DE GRUYTER

Carpathian Journal of Electronic and Computer Engineering 11/2 (2018) 50-55

DOI: 10.2478/cjece-2018-0019

Neural Network Estimation of Tourism Climatic Index (TCI) Based on Temperature-Humidity Index (THI)- Jordan Region Using Sensed Datasets

Ashraf ALDabbas
Faculty of Informatics
University of Debrecen
Debrecen, Hungary
Ashraf.Dabbas@inf.unideb.hu

Zoltan Gal
Faculty of Informatics
University of Debrecen
Debrecen, Hungary
Attila.Buchman@inf.unideb.hu

Buchman Attila
Faculty of Informatics
University of Debrecen
Debrecen, Hungary
Gal.Zoltan@inf.unideb.hu

***Abstract*— Jordan which is located in the heart of the world contains hundreds of historical and archaeological locations that have a supreme potential in enticing visitors. The impact of clime is important on many aspects of life such as the development of tourism and human health, tourists always wanted to choose the most convenient time and place that have appropriate weather circumstances. The goal of this study is to specify the preferable months (time) for tourism in Jordan regions. Neural network has been utilized to analyze several parameters of meteorologist (raining, temperature, speed of wind, moisture, sun radiation) by analyzing and specify tourism climatic index (TCI) and equiponderate it with THI index. The outcomes of this study shows that the finest time of the year to entice tourists is " April" which is categorized as to be "extraordinary" for visitors. TCI outcomes indicates that conditions are not convenient for tourism from July to August because of high temperature.**

Keywords*— (TCI) index; THI index; neural network; analysis of historical sensed data set.

I. INTRODUCTION

Climate has a powerful impact on the recuperation and tourism sector and their services, and many countries constitutes the available resources on which the tourism sector and its services are predicated. Climate and weather have a major role in the process of selecting the destination; due to tourist sensitivity to weather change [1], [2]. Studies had shown that the climate could be considered the third most affecting attribute in decision making for specifying tourists destinations [3]. It is an important factor in selecting a destination for people holidays [4].

By the early 1960, several such metrics and indexes have been applied after a long term of development [5], [6]. One of the most affecting metrics is the Tourism Climate Index(TCI), which has been utilized to synthesize the influence of climate change in the field of tourism. The concept of (TCI) was initiated by [7] to be as a composite measure that could effectively evaluate the elements of the climate, that is most related to the quality of experience for the average tourist; such as the activity of shopping.

The awareness of climate parameters and their convenience for recuperation and tourism are essential knowledge about many potentialities for touristic activities. However, the circumstance of an individual climate parameter could not perfectly describe the climate conditions to specify the destinations for the tourists [8]. On account of messy nature of the atmosphere, the huge computational power will be needed to puzzle out the equations that depict the weather, error implicated in calculating the foremost conditions, and a deficient comprehension of atmospheric processes. A neural network [9] is a robust data epitomizing method that is qualified to apprehend elucidate intricate input /output relevance.

At the present time, neural networks are excessively used to strictly assort data, a fascinating enforcement domain is s the Internet of Things, where a huge group of sensor data should be categorized. Artificial Neural Network(ANN) is a technique for information processing which is biologically inspired, just like the human brain, it is consist of a massive number of extremely interrelated processing components (neurons) cooperates together to solve a particular incident. ANNs, are such as human, acquire a knowledge by example [10]. The purpose of this study is to examine current patterns and prospect changes in the temporal distribution of the climate resource for tourism in Jordan using the TCI for Jordan region, and to specify based on historical datasets which is the most convenient month to visit Jordan.

In this paper MATLAB software is used and utilized the notation of neural network, as the utilization of the neural network concept in MATLAB software, guarantees the efficiency of estimation functionality in which time series is used within the mathematical model of remotely sensed datasets, the process of network training has been evolved through advanced toolboxes to enhance the research quality and merit.

The remaining of the paper work is arranged as follows: related work is discussed in section two. Study area shown in part three, while the data and method are presented in section four. Result and finding of data analysis are given in section five, finally, conclusions of this paper are presented in part six.

