Journal of Himalayan Earth Sciences Volume 54, No. 2, 2021 pp. 70-83

Modelling, analysis and forecasting of climate elements for prevention and management of environmental climate hazards in northern Iran

Vahid Safarian Zengir[1*], Mohammad Taghi Heydari[2], Anita Majidi Heravi[3], Somayeh Naderi[4]

[1]Department of Geography, University of Mohaghegh Ardabili, Ardabil, Iran.
[2]Department of Geography, University of Zanjan, Zanjan, Iran
[3]Department of Geography¸ Payame Noor University Tehran, Iran
[4]Department of Geography, Kharazmi University, Tehran, Iran
[*]Corresponding author's email: safariyan.vahid@gmail.com
Submitted date: 20/05/2021 Accepted date: 22/11/2021 Published online: 30/11/2021

Abstract

Considering the importance of minimum and maximum temperatures in the agricultural and gardening sector, which each year causes significant losses in this sector. In order to avoid hazards in this section, detailed research has to be done and then filed a file with management and planning. The purpose of the present study and forecast the hazardous effects of thirty days extremes temperature on gardening and agronomy crops in the north bar of Iran. For this purpose, the first stage data were obtained for the whole station temperature over a period of 30 years (1989-2018). Then, using ANFIS (Adaptive-Network-based Fuzzy Inference Systems) adaptive neural network model, the data were analyzed for prediction in the next 6 years. Then, to measure the land suitability of Iran's northern strip for cultivating based on the predicted data, two models including Vikor (Vlse Kriterijumsk Optimizacija Kompromisno Resenje) and Topsis (Technique for Order Preference by Similarity to Ideal Solution) were used. Both the Topsis and Vikor multivariate decision making models combined the minimum temperature of the stations well, but did not reflect well at the maximum temperature in the worst-priority stations. According to the findings of the study, with respect to the friction extremes modeling, the maximum temperature showed the lowest defect compared to the minimum temperature. In Golestan province, the maximum temperature peaks and at least both are in weak increment, but in Gilan province, the maximum temperature peaks and at least both the maximum and maximum temperatures are higher. Mazandaran province showed maximum temperature and minimum temperature in both incremental and minimum temperature conditions.

Keywords: Natural hazards, Extreme's temperature, Climate change, ANFIS, Northern Iran.

1. Introduction

Although small changes in temperature cause changes in the occurrence of extreme phenomena such as drought, heavy rainfall and storms (Cobanov and Schnitkey, 2003; Schlenker and Roberts, 2009; Schlenker and Costaroberts, 2009). Temperature climate parameters have important effects on climate change. In recent years, we have faced an increase in temperature, which has shown itself in the form of reduced rainfall and increased meteorological drought (Lobell, 2011; Paltasingh et al., 2012; Mukherhee et al., 2012; Hatfield et al., 2014). Temperature is one of the climate parameters that has had many negative effects on the activities of all living things on Earth (Key and Sneeringer, 2014; Stpierre, 2016; Burke and Emerick, 2016). Climate change is one of the prominent challenges of the current century. Meanwhile, temperature changes as one of the maximum principal weather factors of every area are of particular importance. Since temperature is one of the key factors of weather (Nicola and Tyler, 2019; Stewart and Ewan, 2019; Zuccaro, 2020). It can be stated that the parameter of temperature is important for the cultivation of horticultural and agricultural products. Possible impacts of climate change or climate fluctuations in agricultural productivity in recent studies have attracted much attention (Rosowsky, 2021; Shohrab and Sarker, 2021; Soumen and Biswaranjan, 2021). There are three mainstream literatures on the relationship between climate and climate change/effects of climate and economic activities. One body is focused on biophysics effects by examining the relationship between climate and individual goods production or productivity, such as weather and crop yield (Christian et al, 2021; Ho et al, 2021). The second part of work focuses on adaptive responses at the individual/company level through evaluating how a farm/individual responds to environmental impacts such as a farmer unconscious behavior (Schimmelpfennig, 1996; Kim and Chavas, 2003; Falco and Veronesi, 2013; Yang and Shumway, 2015). The third section of literature is biophysical effects and its effects on the regional/national scale, it affects Adaptation, or other economic effects (Deschenes and Greenstone, 2007; Jones and Olken, 2012; Dell et al, 2012; James, 2021; Joshua and John, 2021). Literature on the impact of climate change on crop production has already shown moderate warming in temperate regions can benefit crop yield and if temperature increasease can reduce crop yield in all areas (Lobell and Asner, 2003; Schlenker and Roberts, 2009; Tubiello et al., 2007). Bozyurt et al. (2014) investigated the relationship between northern fluctuations and minimum temperatures in Turkey and obtained results as index values of North Atlantic fluctuations, the minimum temperature in Turkey increased. The reason could be that the western winds have a lot of wet and hot air to the Mediterranean Basin and moderate the weather. Rao et al. (2014) examined the increasing trend of minimum temperature and its impact on agricultural production in India during recent decades. Results showed the loss of caviar yield from 411 to 859 kg/ha at 1 °C, which indicates the increase in minimum temperature. This warming trend is likely to continue with significant criteria in the product yield and demands the development of appropriate adaptation strategies for production preservation. Singh et al. (2015) examined the current of the max and min temperature forecasted in the Himalayan area. Results predicted that an increase in minimum temperature in Rampur will continue in the future, since the increasing trend will be obtained in both scenarios. The analysis of seasonal trend showed that there are many variables affecting the maximum and minimum temperature over this station for future periods. Dimri et al. (2018) studied the forthcoming changes in min and max temp in the Himalayas. the overall trend of the daily temperature range (DTR) showed an increasing trend across the region, which had the highest value at RCP8.5. This increasing rate was higher for the maximum temperature than minimum temperature. The goal of this investigation was to gaining the necessary data and the public and functional use of minimum and maximum temperature data in the north bar of Iran (Golestan, Gilan and Mazandaran provinces) related to the planning, reviewing and predicting the hazardous effects of monthly extremes temperature on horticultural and agricultural products. For this purpose, the temperature data were analyzed and then the temperature for the next six years was predicted using ANFIS (Adaptive-Network-based Fuzzy Inference Systems) model and finally, Vikor and Topsis were used for prioritization of the lands in the north bar of Iran.

