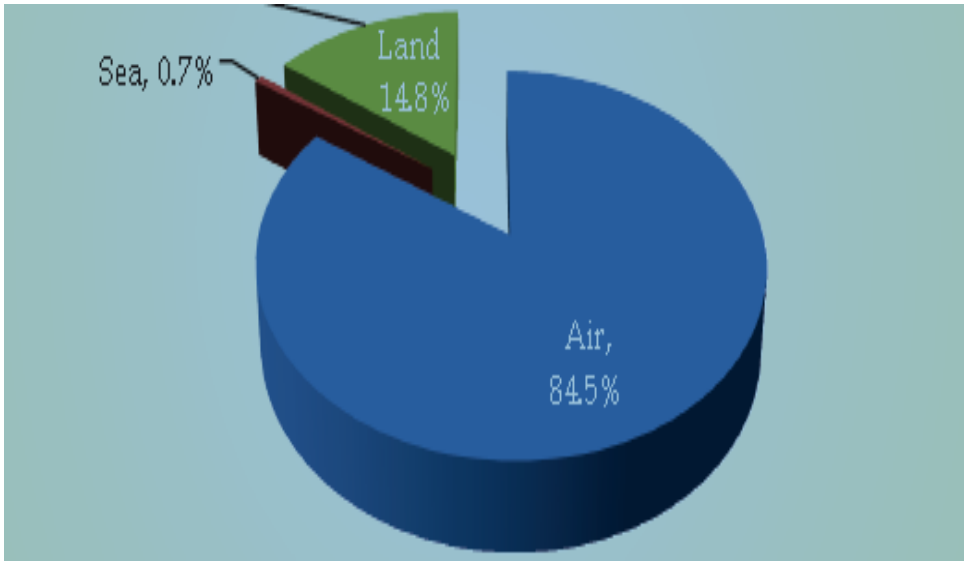

Figure 3.2: Pie-Chart of Mode of Travel of Foreign Tourist Arrivals in India, 2015

The below data shows the most preferred mode of transportation is air ways by the FTAs, and air ways have high contribution to the emission of CO2 which is further causing global warming and hence increase in temperature. The change in the color of the marble of Taj Mahal to slightly yellowish, increase in the death rate due to heat stroke, drought, melting of ice, increase in sea water level.

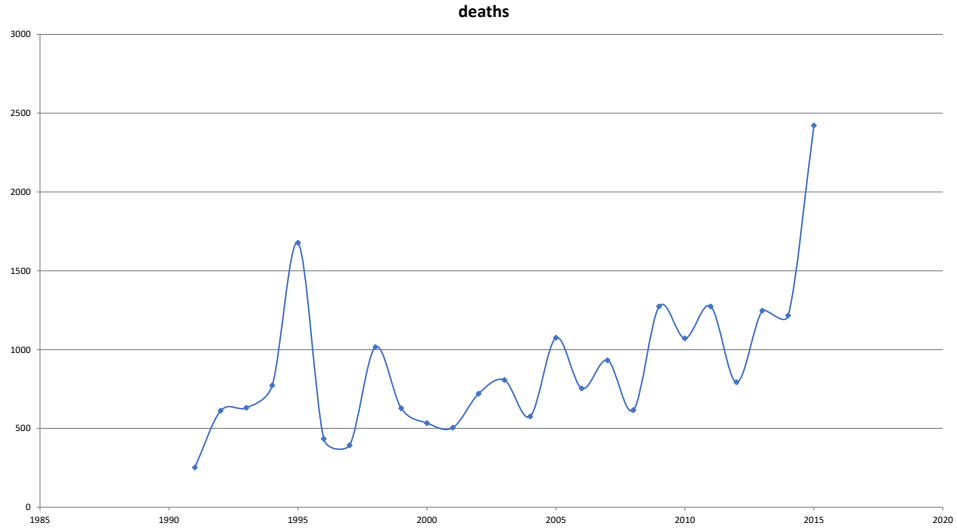

Figure 3.3: Time series of yearly Deaths due to heat stroke from 1991-2015 [National Disaster Management Authority]

The increasing death rate of the human beings can be seen in the graph which has increased substantially past 10 years (fig 2)

Table 3.4: Regression Equation , Slope , Hurst Exponent (H), Fractal Dimension (D), Predictability Index (PI) and nature of maximum temperature 1901-2015