II. Related Work

We came across several research work that have proposed implementation of solution in our related search field, the review of the related work came as the following: The work of Y. Saika and M. Nakagawa search for the ideal conditions on the temperature-humidity index (THI) index at every specimen and power consumption, both of which are evaluated by iterating the Bayesian inference by exploiting the expected a posteriori (EAP) speculation with a raise in the proportion of the coefficient of the paradigm beforehand, then they evaluate static feature of the Bayesian inference of the iterative approach by utilizing several numerical calculations [11]. K. Okamoto et al have forecasted the future circumstances of locations in which the cultivation of cereals take place through utilizing satellite remote sensing data with the amalgamation of geographical information systems [12]. Hao Guo et. al introduced a speculation from Remotely Sensed data by utilizing Climate Data Record with artificial neural networks, as they are combined to analyze for the purpose of evaluating meteorological dryness. The assessment process is performed across china over a period of time that extends between 1983 to 2014 [13].

Anđelković G et al state that the purpose of their research is to subedit premier and ideal mathematical correlation among facilely attainable climate parameters (air temperatures amplitude, the mean of the monthly air temperature, humidity, rainy days, monthly insolation) which they are combined forms the value of (Tourism Climate Comfort Index) this index will yield the values accordant value of the correspondent air , which symbolizes a relative baseline comprehensible for managers, tourism planners and tourists [14]. Dubois et al clarified that their research explores a precise understanding of various ancestry of uncertainty related to indices. Firstly, they evaluate the impact of variations in predilection surveys on the determination of indices thresholds, especially for thermal relief. Secondly, they draw an analogy for computation methods. Thirdly, they evaluate the uncertainty ingrained within long-range expectations by utilizing Mediterranean basin [15].

III. Study Area

The geography of Jordan is varying, with territorial diversity in topography, as shown in Fig. 1. Jordan owns five main morphological areas illustrated as a digital elevation pattern. In spite of the fact that Jordan is not a big state (89,320 km²), and there are three parts of its regions are desert, the visible landscape discloses a considerable variety among small distances. There are five major physiographic zones of Jordan that spread in north–south paving and include: equatorial desert within the rift valley (Ghor), and mountain heights to the east of the region of Ghor, dried plains, the Azraq and Badiya depression [16].

The major features of the climate of Jordan is in a disparity between a comparatively rainy period of time between November till April and has a dry climate for the rest of other months, with two tight metamorphosis seasons. Rain falls occur within winter months only, the weather mainly of the Mediterranean pattern, however that is relevant mostly to the high areas, also affected by the its position at the boundary among more than one climate patterns, which make it a unique climate.

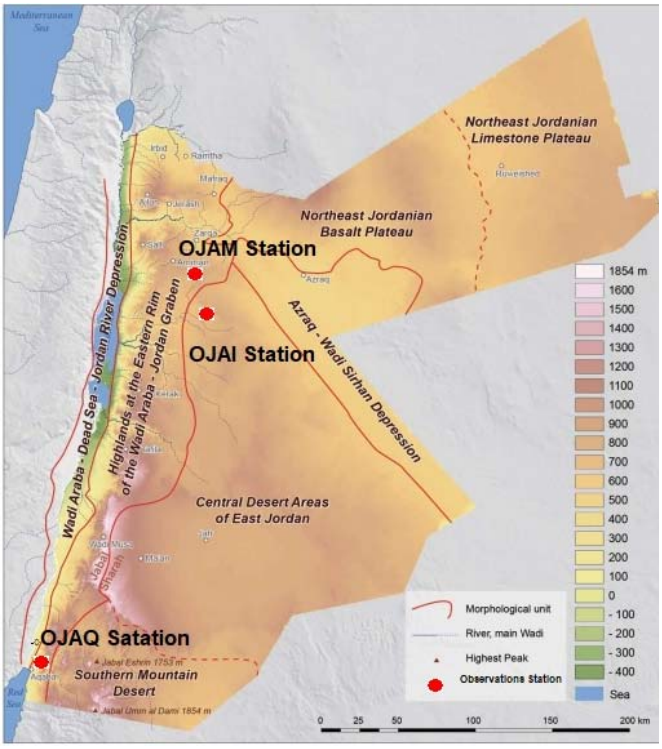

Fig. 1. Topographic map of Jordan shows five main morphological zones

IV. Data And Method

Two websites have been selected to acquire the needed datasets as they contain a huge volume of historical data, the purpose was to collect and integrate the elements of measurements for the obtained data, as this will minimize potential inconsistencies in the data and the process of analysis climate dataset include 1381 months climate time-series comprising precipitation and temperature for the period 1901-2017, The datasets were downloaded from climate change knowledge portal (The World Bank Group) website(Climatic Research Unit (CRU) of University of East Anglia) [17], and Iowa State University website (mesonet.agron.iastate.edu)[18], the second dataset is dedicated to be utilized to specify the TCI values over the last six and half years.