2. Materials and methods

For this research, extremes temperature data (maximum temperature and minimum temperature) were obtained from the Meteorological Organization for a period of 30 years (1989-2018). Also, to do this research data from nine synoptic stations were used (Table 1). After collecting extremes temperatures, the necessary analyzes for error modeling and their prediction were done using the adaptive neuro-fuzzy inference system (ANFIS). Eventually, the two multivariate decision-making models of Vikor (vlse kriterijumsk optimizacija kompromisno resenje) and Topsis (technique for order preference by similarity to ideal solution) were used to prioritize lands for cultivating. At this stage, it is possible to model and predict dust in the study region using the ANFIS model. In this study, the extremes temperatures anomaly event was studied in a time trend series of 276 thirty days (23 × 12=276) at each station were considered. In a time series consisting of n samples, X_1, X_2,.........X_n, the future value is a equation (1) of its previous value.

$$x_k = f\,(x_{k-1}, x_{k-2}, \dots, x_{k-p}) \qquad (1)$$

2.1 Adaptive Neuro-Fuzzy Inference System (ANFIS)

A fuzzy device is a machine based totally at the logical guidelines of "situation-result", which the usage of the idea of linguistic variables and the fuzzy choice method, depicts the gap of enter variables on the space of the output variables. The aggregate of fuzzy systems is primarily based on logical rules and the technique of synthetic neural networks that may extract expertise from numerical statistics, which has brought about the advent of a comparative nervous inference gadget. Fig 1 shows a fuzzy Sugeno system with two inputs (maximum temperature and minimum temperature), an output and two rules and an equivalent ANFIS system.

On this step, artificial neural networks, by modeling the functioning gadget of the human mind, system experimental facts without regard to the physics of the problem, extract the law behind this statistics. as compared to traditional fashions, these fashions require less enter and much less computational effort. A fuzzy gadget is a gadget primarily based on the common sense regulations of "situation-end result" which, the usage of the concept of linguistic variables and the bushy decision-making technique, depicts the space of enter variables over the space of output variables. The mixture of fuzzy systems based totally on logical rules, and the approach of synthetic neural networks which have the potential to extract understanding from numerical statistics, has brought about the presentation of a comparative neural-fuzzy inference device. Fig 2 shows a fuzzy sugeno system with two inputs (maximum temperature and minimum temperature), one output, and two equivalent rules and the ANFIS system. With the following rules:

IF x is A1 and y is B1 Then f=p1x + q1y+r1;
IF x is A2 and y is B2 Then f=p2x + q2y+r2

In this method, the ANFIS model, for example prediction, the maximum temperature data of Ramsar station was used to obtain the membership functions generated by Genfis1 (Generate fuzzy inference system object from data), cover the entire input space. After running the required coding commands, the input membership functions of the graphs were obtained (Fig. 3).

Table. 1 Geographical location of the studied stations in northern Iran.

Row	Stations	latitude	Elevation sea level
1	Ramsar	36° 54′	-20
2	Nowshahr	36° 39′	-20.9
3	Babolsar	36° 43′	-21
4	Astara	38° 22′	-21.1
5	Bandar-e Anzali	37° 29′	-23.6
6	Rasht	38° 22′	-21.1
7	Gorgan	36° 54′	0
8	Gonbad-e Kavoos	37° 15′	37.2
9	Maravetappeh	37° 54′	460

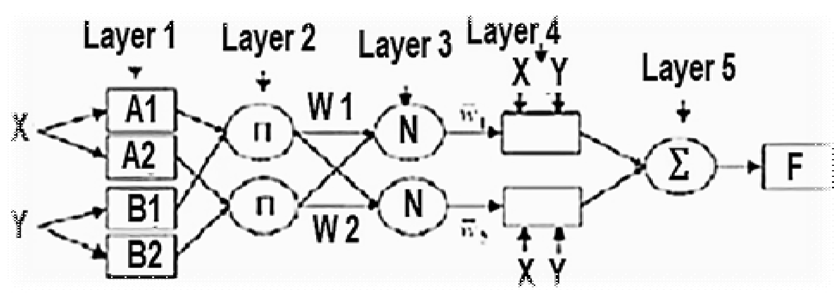

Fig. 1. A fuzzy Sugeno system with a triangular membership function and its equivalent ANFIS system (Kisi and Ozturk, 2007).