Year	Regression equation	b	H	D	PI	Nature
1901-1905	y = 0.695X+0.5334	0.695	0.694976	1.305024	0.389952	P
1906-1910	y = 0.6823X+0.5293	0.6823	0.682337	1.317663	0.364674	P
1911-1915	y = 0.534X+0.7427	0.534	0.53401	1.46599	0.06802	P
1916-1920	y = 0.632X+0.6228	0.632	0.631982	1.368018	0.263964	P
1921-1925	y = 0.517X+0.7461	0.517	0.517023	1.482977	0.034046	P
1926-1930	y = 0.4852X+0.7879	0.4852	0.485244	1.514756	0.029512	AP
1931-1935	y = 0.5567X+0.6915	0.5567	0.556715	1.443285	0.11343	P
1936-1940	y= 0.4698X+0.8145	0.4698	0.469757	1.530243	0.060486	AP
1941-1945	y = 0.5623X+0.685	0.5623	0.563183	1.436817	0.126366	P
1946-1950	y = 0.5442X+0.7154	0.5442	0.544243	1.455757	0.088486	P
1951-1955	y = 0.5952X+0.6447	0.5952	0.595218	1.404782	0.190436	P
1956-1960	y = 0.6067X+0.6421	0.6067	0.606662	1.393338	0.213324	P
1961-1965	y = 0.4772X+0.7886	0.4772	0.477165	1.522835	0.04567	AP
1966-1970	y = 0.5808X+0.6676	0.5808	0.580774	1.419226	0.161548	P
1971-1975	y = 0.5776X+0.6676	0.5776	0.577592	1.422408	0.155184	P
1976-1980	y = 0.5301X+0.7531	0.5301	0.530065	1.469935	0.06013	P
1981-1985	y = 0.5708X+0.6868	0.5708	0.570755	1.429245	0.14151	P
1986-1990	y = 0.5896X+0.6513	0.5896	0.589614	1.410386	0.179228	P
1991-1995	y = 0.5721X+0.684	0.5721	0.572117	1.42789	0.14422	P
1996-2000	y = 0.6379X+0.5993	0.6379	0.637852	1.362148	0.275704	P
2001-2005	y = 0.5452X+0.7053	0.5452	0.545243	1.454757	0.090486	P
2006-2010	y = 0.6052X+0.6335	0.6052	0.60527	1.3948	0.2104	P
2011-2015	y = 0.4729X+0.7905	0.4729	0.4729	1.5271	0.0542	AP

* P- Persistent nature; AP - Anti persistent behavior

Table 4 shows the calculation of Regression Equation, Slope, Hurst Exponent, Fractal Dimension, Predictability Index and nature. If the Fractal Dimension is less than 0.5 then it is considered to be Anti-persistent hence showing chaotic behavior and if Fractal Dimension is greater than 0.5 then it is persistent hence predictable. The table shows at some point the value of Fractal Dimension going below 0.5 which means Anti-Persistence behavior which is result of sudden increase in maximum temperature further followed by intense heat stroke which resulted in increased death. The anti-persistence behavior of temperature is observed for past decade. It is to bring to the notice of the concern authorities to take preventive measures in order to control the global warming hence leading to temperature change which is demoralizing tourism which will gradually affect the GDP especially in terms of tertiary sector of country and many low-level income groups. The focus should be to generate fuels which are environment friendly and emit lesser hazardous gases. Global warming is the most faced challenge for the tourism industry in mountain areas.

4 Conclusion

With India moving a step ahead every day, it is also important for us to look at what happening in our environment too. The day to day modes of transportation are providing us comfort but at the same time release hazardous gases which have directly or indirectly different impact on the living and non-living at the same time. The chaotic behavior of temperature is a matter of concern. Increase in temperature is causing hazardous change in environment in form of Global Warming. The present period of 2005-2015 show Anti-persistence behavior which is alarming due to the chaotic nature. This emphasizes the necessity for global initiative like Paris Climate Agreement 2015 in direction of controlling the carbon emission and reducing Global Warming.

Acknowledgements. For providing research facilities and financial support authors are thankful to Guru Gobind Singh Indraprastha University, Delhi, India. Authors are also thankful to the referee for his suggestions to bring the paper in its present form.

References

[1] J. Aylen, K. Albertson and G. Cavan, The impact of weather and climate on tourist demand: the case of Chester Zoo, *Climatic Change* (2014), 127-183.

[2] R. Bhardwaj, Wavelets and Fractal Methods with environmental applications. *Mathematical Models, Methods and Applications*, Eds: Siddiqi, A.H., Manchanda, P., Bhardwaj, R.; (2016), 173-195..

[3] R. Bhardwaj, D. Pruthi, Predictability and Wavelet Analysis of Air Pollutants for Commercial and Industrial Regions in Delhi, *Indian Journal of Industrial and Applied Mathematics*, **7(2)** (2016), 165-174.