Observation stations reported hourly measurements and are ordinarily provided by professional crew. They frequently specified as having OJAI, OJAM, OJAQ, the A character symbolizes (for Airport) in their name, there adopted observation stations are: [OJAI] Queen Alia International airport station, this observation station is the middle station over the other two stations as shown on the given map on Fig. 1. [OJAM] Marka Intentional Airport [Amman/king Abdullah], that is located nearly to the north, and [OJAQ] Aqaba King Hussein International Airport, which appears on to the south of Jordan area according to the map. Tour agencies and tourists could exploit such indexes specify the ideal time to start their vacation or to plan a travel during a convenient climate. It is worth to mention that for all the incoming tables have been

grabbed from a research of Mieczkowski, published on 1985. For the intention of forming up TCI, the amount of precipitation should be considered as shown in Table 1. Precipitation element has allotted 20 % of TCI weight.

TABLE 1. Precipitation scales variable

Variable rate	*Average monthly precipitation*
5.0	*0.0-14.9 mm*
4.5	*15.0-29.9mm*
4.0	*30.0-44.9 mm*
3.5	*45.0-59.9 mm*
3.0	*60.0-74.9 mm*
2.5	*75.0-89.9 mm*
2.0	*90.0-104.9 mm*
1.5	*105.0-1 19.9 mm*
1.0	*120.0-134.9 mm*
0.5	*135.0-149.9 mm*
0.0	*150.0 mm or more*

The assigning of proper measure of sunshine for the formula of TCI as shown in Table 2. sunshine element has allotted 20 % of TCI weight.

TABLE 2. Sunshine scale variable

Variable rate	*Average monthly hours of sunshine per day*
5.0	*10 hrs or more*
4.5	*9 hrs - 9 hrs 59 min*
4.0	*8 hrs - 8 hrs 59 min*
3.5	*7 hrs - 7 hrs 59 min*
3.0	*6 hrs - 6 hrs 59 min*
2.5	*5 hrs - 5 hrs 59 min*
2.0	*4 hrs - 4 hrs 59 min*
1.5	*3 hrs - 3 hrs 59 min*
1.0	*2 hrs - 2 hrs 59 min*
0.5	*1 hr-1 hr59min*
0.0	*Less than 1 hr*

While assigning the proper measure of wind speeds for the formula of TCI as shown in Table 3. wind speeds element has allotted 10 % of TCI weight.

TABLE 3. Wind speeds scale variable

Wind speed (km / h)	*Trade wind system*
<2.88	*2.0*
2.88-5.75	*2.5*
5.76-9.03	*3.0*
9.04-12.23	*4.0*
12.24-1 9.79	*5.0*
19.80-24.29	*4.0*
24.30-28.79	*3.0*
28.80-38.52	*2.0*
>38.52	*0*

The incoming is an illustration of the “Bullet” pattern, which is the most likely recognized and utilized indices in the tourism field which is the (TCI), The TCI is the most ubiquitous climate index promoted particularly for tourism, the limitations of meteorological data has been minimized as many climatic factors were grouped into the TCI to be five indices instead of seven, as it appears in Table 4. which also include the impact on TCI and the avoirdupois of each element. Computing the TCI was first proposed by Mieczkowski (1985) as shown in the following formula:

$$TCI = 8 \cdot CID + 2 \cdot CIA + 4 \cdot R + 4 \cdot S + 2 \cdot W \quad (1)$$

The score of Daytime comfort index (CID) has been specified by utilizing two parameters comprising minimum relative humidity and the monthly maximum dry temperature, while the score of Daily time comfort index (CIA) has been determined by mean relative humidity and mean dry temperature, R represent rain, S symbolize for sunshine and W for wind speed. TCI scale has categorized to 10 classification characterize climatic conditions. The conditions of Human comfort are detected by other indices depending on a collection of several meteorological parameters. Measurements units used in this research paper include several parameters such as degrees Celsius (°C) for temperature, mm(millimeter) for precipitation, wind speed (km/h).