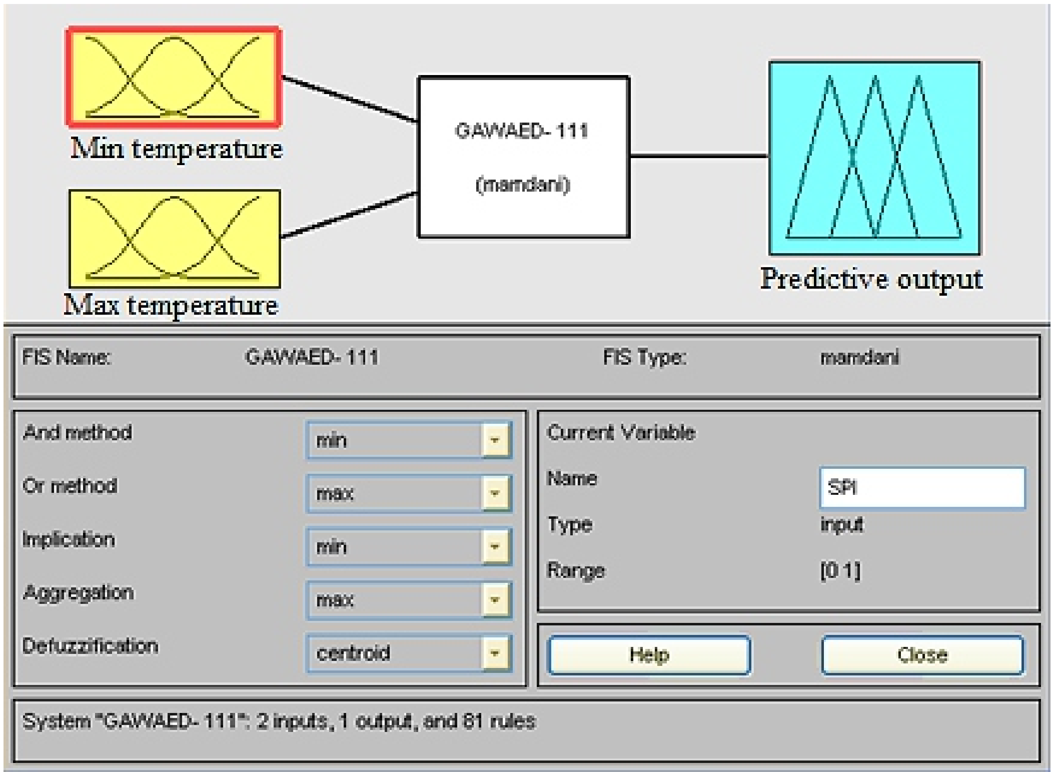

Fig. 2. ANFIS model structure

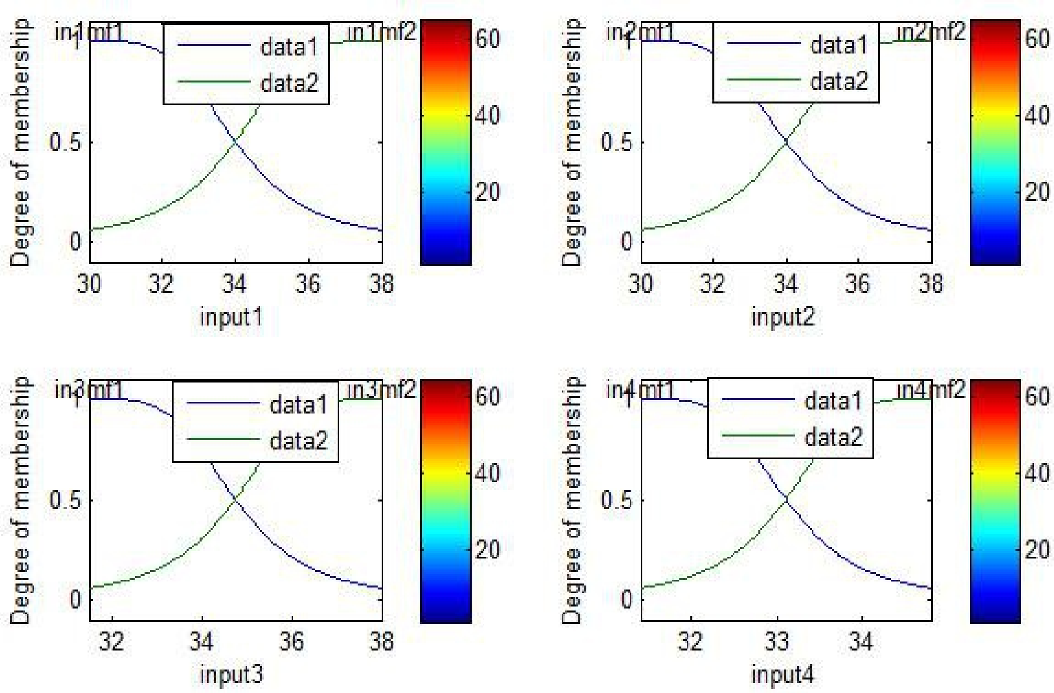

Fig. 3. The input membership functions of ramsar station (data 1: maximum temperature; data 2: minimum temperature)

To start the process, the instructions and the required code were run. Since checking data were sent to this function, the final fis corresponded to the lowest error on the checking set. The result was stored in Fismat2. By running the commands, the new membership function was plotted in graphs. The codes were also used to draw error graphs. The root mean square error was plotted for Ramsar station. Upper curve, is related to training errors (Error1) and the below curve is the checking data error (Error2). (Table 2) shows the training errors and mean error of modeling validation (in percent) of Ramsar station. The coding command was used to obtain and set up time series and predictions as well as mean errors. In Fig 4, the predicted values for the next 6 years and the observed values are showed with green and red circle line. The predicted and observed values for Ramsar station is presented in (Table 3). According to the mentioned method, the maximum temperature can be predicted using Anfis model for the studied stations and the capability of ANFIS model in modeling and predicting the changes trend in mentioned time series index can be monitored and evaluated.

2.2 Topsis Technique (Vector normalization method)

This technique ranks the alternatives, on this approach the 2 concepts of "perfect answer" and "similarity to the proper solution" is used. The perfect solution, as its call implies, is the answer that is the first-class in every way, which typically does no longer exist in exercise, and it tries to get toward it. (Vector normalization method) sees a MADM trouble with alternatives m as a geometric machine with points m within the next n area. The method is consistent with the idea that the alternative need to have the shortest distance from the tremendous-best solution and the longest distance from the bad-ideal solution. TOPSIS defines a hallmark known as similarity with a nice-perfect solution and avoidance of a poor-perfect answer. Then pick out the opportunity technique with maximum similarity to the nice-best solution (Farajzadeh, 1996). Two matrixes 1 and 2 were used to calculate the TOPSIS model.

$$X_{ij} = \begin{bmatrix} x_{11} & x_{22} & x_{1\,n} \\ x_{21} & x_{22} & x_{2\,n} \\ \vdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ x_{m\,1} & x_{m\,2} & \cdots x_{m\,n} \end{bmatrix}$$

Matrix (1)

$$V_{ij} = \begin{bmatrix} v_{11} & v_{22} & v_{1\,n} \\ v_{21} & v_{22} & v_{2\,n} \\ \vdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ v_{m\,1} & v_{m\,2} & \cdots v_{m\,n} \end{bmatrix}$$

Matrix (2)

Table. 2 Mean training error and mean error of modeling validation (%) of Ramsar station.

mean training error	mean error of modeling validation, cheking error
0.016	15.43

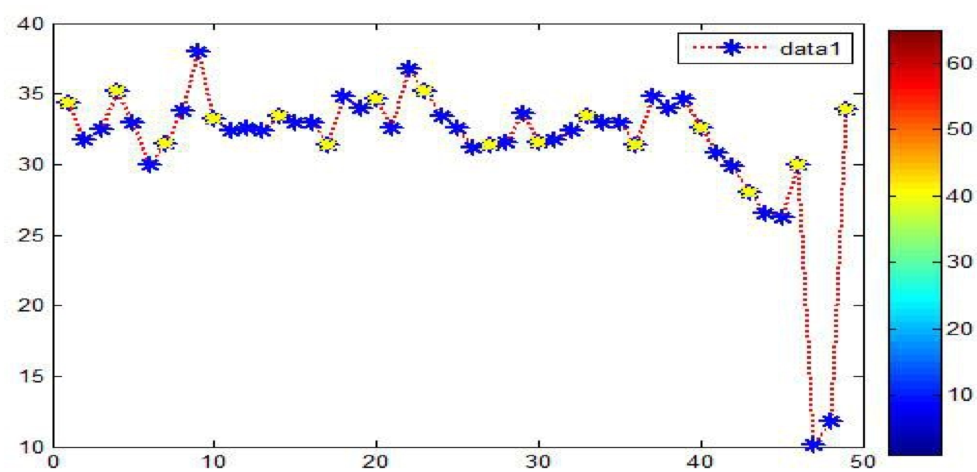

Fig. 4. Observed years and predicted years of Ramsar station for the next 6 years