[4] R. Bhardwaj, A. Bangia, Complex Dynamics of Meditating Body, *Indian Journal of Industrial and Applied Mathematics*, **7(2)** (2016), 106-116.

[5] R. Bhardwaj, Wavelet and Correlation analysis of weather data, *International Journal of Current Engineering* & Technology, **2(1)** (2012), 178-183.

[6] R. Bhardwaj, Wavelet & Correlation analysis of air pollution parameters using Haar wavelet (Level 3), International *Journal of Thermal Technologies*, **2(2)** (2012), 160-164.

[7] R. Bhardwaj, A. Kumar, P. Maini, S.C. Kar and L.S. Rathore, Bias free rainfall forecast and temperature trend-based temperature forecast based upon T-170 Model during monsoon season, *Meteorological Applications*, **14(4)** (2007), 351-360.

[8] R. Bhardwaj and K. Srivastava, Real time Nowcast of a Cloudburst and a Thunderstorm event with assimilation of Doppler Weather Radar data, *Natural Hazards*, **70(2)** (2014), 1357-1383.

[9] S. Becken and J. Wilson, The impacts of weather on tourist Travel, *Tourism Geographies*, **15(4)** (2013), 620-639.

[10] C. Bodri, Fractal analysis of climatic data: Mean Annual temperature records in Hungary, *Theoretical and applied climatology*, **49** (1993), 53-57.

[11] G. Carey, Exploring impact of climate on tourism demand, *Annals of Tourism Research*, **39(4)** (2012), 1859-1883.

[12] H. Ghanim, Z. Bargaoui and C. Mallet, Investigation of the fractal dimension of rainfall occurrence in a semi-arid Mediterranean climate, *Hydrological Sciences Journal*, **58(3)** (2013), 483-497.

[13] D. Jonathon, C. Natalie, S. Sandra and C. Keith, Weather, climate, and tourism performance: A quantitative analysis, *Tourism Management Perspectives*, **5** (2013), 51-56.

[14] J. Fletcher, Input-Output analysis and tourism impact studies, *Annals of Tourism Research* ,**16** (1989), 514529.

[15] Y. Hu and J. Ritchie, Measuring destination attractiveness: a contextual approach, *Journal of Travel Research*, **32(2)** (1993), 2534.

[16] D. Maddison, In search of warmer climates? The impact of climate change on flows of British tourists, *Climatic Change*, **49** (2001), 193208.

[17] R. Morgan, E. Gatell, R. Junyent, A. Micallef, E. Ozhan and A.T. Williams, An improved user-based beach climate index, *Journal of Coastal Conservation*, **6(1)** (2000), 41-50.

[18] G. Nyaupane, and N. Chhetri, Vulnerability to climate change of nature-based tourism in the Nepalese Himalayas, *Tourism Geographies*, **11(1)** (2009), 95-119.

[19] A.B. Robinson, N.E. Robinson and W. Soon, Environmental effects of increased atmospheric carbon dioxide,*Journal of American physicians and surgeons*,**12(3)** (2007), 79-90.

[20] Witt, F. Stephen and A. Christine, (1995) Forecasting tourism demand: A review of empirical research, *International Journal of Forecasting*, **11(3)** (1995), 447-475.

[21] W.W.S. Wei, Time Series Analysis Univariate and Multivariate Methods, *Pearson/Addison-Wesley*,**2**, (2006).

[22] E. Wilkins, S. De Urioste-Stone, A. Weiskittel and T. Gabe, Weather sensitivity and climate change perceptions of tourists: A segmentation analysis. *Tourism Geographies, Taylor & Francis* (2015), 1-17.

[23] E. Wilkins, Effects of Weather Conditions on Tourism Spending: Implications for Future Trends under Climate Change, *Journal of Travel Research*, **57(8)** (2018), 1042-1053.

[24] L. Wang, B. Fang and R. Law, Effect of air quality in the place of origin on outbound tourism demand: Disposable income as a moderator, *Tourism Management*, **68** (2018), 152-161.

[25] F. Stephen, Witt, and A. Christine, Forecasting tourism demand: A review of empirical research, *International Journal of Forecasting*, **11(3)** (1995), 447-475.
[26] B. Susann and W. Jude, The impacts of weather on tourist travel. *Tourism Geographies*, **15(4)** (2013), 620-639.
[27] R. Steiger, B. Abegg and L. Jänicke, Rain, Rain, Go Away, Come Again Another Day. Weather Preferences of Summer Tourists in Mountain Environments. *Atmosphere*. **7(5)** (2016).
[28] http://tourism.gov.in. Government of India, Ministry of Tourism, Market Research Division, Indian Tourism Statistics 2015.