TABLE 4. Elements of (TCI)

Symbols	*Sub-index*	*Climatic elements on monthly basis*	*Impact on TCI*
CID (40%)	Daytime comfort	Maximum Temperature per day and daily respective humidity	Thermal comfort over max tourist vitality
CIA (10%)	Daily comfort	Temperature rate per day and daily respective humidity	Thermal comfort during 1 day
P (20%)	Precipitation	Total precipitation	Negative effect of precipitation
S (20%)	Sunshine	Total hours of sunshine	Impact of the volume of sunshine
W (10%)	Wind	Mean wind speed	Impact on mean wind speed

The process of specifying the tourism climate index will include the following steps: the first step includes the metrology extraction, then to calculate the index of comfort in day time depending on monthly maximum dry temperature and the lowest weather moister (CID), the third step is to compute the Comfort TCI depending on the influential temperature index and the average of moisture as shown in Fig. 2. Then rank specifying associated to raining, radiation of sunshine and wind, then to determine the TCI by using the formula number 1. Finally specifying the tourism climate numerical quantity and its associated category by using Table 5. Time series algorithms contain a concatenation of data explicit points detached orderly in time. The term time series is being directed to inspect advancement towards tourism climatic index, usually in such type of algorithms, the data has to be homogenous, we adopt a huge weather data set of Jordan for a long period of time, and the mean temperature for every month has been computed.

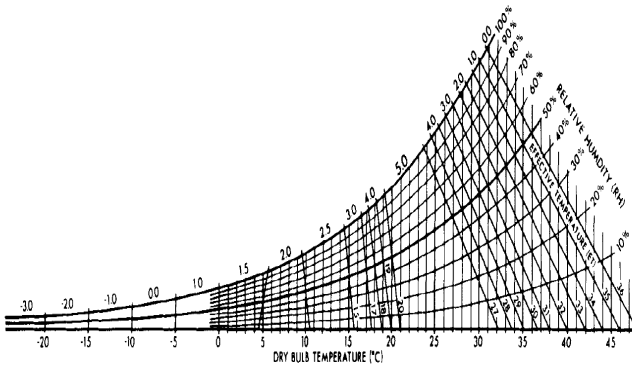

Fig. 2. Specifying the comfort score (Mieczkowski, 1985)

TCI was computed using selected data set for the period of January -2011 till May -2018 for all the three previously mentioned stations (OJAI, OJAM, OJAQ). In this study we utilized monthly climatic data of Jordan from 1901 – 2017 to review the average temperatures and precipitation to conduct the needed analysis also to specify the TCI values for every single month via a more sophisticated data set for the last six and half years.

TABLE 5. TCI numerical quantity and associated category

Amount related to comfort of TCI	*Rank*	*Rank state description*
90-100	9	Ideal
80-90	8	Excellent
70-80	7	Very Good
60-70	6	Good
50-60	5	Acceptable
40-50	4	Marginal
30-40	3	Undesirable
20-30	2	Very Undesirable
10-20	1	Extreme Undesirable
0-10	0	Impossible

We are providing a TCI scale, which can be considered as prognostic, it contains time window scale so by this scale a long term prognostic TCI values are provided, which are suitable for the accordance tourist planned stay period in Jordan.

The approach used to address the missing data stations is comprised of an automated accuracy control and statistical amendment method, only those wrong data, and inhomogeneities falling outside introduced limits would be specified and conveniently addressed, there was periodically missing data, this can be seen in Fig. 3. which may represent a value that was not recorded by the sensor, but it will affect the final results of the research as it has not been included in the calculation process. The approach of time series algorithm was formerly utilized in such researches.

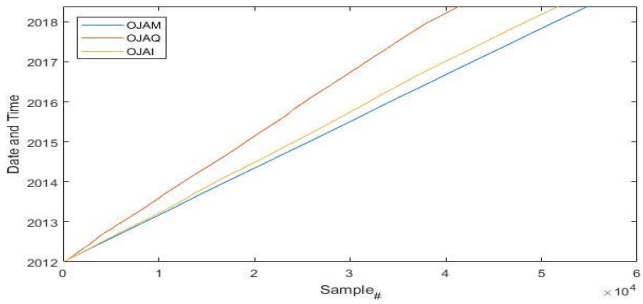

Fig. 3. Sampling over last 6.5 years

The ANN method provide a pounce forward in computational multilaterally, the technique has the merit that it empowers input of a huge number of variables concurrently, the adopted technique within the ANN that we are going to use in our research is the back propagation technique, in which we have split it to two stages: propagation and weight assigning.