Table. 3 Prediction value of Ramsar station obtained from ANFIS modeling (%) for the next 6 years.

number	Future years	predicted value
1	2019	32.6
2	2020	31.2
3	2021	31.4
4	2022	15
5	2023	19.7
6	2024	16.5

2.2.1 Steps of TOPSIS technique

The following steps are accomplished to put into effect and carry out the (Vector normalization method) method: One, form a choice matrix. Two, Scaling the selection matrix (normalizing the decision matrix). Three, decide the weightless scale matrix. Four, find the perfect and counter-best answer. Five, Calculate the distance from the ideal and counter-ideal answer (Ansari et al, 2017). Equations 2 to 9 were used to calculate the TOPSIS model.

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \quad \textbf{(2)}$$

$$A^* = \left\{ (\max_i v_{ij} | j\epsilon J), (\min_i v_{ij} | j\epsilon J' \right\} \quad \textbf{(3)}$$

$$A^* = \{v_1^*, v_2^*, \dots v_n^*\} \quad \textbf{(4)}$$

$$A^* = \left\{ (\min_i v_{ij} | j\epsilon J), (\max_i v_{ij} | j\epsilon J' \right\} \quad \textbf{(5)}$$

$$A^- = \{v_1^-, v_2^-, \dots v_n^-\} \quad \textbf{(6)}$$

$$d_j^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2} \quad \textbf{(7)}$$

$$d_j^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \quad \textbf{(8)}$$

$$C_i = \frac{d^-}{d_i^- + d_i^+} \quad \textbf{(9)}$$

2.3 Vikor Technique (Vlse Criterion Optimization Compromise Resenje)

The (Linear normalization method) method is aimed at focusing on ranking and choosing from a set of solutions to a problem with opposite criteria. The results shown in the Vikors method are an agreed ranking list plus one or more agreement solutions. The following figure shows the general steps of the (Linear normalization method) method, which are the initial inputs of the Vikor method for starting, decision matrix, weight of criteria and weight of group desirability (Farajzadeh, 1996). Two matrixes 3 and 4 were used to calculate the Vikor model.

$$X_{ij} = \begin{bmatrix} x_{11} & x_{22} & x_{1\,n} \\ x_{21} & x_{22} & x_{2\,n} \\ \vdots & \dots & \dots \\ \dots & \dots & \dots \\ x_{m\,1} & x_{m\,2} & \dots x_{m\,n} \end{bmatrix}$$

Matrix (3)

$$V_{ij} = \begin{bmatrix} v_{11} & v_{22} & v_{1\,n} \\ v_{21} & v_{22} & v_{2\,n} \\ \vdots & \dots & \dots \\ \dots & \dots & \dots \\ v_{m\,1} & v_{m\,2} & \dots v_{m\,n} \end{bmatrix}$$

Matrix (4)

2.3.1 Steps to solve the Vikor technique

The following steps are performed to implement and perform the (Linear normalization method) method: One, form a selection matrix. Two, Normalize the decision matrix. Three, figuring out the weight vector of criteria and forming a weighted matrix. Four, decide the superb best point and the poor counter-best factor. Five, Calculate the usefulness (S) and regret (R) values for each index. Six, Calculate the Vicker index (Q) for each option Seven. Sort options by S, Q and R

(Jafarbeigllo and Mobaraki, 2008). Equations 10 to 20 were used to calculate the TOPSIS model.

$$= 1\frac{x_{ij}}{x_j^{max}} \quad x_{ij} \qquad \textbf{(10)}$$

$$w = \{w_1, w_2, \dots w_n\} \quad \textbf{(11)}$$

$$f_j^* = \min_i f_{ij} \quad \textbf{(12)}$$

$$f_j^* = \max_i f_{ij} \quad \textbf{(13)}$$

$$f_j^- = \min_i f_{ij} \quad \textbf{(14)}$$

$$f_j^- = \max_i f_{ij} \quad \textbf{(15)}$$

$$s_i = \sum_{h=1}^{n} w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \quad \textbf{(16)}$$

$$R_i = max\left\{w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}\right\} \quad \textbf{(17)}$$

$$L(A_i) = \sum_{j=1}^{n} w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} = S_i \quad \textbf{(18)}$$

$$L_\infty(A) = max\left[w_j\left(\frac{f_j^* - f_{ij}}{f_j^* - f_j^-}\right)\right] = R_i \quad \textbf{(19)}$$

$$Q_i = v\left[\frac{s_i - s^-}{s^* - s^-}\right] + (1 - v)\left[\frac{R_i - R^-}{R^* - R^-}\right] \quad \textbf{(20)}$$

$$S^{i-} = min\, S_i \qquad s^* = max\, S_i$$

$$\bar{R} = min\, R_i \qquad R^* = max\, R_i$$

2.4 Differences between Vikor and Topsis techniques

The (Linear normalization method) and (Vector normalization method) methods use different types of normalization to eliminate the units of measurement, while the (VIKOR) method uses linear normalization and the TOPSIS method uses vector normalization. The value normalized in the (Linear normalization method) method is not dependent on the unit of measurement, while the values normalized by the TOPSIS method may be dependent on the unit of measurement (Jafarbiglou and Mobaraki, 2008).

3. Results and discussion

According to the modeling to predict the minimum temperature in Gorgan station, the least training error was 0.010 and for the maximum temperature, Maravetappeh had the lowest error (0.015). According to the prediction in Table (4), both maximum and minimum Ferrin temperature had an increasing trend. Considering the modeling to predict the minimum and maximum temperature in Bandare Anzali station, the least training error was 0.010 and 0.013, respectively. According to the prediction in Table (4), both maximum and minimum Ferrin temperature had an increasing trend and the maximum temperature was more intense. According to the modeling to predict the minimum temperature in Babolsar station, the least training error was 0.019 and for the maximum temperature, Ramsar had the lowest error (0.015). According to the prediction in Table (4), both maximum and minimum Ferrin temperature had an increasing trend and the minimum temperature showed a higher intensity.