Stage one: Propagation

Every propagation includes the following phases: Initially Forward propagation of the associated training patterns input is provided via the neural network for the purpose of producing the activations of the propagations output. Then Back propagation of the output of the associated neurons activations propagation over the neural network by utilizing the training patterns entity target for the purpose of producing the deltas of the whole output neurons and hidden neurons.

Stage two: Updating the Weight

A function of sigmoidal activation is multiplied with the input and output to acquire the weight gradient, then to add the Avoirdupois rate of the gradient to the weight. Among the characteristics, there are 5 input nodes that contain the 5 TCI formula components, with one hidden layer and one output node, there is no restricted regulation as to how many neurons or layers, however, a single hidden layer is considered adequate. Neurons number associated with the hidden layer ought to be in the midst of the size of the input and output layer, which is in our case two neurons based on the data suitability. By sure, the output layer has an individual output as we are performing regression.

V. Results and Finding of Data Analysis

When a historical dataset is acquired and investigated, it usually obeys a particular pattern known as statistical distribution, as an example. If 116 years of January precipitation data were gathered and examined, the pattern of the data have which composed of the January precipitation as an example having a trend to a very slight decrease that can be concluded by the value of -0.066 over the mentioned period of time, as illustrated in Fig. 4. while the average temperature for July shows a slight increase over that period with a slope value equals to 0.020 which can be seen in Fig. 5.

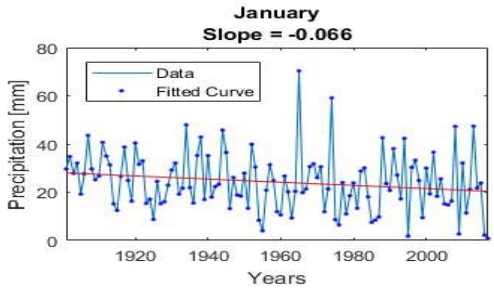

Fig. 3. Precipitation-January slope over 116 years

It can be concluded that the average annual precipitation is around 15 inches and the average annual temperature is around 10.5 °C. It is significant to appraise how climate hold numerous and varied data, the mean monthly precipitation and temperature could be sketched to represent seasonality by month, the next chart illustrates mean monthly precipitation and temperature for Jordan region through the period 1901-2017. According to Fig. 5. tourism climate comfort condition has an attendance in the months of January, February, March, deficiency of climate comfort has shown unpleasant limit.

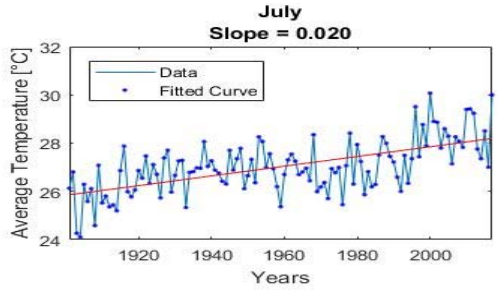

Fig. 5. Average temperature-July slope over 116 years

According to Fig. 6. tourism climate comfort condition has an attendance in the months of January, February, March, deficiency of climate comfort has shown unpleasant limit., in April with instantaneous rise of temperature and reduction of raining, the most perfect months for attending tourist from the mean annual precipitation and temperature perspective is May, June, September and subsequently October. While in November and December after subsequent decrease of temperature is prevailing.

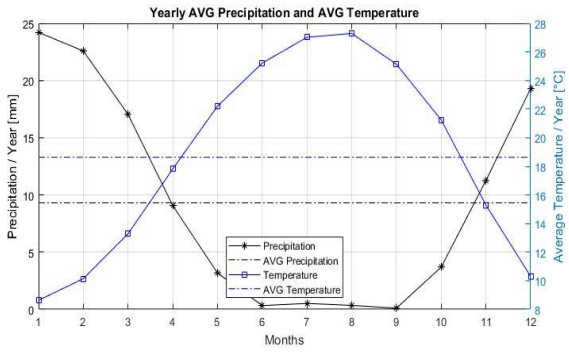

Fig. 6. Average monthly temperature and precipitation for Jordan from 1901-2017

The above figure shows a temperature fluctuation through the various quarters of years with the minimum temperatures in (January, February) while the highest temperatures are in August, which considered to be the least good or desirable month for tourism in terms of climate in Jordan followed by July due to high temperature which tell that this is a model of Mediterranean climate. To show the modification precipitation and temperature in monthly manner, gridded monthly precipitation/temperature time series data obtained and utilized to provide a mean monthly/annual climatologies version archive, the obtained monthly modification of precipitation and temperature (1901-2017), is shown in Fig. 7. This time series illustrates that there is a slight change over the given period.