3.1 Land prioritization for feasibility of cultivation with minimum temperature criterion based on VIKOR model

The VIKOR model was used to rank stations in terms of minimum temperature for selecting suitable and unsuitable places for cultivation in the next 6 years. The top three stations for cultivation were Gonbad-e Kavoos, Astara and Maravetappeh with priority rate of 1.219, 0.993 and 0.990, respectively and the worse three stations were Ramsar, Babolsar and Bandar-e Anzali with priority rate of 0.001, 0.026 and 0.109, respectively (Table 5, Fig. 5).

3.2 Land prioritization for feasibility of cultivation with maximum temperature criterion based on VIKOR model

Considering the importance of VIKOR model, the maximum temperature of the stations was also evaluated. Suitable and unsuitable places for cultivation in the next 6 years were studied in terms of maximum temperature. The top three stations for cultivation were Maravetappeh, Gonbad-e Kavoos and Gorgan with priority rate of 1.160, 1.106 and 1, respectively and the worse three stations were Nowshahr, Rasht and Astara with priority rate of 0, 0.057 and 0.215, respectively (Table 6, Fig 6).

Table. 4 Predicted values of maximum and minimum temperature of studied stations in northern Iran.

Minimum temperature			**Maximum temperature**			**Predicted years**	
Gorgan	Gonbad-eh Kavus	Maravetappeh	Gorgan	Gonbad-e Kavus	Maravetappeh		
-2.40	-0.80	-0.80	32.6	25	28	2019	1
-1.40	-0.60	-3.80	34	23.6	31.8	2020	2
-2.40	-1.60	-3.80	38.1	19	24.8	2021	3
-2.39	0.57	-0.08	17.8	15.4	17.05	2022	4
-0.71	-0.18	-0.66	10.7	13.4	11.4	2023	5
-0.38	-0.11	-0.56	17.4	3.2	2.6	2024	6
Minimum temperature			**Maximum temperature**			**Predicted years**	
Bandare Anzali	Astara	Rasht	Bandare Anzali	Astara	Rasht		
0.80	-1.80	-2.4	36	32.2	26	2019	1
-0.40	-1.20	0	21	33.2	29.6	2020	2
4.80	-2.20	0.20	21.4	32.8	30.5	2021	3
-0.78	-0.97	-0.33	13.2	9.6	5.4	2022	4
-0.70	-1.33	0	3.9	4.5	6.4	2023	5
0.18	-0.59	0.74	11.9	7.4	3.9	2024	6
Minimum temperature			**Maximum temperature**			**Predicted years**	
Ramsar	Nowshahr	Babolsar	Ramsar	Nowshahr	Babolsar		
1	-0.20	2.50	32.6	30.7	24.4	2019	1
-0.60	0	1.60	31.2	30.6	28.2	2020	2
1.80	1.60	-0.60	31.4	30.6	33.2	2021	3
-0.03	0.85	0.26	15	12.8	23.8	2022	4
-0.26	0.54	0.02	19.7	7.41	6.8	2023	5
0.07	0.36	-0.01	16.5	27.9	3.9	2024	6

Table. 5. Prioritization of Stations Based on Minimum Temperature in the VIKOR Model.

Stations	**score**	**rank**
Ramsar	0.001	9
Nowshahr	0.501	6
Babolsar	0.026	8
Astara	0.993	2
Bandar-e Anzali	0.109	7
Rasht	0.551	5
Gorgan	0.952	4
Gonbad-e Kavoos	1.219	1
Maravetappeh	0.990	3

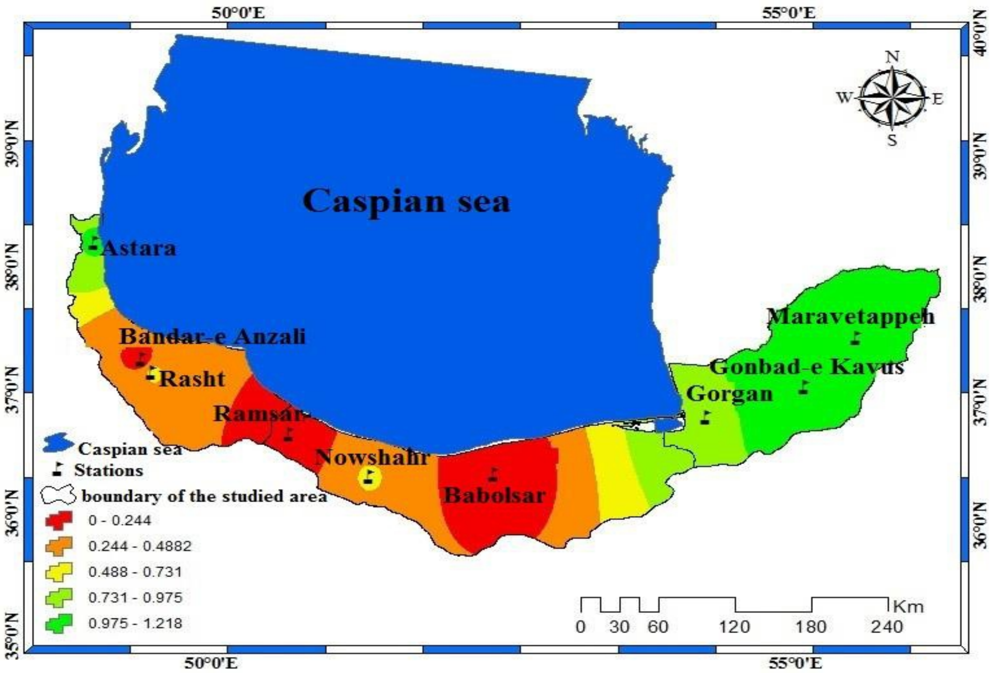

Fig. 5. Areas susceptible to cultivation with the minimum temperature criterion in the north bar of Iran based on the VIKOR model

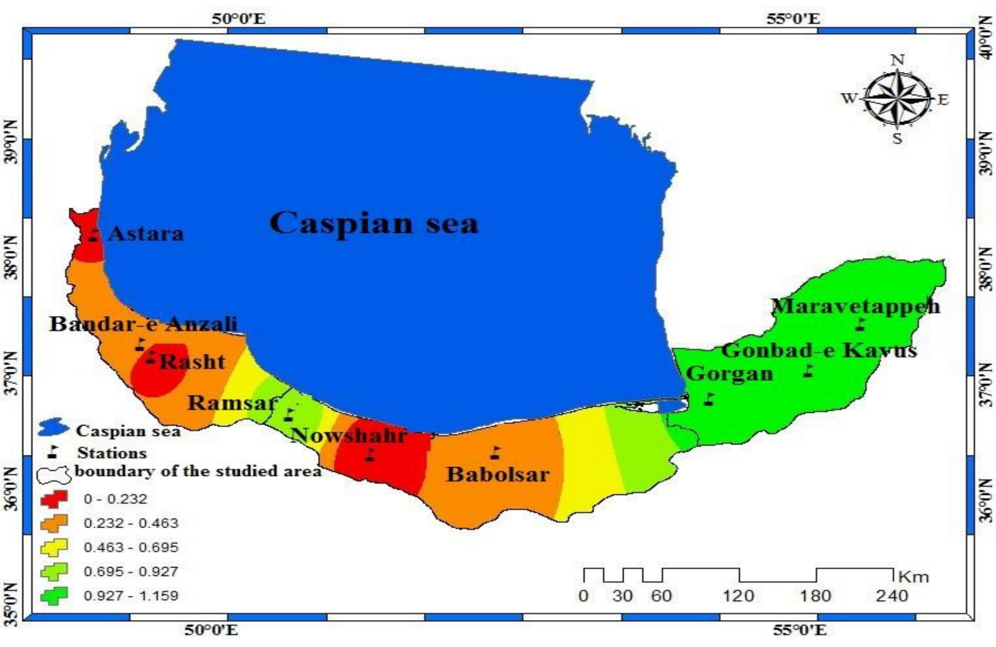

Fig. 6. Areas susceptible to cultivation with the maximum temperature criterion in the north bar of Iran based on the VIKOR model

Table. 6. Prioritization of Stations Based on maximum Temperature in the VIKOR Model

Stations	score	rank
Ramsar	0.911	5
Nowshahr	0	9
Babolsar	0.340	6
Astara	0.215	7
Bandar-e Anzali	0.433	5
Rasht	0.057	8
Gorgan	1	3
Gonbad-e Kavoos	1.106	2
Maravetappeh	1.160	1

Table. 7. Prioritization of Stations Based on minimum Temperature in the TOPSIS Model

Stations	score	rank
Ramsar	0.408	8
Nowshahr	0.507	4
Babolsar	0.477	5
Astara	0.415	7
Bandar-e Anzali	0.377	9
Rasht	0.610	3
Gorgan	0.722	2
Gonbad-e Kavoos	0.728	1
Maravetappeh	0.446	6

Table. 8. Prioritization of Stations Based on maximum Temperature in the TOPSIS Model.

Stations	score	rank
Ramsar	0.302	7
Nowshahr	0.160	9
Babolsar	0.341	5
Astara	0.727	2
Bandar-e Anzali	0.447	4
Rasht	0.266	8
Gorgan	0.791	1
Gonbad-e Kavoos	0.305	6
Maravetappeh	0.559	3

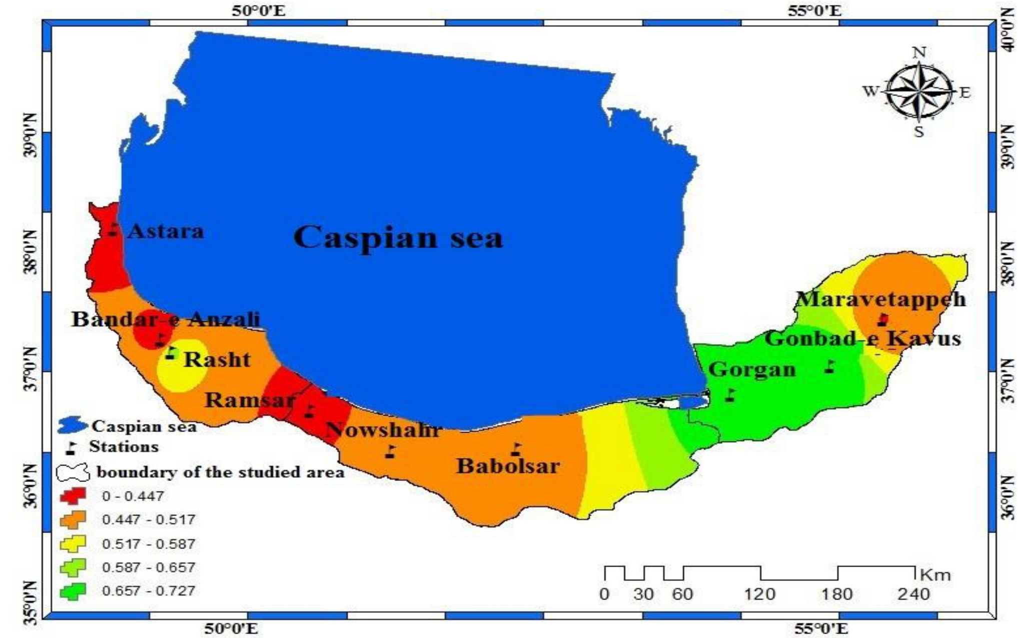

Fig. 7. Areas susceptible to cultivation with the minimum temperature criterion in the north bar of Iran based on the Topsis model.