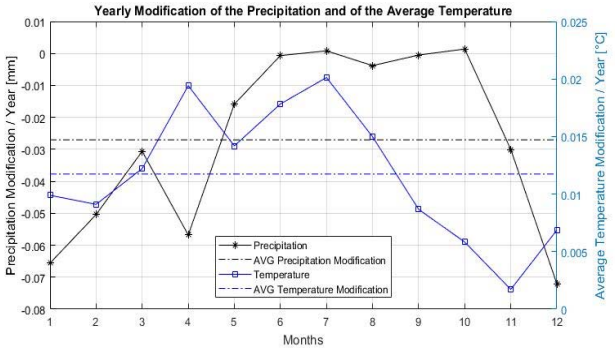

Fig. 7. Monthly modification of precipitation and temperature (1901-2017)

The generated Fig. 8. shows the TCI value of Jordan area for each month. The scores of TCI are slightly greater in several months of autumn and winter (March, April, and October) rather than other months, correspond to the categorization of TCI distributions, which illustrated in Table 5, the prevailing seasonal modality in Jordan is the peak of the winter as it can be seen in Fig. 8. The maximum TCI score is in April, followed by March, May and October, while in the summer period (June, July, August and September), the scores are proportionately weak so that coincide to the category "Marginal".

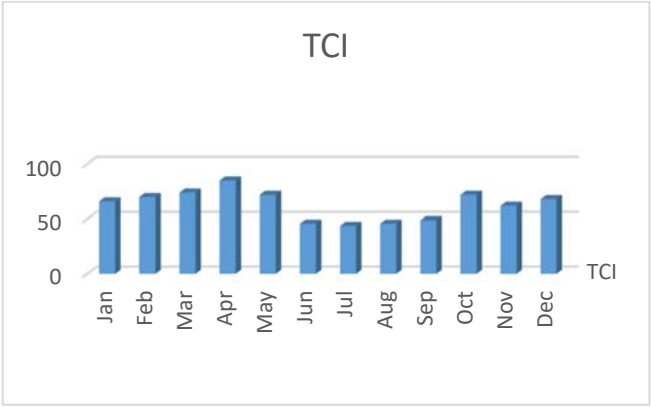

Fig. 8. Monthly TCI in Jordan (2011-2018)

July is observed as the worst month to conduct any activity for tourism in terms of climate. TCI five sub-indices participate variously to the score of TCI for every month, the sub-indices vary from month to month and the contrasting climatic sturdiness. The maximum TCI score is more than (80) in April, consequently categorizing as having ' excellent' (table. 5). Other months such as March, May and October are in the

classification of 'very good', October is the least among them. January, November and December are considered among the classification of 'good '. It can be noticed that their related scores are nearby to each other, also it can be noticed that by table 5. That June, July and August fall with the same category in sub-indices value with subcategory of 'marginal', while February has the rank of 'good'.

There is an indication to mention that higher summer temperatures take part in reduced tourism disbursements in Jordan. It is clear that the months of June, July, August also September possess the greatest hits of temperatures and this will affect their attendance by having inferior circumstances for tourists based on table 5. sunshine and precipitation participate to enlargement of TCI score, Wind speed owns the lowest values in the months of the summer particularly in July and August. Thus, it must be observed that the wind speed to the greatest extent is undesirable element, as it decreases the score of TCI in summer due to snug wind also in January due to wintry wind.

VI. Conclusions

Considering just one parameter just like precipitation alone is insufficient for the climatology of tourism, we should take in our consideration other factors to obtain more accurate results. TCI is a valuable index because it utilizes many elements of climate that is widespread, and easily explainable by the majority of the people. In accordance with the inception period of the research it was concluded that various climate parameter is pivotal for the realization of comfort, after sketching out the distribution maps of tourism comfort index for every month, it has produced a linear diagram shape for the whole months, the period of summer has peak in the research area, based on table number 2, the calibration for TCI rank in Jordan in May and June.

Climate and tourism are convoluted; climate has an influence on tourism by a direct or indirect route. The outcomes presented that utilizing the ANN model in specifying TCI is a vigorous approach conferring the curiosity of low error rate. The results of this research provide that the preferable time of the year to entice tourists is April, followed by November and March. The patterns of the climate are changing perceptible, rain ranges are less equally spread, while temperature augmentation is widening.

References

[1] DE FREITAS, C. R. SCOTT, D AND MCBOYLE, GEOFF, A second generation climate index for tourism (CIT):specification and verification. International Journal of Biometeorology. Volume 52, Number 5 / May, 399-407,2008

[2] A. Bigano, J. M. Hamilton, Tol RSJ. 2006. The impact of climate on holiday destination choice. Climatic Change 76: 389–406.

[3] J. M. Hamilton, , M. A. Lau 2005. Tourism and global environmental change: Ecological, social, economic and political interrelationships. London: Routledge, Taylor and Francis Group. 229–250.

[4] C. R. De Freitas, D. Scott, G. McBoyle, 2008. A second generation climate index for tourism: specification and verification. International Journal of Biometeorology, 52, 399-407.

[5] J. P. Besancenot, 1990. Climate et tourisme. Massonedit. Collection geographie: Paris .

[6] C. R. De Freita, 2003. Tourism climatology: evaluating environmental information for decision making and business planning in the recreation and tourism sector. Int. J. Biometeorology 48: 45-54.

[7] Z. Mieczkowski, 1985. The tourism climate index: A method for evaluating world climates for tourism, The Canadian Geographer. 29: 220-233.

[8] Vitt R., Gulyás A. and Matzarakis A. (2015). Temporal Differences of Urban-Rural Human Biometeorological Factors for Planning and Tourism in Szeged, Hungary. Advances in Meteorology, Volume 2015.

[9] Xinghuo Yu, M. Onder Efe, and Okyay Kaynak, A General Back propagation Algorithm for Feedforward Neural Networks Learning. IEEE Transactions On Neural Networks,Vol. 13, No.1, january 2002.

[10] Mohsen Hayati, and Zahra Mohebi," Application of Artificial Neural Networks for Temperature Forecasting," World Academy of Science, Engineering and Technology " 2007.

[11] Y. Saika and M. Nakagawa, "Dynamics of predicting temperature-humidity index and power consumption in small-scale system utilizing Bayesian inference via the EAP estimation," 2017 17th International Conference on Control, Automation and Systems (ICCAS), Jeju, 2017, pp. 975-980.

[12] K. Okamoto, M. Yokozawa and H. Kawashima, "Evaluation of changes in climatic indices using combined analysis of remote sensing and GIS," 2001 International Conferences on Info-Tech and Info-Net. Proceedings (Cat. No.01EX479), Beijing, 2001, pp. 133-138 vol.1.

[13] Hao Guo, Anming Bao, Tie Liu, Sheng Chen, and Felix Ndayisaba," Evaluation of PERSIANN-CDR for Meteorological Drought Monitoring over China" 2016, remote sensing article, vol. 8, no. 5, pp. 379.

[14] Anđelković G, Pavlović S, Đurđić S, Belij M, Stojković S,"tourism climate comfort index (tcci) – an attempt to evaluate the climate comfort for tourism purposes: the example of serbia" global nest journal, vol 18, 2016.

[15] Ghislain Dubois, Jean Paul Ceron, Clotilde Dubois, Maria Dolores Frias and Sixto Herrera,"Reliability and usability of tourism climate indices" Earth Perspectives, 2016, Volume 3, Number 1, Page 1.

[16] Bender, F. (Friedrich), Geology of Jordan.Berlin : Gebrüder Borntraeger, 1974 , ISBN: 3443117074 9783443117078.

[17] The World Bank Group, "Climate Change Knowledge Portal, For Development Practitioners and Policy Makers" [Online]. Available: http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Asia&ThisCCode=JOR.[Accessed Sept. 12, 2018].

[18] Iowa State University of Science and Technology "College of Agriculture_Department_of_Agronomy"[Online].Available:https://mesonet.agron.iastate.edu/sites/locate.php?network=JO__ASOS. [Accessed Sept. 12, 2018].