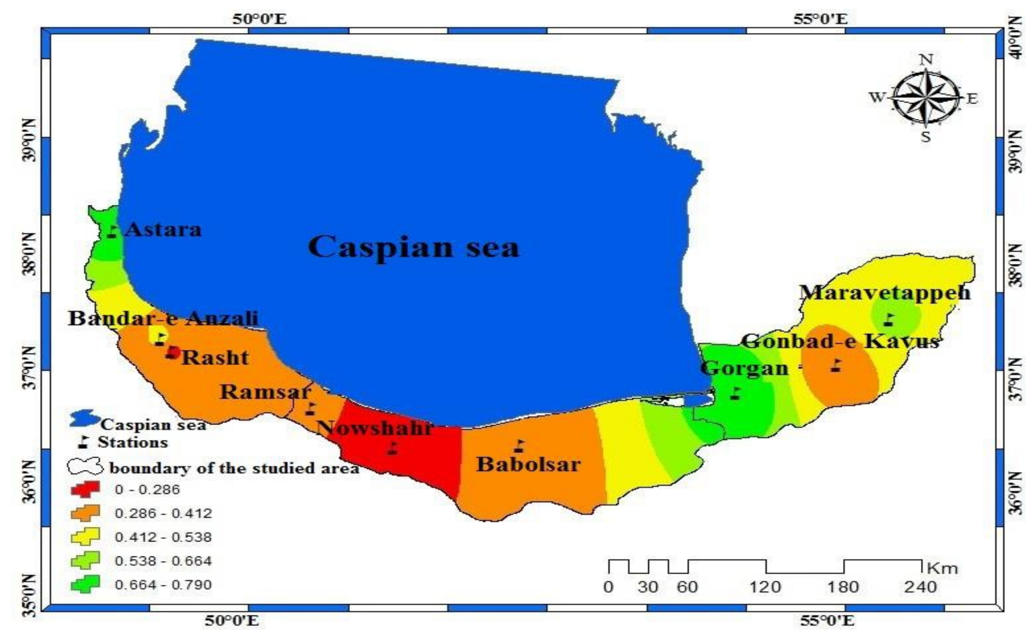

Fig. 8. Areas susceptible to cultivation with the maximum temperature criterion in the north bar of Iran based on the Topsis model

4. Conclusions

In recent years, damage to horticultural and agricultural products caused by extremes temperature has incresed. Accordingly, the prediction of hazardous effects of month-to-month extremes temp on horticultural and agronomy crops in the northern half of Iran was investigated in this study. Modeling and prediction were done using the Anfis. After error detection, the data was predicted for extremes temperature of the next six years. The two multivariate decision-making models of Vikor and Topsis were used to prioritize lands for cultivating. Regarding the error detection modeling of extremes temperature, the least error was obtained for the maximum temperature compared to the minimum temperature. Regarding the obtained errors, with high confidence, Ferrin temperatures were predicted for the next six years. Based on the predicted data, the minimum temperature at

Gorgan station had the lowest training error with the value of 0.010 and the maximum temperature at Maravetappeh station had the lowest error of 0.015. Finally, both maximum and minimum Ferrin temperatures in Golestan province were weak at increasing trend. Minimum and maximum temperature at Bandar-e Anzali station had the lowest training error with the value of 0.013 and 0.010, respectively. In Gilan province, both maximum and minimum Ferrin temperature had an increasing trend and the maximum temperature was more intense. The minimum Ferrin temperature at Babolsar station had the lowest training error of 0.019 and the maximum temperature at Ramsar station had the lowest error of 0.016. In Mazandaran province, maximum and minimum Ferrin temperature were both more intense at increasing trend. The results of land prioritization for feasibility of cultivation of agricultural and horticultural products for the next six years based on Vikor model, after checking the stations in terms of maximum and minimum temperature, two stations of Maravetappeh and Gonbad-e Kavoos allocated the highest priority. However, a common station did not placed in worse ranked stations. Six stations including Ramsar, Babolsar, Bandar-e Anzali, Nowshahr, Rasht and Astara had the worse scores for cultivation. Based on TOPSIS model, Gorgan station as the common station assigned the highest priority in terms of maximum and minimum temperature. However, Ramsar station became the worst common station for cultivation.

Acknowledgements

TThe authors of this manuscript (article) thank the Meteorological Organization of Iran (IRIMO) for providing meteorological data (minimum and maximum temperature) for this research.

Author's contribution

Vahid Safarian Zengir, proposed the main concept and involved in write up, assisted in establishing field data and did provision of relevant literature, and review and proof read of the manuscript. Mohammad Taghi Heydari, did technical review before submission and proof read of the manuscript. Anita Majidi Heravi, did collection of field data. Somayeh Naderi, was involved in 14 assistance in preparation of illustration and plates of figures.

References

Alexander, L.V., 2006. Global observed changes in Daily climate extremes of temperature and precipitation. Journal of Geophysical research, 111, 360-375.

Bozyurt, O., Ozdemir, M., 2014, The relations between north Atlantic Oscillation and minimum temperature in Turkey. procedia social and behavioral, 120, 532-537.

Burke, M., Emerick, K., 2016. Adaptation to Climate Change: Evidence from US Agriculture. American Economic Journal: Economic Policy, 8 (3), 106–140.

Christian, H., Oliver, K., Stephan, G., 2021. Landslide Hazards and Climate Change in High Mountains. Reference Module in Earth Systems and Environmental Sciences, https://doi.org/10.1016/B978-0-12-818234-5.00038-9

Cobanov, B., Schnitkey, G., 2003. Economic Losses from Heat Stress by US Livestock Industries. Journal of Dairy Science, (86), 52–77.

Daneshmand, H., tavousi, T., khosravi, M., tavakoli, S., 2015. Modeling minimum temperature using adaptive neuro – fuzzy inference system based on spectral analysis of climate indices: a case study in Iran. Journal of the Saudi society of agricultural sciences, 14 (1), 33-40.

David, R.E., 1997. Maximum and minimum temperature trend for the Glob. Science, 22, 123-203.

Dell, M., Jones, B.F., Olken, A., 2012. Temperature Shocks and Economic Growth: Evidence from the Last Half Century. American Economic Journal: Macroeconomics, 4 (3), 66–95.

Deschenes, O., Greenstone, M., 2007. The Conomic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather. American Economic Review, 97 (1), 354-385.

Dimri, A., Kumar, D., Choudhary, A., Maharana, P., 2018. Future changes over the Himalayas Maximum and minimum temperature, 162, 212-234.

Falco, S.D., Veronesi, M., 2013. Managing

Environmental Risk in Presence of Climate Change: The Role of Adaptation in the Nile Basin of Ethiopia. Environ Resource Econ, 57, 553–577.

Gadgil, A., Dhorde, A., 2004. Temperature trends in the twentieth century at PUNE India. Atmospheric environment, 39 (35), 6550-6556.

Grieser, J., tromel, C., schonwiese, D., 2002. Statistical time series decomposition into significant components and application to European temperature. theor, appl, climatic, 71, 171-183.

Hansen, J., Rurdy, M., Lo, R., Lea, D., Elizade, M., 2006, Global temperature change, Science, 39, 14288-14293.

Hatfield, J., Takle, G., Grotjahn, R., Holden, P., Izaurralde, R.C., Mader, T., Marshall, E., Liverman, D., 2014. Agriculture. Climate Change Impacts in the United States: The Third National climate Assessment. in J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, (11) 150-174.

Ho G.K., Chan, P., Mingyun, C., 2021. Finding unrevealed landslide hazard area induced by climate change and topography - Case study for Inje-gun, Gangwon-do, ROK. Sustainable Cities and Society, 75, https://doi.org/10.1016/j.scs.2021.103180

James, M.J., 2021. Particularizing adaptation to non-predominant hazards: A history of wildfires in County Donegal, Ireland from 1903 to 2019. International Journal of Disaster Risk Reduction, 58, https://doi.org/10.1016/j.ijdrr.2021.102211

Jones, B.F., Olken, A., 2012. Temperature Shocks and Economic Growth: Evidence from the Last Half Century. American Economic Journal: Macroeconomics, 4 (3), 66–95.

Joshua, H., John, H., 2021. Progressing the integration of climate change adaptation and disaster risk management in Vanuatu and beyond. Climate Risk Management, 31, 100-269. https://doi.org/10.1016/j.crm.2020.100269

Key, N., Sneeringer, S., 2014. Potential Effects of Climate Change on the Productivity of U.S. Dairies. American Journal of Agricultural Economics, 3, 279-286.

Kim, K., Chavas, J.P., 2003. Technological Change and Risk Management: An Application to the Economics of Corn Production. Agricultural Economics, 29, 125-142.

Kisi, O., Ozturk, O., 2007. Adaptive neurofuzzy computing technique for evapotranspiration estimation. Journal of Irrigation and Drainage Engineering. ASCE, 133 (4), 368-379.

Lobell, D.B, Schlenker, W., Roberts, C., 2011. Climate Tends and Global Crop Production Since 1980. Science, 61- 66.

Lobell, D.B., Asner, G.P., 2003. Climate and Management Contributions to Recent Trends in U.S. Agricultural Yields. Science, 10, 32-39.

Mukherhee, D., Bravo-Ureta, B.E., Vries, A.D., 2012. Dairy productivity and climatic 34 conditions: econometric evidence from South-eastern United States. The Journal Agricultural and Resource Economics, 57, 123-140.

Nicola, U., Tyler A.S., 2019. Environmental hazards, rigid institutions, and transformative change: How drought affects the consideration of water and climate impacts in infrastructure management. Global Environmental Change, 59, https://doi.org/10.1016/j.gloenvcha.2019.102005

Paltasingh, K.R., Goyari, P., Mishra, R.K., 2012. Measuring Weather Impact on Crop Yield Using Aridity Index: Evidence from Odisha. Agricultural Economics Research Review, 25 (2), 205-216.

Pandey, K., Chandrakar, C., singh, S., maurya, D., gupta, G., 2017. Identification of most Important weeks on minimum temperature for wheat crop. International Journal of current microbiology and applied sciences, 6 (2), 788-79.

Rao, B., Chowdary, S., Sandeep, V., Rao, V., venkateswarlu, B., 2014. Rising minimum temperature trends over India in recent decades: implications for agricultural production, 117, 1-8.

Rosowsky, D.V., 2021. Projecting the effects of a warming climate on the hurricane hazard and insured losses: Methodology and case study. Structural Safety, 88, https://doi.org/10.1016/j.strusafe.2020.102036

Scheifinger, H., Menzel, A., Koch, E., Peter, C., 2003. Trends of spring time frost eventa and phonological in central Europe. theoretical and applied climatology, (74), 41-51.
Schimmelpfennig, D., 1996. Uncertainty in Economic Models of Climate-Change Impacts. Climatic Change., 33, 213-234.
Schlenker, W., Roberts, M.J., 2009. Nonlinear Temperature Effects Indicate Severe Damages to US Crop Yield under Climate Change. Proceedings of the National Academy of Sciences, 106 (37), 15594-15598.
Shohrab, M., Sarker, H., 2021. Assessing levels of migrant-friendliness in the context of vulnerability to climate variability, change and environmental hazard: A comparison of two different-sized cities. International Journal of Disaster Risk Reduction, 21, https://doi.org/10.1016/j.ijdrr.2021.102525
Singh, D., Jain, S., Gupta, R., 2015. Trend in observed and projected maximum and minimum temperature over Himalayan basin, Journal of mountain science, 12 (2), 417-433.
Soumen, G., Biswaranjan, M., 2021. Assessing coastal vulnerability to environmental hazards of Indian Sundarban delta using multi-criteria decision-making approaches. Ocean & Coastal Management, 209, 105- 651. https://doi.org/10.1016/j.ocecoaman.2021.105641
Stewart, B., Ewan, W., 2019. Enabling communities for a changing climate: Re-configuring spaces of hazard governance. Geoforum, 100, 116-127. https://doi.org/10.1016/j.geoforum.2019.02.007
Stpierre, N.R., Cobanov, B., Schnitkey, G., 2003. Economic Loss from Heat Stress by US Livestock Industries. Journal of Dairy Science, 86, 52-77.
Tanarhte, M., Hadjinicolaou, P., Lelievehd, J., 2012. Intercomparison of temperature and precipitation data sets based on observations in the Mediterranean and the middle East. Journal of Geophysical research atmospheres, 117 (12), 60-79.
Tao, F., Xiao, D., Zhang, S.h., Zhang, Z., Rotter, R., 2017. Wheat Yield benefited from increases in minimum temperature plain of china. Agricultural and forest meteorology, 239, 1-14.
Tubiello, F.N., Soussana, J.F., Howden, M., Easterling, W., 2007. Crop and pasture responses to climate change: fundamental processes. Proceedings of the National Academy of Sciences, 104, 19686–19690.
Turkesh, M., summer, M., Dernirj, I., 2002. Re-evealuation of trends and change in mean, maximum and minimum temperature of Turkey for period 1991-1999. International Journal of climatology, 22, 947-977.
Vincent, W., Zhang, X., Lucie, A., Hogg, D., Ain, N., 2000. Temperature and precipitation trends in Canada during the 20th century, climate research branch. meteorological service of Canada, 11, 395-417.
Yang, S., Shumway, C.R., 2015. Dynamic Adjustment in US Agriculture under Climate Change. American Journal of Agricultural Economics, 3, 1-15.
Zuccaro, G., Leone, M.F., Martucci, C., 2020. Future research and innovation priorities in the field of natural hazards, disaster risk reduction, disaster risk management and climate change adaptation: a shared vision from the ESPREssO project. International Journal of Disaster Risk Reduction, 51, https://doi.org/10.1016/j.ijdrr.2020.101783